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OPERABLE UNIT 9, SITE SCOPING REPORT: VOLUME 7 - WASTE MANAGEMENT

MOUND PLANT
MIAMISBURG, OHIO

February 1993

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Department of Energy
Albuquerque Field Office

Environmental Restoration Program
EG&G Mound Applied Technologies

ENVIRONMENTAL RESTORATION PROGRAM

OPERABLE UNIT 9
SITE SCOPING REPORT:
VOLUME 7 - WASTE MANAGEMENT

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DEPARTMENT OF ENERGY
ALBUQUERQUE FIELD OFFICE

ENVIRONMENTAL RESTORATION PROGRAM
EG&G MOUND APPLIED TECHNOLOGIES

FINAL

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This report is Volume 7 of a multiple-volume Site Scoping Report providing the background information pertinent to the remedial investigation/feasibility study (RI/FS) of the Mound Plant. Under the terms of the Federal Facility Agreement between DOE and US EPA, this report is submitted to US EPA for approval.

This report is approved by US EPA only for the purposes of scoping the RI/FS, and approval does not imply concurrence with the interpretations presented herein. It is recognized that additional information will be collected during the RI/FS and may supersede information contained in this report.

APPROVED: Diana Mally
Remedial Project Manager
U.S. Environmental Protection Agency
Region V

Diana Mally

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	Overflow Pond Section Station 2 +50	Drawing No. FS 16669
	Overflow Pond Section Station 3 +00	Drawing No. FS 16977

Overflow Pond Section Station 3 +50	Drawing No. FS 16978
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ACRONYMS

ADP	Advanced Devices Plastics
ADS	air detritiation system
AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ALO	Albuquerque Operations Office (U.S. DOE)
ANL	Argonne National Laboratory
ANPP	Aircraft Nuclear Propulsion
BNA	base-neutral acid
BTU	British Thermal Unit
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COE	U.S. Army Corps of Engineers
CP	perchlorate
D&D	decontamination and decommissioning
DEHPA	di-2-ethylhexyl-phosphoric acid
DIBC	diisobutyl carbinal
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DSBPP	di-sec-butylphenyl phosphonate
ECS	emergency containment system
EG&G-MAT	EG&G Mound Applied Technologies
EP	extraction procedure
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration (Program)
ERDA	Energy Research and Development Administration
ERS	effluent removal system
FFA	Federal Facility Agreement
FP/IA	fission products/induced activity
FS	feasibility study
FWCU	feedwater cleanup system
FWPCA	Federal Water Pollution Control Act
GADS	glove box atmosphere detritiation system
GP	general purpose (building)
HEPA	high efficiency particulate air
HISS	hydrogen isotope separation system
HMX	octahydro-1,3,5,7-tetranitro-1,3,5,6-tetrazocine
HNS	hexanitrostil benecyclo-tetramethylenetetranitramine
HSWA	Hazardous and Solid Waste Amendment of 1984
ICC	Interstate Commerce Commission
INEL	Idaho National Engineering Laboratory
LDR	land disposal restrictions
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
LSA	low specific activity
MCC	Monsanto Chemical Company
MCL	maximum contaminant level
MRC	Monsanto Research Corporation
MTR	materials test reactor
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NPDES	National Pollution Discharge Elimination System
NPL	National Priority List

NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
PBX	plastic bonded explosive
PCB	polychlorinated biphenyl
PETN	pentaerythritol tetranitrate (explosive)
PMC	plutonium-molybdenum cermet
PPO	pressed plutonium oxide
PR	preliminary review
PVC	polyvinyl chloride
RAPCA	Regional Air Pollution Control Agency
RCG	radioactivity concentration guide
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-s-triazine cyclotetratmethylene-tetranitramine
RFA	RCRA Facility Assessment
RI	remedial investigation
RTG	radioisotopic thermoelectric generator
SALE	Safeguards Analytical Laboratory Exchange
SNAP	space nuclear auxiliary power
SRDS	storm water retention and discharge system
SRP	Savannah River Plant
SWMU	solid waste management unit
TAWRS	tritium aqueous waste recovery system
TDF	thermal diffusion facility
TOPO	tri-n-octylphosphine oxide
TRC	tritium recovery column
TRU	transuranic (waste)
TRUPACT	Transuranic Package Transporter-11
VSI	visual site inspection
WIPP	Waste Isolation Pilot Plant
WTS	Waste Transfer System

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1. INTRODUCTION

The U.S. Department of Energy (DOE) Mound Plant, Miamisburg, Ohio, was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) list (also known as the Superfund National Priority List [NPL]) on November 21, 1989 (54 Federal Register 48184). Pursuant to its NPL status, the DOE signed a CERCLA Section 120 Federal Facility Agreement (FFA) with the U.S. Environmental Protection Agency (EPA), which became effective October 11, 1990. A similar agreement is in negotiation between the DOE and the Ohio EPA (December 1990). The terms of the FFA require that the DOE develop and implement remedial investigations (RIs) and feasibility studies (FSs) and conduct interim remedial actions in order to ensure that environmental impacts associated with past and present activities at the Site are thoroughly investigated and appropriate action is taken to protect the public health and welfare and the environment.

The Albuquerque Operations Office of the DOE established the Environmental Restoration (ER) Program in 1984 to collect and assess environmental data in order to develop a conceptual site model, to assess both the nature and extent of contamination, and to identify potential exposure pathways and potential human and environmental receptors. These activities have been conducted under DOE policy for all facilities to comply with applicable environmental regulations. In order to provide EPA with sufficient information and data gathered during these previous investigations, a multi-volume scoping report, providing background information, has been prepared. The Site Scoping Report will provide descriptions and summaries of the current conditions and characteristics of Mound Plant and will consist of at least the following volumes:

1. Groundwater Data: February 1987 - July 1990
2. Geologic Log and Well Information Report
3. Radiological Site Survey Report
4. Engineering Map Series
5. Topographic Map Series
6. Photo History Report
7. Waste Management
8. Environmental Monitoring Data
9. Annotated Bibliography
10. Permits and Enforcement Actions
11. Spills and Response Actions

1.1. SCOPE OF REPORT

This report provides a history of the operation of Mound Plant, originally called Mound Laboratory, from its beginnings in the 1940s to its operations in the late-1980s. It provides descriptions of waste generation, treatment, storage, and disposal activities through the main projects and the plant support facilities. Data for this report were compiled from extensive personnel interviews and reviews of existing records. The records search included project proposals, progress reports, final reports, file correspondence, and health physics, waste management, and engineering records. The personal interviews generally augmented documented information, but were in conflict in some cases. The documentation for the various projects varies widely. Some projects have nearly complete records of project beginnings, progress, and completion, while others have few documented records or reports. In general, project reports included data and information on how well the project was proceeding; however, little or no information on the types and dispositions of wastes was ever included. Such information was generally obtained through personal interviews or health physics documents.

In reviewing the documented and oral history of Mound operations against some of the existing documents, such as other ER Program reports and the unpublished Resource Conservation and Recovery Act (RCRA) Facilities Assessment (RFA) (EPA 1988), many discrepancies and divergent descriptions were encountered. Where possible, these discrepancies have been noted and discussed within the text of this report. The information provided in this report is believed to be the most accurate to date.

1.2. SUMMARY OF THE DAYTON PROJECT

In the summer of 1942, the United States Army organized the Manhattan Engineer District for the purpose of developing an atomic bomb. This undertaking became known as the Manhattan Project. In 1943, Charles Allen Thomas, Director of Monsanto Chemical Company's (MCC's) (the word Chemical has since been deleted) Central Research Department in Dayton, Ohio, accepted responsibility for the chemistry and metallurgy of radioactive polonium-210, and the Dayton Project was launched. Visible quantities of polonium-210 had never before been produced. Significant quantities of this extremely rare isotope were required as an essential "trigger" for the atomic weapon.

MCC began its organization for the highly classified program by initiating the recruitment program at its Central Research Department facilities on Nicholas Road in Dayton, Ohio. This site became known as Unit I of the Dayton Project. Within a short time, it became apparent that larger facilities were required to produce the needed polonium, and three additional sites were obtained in Dayton during the mid-1940s. These included Units III and IV and a downtown warehouse.

A building known as the Bonebreak Theological Seminary, dating from 1879, located at 160 West First Street in Dayton, was rented and hastily renovated. It was occupied in October 1943 and became known as Unit III. A steel Quonset hut and several small block buildings were erected to increase the usable space for machine operations, a powerhouse, and a cafeteria. Unit III finally consisted of 20 buildings (Moyer 1956).

In February 1944, the U.S. Army Corps of Engineers (COE) rented the Runnymede Playhouse located in Oakwood, Ohio, at the southern boundary of Dayton, and turned it over to MCC. The Runnymede facility was a relatively large, private recreational building constructed in 1927 by the Talbott family for private activities. This facility, known as Unit IV, included several greenhouses, an indoor tennis court, a stage, a squash court, lounges, and an outdoor swimming pool. Part of the structure had a corrugated glass roof (Gilbert 1969).

During the early years of the Dayton Project, MCC also independently operated a facility, known as Unit II, for the production of rocket propellant. Explosives produced at Unit II included ammonium picrate and ammonium nitrate; however, no radioactive materials were handled at this location. Scrap explosives were burned onsite at Unit II. No fuel wastes, refuse, or other waste materials were buried on-plant. Radioactive materials were not handled, so there was no nuclear disposal to be considered. MCC phased out this operation around the fall of 1945 (Meyer 1979b).

In the Dayton Project, polonium was not produced at Unit I. The production process was set up initially at Units III and IV and later, in 1948, at Mound Laboratory (known as Unit V). In subsequent years, various research projects that did involve radioisotopes were undertaken at Unit I, some of which were transferred from Mound. Work was done under Atomic Energy Commission (AEC) and, subsequently, Nuclear Regulatory Commission (NRC) licenses. These projects involved relatively small quantities of various isotopes such as carbon-14 and tritium. Some sealed sources were used in curie quantities. Trace quantities were discharged to the domestic sewer but under rigid controls according to the terms of the licenses and the provisions of 10 Code of Federal Regulations (CFR) Part 20. Radioactive material was not buried onsite. Solid waste was packaged in compliance with the stringent Interstate Commerce Commission (ICC) regulations. In the early years of operations at Unit I, other toxic materials, such as spent acids, were disposed of in onsite acid pits and allowed to neutralize in the soil. For example, 5-gallon containers of hydrochloric acid were emptied into an acid pit every few days (Meyer 1979b).

The principal contaminant at the Dayton units was polonium-210 (DOE 1986). Other contaminants included tellurium, bismuth, cobalt, nickel, beryllium, and thorium (Hochwalt 1948). Tellurium was a common contaminant in the irradiated bismuth slugs. Cobalt was a common impurity in the aluminum

cans used to jacket the bismuth slugs. Other impurities were also present and are described in the polonium section of this report. The nickel and beryllium originated from the polonium source and initiator production programs as well. The extent of thorium use at the Dayton units probably involved research quantities of materials.

The work at the Dayton units principally involved the separation and purification of polonium-210. Work also involved research and development of calorimetry and other instruments for measuring small quantities of alpha-emitting radionuclides, such as polonium. Other work included mechanical development of micro beam balances and electronic equipment and limited biological research on the toxic effects of polonium (Svirbely et al. 1947). Neutron and alpha particle sources, powered by polonium-210, were manufactured for sale to government and research organizations.

Pilot plant investigations of waste disposal by incineration were started in February 1948 at Unit III. The first pilot plant operated about six weeks (MCC 1949).

All radioactive waste generated at Unit III was packaged in strong, leak-proof containers according to ICC regulations and shipped on government vehicles to Oak Ridge National Laboratory (ORNL) for onsite burial. No materials were buried onsite at Unit III or sent to city landfills or other disposal sites. Disposal was controlled. Wastewater containing low-level alpha activity was discharged to the Dayton sewer system and was monitored at the Great Miami River by health physics personnel (Bradley 1951a). All operations ceased at Unit III in 1948. The facilities and site were decontaminated and turned over to the Dayton Board of Education, the site owner (Halbach 1949). Some Unit III block structures were demolished and transported to Mound for disposal. The Quonset hut was dismantled and subsequently rebuilt at Mound and still stands today as Building 19.

All radioactive waste was handled at Unit IV in the same manner as at Unit III. It was packaged and shipped by government vehicles to ORNL for burial. The principal isotope was polonium-210. Radioactive waste was not buried onsite or in the immediate area of Unit IV. All operations at Unit IV ceased and were transferred to Mound late in 1948. By the spring of 1950, all Unit IV structures, services, and utilities were removed, and the soil was excavated to a depth of 7 ft (Halbach 1950). Highly contaminated materials were packaged and shipped to ORNL for burial. Most of the Unit IV structure was transported to Mound for disposal. Clean fill dirt replaced the excavated soil, and the site was completely landscaped to blend with the surrounding well-kept, upper-class suburban Oakwood neighborhood. The property was then returned to the Talbott family estate.

Radioactive materials present at the warehouse were limited to trace quantities of polonium-210 from the analysis of environmental monitoring samples, bioassay samples from the project personnel, and

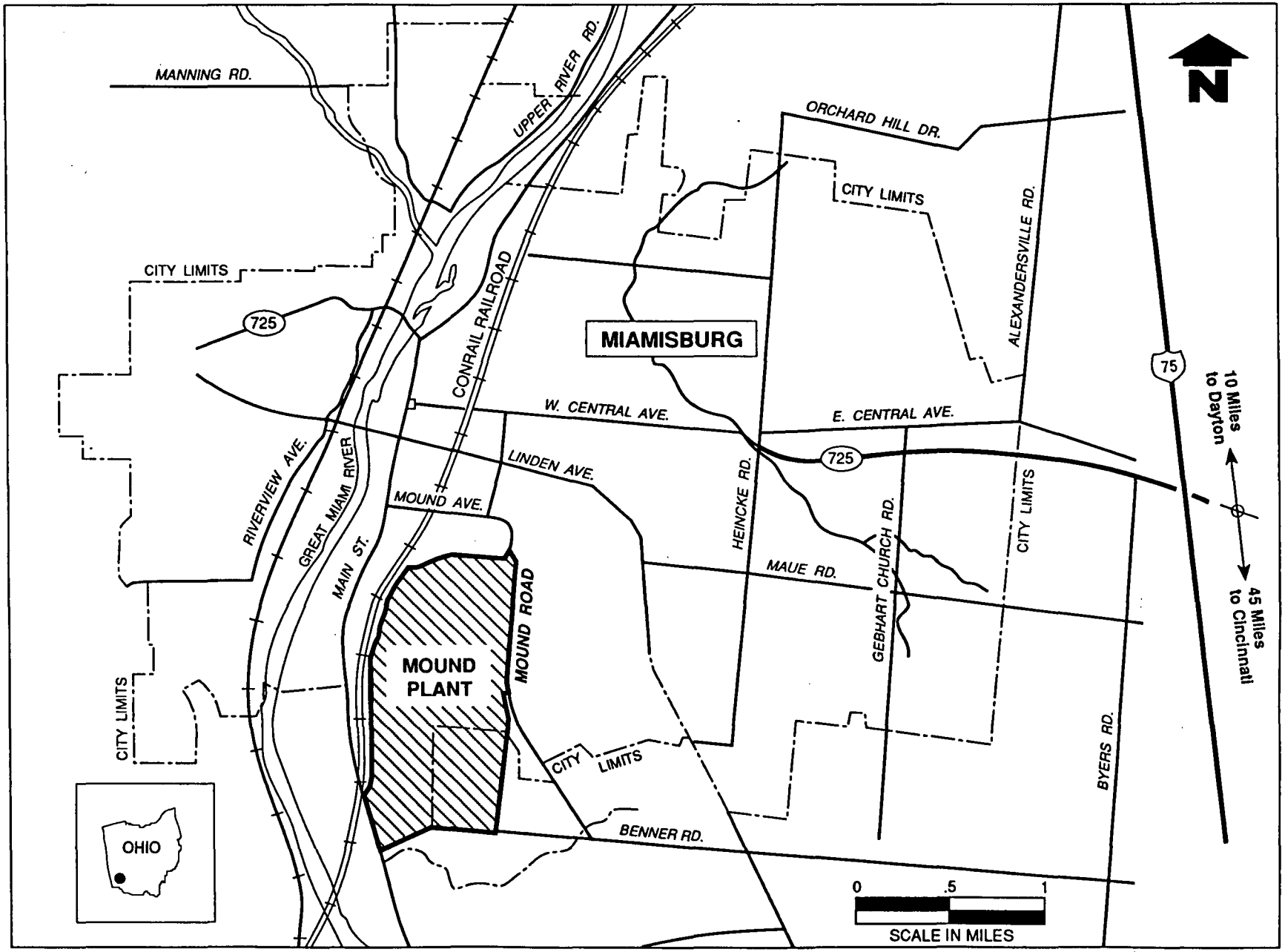
preliminary biological studies on the effects of polonium on laboratory animals. These activities were conducted at the warehouse rather than at Units III or IV because a very low background of polonium was necessary to prevent contamination of the samples being processed. Samples, waste materials, and plated copper discs from the polonium analyses were discarded into the general warehouse wastes because the amounts and concentrations of polonium were so small (Meyer 1979b). The warehouse operation was also transferred to Mound in 1949. Equipment was moved to Mound, and the area was scrubbed down and returned to the building manager for rental to other clients. The environmental, bioassay, and animal studies were set up at Mound (Meyer 1979b).

1.3. SUMMARY OF OWNERSHIP AND OPERATION OF MOUND

In 1946, a 182-acre site on the outskirts of the town of Miamisburg in Montgomery County, Ohio (Figure 1.1), was selected as the location of the permanent research facility in support of the Manhattan Project. The site is approximately 10 miles south-southwest of Dayton and 45 miles north of Cincinnati (Figure 1.2). In July of 1946, Monsanto Research Corporation (MRC), a subsidiary of MCC, engaged the firm of Giffels and Vallet of Detroit, Michigan, to design the plant. The plant was called Dayton Unit V (more formally the Dayton Engineer Works under the Dayton Engineer District). Construction of the new facility, consisting of 14 original buildings, began in February 1947 by Maxon Construction Co., Dayton, Ohio. The plant was the first permanent facility of the AEC, which had succeeded the wartime Manhattan Engineer District. The Mound Laboratory was occupied by MRC personnel in May 1948, and operations involving radionuclides began in January 1949 (Meyer 1991).

Mound is a government-owned and contractor-operated facility, originally administered under the Oak Ridge Operations Office of the AEC. The plant was assigned new production and development functions in 1955 when the administrative control was assumed by the AEC's Santa Fe Operations office. The Santa Fe Operations Office was changed to the Albuquerque Operations Office in April 1956. In January 1975, the plant formally came under the Energy Research and Development Administration (ERDA) upon dissolution of the AEC. In October 1977, the plant was incorporated into the DOE complex and the facility designation changed from Mound Laboratory to Mound Plant. MRC was the sole operating contractor until October 1988, when EG&G-Mound Applied Technologies (EG&G-MAT) took over.

The early Mound programs investigated the chemical and metallurgical properties of polonium-210 and its applications, including the fabrication of neutron and alpha sources for weapons and non-weapons use. Investigations involving uranium, protactinium-231, and plutonium-239 were performed from 1950 to 1963 as part of the national civilian power reactor program. In 1954, separation of the stable isotopes of noble gases was begun, as well as a program to separate thorium-230 for the AEC.



Mound location map/5-4-92

Figure 1.1. Location of Mound Plant, Miamisburg, Ohio.

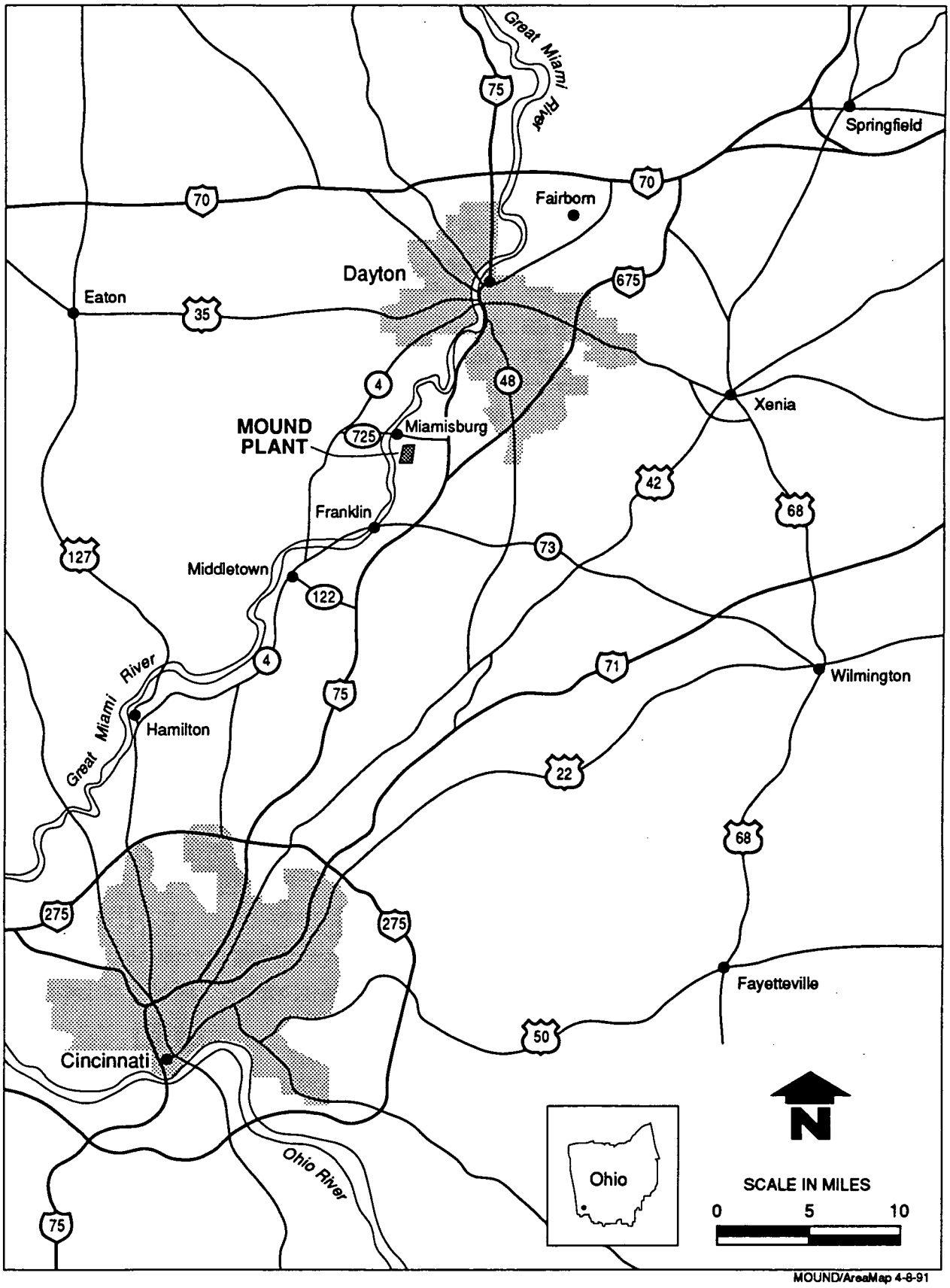


Figure 1.2. Regional location of Mound Plant.

In 1955, construction began on a thorium refinery at Mound for the thorium-232 project of the breeder reactor program. Approximately 5,900 55-gallon drums of thorium hydroxide, oxalate, and oxide were received. A pilot plant was assembled and tested, but the ores were never processed. From 1955 to 1965, the thorium ore and sludges were repackaged three times, and the drums were stored in large groups. In 1966, the thorium was moved to a bulk-type storage silo (Building 21) and was completely removed from the silo in 1974. Uranium sludge containing thorium (Cotter Concentrate) was later obtained and processed for extraction of protactinium-231. The Cotter material was removed for storage at the Nevada Test Site (NTS) in late 1987.

In 1954, a thermoelectric generator fueled with polonium-210 was invented at Mound and was patented. This invention used heat from the radioactive decay of polonium-210. The first space nuclear auxiliary power (SNAP) generator, a SNAP-3A fueled with polonium-210, was demonstrated in 1959. In 1961, the development of plutonium-238 heat sources was started at Mound. Plutonium-238 was used because of its high specific activity and relatively short half-life (87.74 years). Since that time, heat sources fueled with plutonium-238 have been developed and fabricated for use in thermoelectric generators and for lunar experiments, weather satellites, navigational satellites, and spacecraft. The SNAP-27 units placed on the moon during the Apollo program and the satellite for the Jupiter Fly-By mission were powered by plutonium-238-fueled thermoelectric generators built at Mound. Power sources for the Mariner program's Jupiter-Saturn mission were built at Mound as well as the heat sources used to power the Pioneer spacecraft and to provide heat for the delicate instruments carried on-board. Other heat sources have been developed by Mound for use in life-support systems, swimsuit heaters, artificial hearts, and cardiac pacemakers (MRC 1981a). In 1957, Mound was assigned a new mission to develop, produce, and provide surveillance of detonators for military applications. Development of explosive timers in 1959 led to their manufacture at the plant starting in 1963. The development and manufacture of ferroelectric transducers and firing sets (components that control initiation of detonators) began at Mound in 1962. All of these programs continue today.

The first of several programs requiring tritium-handling technology was initiated at Mound in the mid-1950s. Today, the plant has extensive capabilities for handling and studying tritium and tritium compounds for weapons or non-weapons applications. Plant facilities exist for the recovery and purification of tritium from all types of wastes generated at DOE sites and for the development of tritium-containing materials and processes for weapons applications and possible manufacture (MRC 1981a).

In the early 1970s, as national concerns about the environment and the conservation of resources mounted, Mound expanded its programs in environmental monitoring and waste management. The environmental monitoring program is discussed in the Site Scoping Report: Volume 8 - Environmental Monitoring Data (DOE 1992d), and the waste management program is detailed in this report.

Mound is currently an integrated research, development, and production facility performing work in support of DOE weapons and energy programs, with emphasis on explosives and nuclear technology. Energy-related activities support the DOE programs and include

- research, development, and fabrication of radioisotope-fueled heat sources for space, terrestrial, and marine applications;
- radioisotopic thermoelectric generator (RTG) fabrication and testing;
- separation, purification, and world-wide sales of stable noble gas isotopes, such as helium-3, and carbon-13;
- production of a selected group of other radionuclides;
- development of measurement technology for nuclear materials as required for safeguards;
- basic research in metal hydrides, solar fluids, gas dynamics, and isotope separation;
- research and development of nuclear waste management techniques; and
- development of instrumentation and verification procedures for radioactive studies of radiation workers.

In addition, Mound is involved in the decontamination and decommissioning (D&D) of some of its plutonium-238-handling facilities.

1.4. SUMMARY OF THE WASTE MANAGEMENT PROGRAM AT MOUND

The scope and character of the waste management program at Mound have changed significantly since the plant began operations in 1949. Until 1970, Mound personnel separated nonradioactive from radioactive wastes. Nonradioactive wastes were burned or disposed of in the historic landfill or in other areas designated for general debris disposal, as described in later sections of this report. Radioactive wastes were generally drummed and shipped offsite to an approved disposal facility, although some residual materials containing radioactive low-level wastes (LLW) were buried onsite. On July 1, 1972, the waste management program became a formal part of the Mount organization.

The program produced plans for managing and reducing the amount of wastes generated; proposed and reported results of treatment facilities; reported achieved and expected waste management accomplishments; and reported actual and projected budget requirements. These plans have been produced annually since 1972 (MRC 1972; 1973b,c; 1974b,c,e; 1975a,b; 1976a; 1977a; 1978a; 1979; 1980; 1981b; 1982; 1983; 1984b; 1985c; 1986; and 1987; EG&G 1988, 1989b, and 1991a). At first, the plans provided for the management and reduction of only radioactive wastes, essentially the unclassified updates of older classified plans required by the AEC. The focus was on handling, minimizing, and disposing of polonium, plutonium, and tritium wastes. Nonradioactive wastes were added to the program plans in 1978, although chemical wastes had been part of the formal waste management program since 1972. The 1980 Waste Management Plan (MRC 1980) included sanitary wastes, solvent wastes, and other liquid wastes such as oils, paints, thinners and photoprocessing wastes, solid wastes, and kitchen garbage.

The management of radioactive wastes has always been of primary concern at Mound. During the 1940s and 1950s, all radioactive wastes were shipped to ORNL for burial. Much of the LLWs were shipped to commercial facilities such as Maxie Flats, Kentucky; Barnwell, South Carolina; and West Valley, New York. Classified wastes were shipped to ORNL or Savannah River Plant (SRP), South Carolina. In the early 1970s, the AEC Manual, Chapter 0511, Waste Management, required that all transuranic (TRU) wastes be packaged in containers that would withstand up to 20 years of retrievability and be buried at an AEC site. The criteria for disposal of TRU wastes exempted Mound's principal contaminant, plutonium-238, if the activity was below 10 nanocuries per gram (nCi/g). As a result, in the mid-1970s, Mound began subdividing the TRU waste streams and implemented a program to reduce the volumes of LLWs by compaction or onsite incineration.

In 1982, as a result of the ever-increasing volumes of TRU wastes nationally, the National Council on Radiation Protection and Measurements recommended to the NRC that the criteria for TRU wastes limits be raised to 100 nCi/g (NCRP 1982). This action reduced the quantities of TRU waste that required retrievable storage. Through the 1980s, Mound shipped non-TRU wastes (<100 nCi/g) to the NTS for burial and TRU wastes (>100 nCi/g) to the Idaho National Engineering Laboratory (INEL) for burial. By gubernatorial order, shipments to INEL stopped in 1988.

In 1985, Mound's certification plan for solidified sludge TRU waste shipments to the DOE's Waste Isolation Pilot Plant (WIPP) in New Mexico was the first within the DOE complex to be approved. By June 1988, all four of Mound's TRU wastes (cemented sludge, noncombustible, combustible, and soils) were certified for disposal at WIPP (EG&G 1989b). To date, WIPP has not opened nor have tests been undertaken. Mound is currently scheduled to receive the WIPP mobile assay system to conduct a nondestructive examination and evaluation of its TRU waste inventory. It is anticipated that this

evaluation will provide the data necessary to determine what additional processing may be required, if any, to provide both WIPP and Transuranic Package Transporter (TRUPACT)-II certification. Before using the TRUPACT-II, Mound will have to comply with a preshipment audit (EG&G 1991a).

In 1984, the plant established waste management policies and procedures involving hazardous, toxic, mixed, and certain other designated wastes, such as mineral and silicone oils, as required by DOE Order 5480.2. The implementation plan for this order (MRC 1984a) required Mound to comply with environmental regulations for the handling, treatment, storage, and disposal of wastes containing hazardous materials identified in 40 CFR 261; 40 CFR 116; 40 CFR 61; 40 CFR 761; Section 5a of DOE Order AL5480.2; and Appendix A, Item J, of DOE Order AL5480.2, as described below.

- 40 CFR 261, EPA Regulations for Identifying RCRA Hazardous Wastes, includes any waste that 1) exhibits the characteristics of ignitability, corrosivity, reactivity, and extraction procedure (EP) toxicity; 2) is listed in Part 261 as a waste from a nonspecific or specific source or as a discarded commercial chemical product or associated off-specification material, container, or spill residue; or 3) is a mixture of a solid waste and a hazardous waste listed in Part 261 solely because it exhibits any of the characteristics noted in item 1 above;

- 40 CFR 116, EPA Regulations on Designation of Hazardous Substances Under the Federal Water Pollution Control Act (FWPCA), includes 339 elements and compounds listed in Part 116 that have been designated as hazardous substances in accordance with Section 311(b)(2)(A) of the FWPCA;

- 40 CFR 61, EPA Regulations on National Emission Standards for Hazardous Air Pollutants (NESHAP), includes asbestos, beryllium, mercury, and vinyl chloride;

- 40 CFR 761, Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Limitations, includes PCBs and PCB-contaminated equipment or materials;

- Section 5a of DOE Order AL5480.2, Hazardous, Toxic, and Radioactive Mixed Waste Management, includes waste-containing materials considered to be carcinogenic, such as those in Occupational Safety and Health Standards, Subpart Z, Toxic and Hazardous Substances 29 CFR 1910.1001 to 1910.1018; and

- Appendix A, Item J, of DOE Order AL5480.2, which includes mineral and silicone oils, transformers, and capacitors containing more than 5 gallons of oil.

In compliance with permit requirements under these regulations, Mound has applied for or has received permits for its surface water discharges, air emissions, and hazardous waste program. Mound maintains a National Pollution Discharge Elimination System (NPDES) surface water permit with facility I.D. Number OH0009857. In 1973, Mound was awarded a patent for a process for removing radioactive nuclides, primarily plutonium-238, from its radioactive wastewater. Filtration through a bed of calcium phosphate (actually natural calcium hydroxyapatite as bone char) allowed removal of 95 to

99 percent of the colloidal particles and reduced the plutonium content of the wastewater effluent to the Great Miami River. Permits for the open burning of wastes involving explosives and other fuels have been issued by the Regional Air Pollution Control Agency (RAPCA). Other operations that may produce particulate or vaporous emissions are registered with RAPCA and the Ohio EPA. Further descriptions of these activities and permits are beyond the scope of this report. A full listing of the permits and registrations applied for or received by the plant is detailed in the Operable Unit 9, Site Scoping Report: Volume 10 - Permits and Enforcement Actions (DOE 1992f).

In November 1980, Mound submitted to EPA a Notification of Hazardous Waste Activity (EPA Form 8700-12). The facility I.D. Number is OH6890008984. At the same time, Mound submitted a General Information Form (Form 1 General, EPA Form 3510-1) and a RCRA Part A Hazardous Waste Permit Application (Form 3 RCRA, EPA Form 3510-3) to store hazardous waste in containers and to treat hazardous waste onsite. The RCRA Part A permit application has been revised several times: in November 1984, Mound submitted additional waste management information and recorded the acquisition of the 124 acres of new property; in January 1985, the two thermal treatment units — the glass melter furnace and cyclone incinerator — were described; in March 1985, explosive wastes were described that were treated onsite; in May 1985, the hazardous wastes storage Building 72 relocation was described; and in August 1986, the cyclone incinerator was withdrawn from the application. In November 1986, Mound submitted the RCRA Part B permit application with EPA Region V. The Part B permit application includes a glass melter furnace intended for use in burning hazardous and mixed wastes, the waste storage Building 72, and the mixed waste storage Building 23.

In May 1988, the Preliminary Review (PR) and Visual Site Inspection (VSI) were conducted as part of the RCRA Facilities Assessment (RFA) for the plant. The PR and VSI resulted in the identification of 86 Solid Waste Management Units (SWMUs) and 38 other areas of concern. A draft PR/VSI Report was prepared by A.T. Kearney, Inc., under contract to EPA Region V, but was never finalized (EPA 1988). All of the 124 sites identified by the PR/VSI are currently included in the ER Program (DOE 1992g), but may not necessarily be discussed in this report, as many of the PR/VSI areas do not pertain to the past or current waste management practices of Mound.

In May 1989, Mound submitted a revised Part A permit application identifying EG&G-MAT as the new plant operator. The revised Part A permit application was reviewed and approved by the EPA Region V in early June 1989. On June 30, 1989, the state of Ohio was granted final authorization by the EPA to operate its program in lieu of the federal program. In anticipation of the approval of the permit application, EPA and Ohio EPA have recently conducted inspections of the plant.

On September 12 and 13, 1989, the Ohio EPA conducted a hazardous waste compliance inspection. That inspection resulted in five findings that were corrected by Mound and reported back to the Ohio EPA. The EPA Region V conducted a federal facilities compliance with RCRA inspection of the plant's hazardous waste facilities on September 28 and 29, 1989. In a letter dated June 12, 1990, the EPA identified the storage of mixed waste at Mound to be in violation of land disposal restrictions (LDR) of the Hazardous and Solid Waste Amendment Act (HSWA) of 1984. HSWA (42 U.S.C. 6924(j)) prohibited the continued storage of the LDR wastes unless it was solely to accumulate quantities necessary to facilitate proper recovery, treatment, or disposal. In conjunction with all other DOE facilities, Mound listed information on its specific LDR mixed waste noncompliance issues in the National Storage Report, provided to EPA in Washington, D.C., on January 17, 1990. In a letter received in October 1990, EPA notified Mound that it was in compliance with applicable LDR rules and regulations.

At the request of the state of Ohio, a revised RCRA Part A and Part B Permit Application was submitted to the state in May 1990 (DOE 1990a). This application includes a trial burn plan for the glass melter thermal treatment unit (glass melter furnace). Copies of the application and the trial burn plan were submitted to the EPA and are, at this writing, under review. The RCRA Part B permit application was resubmitted to the state of Ohio in October 1991. At this writing, Mound operates in interim status to store and dispose of hazardous and mixed wastes (DOE 1992f).

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2. HISTORY OF KEY PROJECTS AT MOUND: WASTE GENERATION

Mound, originally called Mound Laboratory, has been a research, development, and production facility since its beginnings in the late-1940s. As an integral part of the DOE (originally the AEC, and briefly, the ERDA), Mound has performed work in support of weapons and nonweapons energy programs with emphasis on explosives and nuclear technology. Historical projects have included research and production of polonium-210 and plutonium-238, thorium and protactinium-231, radium-226 and actinium-227, and stable isotopes of noble gases such as helium, argon, neon, krypton, and xenon. Tritium recovery has been a large part of plant operations since the 1950s.

The following subsections summarize the salient features of the major programs at Mound. Each subsection includes an overview of the project activity, the general scale of the project, dates, process descriptions associated with the project, wastes generated by the project, and the disposition of the wastes, if known. The ideal program cycle includes research, pilot plant, production, and then D&D phases. Not all programs followed the entire ideal cycle. Locations referred to in the following subsections are shown on Figure 2.1.

2.1. POLONIUM PROJECT

In the summer of 1942, the COE organized the Manhattan Engineer District. The purpose of the District's Manhattan Project was to build an atomic bomb. Polonium-210 was vital to this program, because it was to be used in a neutron source that would ensure initiation of a chain reaction. The polonium project was undertaken by MCC at the company's Central Research Department in Dayton, Ohio, in September 1943 (Gilbert 1969), and became known as the Dayton Project. Subsequently, polonium-based neutron sources were produced for other industrial and research applications.

In 1954, the Mound began a program using polonium-210 to convert nuclear energy to useable electric energy. This application of nuclear energy, using a thermoelectric principle, was demonstrated that same year, and in February, Mound received a directive to fabricate a polonium-powered model steam-electric plant (Roberson 1954). A model was built and demonstrated in 1954 (Olt et al. 1954). In 1956, a conceptual design to produce a mercury boiler fueled with polonium was described (Hittman 1956). By 1958, an RTG powered by polonium-210 was built.

The power density of polonium is unique and made it attractive as a power source. One pound of polonium-210 occupies a volume of approximately 3 cubic inches and produces heat at the rate of 3.6×10^6 British Thermal Units (BTUs) per minute or about 64 kilowatts of electric power. With a thermal energy output of 120 watts per g, polonium-210 was selected initially for use in the RTG.

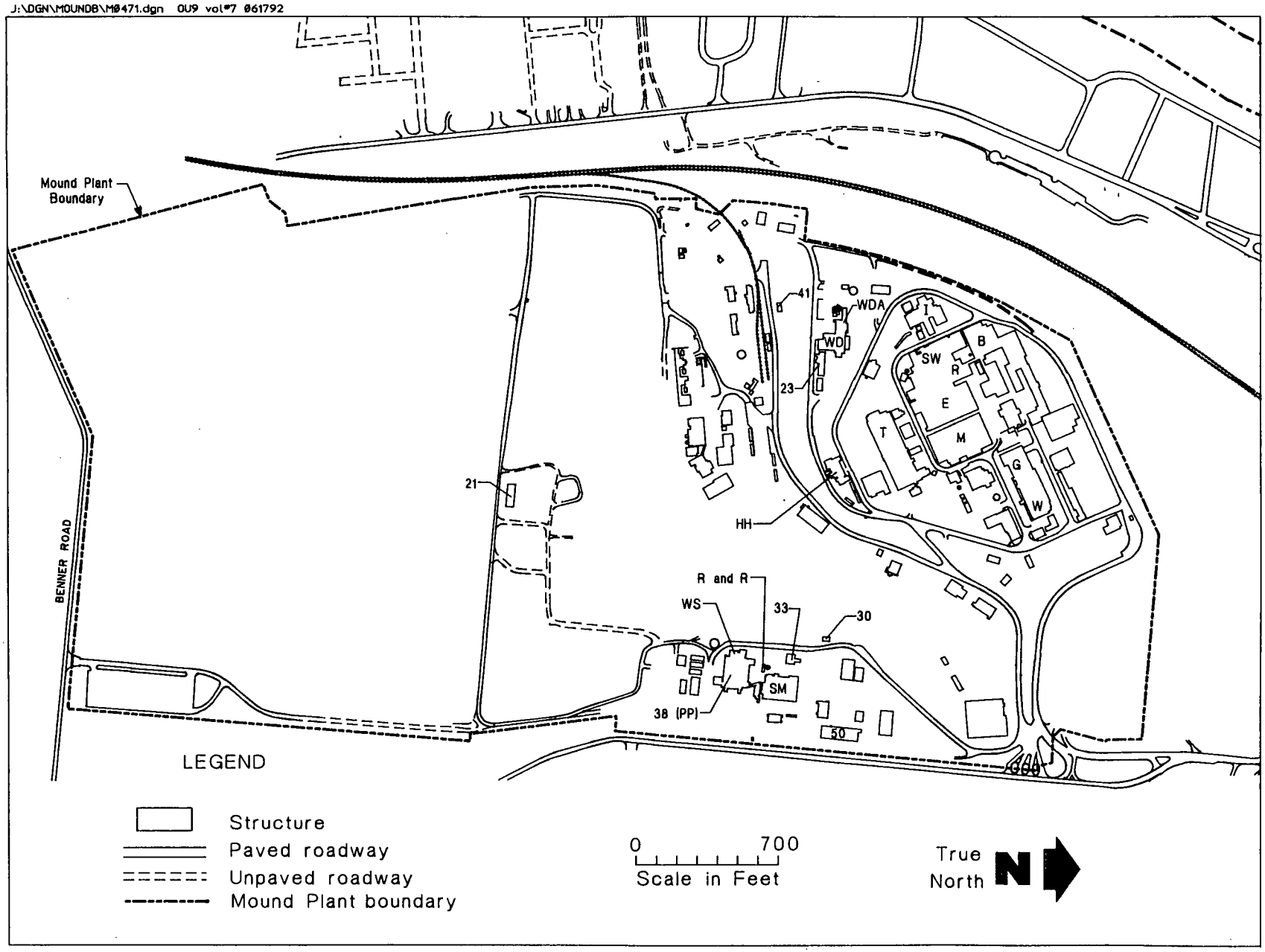


Figure 2.1. Mound building locations.

Known as SNAP, these generators convert the thermal energy generated by radioactive decay to electrical energy. The first SNAP-3A, fueled with polonium-210, provided power to a satellite radio transmitter. The use of satellites powered by SNAP for global communication was first demonstrated under President Eisenhower in 1961, at which time the President's peace message was broadcast via a satellite containing a radio transmitter powered by the SNAP-3A RTG.

Because polonium-210 has a short half-life (138 days), its usefulness was limited for application on long duration satellite and space probe missions. Polonium research and production at Mound were eventually phased out in 1971.

2.1.1. Project Description

Prior to 1944, polonium had not been isolated in pure form or in any appreciable quantity. Therefore, any program involving the recovery, purification, and fabrication of polonium metal from a variety of sources required an understanding of the chemical and physical properties and the metallurgy of polonium-210. The Dayton Project's goal was to develop an understanding of the properties of polonium and its metallurgy (Gilbert 1969).

Initially, the recovery of polonium was attempted from naturally occurring sources such as lead-containing wastes from uranium, vanadium, and radium refining operations. Upon investigation, it became apparent that sufficient quantities of polonium could not be recovered from these sources without processing prohibitively large amounts of material. To obtain polonium in the quantities needed, other approaches to its production were investigated, and the transmutation of bismuth metal to polonium-210 by neutron irradiation was selected for production scale operations.

2.1.2. Process Description

In February 1949, the polonium operations were transferred from Dayton to Mound (Moyer 1956). At this time, the process for producing polonium-210 had been decided upon. Polonium-210 would be produced by the transmutation of bismuth by neutron bombardment. The reaction proceeds as shown in the equation

$$_{83}Bi^{209} + {}_{0}n^{1} \rightarrow {}_{83}Bi^{210} \rightarrow {}_{84}Po^{210} + \beta^{-}$$

with the $_{83}Bi^{210}$ decaying to polonium-210 in 5.4 days. All polonium processing activities at Mound involving irradiated bismuth were conducted on the first and second floors of T Building. Initially, bismuth, in the form of 12-inch by 3-3/4-inch by 3-3/4-inch bricks weighing 58 pounds, was irradiated

in the Clinton reactor at Oak Ridge, Tennessee. Subsequently, bismuth metal was cast into slugs and inserted into 2S aluminum cans. Aluminum covers were welded to the cans, sealing in the bismuth metal. This operation and the neutron irradiation were performed at the Hanford operations facility in Richland, Washington, where a higher neutron flux was achievable.

After irradiation, the aluminum cans containing bismuth were shipped to Mound in lead casks that provided radiation shielding. Upon arriving at Mound, the aluminum cans were removed from the casks and stored in a pool of water that provided further shielding until they were removed for use in the polonium recovery process. The pool was located on the second floor of T Building. The lead casks were surveyed for radiation and, if necessary, were rinsed with water to remove surface contamination. They were then shipped back to the Hanford facility for reuse. Numerous approaches to decanning were investigated including mechanical cutting, chemical dissolution, and melting the bismuth in a furnace and pouring it out of the can. In those instances where the aluminum can was separated from the bismuth slug, the aluminum can was shipped to Oak Ridge for burial.

In the polonium production process, the separation of the bismuth slug from the aluminum can was accomplished by chemical dissolution. This occurred on the second floor of T Building where the can was dissolved in a 17 percent hydrochloric acid bath. The bismuth slug did not react with hydrochloric acid and was removed from the bath and washed with water to prepare it for dissolution. The aluminum used in fabricating the can and the bismuth contained impurities such as iron, silicon, cobalt, lead, tin, zinc, silver, chromium, vanadium, and gallium. Upon irradiation, these impurities produced gamma-emitting isotopes that, at the time of bismuth processing, created a radiation health hazard.

The processing techniques for bismuth and polonium varied depending on the required form and purity and because of the research and development nature of this program. Most bismuth research and development was performed in the R Building. As the knowledge of physical and chemical properties grew, it was applied to production techniques to meet and improve product purity requirements.

2.1.2.1. Chemical Separation of Polonium from Irradiated Bismuth

The separation of polonium-210 from bismuth took place on the second floor of the T Building. This chemical separation process is shown in Figure 2.2. The process is generally described by Huddleston et al. (1963). The process began with the dissolution of the bismuth metal slug in a mixture of nitric and hydrochloric acids (Lonadier and Huddleston 1964). During this step, gaseous nitric acid, nitrogen dioxide, and hydrogen gas were generated. These gases were passed through a caustic scrubber, and the acidic components were neutralized before being exhausted through the high efficiency particulate air (HEPA) filter bank to the building's stack. After the bismuth slug was completely dissolved, the resulting solution was denitrated by the addition of formic acid and heating the solution to 100°C.

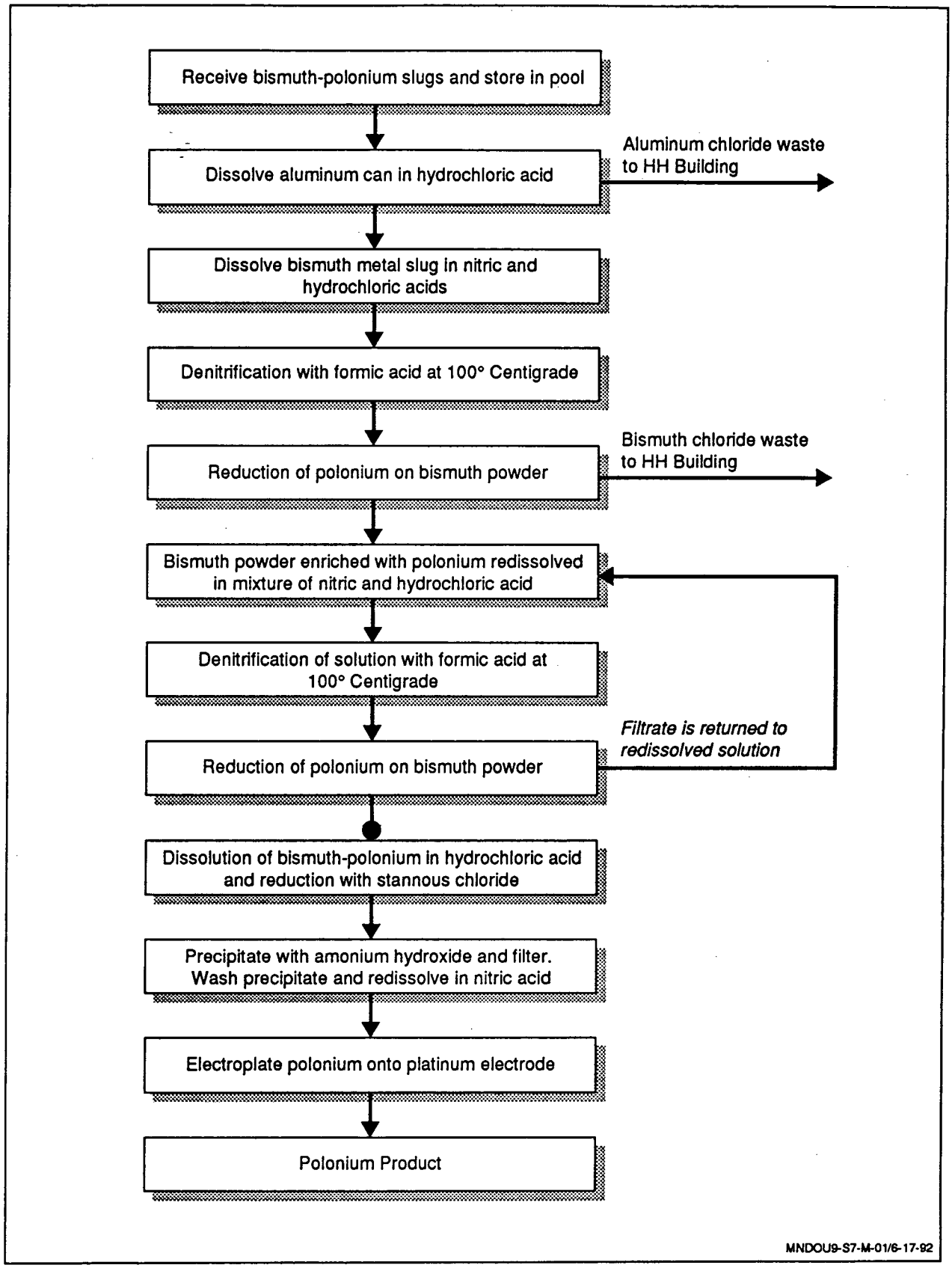


Figure 2.2. Bismuth-polonium separation process.

The next step in the process involved the separation of polonium from the polonium-bismuth solution. The polonium was recovered from the mixture by passing the solution over a bed of 140- to 200-mesh bismuth metal powder. The polonium was deposited on the bismuth powder and the filtrate was sent to the HH Building where it was processed as a waste. The aluminum chloride and bismuth chloride wastes were processed in the HH Building until other commitments for space required moving the waste treatment facility to the T Building in 1959. The polonium waste treatment facility was set up on the first floor of T Building, but the waste continued to be referred to as HH sludge.

The bismuth-polonium powder was redissolved in a mixture of nitric and hydrochloric acid, and the resulting solution was denitrated with formic acid. The denitrated solution was again passed over bismuth powder and polonium was reduced on the surface of the bismuth powder. The supernatant solution, containing some polonium, was returned for recycling to the previous concentration step in the process. When a polonium concentration of approximately 15,000 parts per million (ppm) was reached, the polonium-bismuth powder was dissolved in hydrochloric acid catalyzed by hydrogen peroxide. The polonium in this solution was reduced using stannous chloride, and the polonium was filtered from the solution and washed with stannous chloride and a dilute hydrazide hydrogen chloride solution. After the polonium metal was washed, it was redissolved using hydrochloric acid and hydrogen peroxide. This solution was then treated with ammonium hydroxide, and the polonium was precipitated as the hydroxide. The hydroxide was filtered and washed to prepare it for the final step of polonium purification. The polonium hydroxide was redissolved in nitric acid, and the polonium was electroplated onto a platinum gauze electrode. The polonium metal was then ready for fabrication.

Other processes have been developed at Mound to separate polonium-210 from bismuth. Two additional processes, the silver process and the tellurium process, were actually employed on a production scale. Both processes could be used with the denitrated solution of the bismuth slugs. In the case of the silver process, the polonium spontaneously deposited onto the silver surface as polonium metal. Bismuth was not reduced by silver and therefore remained in solution. Next, the silver containing polonium was dissolved in nitric acid. This solution was treated with ammonium hydroxide, which precipitated the polonium. The silver remained in solution as a silver ammonium ion.

The tellurium process was used following the first step of polonium concentration using bismuth powder. Telluric acid and stannous chloride were added to a denitrated solution of polonium and bismuth, and the solution was heated. The tellurium precipitated and coagulated, and the polonium co-precipitated with the tellurium. This process resulted in the precipitation of some bismuth, which was eliminated by repeating the process. After the second precipitation step, the washed precipitate was dissolved in aqua regia, and the polonium recovery proceeded as in the bismuth process.

2.1.2.2. Bismuth Metal Recovery

At the beginning of the polonium program, the bismuth oxychloride sludge produced in the HH Building was stored at Mound for possible recovery of the bismuth and re-irradiation at the Hanford facility (McEwen 1952b). In 1948, an electrolytic process was developed that successfully recovered bismuth, and in March 1950, seven bismuth slugs were produced from recovered metal. These were sent to Hanford for neutron irradiation. In 1952, Mound constructed a bismuth metal recovery facility in the HH Building, with the capacity to produce 17,000 pounds of bismuth annually, that would process the accumulated drums of bismuth sludge (Belcher 1952b). The amount of sludge being stored at Mound in 1952 was equivalent to 62,000 pounds of bismuth. This amount of sludge represented approximately 200 55-gallon drums, which were reportedly stored inside of T Building (Grasso 1991b). In 1953, a large quantity of high purity bismuth was located at the Brookhaven National Laboratory. This material, amounting to 64 tons, was made available to Mound and was sufficient to satisfy requirements for several years. This eliminated the need for the recovery facility and the recommendation was made that it be dismantled (Anson et al. 1953).

2.1.2.3. Separation of Polonium from Bismuth by Distillation

A major element of the polonium program was to develop improved processes for the separation of polonium from bismuth. During the period from 1949 to 1952, Mound conducted experimental work on the separation of polonium by distillation (Endebrock and Engle 1953). This work turned into a materials research program; however, as of 1953, no satisfactory alloys had been found that remained inert to bismuth and polonium under the conditions required for distillation.

2.1.3. Waste Generation

Liquid and gaseous wastes were generated in the T, HH, and WD buildings resulting from the production of polonium-210. In T Building, two aqueous waste streams were generated as a result of the aluminum can and irradiated bismuth slug separation and the polonium-210 recovery and purification processes. These waste streams were highly acidic and contained high concentrations of chloride, nitrate, aluminum, and bismuth. In addition to their acid nature, these waste streams contained gamma- and beta-emitting radioisotopes that were generated during the neutron irradiation of trace elements contained in the aluminum can and bismuth metal. The trace impurity metals contained in 2S aluminum included iron, manganese, copper, lead, tin, zinc, silicon, titanium, nickel, magnesium, chromium, vanadium, bismuth, and gallium (Payne 1948, Lange 1963). The trace impurity metals found in bismuth included silver, arsenic, calcium, cadmium, iron, magnesium, tellurium, selenium, and antimony (Lange 1963). As a result of neutron activation, gamma-emitting isotopes of

the trace metals contained in 2S aluminum and bismuth were produced by an (n,γ) reaction. The most important isotopes were silver-110, cobalt-60, and iron-59 with half-lives of 270 days, 5.3 years, and 45 days, respectively (Moyer 1956, Watrous 1948). Isotopes of lesser interest included selenium-75 (127 days), tellurium-125,127,129 (30-90 days), and antimony-124 (60 days) (Lange 1963). Except for cobalt-60, which has a half-life of 5.3 years, these decayed out several years after polonium processing ceased at Mound.

The aqueous wastes generated in the polonium process were sent to the HH Building for pretreatment prior to being transferred to WD for final treatment. The HH and T Buildings were connected by a 6-ft-diameter concrete tunnel that contained four Pyrex waste lines, which were suspended from the roof of the tunnel. The Pyrex lines were 4 inches in diameter and were used to carry polonium process wastes to the HH Building for treatment. The acidic aluminum chloride waste from the decanning operation was transferred from the T Building to the HH Building via one of the 4-inch Pyrex waste lines. The bismuth chloride solutions were also transferred to HH Building for treatment via a separate 4-inch Pyrex waste line.

The bismuth and aluminum wastes were managed and treated separately. The rationale for keeping these two waste streams separated was that the long range goal was to develop a bismuth metal recovery process and build a refinery at Mound. It was planned that the reclaimed bismuth metal would be fabricated into slugs and shipped to the Hanford Test Reactor for re-irradiation (McEwen 1952b).

This recovery never actually came to pass. The bismuth salts were stored in the Quonset hut until 1954 when they were shipped offsite for burial (Bradley 1953h, 1954b,c). The shipment of this waste was completed by September 1954 (Bradley 1954d). As the program continued through the 1960s, the bismuth wastes, sometimes referred to as the HH sludge, were staged inside T Building and shipped offsite weekly (MRC 1961a; Adams 1964; Adams et al. 1966; Anderson and Sheehan 1966, 1968a, 1968b, 1969). The wastes from the decanning operations were stored at the old explosives bunker, at least through the mid-1950s, and shipped either weekly or monthly. During the later years, the decanning operations wastes were handled with the bismuth sludge.

The dissolution of the bismuth slug with hydrochloric and nitric acids and the denitrification of the bismuth solution by formaldehyde or formic acid resulted in the generation of nitric oxide, nitrogen dioxide, and carbon dioxide. These gases were scrubbed with sodium hydroxide, and the basic scrubber solution containing sodium nitrate and nitrite was transferred to the 30,000-gallon influent tanks for treatment in the WD Building. A bismuth recovery process was developed involving the

electroplating of the metal from a bismuth chloride solution. This process is described in subsection 2.1.2.2.

The acidic aluminum chloride waste from the decanning operation was sent to the hydrolysis building, HH Building, for processing. Bismuth chloride solutions from the polonium processing operation also went to the HH Building for processing. The individual bismuth and aluminum chloride solutions were adjusted to a pH of 12 by the addition of caustic, which produced a gelatinous sludge and a supernatant liquid. The sludge was considered to be a high-risk waste, as it contained high levels of radioactivity, including alpha radiation at 0.02 Ci per L (Ci/L), beta radiation at 0.002 Ci/L, and gamma radiation at 100 mrem at 1 ft (Lamberger 1991). The aluminum sludge from this waste processing operation was separated by filtration and was solidified, drummed, temporarily stored in the old bunkers, and shipped off-plant for burial. In 1959, all polonium wastewater precipitation processes were moved to T Building (Meyer 1959b), and polonium operations ceased in the HH Building.

Since the start-up of the polonium program at Mound, the bismuth sludge from the precipitation process was stored in the eventuality that a feasible bismuth recovery method could be developed. In January 1952, the accumulated sludge represented 30 tons of recoverable metal (McEwen 1952a). About 650 drums of sludge were stored at the Quonset hut and were not shipped off-plant as waste until April 1954 (Bradley 1954b).

The supernatant liquids were transferred from the HH Building through a 3-inch steel pipe to 30,000-gallon influent holding tanks in the WD Building for processing as a low-level alpha wastewater (Bixel et al. 1975). Leaks are known to have occurred along this pipe in the 1950s, although the number of leaks is unknown. One leak was reported in December 1955 (Meyer 1956a). The pipe remains today, abandoned in place after its discontinuance in 1959 (Meyer 1959b). The contaminated soil along the pipeline from HH to WD buildings is now referred to as Area 20 (DOE 1992g). The volumes of water and sludge generated by the polonium program and processed by the WD waste treatment facilities in selected months in 1952 and 1953 are shown in Table II.1 (MCC 1952c, 1953d, 1953e). The activity of the waste in millicuries (mCi) for alpha and beta radiation is also shown in Table II.1. The monthly volume of water discharged was on the order of one-half million gallons from WD to the Great Miami River. Treatment processes for polonium are described in detail in Section 4. Maximum permissible concentration levels of polonium in the wastewater effluents (7×10^{-7} μCi/mL) were guided by U.S. Department of Commerce, National Bureau of Standards Handbook 69. In 1965, AEC adopted these standards into the USAEC Manual, Chapter 0524, for Radioactivity Concentration Guides (RCGs).

In the early years of polonium processing, the low-level alpha waste disposal system was generally designed so that there were no restrictions on what was poured down the drains. The waste disposal

Table II.1. Effluent Waste Generated by the Polonium Program

Month/Year	Monthly Water	Discharge/Gallons Sludge
September 1952	483,000	1,560
October 1953	695,000	780
November 1953	488,000	260

Activity Measured in Effluent Waste

Month/Year	mCi Water	mCi Sludge
September 1952	6.7	108.0
October 1953	9.6	69.3
November 1953	10.0	30.0

Note: Data taken from Mound monthly reports for October 1952, October 1953, and November 1953 (MCC 1952c, 1953d, 1953e).

facility at the WD Building served scientists, craftsmen, decontamination workers, and others, who were in no way limited as to what kinds of liquids could be poured into the waste stream. Although it is not known exactly what types and at what concentrations waste chemicals were dumped into the system, waste chemicals used at Mound included citric acid, various detergents, chelating agents, soaps, lubricating oils, organic solvents, strong inorganic acids, sodium hydroxide, formic acid, sodium tartrate, formaldehyde, and many other substances, in trace amounts to large quantities (Moyer 1956). It is unknown how long these practices continued, but they may have accompanied the polonium processing activities at least into the 1960s.

In addition to solid and liquid wastes generated in the production of polonium, concentrations of polonium emitted from the stacks were monitored and reported on a monthly basis (Bradley 1952a). Polonium concentrations discharged to the atmosphere in 1950 and 1951 are shown in Table II.2. No data appear to exist that establish the actual amounts of polonium released over the lifetime of the program. Air concentration data recorded in health physics reports (see discussions in Section 3 of this report) cannot easily be turned into emission rates without substantial assumptions concerning stack air flux and other engineering data. No attempt has been made to calculate the total emissions.

Table II.2. Polonium Discharged to Atmosphere 1950-1951

Year	Month	mCi/Day
1950	Sept	6.9
	Oct	4.1
	Nov	6.2
	Dec	13.0
1951	Jan	9.1
	Feb	10.0
	Mar	14.0
	Apr	21.2
	May	11.2
	June	23.6
	July	17.0
	Aug	24.0
	Sept	26.9
	Oct	22.4

(Data from Bradley 1952a)

Maximum permissible concentration levels of polonium in the air effluents (2×10^{-11} μCi/mL) were guided by U.S. Department of Commerce, National Bureau of Standards Handbook 69. In 1965, AEC adopted these standards into the USAEC Manual, Chapter 0524, RCGs. The annual environmental monitoring reports, published since the early 1960s, compare RCGs with release concentrations. The last polonium reported was in 1974, and was associated with the D&D of the polonium processing facilities.

2.2. PLUTONIUM PROJECT

Plutonium-238 research and development activity began at Mound in the mid-1950s. Initial research concerning plutonium-238 was transferred to Mound from Lawrence Livermore National Laboratory in 1959. The first reduction of metallic plutonium-238 was achieved at Mound in the spring of 1960. Research and development relating to the application of plutonium-238 as a radioisotopic heat source material followed the initial work. These research and development activities included materials research, the development of processes for the production of heat source materials, and development of fabrication and metallurgical technology that would ensure the containment and stability of heat source materials in RTG systems. Research and development activities were also conducted on the design of RTG systems for the various applications of this technology. During that time, Mound produced well over 500 RTG units.

The RTG systems were used in a variety of applications including electric power generators for satellites, life support systems, spacecraft, pacemakers, and an artificial heart. Table II.3 is a list of some of the RTG units manufactured at Mound. Between 1961 and the end of 1982, 34 RTGs were employed in 19 space systems; most of these were manufactured at Mound. The first SNAP was launched to provide 2.6 watts of power to the TRANSIT navigation satellite (Morse 1963). Metallic plutonium was used in the SNAP units during the early 1960s, because the heat sources were designed to disintegrate and burn up completely upon reentry from orbit. The heat sources were encapsulated in exotic metals, such as iridium, to isolate the plutonium, prevent chemical reactivity, and provide containment in the event of an accident during launch. This philosophy was changed in the mid-1960s, and the SNAP units were redesigned to retain integrity under all circumstances rather than to burn up upon reentry. Metallic plutonium was abandoned in favor of plutonium oxide. The plutonium oxide heat sources were not as susceptible to fire or other accidental processes of oxidation.

A major technological development from the reactor fuels research conducted at Mound contributed to the heat source program as well. Chemically and thermally stable microspheres produced in an inductively coupled plasma torch exhibited a remarkable freedom from loose contamination. This eliminated many of the hazards normally associated with the handling of plutonium oxide and made previously unattractive applications feasible.

From the early 1960s to the late-1970s, Mound processed plutonium-238 for use in heat sources within the RTG and manufactured the RTG units themselves (Luthy 1991). Processing of plutonium metal and plutonium oxide from materials supplied from the SRP was conducted in the SM and PP (later known as Building 38) buildings constructed in 1960 and 1967, respectively. Other work was performed in R Building and in Building 50. The fabrication of heat sources from plutonium metal was

Table II.3. Radioisotope Fueled Thermoelectric Generator Program

Program	Year	Fuel Form	Watts/Unit
SNAP 3A	1958	Polonium-210	96
SNAP 3B	1961	Plutonium-238	52
SNAP 15B	1963-64	Plutonium-238	1
SNAP 15A	1964	Plutonium-238	1.6
Heat Pipe	1964	Plutonium-238	104
Poodle	1964	Gadolinium polonide	250
SNAP 3C	1965	Plutonium zirconium	58
SNAP 19	1965	Plutonium-238	102
SNAP 27	1965-71	Plutonium dioxide (microspheres)	1480
Life Support	1966	Plutonium dioxide (shards)	70
SNAP 19B	1966-67	Plutonium dioxide (microspheres)	570
SNAP 19B Intact Reentry Heat Source	1966-67	Plutonium dioxide (microspheres)	570
Artificial Heart	1967	Plutonium-238	25
Swimsuit Heater	1967	Plutonium zirconium	105
Dart I	1967	Plutonium dioxide (microspheres)	157
Pacemaker	1967	Plutonium-238	0.134
SNAP 19B Intact Reentry Heat Source	1968	Plutonium dioxide (microspheres)	620
Dart II	1968	Plutonium dioxide (microspheres)	155
Apollo Lunar Radioisotope Heater	1968	Plutonium dioxide (microspheres)	15
Pacemaker	1968-69	Plutonium-238	0.238
Life Support II	1969	Plutonium dioxide (microspheres)	105
Life Support II	1969	Plutonium dioxide (microspheres)	50
Pacemaker	1969-72	Plutonium-238	0.238
Pioneer	1970-72	Plutonium metal cermet	650
Pioneer Radioisotope Heater Unit	1970-72	Plutonium metal cermet	1
Rite I	1971	Plutonium dioxide (microspheres)	420
Milliwatt Generator	1971---	Plutonium dioxide (shards)	4.5

Table II.3. (page 2 of 2)

Program	Year	Fuel Form	Watts/Unit
Artificial Heart	1972	Plutonium dioxide (microspheres)	33
Transit	1972	Plutonium metal cermet	850
Rite II	1972	Plutonium metal cermet	825
X-Ray	1972	Plutonium dioxide	0.6
X-Ray	1972	Plutonium dioxide	1.8
Army Corps	1972	Plutonium dioxide (shards)	6
Pacemaker	1972-73	Plutonium dioxide (shards)	0.226
Viking	1972-73	Plutonium metal cermet	685
Multi-Hundred Watt (Lincoln Experimental Satellite 8/9)	1972-76	Plutonium dioxide	2400
NAVY	1975	Plutonium dioxide (shards)	18
Voyager Radioisotope Heater Unit	1976-77	Plutonium dioxide	1
Multi-Hundred Watt (Voyager)	1977	Plutonium dioxide	2400
Five-Watt RTG (heat source)	1983	Plutonium dioxide	125
Light Weight Radioisotope Heater Unit	1985	Plutonium dioxide	1
General Purpose Heat Source[a]; Galileo and Ulysses	1984-86	Plutonium dioxide	4500
Five-Watt RTG[a]	1987	Plutonium dioxide	125
High Performance Generator MOD-3[a]	(pending)	Plutonium dioxide	2400

[a]RTG programs include RTG assembly and testing in addition to heat source hardware fabrication.
RTG - radioisotopic thermoelectric generator

terminated in the mid-1960s, although the oxide processes continued into the late-1970s. Encapsulation of the processed plutonium heat sources with exotic metals was also performed at Mound until the late-1970s. After that, the encapsulated plutonium oxide heat sources were supplied by the SRP. Since early 1979, Mound has not handled unencapsulated plutonium-238. Throughout the history of the plutonium-238 processing program, a plutonium recovery process was included as part of the total material control and recycling effort. Some of the recovery processes were transferred to the SRP in 1975. Limited operations continued at Mound until 1982 in support of the D&D activities of the former plutonium processing facilities.

2.2.1. Process Descriptions

Plutonium-238 used in RTG systems was shipped to Mound from the SRP. Initially, the plutonium was received as an oxalate or a nitrate and subsequently as an oxide. These materials were stored in vaults in Buildings 50, SM, and T. The plutonium was taken from storage and entered into any one of the following processes for the production of heat source materials: pressed plutonium oxide (PPO), plutonium-molybdenum cermet (PMC), or plutonium metal (Luthy 1991).

In order to control and contain plutonium during processing and fabrication and to protect the process operators and other building personnel, operations were performed in alpha glove boxes. These glove boxes were identified by glove box number and glove box line. Buildings SM, 50, R, and 38, which housed plutonium operations, were designed to control emissions to the atmosphere. The buildings operated under a slight negative pressure to the atmosphere, and the glove box line's atmosphere and building air were filtered through a double HEPA filter system before venting to the atmosphere via a stack. Table II.4 shows a summary of the amounts of plutonium released through stack emissions during the period of plutonium processing and subsequent D&D of the facilities.

2.2.1.1. Pressed Plutonium Oxide (PPO) Fabrication Sphere Process

The PPO process for the production of RTG heat sources was the longest lived plutonium heat source program at Mound. The PPO process was used at Mound from the mid-1960s to the late-1970s and thereafter at other RTG heat source facilities. RTG units with PPO heat sources were used in equipment for the lunar Apollo program, numerous types of life support equipment, the Lincoln Experimental Satellite, and the Voyager spacecraft. The Milliwatt Generator still uses this technology.

Table II.4. Summary of Mound Plutonium Effluents 1960-1989

Year	Plutonium	
	Air (μCi)	Water (μCi)
1960	250,125	
1961	160	
1962	140	
1963	108	
1964	252	
1965	5,803	
1966	30,442	
1967	54,347	24,900
1968	5,720	243,800
1969	10,544	109,700
1970	4,342	7,420
1971	401	15,234
1972	74	60,586
1973	84	16,043
1974	28	19,755
1975	23	17,862
1976	15	2,973
1977	12	3,584
1978	14	4,947
1979	12	3,157
1980	15	773
1981	8	1,110
1982	21	1,207
1983	4	1,003
1984	7	1,342
1985	5	991
1986	6	691
1987	5	472
1988	5	997
1989	4	1,419
1990	18	670

Note: Data from Mound Environmental Monitoring Reports (EG&G 1989a) and unpublished data

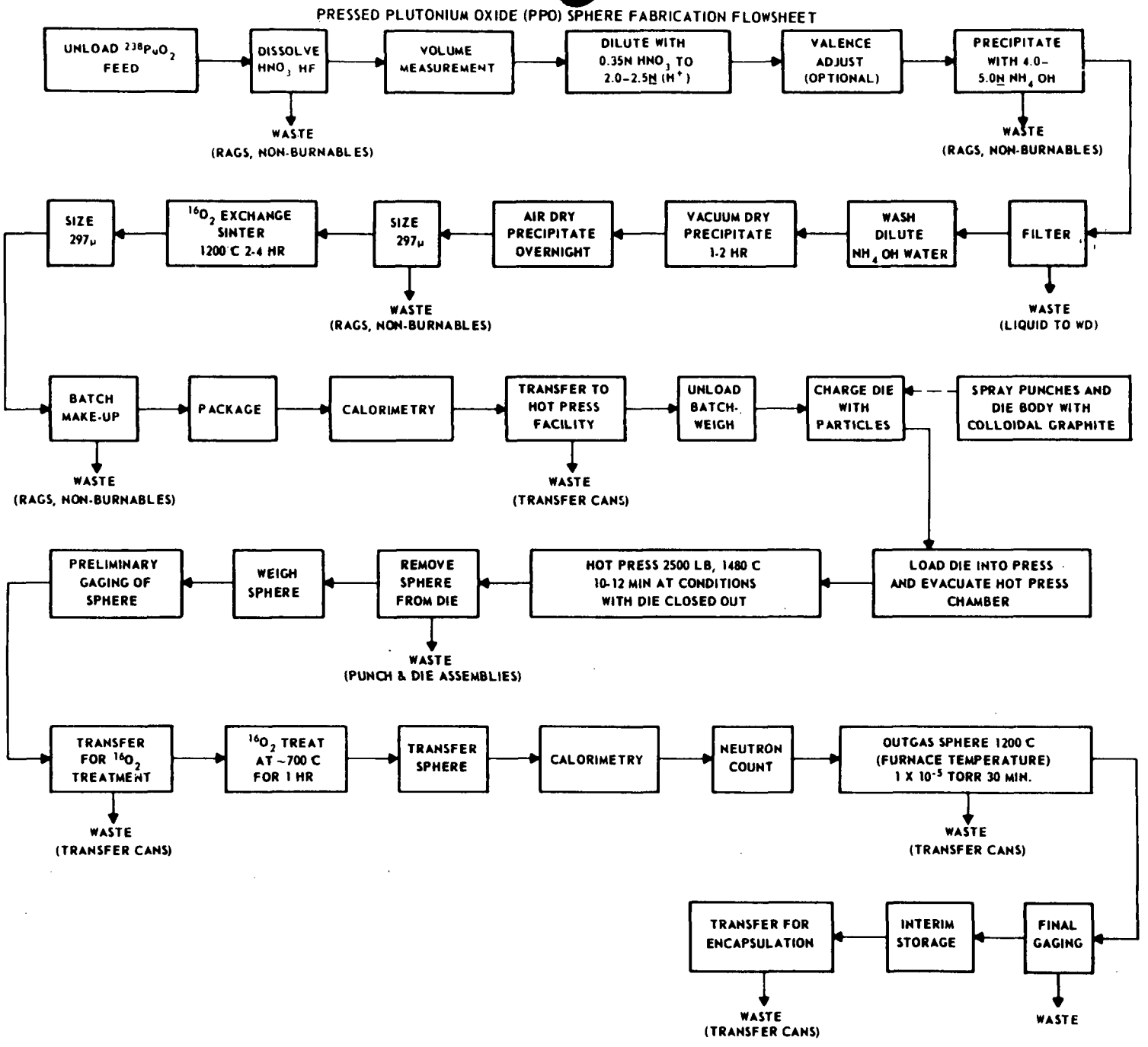


Figure 2.3. Pressed plutonium oxide (PPO) sphere fabrication flowsheet (MRC 1973b).

The PPO process shown in Figure 2.3 involved either a microsphere or shard process for which all but a few steps were identical. The process began by transferring plutonium-238 dioxide into the glove box. The oxide was unloaded from its container and dissolved in a mixture of nitric-hydrofluoric acids. After dissolution was completed, the resulting plutonium nitrate solution was adjusted with nitric acid to provide a 2.0 to 2.5 normal (N) hydrogen ion concentration. If necessary, a valence adjustment was made, and the resulting solution was treated with ammonium hydroxide to precipitate a plutonium hydroxide. The solution was filtered, and the plutonium precipitate was washed with dilute ammonium hydroxide solution. The washed precipitate was then vacuum dried for 1 to 2 hours and air dried overnight. The dried plutonium precipitate was crushed to produce a fine powder. The ratio of isotopes in the final production was 80% plutonium-238, 16% plutonium-239, 3% plutonium-240, 0.8% plutonium-241, and 0.2% plutonium-242.

In the microsphere process, the powder was fed through a plasma torch, producing microspheres of uniform size that went directly to the hot press facility. In the shard process, the powder was sieved for size and placed in a controlled atmosphere furnace at an atmosphere of oxygen-16. The material was heated to 1,600°C for 2 to 4 hours. This step produced a sintered plutonium-238/oxygen-16. The sintered oxide was then transferred to the hot press facility where a sphere was fabricated. The die body was sprayed with colloidal graphite and then charged with plutonium dioxide particles. The die was loaded into the press, and the hot press chamber was evacuated. With a force of 2,500 pounds per inch and a temperature of 1,480°C, a sphere of plutonium dioxide was formed. The plutonium dioxide sphere was removed from the die, weighed, and gauged. The sphere was placed in a controlled atmosphere furnace and treated with oxygen-16 at 700°C for 1 hour. Next, the sphere was placed in a vacuum furnace and was allowed to outgas for 30 minutes at a temperature of 1,200°C and a vacuum of 1×10^{-5}. The sphere at this point underwent calorimetry for specification testing. Now ready for encapsulation, the sphere was transferred to the R Building. Encapsulation involved welding a machined metal cover over the sphere. Encapsulation materials included iridium, graphite, tantalum, titanium, and hastelloy (an alloy of cobalt, molybdenum, chrome, tungsten, and iron).

2.2.1.2. Plutonium-Molybdenum Cermet (PMC) Production Process

The PMC process used as a heat source, a cermet consisting of a sintered granular plutonium dioxide coated with molybdenum. The cermet is processed to produce a solid material that can be machined to required dimensions and assembled into the heat source capsules. The PMC process is shown in Figure 2.4 (MRC 1974c).

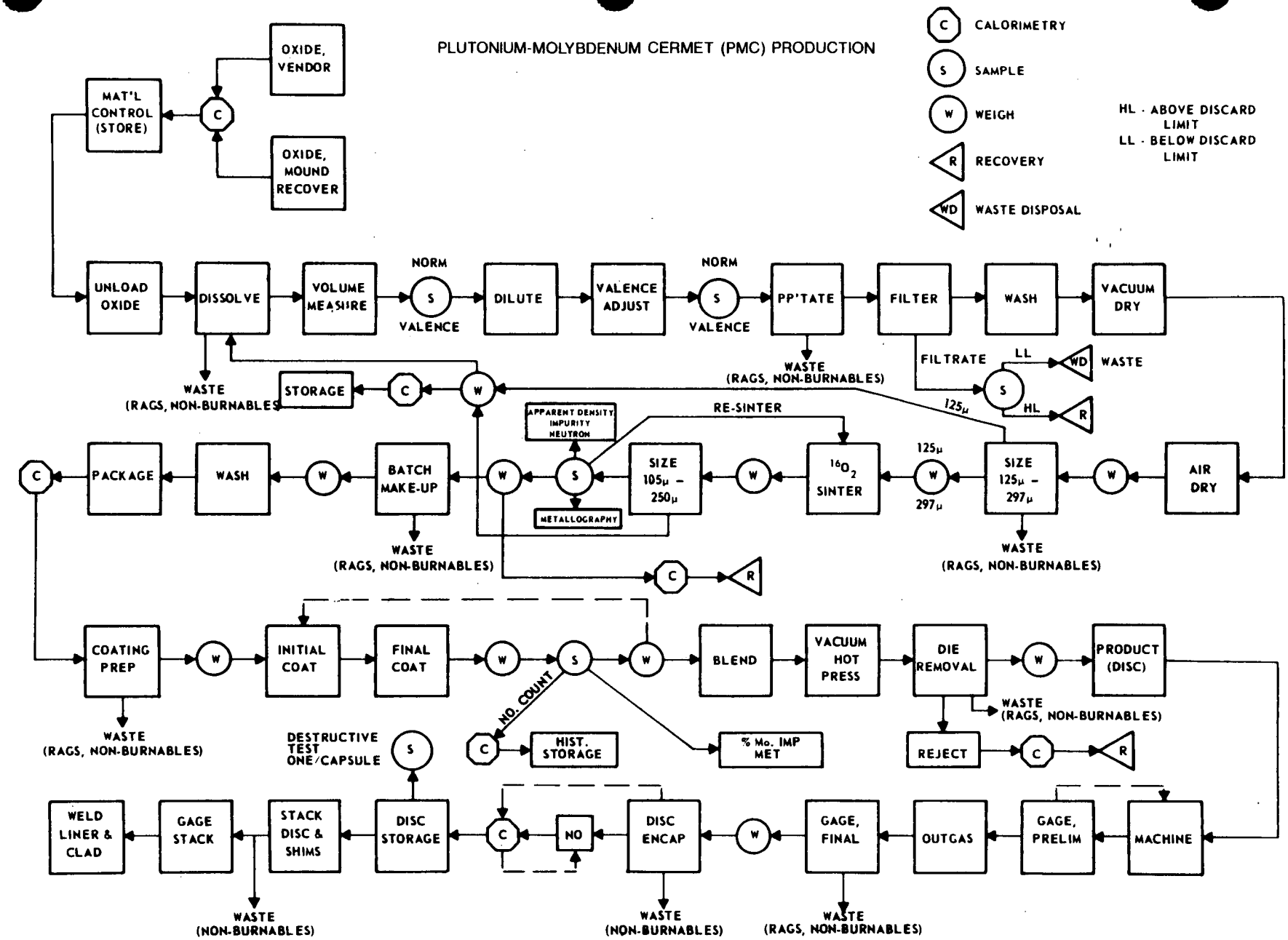


Figure 2.4. Plutonium-molybdenum cermet (PMC) production (MRC 1973b).

RTGs employing PMC heat sources were widely used in many applications, including the National Aeronautics and Space Administration Pioneer F spacecraft launched in March 1972. This was the first spacecraft to rely entirely on an RTG system for electric power. The Pioneer spacecraft was also fitted with 12 1-watt radioisotopic heater units fabricated from PMC heat source material. These units provided the thermal energy required to prevent damage to sensitive instrumentation. The U.S. Navy also used cermet RTG systems in their TRANSIT satellite, which was part of a world-wide navigational system. The Viking I and II Mars mission spacecraft launched in the early 1970s used PMC heat sources in their RTGs. The PMC process for RTG heat sources was used at Mound until 1973 when it was discontinued in favor of the PPO process.

The initial steps of the PMC process are identical to the PPO process. Plutonium dioxide received from the SRP and Mound plutonium recovery underwent dissolution with nitric acid and hydrofluoric acid followed by a hydrogen ion concentration and valance adjustment using nitric acid. Precipitation took place using ammonium hydroxide, and the plutonium precipitate was separated from the supernatant liquid by filtration. The precipitate was washed with dilute ammonium hydroxide and then dried. The dried precipitate was sized and then sintered in a furnace at 1,200°C. Sintering took place in an atmosphere of oxygen-16. The isotopic composition was similar to the products of the PPO process. If the sintered material met acceptance criteria, it continued to the next step of the process, which resulted in a molybdenum coating of the plutonium dioxide. After molybdenum coating, the material was pressed into discs using a hot die press. This cermet material was capable of being machined and was processed to produce discs of 2.1 inches in diameter and 0.2 inch in height. The discs were then assembled into the heat source capsules. The assembly of the machined cermet elements into containment capsules involved tungsten inert gas and electron beam welding of metal and metal alloy containers and internal components. Materials used in fabrication included inconel, tantalum, platinum-rhodium, yttrium, and iridium.

2.2.1.3. Plutonium Metal Production Process

In the early 1960s, the production of plutonium metal began with the plutonium nitrate solution received from the SRP. The process was housed in a dry air glove box line in R Building. The process was transferred to the SM Building in 1963 and remained there until the use of plutonium-238 metal gave way to PPO, microsphere, and cermet as heat source materials. The plutonium nitrate solution was received into the glove box line in R Building, where the plutonium was precipitated with oxalic acid. The plutonium oxalate was filtered, and the filtrate was returned to plutonium recovery. The plutonium oxalate precipitate was washed and dried. The oxalate was placed in a platinum crucible and converted to plutonium tetrafluoride using hydrogen fluoride gas. The plutonium tetrafluoride was transferred to a magnesium crucible, and finely divided calcium metal and iodine were added. The

crucible was placed in a steel reduction bomb, and the assembly was purged thoroughly with argon gas and then sealed with a bolt-on cover. The bomb assembly was placed in an induction furnace and heated. When the material in the crucible reached a temperature of 300°C, the reduction process began and continued as the exothermic reaction proceeded and the temperature reached approximately 1,600°C. After the bomb was allowed to cool to room temperature, it was opened, the plutonium-238 metal was broken away from the slag, and the metal was cleaned with a brush to remove adherent slag and calcium metal. The clean plutonium metal then went to the foundry. The nitric acid wash solution and the slag from the reduction process was sent to plutonium recovery. The crucible went through a leaching process to recover the residual plutonium-238. The solution went to plutonium recovery and the crucibles were packed and shipped for burial as high-risk waste, because they were a line-generated material.

The plutonium metal "button" was placed in a crucible, and, in an inert atmosphere, the metal was melted and poured into a mold that had the shape of a truncated cone. After the metal cooled, it was removed from the mold and was ready to be encapsulated. All solid materials coming in contact with plutonium in this process were treated to recover plutonium. Ash and leach solutions went to plutonium recovery for processing.

Plutonium-238 metal was used for RTG heat sources from the late-1950s to the mid-1960s. The metallic heat sources were first used in SNAP-3B and SNAP-9A and were among the first to be launched into space. Many of the TRANSIT series navigational satellites in the early 1960s were powered by metallic plutonium heat sources. Mount Plant stopped producing metallic RTG heat sources in the mid- to late-1960s in favor of the PPO and PMC processes.

2.2.1.4. Plutonium-238 Recovery Process

Plutonium production activities resulted in line-generated byproducts and waste materials that were evaluated for appropriate treatment, recovery, and disposition. The recovery of plutonium-238 from production activities represented a significant element of the plutonium program. The processes of plutonium recovery evolved over time. In 1959 and 1960, all wastes from the research and development activities in R Building were drummed for offsite recovery. In the first few years of SM operations, plutonium recovery consisted of processing all high-risk aqueous wastes. In late 1962, the processing of high-risk wastes was curtailed and Mound began to distinguish between disposable and recoverable high-risk wastes. The disposable high-risk wastes were processed for offsite disposal. The recoverable aqueous process streams were initially processed by simple evaporation and ion exchange. In 1963, no facilities were available for the dissolution and processing of solid materials (Brown 1963). Most solid materials were saved for future processing. The processes of dissolution,

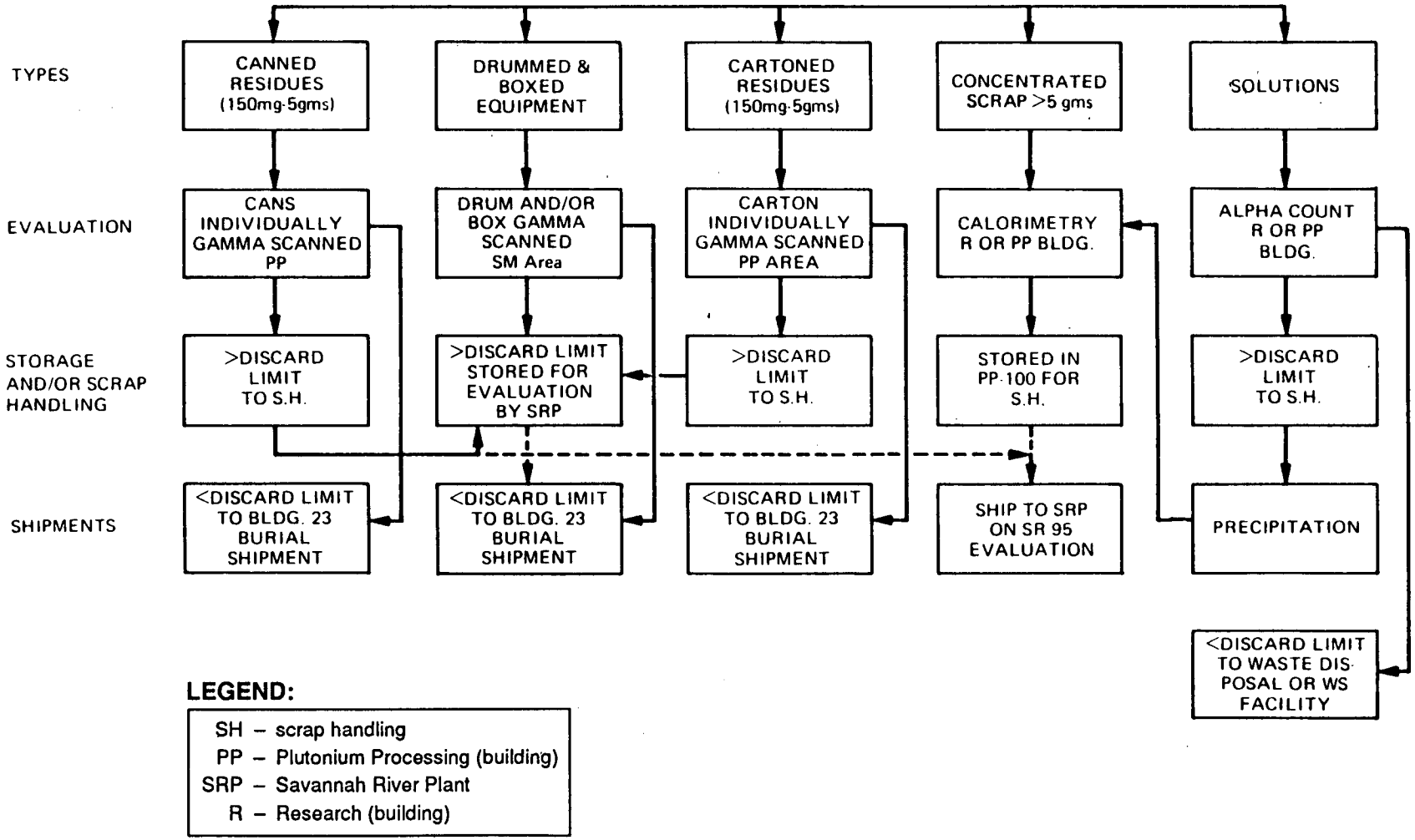


Figure 2.5. In-line plutonium process wastes (MRC 1973b).

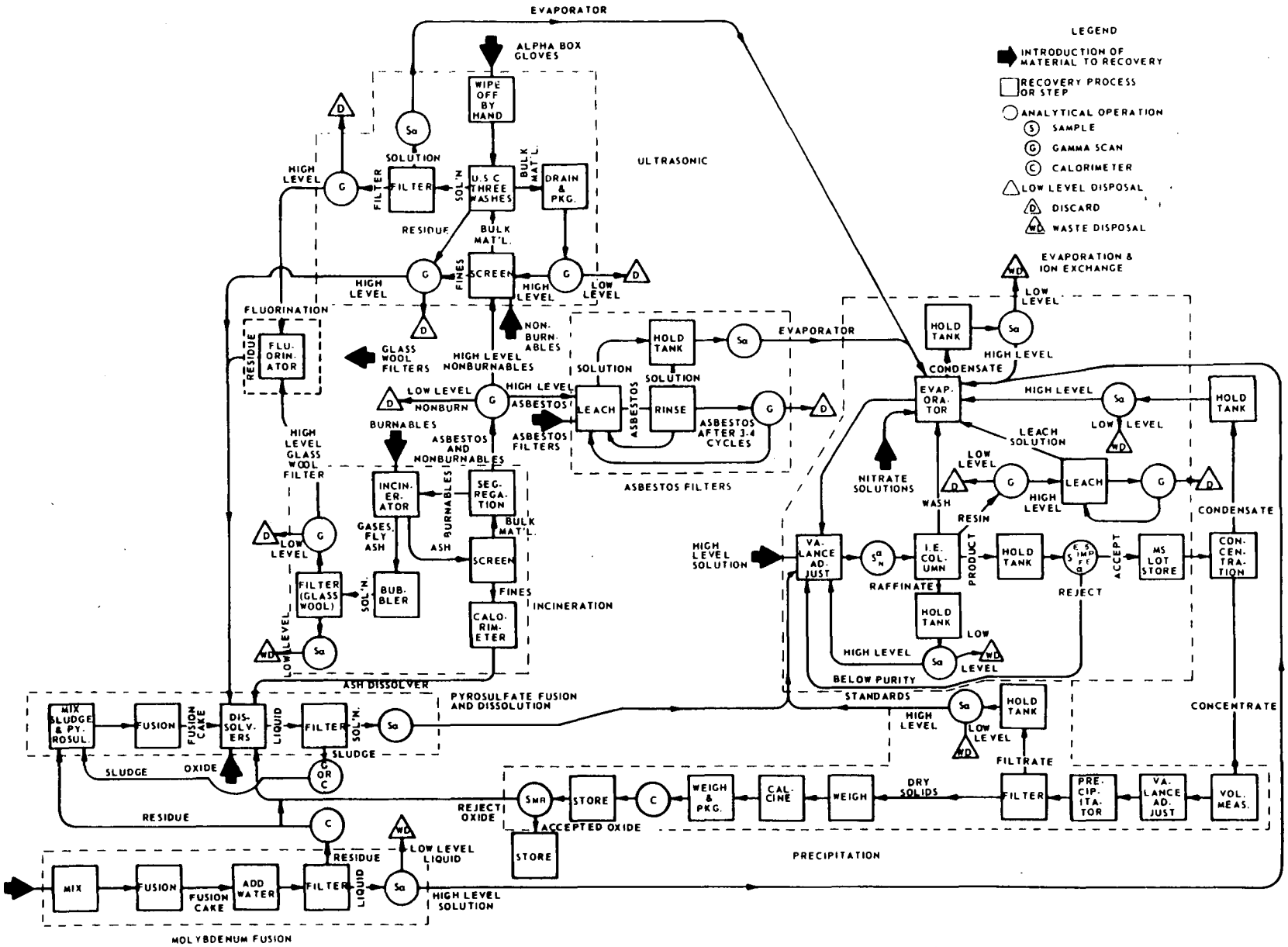


Figure 2.6. Plutonium recovery flow diagram (MRC 1973b).

fluorination, incineration, and pyrosulfate fusion were added over the next several years (McMannon 1963-1966; Geichman 1992). In 1967, the recovery processes were moved to Building 38. The discussions that follow provide details of these processes.

Wastes and byproducts from the production processes were characterized on the basis of their plutonium content and were classified as recoverable, high-, or low-risk waste. Solid or liquid wastes that had a plutonium content exceeding the economic discard limit would be classified as recoverable wastes, and the materials were sent to the plutonium recovery process in SM Building. The economic discard limit was established by comparing the cost involved in recovering the plutonium-238 contained in a specific type of waste to the cost of obtaining the same quantity of plutonium-238 from normal production of the radionuclide (Vallee 1967). When the cost to recover the plutonium-238 from a waste material was less than the cost to produce the same quantity of plutonium from materials obtained from the SRP, then that waste material contained plutonium in excess of the discard limit. Recoverable materials contained plutonium in excess of the discard limit were recycled through the recovery processes. Waste materials that contained plutonium below the discard limit were defined as high- or low-risk wastes. Figure 2.5 identifies the in-line plutonium process wastes and their disposition as they had developed by 1973.

During the first years of SM operation, plutonium-bearing acidic solutions were accumulated in holding tanks in SM-1. These solutions were processed in a steam evaporator, and the evaporator condensate was processed by an ion exchange column. The effluent from the ion exchange column was treated as low-risk waste. This system was taken out of service in 1962. Plutonium recovery of aqueous wastes was moved out of the waste treatment area into the process area. From 1963 to 1968, the plutonium recovery process for aqueous wastes consisted of two ion exchange columns, 6 inches in diameter by 2 ft in length. Approximately 100 gallons of waste, containing 1 to 200 g of plutonium, would be processed every other day. The effluent from the ion exchange columns was sent to an in-line glove box evaporator. The evaporator condensate went to SM-1 as a low-risk waste. The solid residue from the evaporator went back for plutonium recovery if it exceeded the discard limit, or was designated as a high- or low-risk waste.

Within the production lines, the recovery processes for a given plutonium waste depended on the form and composition of the waste and whether it had a low or high plutonium concentration. The major steps in this process included physical and chemical processing elements. The physical process included ultrasonic wash, evaporation, and filtration. Simple washing and leaching of glove box material occurred in the process since the beginning of the program. Chemical processing elements included dissolution, precipitation, fusion, incineration, ion exchange, and fluorination. The chemical processing of solids began in 1964. Incineration did not become part of the operations until 1965.

The plutonium recovery processes are shown in Figure 2.6 as they had developed by 1973. In glove boxes, solid objects contaminated with plutonium would be washed or leached in water or acid solutions with the aid of ultrasonic cleaning equipment. Following this step, the objects would be gamma scanned or wiped and counted. They were then returned to their original use or, based on the activity, they were declared high- or low-risk waste. The wash water and leachate were sent to plutonium recovery. High temperature-fired plutonium oxide and ceramic RTG materials, not meeting product specifications, were dissolved in a mixture of nitric and hydrofluoric acid or underwent fusion with pyrosulfate. Glass fiber filters were dissolved in a hydrofluorinator-pressurized vessel, and the volatile silicon tetrafluoride generated in the process was removed via a caustic scrubber. The highly acidic solutions containing plutonium were sent to the plutonium recovery process. The caustic scrubber solutions were designated as recoverable, high-risk or low-risk waste, based on the discard limit, and either sent to recovery or waste treatment. Other solid materials containing recoverable plutonium or off-specification RTG material that resisted efforts at dissolution would undergo pyrosulfate fusion followed by dissolution.

Combustible wastes generated in the glove box line were processed in one of two ways: During production, if paper towels or rags accumulated significant quantities of plutonium-238, the thermal energy released by the plutonium would cause the towel or rag to start smoldering. The glove box operator would put the towels and rags in an open-topped metal can and allow the process to continue. Since the glove box had an inert atmosphere, there was no open flame. After a period of time, the can contained a carbonized ash that contained plutonium oxide. The process is analogous to pyrolysis and low-temperature ashing. The volatile pyrolysis products were swept from the glove box and, after HEPA filtration, were discharged to the atmosphere via the building's stack (Geichman 1992). All other combustible wastes including paper, wood, leaded neoprene gloves, and in-line glove box HEPA filters were treated in an incinerator installed in a glove box. The incinerator consisted of a large steel tub that was heated by means of a natural gas burner. The atmosphere in the glove box and incinerator chamber was deplete of oxygen; therefore, the process was identical to that described earlier except for the fact this pyrolysis process took place at a very high temperature. The gaseous pyrolysate from the incinerator was scrubbed using a sodium hydroxide solution (Geichman 1992). The pyrolysate, after scrubbing and glass fiber/asbestos filtration, was discharged to the atmosphere via the building stack. The ash residue from the incinerator was sent back for dissolution and leaching.

In the early 1960s, nearly all potentially recoverable solid materials were stored for future plutonium recovery. Solid process wastes, such as the slag from the metal reduction of plutonium, could not be processed until the recovery methods were developed. Large items could not be processed by washing and leaching operations. These potentially recoverable materials were packaged in 30-gallon drums and stored in the SM drum storage area, as described in Section 5 of this report. In time, some drums

corroded and began to leak. When leaking drums were discovered, a major effort was undertaken to correct the problem by overpacking the drums into 55-gallon drums. In August 1964, a small facility was constructed in which drummed recoverable wastes could be sorted and redrummed or sent to plutonium recovery (Bowser 1992). The facility, known as the R and R Building (Figure 2.1), contained a special glove box facility in which the 55-gallon drums were opened. The contents of the inner 30-gallon drums were sorted by plutonium concentration. Recoverable materials above the discard limit were returned to the plutonium recovery process, liquids were sent to the wastewater treatment, and other solids below the discard limit were drummed for offsite disposal.

2.2.2. Waste Generation

During the 1960s and 1970s, the plutonium-238 processing, fabrication, and recovery operations (including metallic, PPO, and PMC) resulted in the generation of significant volumes of solid and liquid waste streams from the research and development, production, and recovery operations. In 1959 and 1960, these activities took place in the R Building. When the SM Building became operational in 1961, a waste treatment facility was installed in room SM-1 of the building. From 1961 to 1967, all recoverable, high-risk, and low-risk wastewater generated in the SM Building was processed for plutonium-238 recovery, treated in the SM-1 waste disposal facility, or packaged in drums and stored in the SM drum storage area. In 1966 and 1967, Building 38 and an annex on the WD Building (WDA) were constructed to take over the increased program needs. This subsection summarizes the wastes generated by the program over time, their characteristics, and their treatment. Additional details of waste treatment and storage facilities are included in Sections 4 and 5, respectively.

From 1959 to 1960, the initial plutonium program activities were conducted in R Building. During this early phase, the program was characterized as research and development efforts to understand the chemistry and metallurgy of plutonium-238. Plutonium-238, like polonium-210, is thermally hot because of its high specific radioactivity. This property led to major concerns for health and safety in the workplace and the environment because of chemical reactivity and the containment of plutonium during processing and fabrication. During this phase of the program in the R Building, the majority of the wastes generated were solid materials. The high concentration of air emissions in 1960 (Table II.4) were from R Building operations. The glove box atmosphere could not tolerate water vapor or oxygen. Therefore, water was not a significant ingredient in the process activity nor in the generation of liquid wastes. The small quantities of liquid waste that were generated came from decontamination activities associated with production, glove box operations, and the workplace. These aqueous wastes were solidified without prior treatment, packaged in 30-gallon drums, and shipped to the SRP for plutonium recovery. The glove boxes in R-120 that were used in the plutonium studies were eventually removed

from service, packaged in a cargo trailer, and remained at Mound for approximately a year before being shipped offsite (Garner 1992a).

The plutonium-238 program quickly outgrew the facilities in the R Building and a new facility was needed that would provide both the technical and safety-related features that were missing in R Building. In 1960, the SM Building was constructed to house the plutonium-238 production, recovery, waste treatment facilities, research and development, and analytical laboratory support activities (Flanagan 1976). Waste generation in the SM Building took place during processing, fabrication, recovery operations, decontamination activities, and building maintenance. Glove box line-generated wastes came from plutonium processing and fabrication of RTG materials such as plutonium metal, PPO, and PMC. Quality assurance procedures associated with the production of RTG material required periodic sampling within the glove box line followed by analysis in the laboratory. Materials not meeting specifications were removed from the production line and were returned to the plutonium recovery process. The production processes generated combustible and non-combustible wastes contaminated with plutonium and airborne plutonium particulate. Combustible wastes consisted of leaded gloves, paper towels, HEPA filters, plastic, wood, and rags. Noncombustible wastes consisted of ceramic material, graphite and tantalum crucibles, glassware, metal, tools, filter materials, aqueous solutions, and other miscellaneous items of process equipment and instruments. Aqueous wastes were generated from the production and recovery processes and glove box decontamination. Decontamination within the glove box generally produced a recoverable or high-risk waste. Decontamination outside the glove box produced either a high- or low-risk waste, depending on the plutonium activity.

The recovery of plutonium-238 from production activities represented a major source of wastes generated by the plutonium operations. Chemicals used in the recovery operations included nitric and hydrofluoric acids, hydroxylamine, sodium carbonate, ferrous sulfamate, and sodium hydroxide. Plutonium recovery operations produced solid, liquid, gaseous, and airborne particulate wastes. Liquid and solid wastes, which did not meet the definition of recoverable waste but which had a plutonium content that was greater than 10 nCi/g, originating in the glove box line, were designated as high-risk wastes. Low-risk waste, regardless of origin, was defined as a material containing less than 10 nCi/g as measured by calorimetry or gamma scan (Garner 1992a; Geichman 1992). High- and low-risk aqueous wastes were sent to the wastewater treatment facility for processing. Particulates from the in-line incinerator in the SMA were vented through the double HEPA filtration system, as part of the glove box system, before being released to the SM stack.

In 1961 and 1962, all high-risk liquids were processes in SM-1. The high-risk liquids were processed through a steam evaporator; the condensate passed through an ion exchange column before being

released to the storm sewer. After 1962, the high-risk liquids below the recoverable discard limit were simply absorbed onto a clay material, such as Florco, in 30-gallon drums and shipped offsite for disposal. In 1967, this operation was moved to the WDA Building (see descriptions in Section 4 of this report). Approximately 100 gallons of high-risk waste were processed in SM-1 daily (Garland 1992). High-risk wastes from plutonium production and recovery were acidic or basic, depending on where they were generated in the process. Basic waste was generated when ammonium hydroxide was used to precipitate plutonium from the solution. Acidic and basic wastes contained nitrate and fluoride. Acidic waste was generated in leaching and dissolution operations. The acidic wastes contained nitric and hydrofluoric acids, plutonium-238, and trace quantities of the radionuclides contained in the original plutonium-238.

Low-risk waste generated in plutonium production was basic or acidic and contained plutonium-238; lesser amounts of plutonium-239, americium-241, neptunium-239, and uranium-234; and trace quantities of plutonium-240, plutonium-241, and plutonium-242. The acidic waste came from leaching operations and dissolution of solid waste with the use of nitric and hydrofluoric acids, as well as decontamination and shower water. Other trace metals were present in the acidic waste as a result of leaching various pieces of equipment and tools with nitric acid in an effort to recover plutonium or decontaminate tools. The cations present were ammonium, sodium, tantalum, molybdenum, iron, chromium, and nickel, as well as lead that came from the neoprene leaded gloves. The acidic waste also contained concentrations of nitrate, sulfate, and fluoride as anions. No records have been found that document the volumes of wastewater that were processed in SM-1. In the 1963 time frame, the annual discharge of treated effluent from SM-1 was on the order of 150,000 gallons (Creamer 1964). This volume is consistent with process estimates of the capacity of the clarifier tanks to process 3 gallons per minute for 10 hours per day (Garland 1992).

Air emissions from plutonium operations in SM consisted of volatile acids such as nitric and hydrofluoric, oxides of nitrogen, and particulate plutonium oxide. Volatile acids and oxides of nitrogen, which evolved during the acid digestions, were passed through a sodium hydroxide scrubber and exhausted from the glove box via the filter plenum to the stack. The glove box atmosphere was filtered by means of an in-line, fire-resistant HEPA filter. The glove box atmosphere was then directed to a plenum, which originally contained a single stage of HEPA filtration, prior to being discharged through the building's stack to the atmosphere. The frequent exchange of glove box filters resulted in the release of plutonium oxide to the atmosphere. The integrity and proper installation of the filter could not be verified as part of the installation procedure. In 1962, a second bank of HEPA filters was installed in the SM Building plenum. After 1965, the plasma torch process used in microsphere production of the RTG program generated a large volume of very fine particulate material. Much of

this was recovered in the glove box. The process was also a major source of particulate material released to the stack.

The continued growth of the plutonium program through the 1960s and the forecasted expansion into the 1970s resulted in the construction of a new plutonium-238 processing facility. The construction of Building 38, also known as the PP Building, was completed in December 1967. The SM processes and fabrication operations were transferred to the new facility. The low- and high-risk waste lines that served the SM Building were extended to Building 38. This system allowed the transfer of low- and high-risk wastewater to WDA via the Building 41 lift pumps. When the polonium operations phased out in 1970, the plutonium low-risk wastewater treatment moved into the WD Building, as described in Section 4 of this report. Leakage problems associated with these waste lines prompted the construction of the high-risk waste solidification (WS) Building in 1974. The WS Building was an addition to Building 38 and was used to process high-risk waste. In 1976, the low-risk waste pipeline from Building 38 to the WD Building was abandoned in favor of a 5,000-gallon tanker truck used to transport low-risk waste generated in Building 38 to the WD Building for treatment. Details of these systems are included in Section 4 of this report.

The plutonium processing in Building 38 was no different from processing in the SM Building, with a continued emphasis on production of PPO and PMC. Building 38, like the SM Building, had its own plutonium recovery process, including an in-line glove box incinerator, for destruction of combustible wastes generated in production and plutonium recovery processes. However, leaded gloves were no longer incinerated following an explosion associated with this process in the SM Building. The leaded gloves were subjected to an acid leaching procedure, and the leachate went to the plutonium recovery process. The leached gloves, based on the 10 nCi/g discard criteria, were packaged as low- or high-risk waste and shipped offsite for disposal.

Prior to December 1975, the acidic and caustic high-risk liquid wastes were processed separately. After the plutonium recovery operations were transferred to the SRP in late 1975, the volume of acidic waste was greatly reduced and separate processing was no longer required. After December 1976, the acidic and caustic wastes were combined for processing and nearly all the high-risk waste liquids were slightly basic. The acidic liquids were typically drummed with an absorbent material such as AutoDri, Sorbal, or Florco (MRC 1972); allowed to degas; and shipped off-plant for burial. The use of AutoDri, before July 1976, caused some problems with the TRU containers. The absorbent contained diatomaceous earth and the reaction between the calcium carbonate and the acidic solutions produced carbon dioxide. Florco did not contain calcium carbonate and did not produce the reaction.

As with the SM operations, low-risk wastewater from plutonium operations in Building 38 largely originated outside the glove box lines. Mop and wash water was collected in a 5,000-gallon above-ground tank adjacent to the SM Building. Shower water was collected in the 3,000-gallon below-ground tank, originally installed for use in the SM Building. These tanks were pumped through the low-risk side of the WTS to the WDA or WD Building for processing. A study of other constituents in these low-risk wastes, conducted sometime in the late 1970s, indicates that small quantities of chemicals used in the plutonium production and recovery operation became constituents of the low-risk wastewater. These included cooling water; trace amounts of alcohols (methanol, ethanol, isopropanol); detergents; shower water; and janitorial wastes such as wax, wax stripper, bowl cleaner, paint, sawdust, acetone, and trace amounts of trichloroethene (Blauvelt n.d.). Estimated quantities of these chemicals generated annually (in the late 1970s) are listed in Table II.5. As the plutonium operations expanded, the volume of treated effluent also increased. In 1969, when the low-risk waste line was found to be leaking, the low-risk waste was temporarily transferred to WDA in a 2,000-gallon tanker truck. This tanker made one or two trips per week, delivering waste to WDA. This represented an annual rate of 100,000 to 200,000 gallons. The volume of low-risk aqueous waste that was forecast to be generated in 1977 was approximately 600,000 gallons (MRC 1977b).

The airborne releases from plutonium processing into the workplace were significantly reduced in Building 38. This was accomplished by a new HEPA filter design and a filter change-out procedure that did not result in a direct coupling of glove box atmosphere with the workplace. This feature, coupled with two stages of HEPA filtration, resulted in significant reductions of airborne emissions via the building stack.

In August 1968, the D&D of the SM Building began and continued until August 1972 (MRC 1976a). These efforts produced both aqueous and airborne wastes. Seventy percent of the annual atmospheric emissions of plutonium-238 from 1968 through 1972 (Table II.4) came from the D&D activities associated with the SM Building. The increase in plutonium-238 in water effluent during the same years (Table II.4) was also a result of these D&D activities (Flanagan 1976).

From startup, the maximum permissible concentration levels of plutonium in the air (6×10^{-14} μCi/mL) and wastewater (5×10^{-6} μCi/mL) were guided by U.S. Department of Commerce, National Bureau of Standards Handbook 69. In 1965, AEC adopted these standards into the USAEC Manual, Chapter 0524, RCGs. In 1972, the RCG for plutonium in water was reduced to 2×10^{-6} μCi/mL. The annual environmental monitoring reports, published since 1959, compare RCGs with release concentrations.

Table II.5. Estimated Annual Quantities of Chemical Wastes Processed through the WD Building

Chemical	Quantity (lbs)
Potassium carbonate (K_2CO_3)	4.0
Potassium sulfate (K_2SO_4	1.0
Copper sulfate ($CuSO_3$)	1.0
Calcium carbonate ($CaCO_3$)	3.0
Oxalic acid ($H_2C_2O_4$)	1.0
Lithium chloride (LiCl)	2.0
Zirconium oxide (ZrO_2)	2.5
Sodium carbonate (Na_2CO_3)	0.25
Caustic soda and lime	60.0
Potassium pyrosulfite ($K_2S_2O_5$)	5.0
Potassium bromide (KBr)	2.5
Nickel sulfate ($NiSO_4$)	4.0
Asbestos fiber	1.0
Methylene blue	1.0
Mercury (Hg), Lead (Pb)	Trace
Beryllium (Be), cyanides	Trace

(Data from Blauvelt n.d.)

2.3. TRITIUM PROCESSES

The start up of tritium-related operations at Mound began in the mid-1950s (Meyer 1957d, 1958b). Tritium processing activities included production, disassembly, analysis, and development of nuclear components that contained tritium. In support of these activities, Mound has been involved in development of tritium enrichment and recovery process technology and the processing and containment of tritium-contaminated wastes. At the present time, Mound has the facilities for the recovery and purification of tritium from all types of materials and wastes generated by other DOE sites. This recovery and purification system is known as the tritium recycle and enrichment system.

In the early 1970s, a major effort was undertaken at Mound to reduce the fugitive emissions of tritium. As much as 80% of the total annual release of tritium to the atmosphere could be attributed to diffusion of tritium out of glove box operations and other containment areas to the room ventilation systems (Bixel et al. 1975). In January 1972, a tritium effluent control project was undertaken with the goal of reducing fugitive tritium emissions to less than 10% of the RCG for hydrogen/tritium (HT) and hydrogen/tritium oxide (HTO). Table II.6 shows the history of tritium effluents from 1959 to 1989.

Tritium is also processed at Mound to recover helium-3. This activity is described in the subsection 2.10. Small amounts of tritium from this recovery process were vented to the atmosphere via the HH stack. After 1970, the tritium gas from this process was collected in cylinders and transported to the SW Building and fed to the effluent removal system (ERS). The use of cylinders was discontinued after the installation of a pipeline between the HH and the SW Buildings to transfer tritium from the helium-3 process to ERS (MRC 1984b).

2.3.1. Process Description

Tritium processing activities take place in the T, SW, R, and HH Buildings (Phipps 1991). Processes associated with tritium are performed in inert atmosphere glove boxes, in analytical glove boxes, and in systems that are enclosed in high velocity fume hoods. Gaseous effluents from glove boxes, pass boxes, vacuum pumps, and process lines are processed to remove tritium and tritium oxide before these gaseous effluents are released to the atmosphere. Mound refers to this process as the tritium recycle and enrichment system.

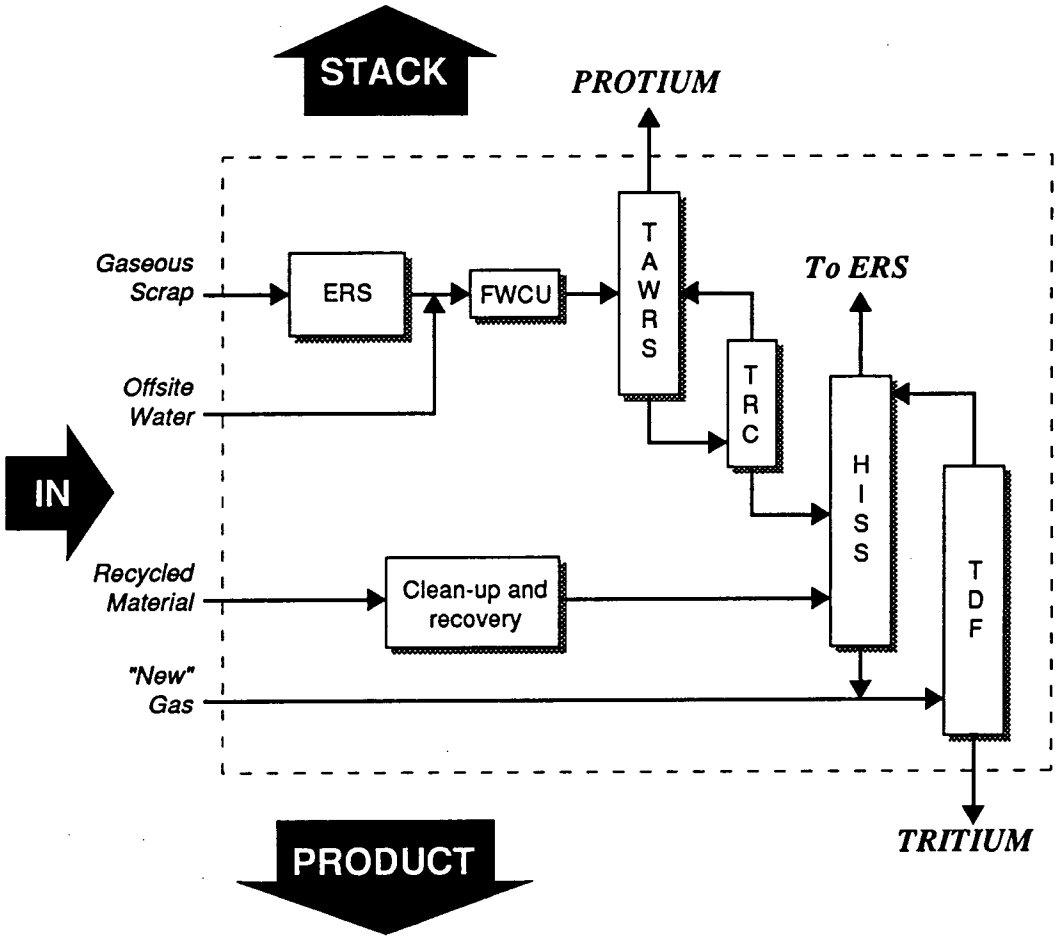
Various tritium-containing scrap materials are processed for the recovery of tritium. These tritium-containing materials include gaseous scrap, offsite tritiated water, recycled material, and new gas. Scrap material containing tritium is processed in the isotope recovery system, and the tritium gas is transferred to the tritium recycle and enrichment system. Tritium gas and tritiated water enter into the recovery process based on the concentration of tritium in the gas feedstock. In the isotope recovery system, the tritium is absorbed onto a molecular sieve column that is cooled with liquid nitrogen. Gases such as nitrogen, argon, helium, and methane are separated from tritium by this process and are exhausted to the atmosphere via the stack in SW Building. The tritium is desorbed from the molecular sieve column and is enriched by the thermal diffusion process. The tritium product is stored for future use, and the waste gas from the thermal diffusion column goes to the ERS for further recovery of tritium.

2.3.1.1. Tritium Recycle and Enrichment System

In the late 1980s, Mound began operating an integrated tritium recovery and purification system that is referred to today as the tritium recycle and enrichment system (Hedley 1991). This system evolved over the years and began with the ERS. Other components of the recycle and enrichment system are: the tritium aqueous waste recovery system (TAWRS); the tritium recovery column (TRC); the hydrogen isotope separation system (HISS); and the thermal diffusion facility (TDF). This system produces tritium of better than 99% purity. The process flow sheet for the tritium recycle and enrichment system is shown in Figure 2.7.

2.3.1.2. Effluent Removal System

The ERS is a detritification system used to process tritium-contaminated gases generated at Mound. It serves primarily to process gases from vacuum pump exhausts, pass boxes, and glove box lines. The ERS has also proven useful in processing gaseous atmospheres associated with maintenance- and decontamination-related activities. The ERS receives tritium-containing gas at a volumetric flow rate of up to 40 cubic ft per minute; at higher volume flows, an emergency tank can be used to divert high peak flows to prevent system overload (MRC 1977a). A process flow diagram of the ERS is shown in Figure 2.8. The tritium-containing gas stream enters the ERS refrigerated filter system, which separates water, organic solvents, and vacuum pump oil from tritium and other fixed gases. The gaseous stream passes through two additional beds of molecular sieve to remove traces of water and organic vapor. The tritium-containing gas stream is heated to a temperature ranging from 500° to 700°C and then passes over a bed of hopcolite (copper oxide and magnesium dioxide) and a second bed containing a platinum catalyst. Tritium is converted to the oxide, and tritiated organics are oxidized to carbon dioxide and tritium oxide. The tritium oxide is removed from the process stream



ERS – effluent removal system

FWCU – feed water cleanup system

TAWRS – tritium aqueous waste recovery system

TRC – tritium recovery column

HISS – hydrogen isotope separation system

TDF – thermal diffusion facility

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Figure 2.7. Tritium recycle and enrichment system (EG&G n.d.).

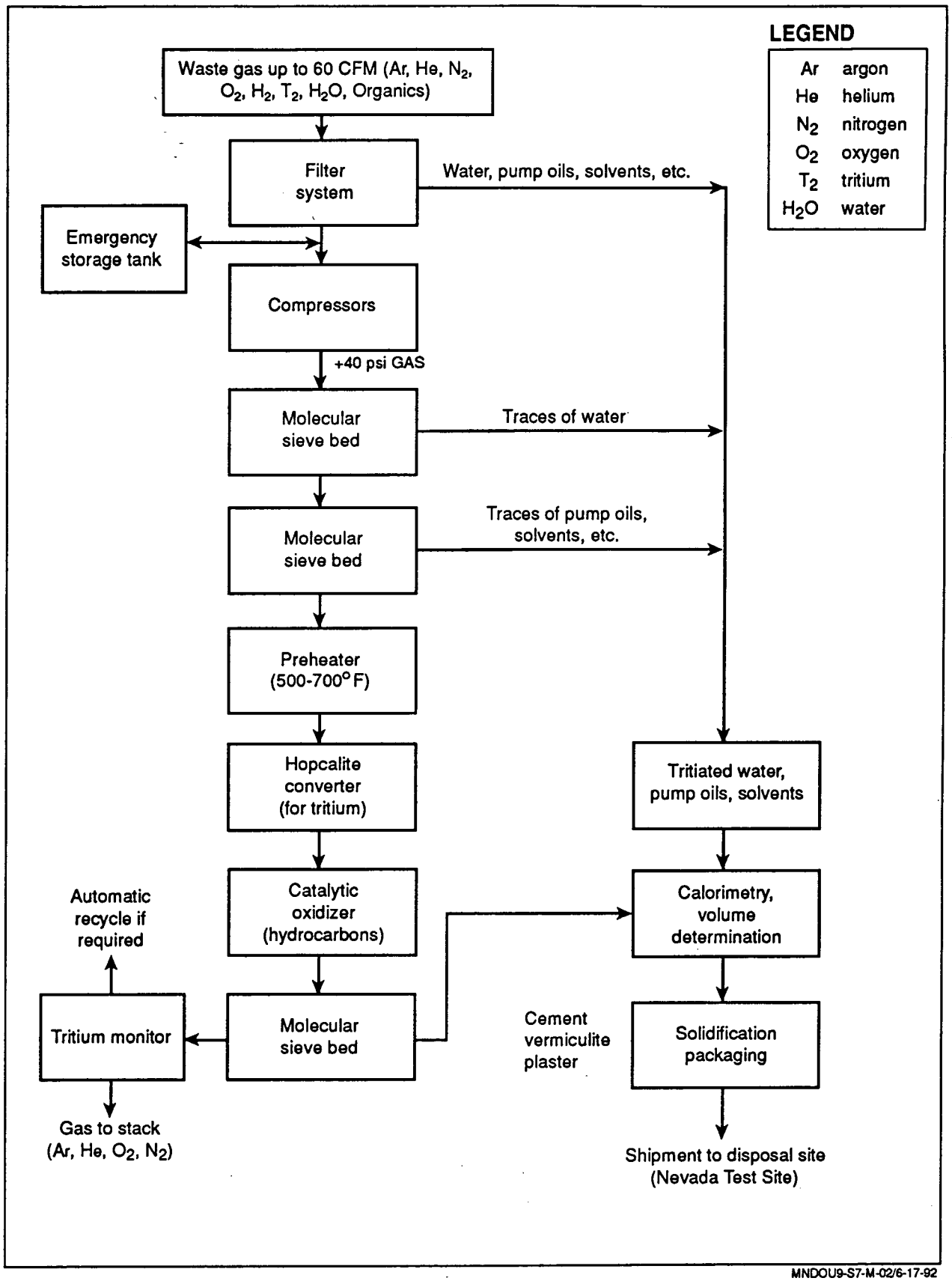

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Figure 2.8. Flow diagram of effluent removal system (MRC 1979).

with a 13 X molecular sieve bed downstream of the oxidation catalyst beds. The absorbed HTO is recovered from the dryers and the tritiated hydrogen and tritium are recovered in the TAWRS. The gas stream is monitored and analyzed for tritiated hydrogen and HTO. If the processed gas stream meets discharge criteria (see subsection 2.3.2), it is vented to the atmosphere via the SW Building stack. If it does not meet discharge criteria, the gas can be recycled through the ERS process.

2.3.1.3. Tritium Effluent Control

The tritium effluent control project was initiated at Mound in 1972 in order to develop the state-of-the-art tritium control technology necessary to achieve reduction of tritium in effluents to 10% of the RCG values (MRC 1976a). The glove box atmosphere detritiation system (GADS) was an outgrowth of this program. The GADS was a significant development for reducing fugitive emissions from glove box operations. As mentioned earlier, 80% of the annual fugitive emissions of tritium resulted in diffusion of tritium into the room and building atmosphere from glove box operations. The GADS consists of a recirculating helium purification unit that removes tritium along with other gases such as nitrogen, oxygen, and water vapor from the glove box inerting atmosphere. The GADS operates on the principle of catalytic oxidation and adsorption of these gases at liquid nitrogen temperatures, on a bed of 5A molecular sieve.

In 1976, the tritium effluent control laboratory was near completion. This laboratory was responsible for developing separation and tritium-enrichment technology for both gaseous and liquid effluents. Two support systems were operational relative to tritium developmental activities. These support systems were known as the emergency containment system (ECS) and the air detritiation system (ADS). In the event a tritium-containing system failed during testing in the environmental test laboratory, the ECS swept the tritium-contaminated atmosphere in the test laboratory to an evacuation tank. The ADS consisted of a platinum catalyst bed that converted tritium in the effluent to an oxide. A drier bed removed the oxide from the gas stream, and a blower recirculated the air in the glove box line until the tritium level was low enough to permit discharge to the atmosphere via the building stack. In the event there was a glove box line breach, the ventilation system in the laboratory was isolated and the entire room air was recirculated through a large platinum catalyst reactor and a drier or oxide removal system until tritium levels returned to normal values.

2.3.1.4. Tritium Aqueous Waste Recovery System (TAWRS)

In the 1980s, the TAWRS became operational to process tritium oxide coming from SW and T Buildings. High-level tritium oxide was dissociated by electrolysis, and the hydrogen/tritium gas mixture was sent to a cryogenic distillation/palladium chromatography processing unit. The tritium

from this process was transferred to the HISS; the hydrogen gas, containing on the order of 10^{-4}% tritium, was sent to the intermediate level of the TAWRS for tritium recovery or was discharged to the atmosphere via the stack. The tritium-rich gas stream from the high-level side of TAWRS was further purified by the TRC and the HISS. The tritium product went into storage prior to shipment to the SRP or was used in Mound tritium programs. The less pure tritium stream from the TDF was returned to the high-level TAWRS.

The TRC is a single column cryogenic distillation system that receives the low concentration tritium stream produced by the TAWRS. The distillate from the TRC is returned to the TAWRS, and the still bottom is the feedstock to the HISS. There is no waste stream generated by the TRC system.

The HISS is a tritium recovery and enrichment system that employs low-temperature distillation as the separation process. The HISS receives recycled tritium-containing material and tritium-containing gaseous material from the TAWRS and the TRC. The HISS enriches the tritium via a three-stage cryogenic distillation process and is capable of producing tritium enrichments greater than 90%. The process flow sheet is shown in Figure 2.9. The tritium-enriched stream is transferred to the TDF, and the distillable is returned to the ERS. No waste stream is generated by the HISS.

The TDF employs gaseous phase thermal diffusion technology to process the still bottom from the cryogenic distillation system in the HISS. The TDF produces gaseous tritium of better than 99% purity. The low tritium side of the TDF is returned to the HISS for recycling. No waste stream is generated by this process.

2.3.2. Waste Generation

Tritium processing, recovery, and decontamination activities in SW, T, and HH Buildings generate gaseous, liquid, and solid wastes containing tritium. Two major factors influence the generation of tritium waste at the Mound. From the early 1950s, when the tritium program came to Mound, the tritium processing activities grew significantly. In 1960, the ERS was installed. In the early 1970s, the tritium effluent control project was implemented. This program addressed the development of new technology and reflected a major philosophical change in Mound's approach to tritium waste generation, treatment, and controls. Table II.6, Summary of Mound Tritium Effluents 1959-1989, reflects these strategies. There are no currently existing data for air emissions for 1957 and 1958 or water effluents from the later 1950s to the mid-1960s. As the tritium program grew at Mound, so did tritium emissions to the atmosphere and tritium concentrations in wastewater.

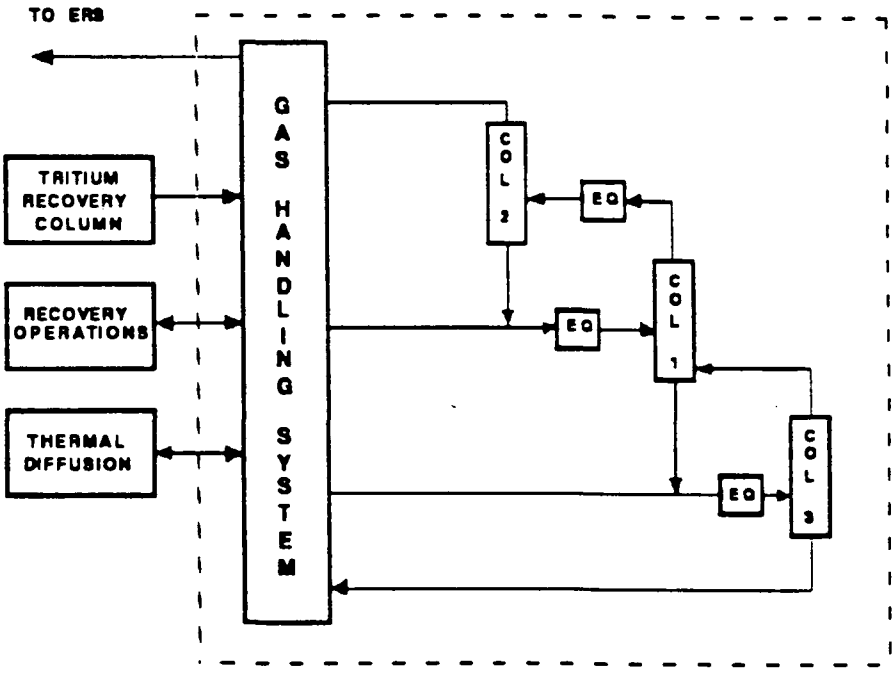

Figure 2.9. Hydrogen isotope separation system (HISS) (EG&G n.d.).

Table II.6. Summary of Mound Tritium Effluents 1959-1989

Year	Tritium	
	Air (Ci)	Water (Ci)
1959	31,527	
1960	102,427	
1961	240,644	
1962	244,455	
1963	313,932	
1964	262,638	
1965	206,750	
1966	199,561	
1967	364,685	169
1968	275,856	202
1969	315,252	2,332
1970	179,468	250
1971	73,503	399
1972	30,483	244
1973	15,331	149
1974	10,031	105
1975	8,859	58
1976	6,206	46
1977	4,896	57
1978	7,346	32
1979	3,831	34
1980	3,795	26
1981	4,285	22
1982	4,283	14
1983	4,293	8
1984	3,430	8
1985	4,795	6
1986	3,555	6
1987	3,863	6
1988	3,204	4
1989	41,534	6

Ci - curies

The implementation of controls and new technology in the early 1970s resulted in a dramatic reduction in emissions (Table II.6); this reduction continues to the present time. An anomaly appears in the tritium emissions to the atmosphere for the year 1989. On November 18th, a single accidental release of 38,000 Ci of tritium took place (DOE 1992e). Currently, normal tritium releases to the atmosphere are on the order of 4,000 Ci per year.

From startup, the maximum permissible concentration levels (discharge limits) of tritium in the air (2×10^{-7} μCi/mL) and wastewater (5×10^{-3} μCi/mL) were guided by U.S. Department of Commerce, National Bureau of Standards Handbook 69. In 1965, AEC adopted these standards into the USAEC Manual, Chapter 0524, for the RCGs, but reduced the RCG for tritium in wastewater to 3×10^{-3} μCi/mL. In 1972, the RCG for tritium in wastewater was again reduced to 1×10^{-3} μCi/mL. The annual environmental monitoring reports, published since 1959, compare RCGs with release concentrations.

2.3.2.1. Gaseous Tritium

The majority of gaseous tritium effluent streams in T, HH, and SW Buildings are processed by the tritium recycle and enrichment system. The ERS and the tritium recovery and purification systems, TAWRS, TRC, HISS, and TDF, are the primary processors of gaseous tritium waste. The ERS processes tritium-containing gaseous streams generated by the SW and R Buildings tritium complex. The ERS converts the tritium to an oxide, and the gaseous wastes are discharged to the stack. The TAWRS generates a gaseous tritium waste stream. This gas stream can be returned to the intermediate level of the TAWRS or, upon meeting discard criteria, can be discharged to the atmosphere via the building stack.

In the stable isotope program, helium-3 is separated from aged tritium. Prior to 1970, tritium was released from the helium-3 process via the HH Building stack. After 1970, the tritium was collected in cylinders and transferred to the ERS in the SW Building. Tritium collection in cylinders was curtailed when a tritium gas pipeline was installed between HH Building and the ERS.

In summary, significant reductions in gaseous tritium emissions to the atmosphere and the workplace have been realized because of the ERS and the tritium effluent control project.

2.3.2.2. Aqueous Tritium Wastes

Numerous sources of low-level aqueous tritium wastes are generated in the SW/R complex and the T Building. Aqueous wastes contaminated with low-levels of tritium drain to hot sumps in rooms SW-8, SW-21, SW-125, and SW-143. The wastes are pumped from the sumps to the waste disposal facility

in the WDA Building, where the liquid is solidified, drummed, and shipped offsite for burial. In the 1960s and early 1970s, low-level tritium wastewater was diluted and released from the SW Building storm sewer and WD Building, respectively.

The major producer of tritiated-liquid is the ERS. The tritiated water generated by the ERS and that received from offsite is scrap, not waste, and it can be recycled to recover the tritium. The ERS liquid is transferred by vacuum from the ERS filter station tanks and the condensate collection station to room SW-149A where the feedwater cleanup system (FWCU) removes particulates and organic impurities from the water. The liquid is then shipped by drum to the TAWRS and HISS located in T Building. At times, the TAWRS is inoperative and some of the ERS liquid must be solidified and buried. The tritiated water received from offsite scrap is held until the TAWRS is operating.

Higher level liquid wastes and offsite scrap are handled by the offsite waste recovery facility and the FWCU located in the SW Building. These liquids are not considered as waste and are processed by the TAWRS. High specific activity (≥ 1 μCi/mL) contaminated waste is solidified, packaged, and shipped offsite for burial.

Low-level tritium-contaminated liquid wastes, primarily from shower and decontamination operations in the SW Building, are transported to the WDA facility in doubly enclosed above-ground pipelines, and the liquids are solidified with cement in 55-gallon DOE 17H steel drums (approximately 25 gallons of wastewater mixed with 3 bags of portland cement and 2 bags of Florco clay absorbent). Activity per package averages 20 mCi or less. Approximately 1,200 drums are generated annually.

2.3.2.3. Solid Tritium Wastes

The decontamination technician is responsible for handling tritium-contaminated solid waste in the SW and R Buildings tritium complex. There are three categories of radioactive solid waste: low-specific activity (LSA), intermediate-activity (Type A), or high-activity (Type B), as discussed in subsection 6.1.2.1. The Type A and Type B wastes are defined as having activity less than or greater than 0.3 mCi, respectively.

LSA waste is segregated into compactible waste or non-compactible waste, then placed in either metal drums (17H or 17C) or plywood boxes for offsite burial. Type A waste is packaged in sealed 50-gallon steel drum liners. Material that may offgas is first placed in sealed plastic bags or sealed 5-gallon metal cans before being packed in the 50-gallon metal drum liner. After the liner exterior is checked by Health Physics, the drum liner is placed in a 55-gallon 17H overpack drum that is sealed with a sponge rubber gasket and lid. A drum ring and bolt hold the lid firmly in place. Welded metal boxes may also be used for heavy or large pieces of contaminated solid waste. To assure that no free liquids are

present in the disposal containers, a clay absorbent is added to the bottom of each drum liner, drum overpack, and box. The primary confinement container for Type B waste is a 5-inch-diameter by 11-inch-long welded steel container. Loading and welding are done in an inert atmosphere. Calorimetry is performed to determine the amount of tritium present in the container. The containers are then decontaminated and checked for leaks. The primary confinement containers are packed in an asphalt-coated 30-gallon 17H drum that is half filled with nonhardening asphalt.

2.3.2.4. Miscellaneous Tritiated Wastes

Low-Level Laboratory Waste

This waste stream consisted of tritium contaminated LSA and Type A laboratory waste including paper, plastic, glass, rubber, small equipment, tools, laboratory furniture, and clothing. Drummed waste is compacted. The waste is packaged in U.S. Department of Transportation (DOT) 17H 55-gallon steel drums, 48 inches by 52 inches by 84 inches, and in wood boxes, 48 inches by 28 inches by 84 inches. The average activity is 10 mCi per package. The annual generation rate is about 400 drums and 200 boxes.

Offgassing Laboratory Waste

This stream consists of tritium-contaminated laboratory wastes such as plastic, paper, rubber, cloth, small laboratory equipment, piping, small tools, and glass. Most of this material is from glove box or in-line operations. These wastes are packaged in 55-gallon steel drums, with 50-gallon drum liners, or Mound welded steel boxes to retard tritium offgassing. Typical activities for this waste form are 10 to 50 Ci per package. Mound generates approximately 4,800 ft^3 of this waste annually.

Contaminated Equipment

This waste stream consists of tritium-contaminated process equipment, including pumps, motors, and laboratory equipment too large for disposal in drums; this waste stream also includes glove boxes and other internally contaminated equipment. The waste is packaged in wooden boxes, steel boxes, and welded steel boxes, depending primarily on activity levels that may range from a few millicuries up to 1,000 Ci per package. Annual generation rates vary based upon D&D activities.

High-Activity Tritium Solid Waste

This waste stream consists of solid wastes from laboratory and process operations (e.g., mole sieve, laboratory equipment) and is packaged in 17H 30-gallon coated steel drums or 50-gallon steel drum liners inside 55-gallon 17H Type A steel drum overpacks. Tritium activity is above 1,000 Ci per package. This waste will be shipped in DOT Type B containers and overpacks and will require greater confinement disposal. The annual generation rate averages four drums per year.

High-Activity Tritium Solidified Wastewater

This waste stream consists of liquid wastes from laboratory and process operations contaminated with high levels of tritium. The liquid waste is solidified in cement and packaged in 30-gallon steel drums with polyethylene drum liners, which are emplaced in bituminous asphalt inside 55-gallon 17H Type A steel drum overpacks. This waste stream is shipped in DOT Type B containers and overpacks and requires greater confinement disposal. Activity levels range from 1,000 up to 30,000 Ci per package, and the annual generation rate averages 30 packages per year.

High-Activity Tritium Waste Oil

This waste stream consists of waste oil from vacuum pumps and other laboratory and process operations contaminated with relatively high levels of tritium. The waste oil is absorbed onto Florco in lined 30-gallon 17H and 55-gallon steel drum overpacks. This waste stream, if greater than 1,000 Ci per package, is packaged and shipped in DOT Type B containers and overpacks and requires greater confinement disposal. Activity levels can range from a few millicuries up to 2,000 Ci per package. Approximately 5 to 10 drums of high-activity tritium waste oil are generated annually.

2.4. RADIUM-226 AND ACTINIUM-227 PROGRAMS

Because of the short half-life of polonium-210, a search for other alpha-emitting isotopes, with a specific activity and neutron-generating efficiency comparable to polonium-210, was undertaken in the 1940s, as part of the substitution materials program. Actinium-227, being an alpha-emitter with a half-life of 21 years, was selected as a possible replacement for polonium-210 in the production of initiators. There were several problems with using actinium-277 in weapons components. Actinium-227 is not present in sufficient quantities in natural source materials; but, like polonium-210, it could be produced by neutron irradiation of a target material. In the case of actinium-227, radium-226 was the target material.

Radium-226 occurs with uranium in pitchblende ores at about 1 part in 3 million. The actinium must be separated from the radium after irradiation, a considerable effort since the workers must be shielded from the high-gamma radiation. The actinium must then be purified and reduced to its metallic state. Only then can the actual weapons initiator be fabricated. All of these processes went through the research and development stage at Mound (MCC 1950a,b). The actinium work generally lagged behind the radium work because large quantities of actinium were needed. The program grew rapidly from 1951 to 1952; but, by July 1953, the program was de-emphasized (MCC 1953a,b). A few initiators were produced at Mound that were probably never used by the AEC.

In support of the actinium program, a decision was made to develop a radium recovery process and a radium processing plant at Mound. Sources for radium were researched in the late 1940s and were identified in the United States, Canada, and Belgium. In the process of recovering uranium from the Belgian Congo pitchblende ore at the Mallinckrodt Chemical Works, St. Louis, Missouri, a residue containing radium, known as K-65 residue, was produced (MCC 1951). In September 1949, Mound requested 200 pounds of the K-65 (Miller 1949; Haring 1949a). In December of that year, Mound workers toured the Mallinckrodt plant to observe the processing operations of the pitchblende ore. Mound had received the K-65 residue in October and was using it to develop the process chemistry that would be used to recover radium from K-65. This research effort, performed in R Building, included studies on radium separation chemistry, concentration of radium from barium, coprecipitation of lead and radium, and separation of barium and radium by ion exchange and fractional crystallization (Salutsky et al. 1953). At the same time the research work was taking place, preliminary engineering studies concluded that the pilot plant at Mound should be able to process 300 pounds of K-65, or about 100 mg of radium, per day (Rauscher 1950). It is unclear from the available records how much actual processing of K-65 residue took place, but it appears that the pilot plant was never built. The actual yield of radium from the K-65 residue is unknown, but it appears to have been small.

Radium from other AEC sources was directed to Mound to expedite the program. In February 1950, 30 g of radium were being prepared for irradiation at the Hanford reactor, with costs incurred and accountability assigned to Mound (Bobbitt 1950). The source of this radium was Argonne National Laboratory (ANL). In November 1950, Mound was assigned the responsibility of processing the 30 g of radium that were then still in the Hanford reactor. Plans were also made to re-irradiate radium that was purified through processing.

In February 1950, Mound personnel visited ANL to observe the separation and purification of actinium from irradiated radium (Engle 1950). The radium-actinium technology developed at ANL was essentially transferred to Mound. To conduct this program, a new general purpose (GP) Building was planned that later became known as the SW Building. In June 1951, a special shielded process

facility, which is generally referred to as the old cave, was constructed in a room on the east side of the building.

The cave design was duplicated from one in use at ANL. The cave was approximately 20 ft by 5 ft by 12 ft high and was placed approximately in the center of the room. The front had a shielded portion about 6 ft high, constructed of concrete and steel, with four large plate glass window tanks. The working surface inside the cave was about 3 ft high with lead access doors along the back and sides. A 1-ton traveling crane served the entire cave room and facilitated moving the heavy casks. The area in front of the cave was considered the low-risk side; the area around the ends and back, where feed materials and supplies were stored, was the high-risk area. All entry into the cave was controlled (Engle 1950). Drainage in the building was provided by a series of lateral channels in the floor. Within the cave area, these channels were lined with concrete and drained to enclosed sumps: one in the high-risk area and one in the low-risk area. A construction drawing of the drainage system of the old SW Building is provided in Appendix A.

The wastes generated in the cave could not be treated by the waste treatment process in the WD Building. A separate processing facility was constructed in room 1-B, adjacent to the cave in room 1-A. An evaporation treatment system was chosen (Jackson 1953, McEwen 1951). The system consisted of the evaporator and three waste storage tanks: one with a capacity of 1,000 gallons and the other two with capacities of 500 gallons each. This process equipment was installed and cold test runs were completed in early 1952 (Mead 1952). Hot test runs were made using wastes generated from research activities in the R Building. The 1,000-gallon tank and evaporator were also used for the Purex pilot plant in late 1952 and early 1953.

By March 1952, three radium-actinium separation runs had been completed in the cave. The first run contained 0.6 g of radium, the second and third contained 5 g each. By June 1952, 7.751 Ci of actinium had been separated from irradiated radium. Four additional irradiated slugs were due in from Hanford in August 1952. The radium that resulted from the separation was to undergo additional irradiation. A can designed to hold radium was approved for use in the materials test reactor (MTR) in Idaho, and the first charging of radium at the MTR was scheduled for November 1952. About 60 g of radium were actually in storage (Schauer 1953).

The research and development work on actinium was actually conducted on lanthanum until a source of actinium became available in 1951. Experiments focused on the separation of lanthanum from barium using an ion exchange process. Dowex-50 was the typical exchange resin used. Reduction of lanthanum fluoride with lithium suggested yields up to 100% (Mead 1952). In October 1952, Mound was directed to construct a laboratory and pilot plant for actinium initiators. Equipment needed

for housing the actinium purification and fluoride preparations was installed in the R Building. By July 1953, however, the actinium pilot plant was de-emphasized by the AEC (Schauer 1953).

By July 1952, an assessment of the cave area indicated high levels of contamination that represented a serious radiological hazard to personnel working in the area (Bradley 1952d). The health physics surveys indicated surface and airborne contamination so high that instrument readings could not be evaluated. All work in the cave area stopped until decontamination and modifications were made (Mead 1953, Bradley 1952g). These were not finished until nearly spring of 1954. During this hiatus, research on the separation methods was continued.

On June 1, 1954, work was resumed on the separation and purification of radium-226, actinium-227, and thorium-228 from neutron-irradiated radium-226. By October 1954, almost 48 g of radium had been processed and canned (MCC 1954). As a result of this work, 47.5 Ci of radium, 14.9 Ci of actinium-227, and 24.6 Ci of thorium-228 were purified by the end of that year (McCarthy 1955).

By December 1954, plans for final cleanup of the cave were being made (Mead 1954). D&D of the cave was performed over the next few years, as budget permitted. A shipment of 47 g of radium was returned to the AEC of Canada, Ltd., in Ottawa, in December 1957 (Meyer 1958a).

2.4.1. Process Description

The production of actinium at Mound involved both the separation of radium from the K-65 residues and separation and purification of radium and actinium from irradiated radium. Radium separated from the K-65 residues and radium obtained from other sources was shipped to the Hanford reactor facility where it was irradiated with neutrons in accordance with the following reaction:

$$_{88}Ra^{226} + {}_{0}n^{1} \rightarrow {}_{88}Ra^{227} \rightarrow {}_{87}Ac^{227} + \beta$$

After irradiation, the material was returned to Mound for the separation and subsequent purification of actinium-227. The radium was also recovered and stored.

2.4.1.1. K-65 Residue Pilot Plant

Mallinckrodt Chemical Works, St. Louis, Missouri, had been processing Belgian Congo pitchblende ore to recover uranium. As a result of the process, the radium that occurs in pitchblende ore remained in the gangue when the ore was extracted with nitric acid. The gangue was neutralized with sodium carbonate and bicarbonate and stored for eventual recovery of radium. This neutralized gangue was referred to as K-65 residue. This material was caustic and had a 30% moisture content (Rawlings

1951). The acidic liquid containing the concentrated uranium nitrate underwent a solvent extraction procedure with diethyl ether, and the aqueous phase was again treated with sodium hydroxide; this resulted in the formation of a caustic sludge referred to as the St. Louis Residue or the Cotter Concentrate. Mound also processed Cotter Concentrate to recover protactinium-231 and thorium-230. No analytical data are available that characterize the K-65 residue. However, there are analytical data available for the Cotter Concentrate. The metals found in the Cotter Concentrate can be expected to be present in the K-65 residue as well, but not necessarily in the same concentrations. The constituents found in K-65 residues are presented in Table II.7 (Rawlings 1951). A discussion on the composition of Cotter Concentrate can be found in subsection 2.9.

Table II.7. Composition of K-65 Residue (Rawlings 1951)

Constituent	Concentration Weight %
Water	30
Lead oxide	19
Barium sulfate[a]	7
Silicon dioxide	35
Metals[b]	9

[a]375 mg of radium contained with the barium.
[b]Metals that may be found in the K-65 are similar to those identified in Cotter Concentrate. See subsection 2.9 for a discussion of those metals.

In October 1949, 200 pounds of the K-65 residue were shipped from Mallinckrodt in a single 55-gallon steel drum and stored in the old explosives bunker at Mound (Garner 1991). The radium recovery process began with the transfer of an aliquot sample to the SW Building. The process developed at Mound for extracting radium from the K-65 residue is a modification of the method used by Madame Curie and her co-workers. Whereas the Curie process separated the radium as a bromide, the Mound process separated it as a chromate. The processing of the residue began with leaching the material with water to extract soluble salts. The residue was then treated with a mixture of sulfuric and hydrofluoric acid to remove silica. The residue was then treated with sodium carbonate solution to convert radium and barium sulfates to carbonates. The traditional Curie process used fractional crystallization to separate the radium from the barium, but this was slow and difficult. Experiments were performed using ion exchange as a substitute, but it is not clear that any technique was ever used to produce any quantity of radium. There is no evidence that Mound ever received additional shipments of the K-65 residues after the initial 200 pounds. Sources of refined radium were identified in Canada and Belgium to satisfy the radium-actinium program.

2.4.1.2. Radium-Actinium Separation Process

The process of separation of actinium from radium developed by ANL used solvent exchange. The irradiated radium bromide was dissolved in water and the actinium was extracted in a solution of thenoyltrifluoracetone. The thenoyltrifluoracetone was found to polymerize and turn gummy upon standing, and the process was modified to include benzyl acetone. Eventually, an oxalate precipitation method was developed.

The oxalate precipitation method used for separation and purification of actinium began with the dissolution of the irradiated radium in 90% nitric acid and the formation of an insoluble radium nitrate. The radium nitrate was redissolved and then precipitated as a carbonate. The radium carbonate was recovered by filtration and placed in a platinum container for future neutron irradiation. The filtrates from the dissolution and precipitation steps described above contained actinium-227 and thorium-228 and were combined. Thorium was precipitated as the iodate. The filtrate containing actinium was treated with dimethyl oxalate, and the actinium was precipitated as the oxalate. Additional purification may have taken place within ion exchange columns, but this process is not well documented.

Metallic actinium was prepared by igniting the oxalate to form an oxide. The oxide was dissolved in nitric acid and precipitated as a fluoride by addition of hydrofluoric acid. The actinium fluoride was then treated with lithium to reduce the actinium to the metal.

2.4.2. Waste Generation

Both the research and production phases of the radium-actinium program required the processing of aqueous waste streams that could not be processed by the waste treatment facility in the WD Building. The need for a dedicated aqueous waste treatment facility that would be capable of treating wastes generated by this program was recognized early. A small waste evaporator system supported the process chemistry development activity in the R Building. This evaporator had a capacity to treat 3 gallons of waste per hour and received waste from the radium-actinium program as well as wastes from the reactor waste program. The condensate from this evaporator went to the WD Building. A similar but larger evaporator was installed to treat the aqueous wastes from the cave operations.

The K-65 residue research program produced aqueous, gaseous, and solid waste streams. The water leach of K-65 residue generated an aqueous waste that contained 10% dissolved solids. The sulfuric and hydrofluoric acid digestion of the remaining residue generated silicon tetrafluoride, a gas that was discharged to the cave. This step removed 75% of the silica contained in the residue. The addition of sodium hydroxide neutralized residual acid. This step generated a precipitate containing sodium

carbonate that was treated as a solid waste. The carbonation steps that followed generated an aqueous waste stream high in sodium carbonate and sodium sulfate. The residue remaining after nitric acid treatment generated a silica residue, which was discarded as a solid waste, and a liquid solution containing barium and radium. The barium-radium solution underwent fractional precipitation followed by ion exchange. This process generated an aqueous waste containing barium nitrate, trichloroacetate, and a small quantity of radium that was not recovered. The effluent that was discarded from the ion exchange columns contained ammonium citrate and barium. The spent ion exchange resin was treated as a radioactive waste. The aqueous wastes generated in this process also contained other radionuclides that were present in the original K-65 residue. The decay of radium generated radon and radon daughter products. The volumes or extent of these waste streams are unknown.

In the actinium process, radium was precipitated with fuming nitric acid resulting in a gaseous waste stream containing nitrogen dioxide. The nitrogen dioxide, scrubbed with caustic, produced a sodium nitrite waste. The filtrate was treated with dimethyl oxalate to precipitate actinium. The filtrate was then considered as waste. The actinium precipitate was converted to the fluoride with hydrogen fluoride, and the actinium was reduced to the metal with lithium. This process produced a solid waste consisting of lithium fluoride.

The aqueous wastes generated in the cave by the actinium and radium processes drained to a concrete channel in the floor of the cave and collected in sumps on either end of the channel. The sump behind the cave received high-risk waste, and the sump in front of the cave received low-risk waste. During the interim cleanup of the cave in 1953, a wooden dam was inserted into the trench. This was an attempt to prevent the movement of the high-risk liquids into the operator areas to reduce the radon levels. The sumps were periodically pumped to the evaporator treatment system in the adjoining room.

The evaporator treatment system consisted of storage tanks and a simple evaporator that concentrated the solids. The radioactive solids were packaged in 30-gallon steel drums for shipment and disposal off-plant. These drums were stored at the old explosives bunker (now known as Area 21) before shipment, as they had high gamma radiation levels. The condensate was routed through an ion exchange column to reduce the levels of radioactivity before it was discharged to the storm sewer. The effluent from the ion exchange column registered 4 to 38 alpha counts per minute per L and less than 50 beta counts per minute per L. The capacity of the waste evaporator system was rated at 100 gallons per hour. In December 1952, 12,747 gallons of waste were processed, generating 105 gallons of sludge (McEwen 1952a). It is not known if this 12,747 gallons of waste was the total or the total for the month or the total for the program to that point. Low-level wastes from the cave operations were stored in Warehouse 13 until they were shipped offsite (Bradley 1952f).

A large quantity of particulate was generated in the area of the evaporator, typically during drumming operations, because of high air velocities created by the process equipment. This particulate entered the building ventilation system located along the east wall of the building. This ventilation system was connected by an underground concrete duct to the building's main ventilation system. A booster blower fan was located in the maintenance facility. The booster blower directed the air to the stack in R Building. The particulate, containing radium, actinium, radon, and its daughter products, as well as contaminants from the Purex pilot plant, contaminated this ventilation system (MCC 1952-1957). As part of the D&D of the cave area, the ductwork and booster blower fan were decontaminated and removed from the building by the summer of 1958 (Meyer 1958d). The underground concrete duct is still in place, and the level of decontamination has not been established.

The D&D of the cave area was accomplished from 1955 to 1958, as funding permitted. All the equipment in the cave was boxed for shipment and off-plant disposal. The evaporator equipment was dismantled and stored on the ground for several years in the "Lower Storage Area" (MCC 1953-1957). It was not shipped to ORNL for burial until 1960. No information was developed that would indicate to what level this process equipment was decontaminated. One report indicates that during the moving of the evaporator, a connector was broken off and the truck was contaminated. No data were given (MCC 1953-1957).

The cave area was entombed with concrete after most of the equipment was removed. First, the crane assembly and lead doors were laid down on the floor behind the cave itself. The sumps in both the cave and treatment rooms were filled with sand, and the entire floor area was covered with 3 inches of concrete (Meyer 1955d). Over the old cave walls, the concrete is over 2 ft thick; in the other room, however, it is only a few inches thick (Meyer 1959a). The entire entombment is now known as Area 15 (DOE 1992g).

In 1955, after the entombment was complete, the large open room to the west, known as room 1-C, was being remodeled for the addition of the thorium refinery. The concrete floor and gravel from one of the trenches was found to contain a high level of radium and actinium, suggesting that the sump on the high-risk side of the cave had leaked (MCC 1953-1957).

2.5. THORIUM-232 REFINERY PROGRAM

In the mid-1950s, Mound was directed to conduct research toward the development and operation of a process for extraction of thorium from Brazilian Monazite sludge and other AEC waste materials. The goals were to develop a large-scale process for the recovery of thorium from a variety of thorium-bearing ores and other thorium-containing feed materials and to construct a refinery to produce thorium

in quantities required by the AEC. The refinery was to provide a thorium salt suitable for the preparation of metallic thorium of high purity for the thorium fuel cycle planned for the breeder reactor. Pilot-scale studies in preparation for a large-scale thorium refinery were conducted at Mound to refine the techniques that had been developed elsewhere. The process developmental work done at Mound is known as the Monex process (MRC 1973a). The Monex pilot plant was assembled in room 1B of the SW Building in the spring of 1955. At the same time, construction began on the thorium refinery that was to be built in the west side of the SW Building. Extensive remodeling of the WD Building was also planned, but never implemented. Wastewater processing was to be focused on reduction of trace radium contaminants (Huddleston 1955). The project hardly got started before it was cancelled. The actual directive to construct the facility was issued March 11, 1955 (Wende 1955), but construction was canceled May 9, 1955 (MCC 1955d). The roof that had been removed for construction was replaced and sealed. All the foundations, footings, and piers had been poured inside the building. A construction drawing of the refinery, as it was to have been built on the west side of the SW Building, is supplied in Appendix A. All the extensive interior excavations were backfilled with gravel and soil. Research work on the pilot plant was continued after the construction was halted and was completed by July 1955 (McCarthy 1955).

In anticipation of the completion of the thorium refinery, Mound received at least 1,650 tons of thorium-containing sludge from United Lead Company between December 1954 and June 1955 (McCarthey 1955). These shipments included Brazilian Monazite sludge, thorium oxalate, and sulfate sludge residues (Weisler 1955). The Brazilian Monazite sands are treated with caustic to recover the phosphates as sodium phosphate. The residual Monazite sand is then treated with hydrochloric acid to dissolve the rare earths. These are removed in the supernate. The remaining residue was known as Brazilian Monazite sludge (Mead et al. 1955). The sludge was extremely corrosive, being basic or acidic depending on the pretreatment it received, and contained approximately 55% water. The analysis of this sludge showed a wide range of thorium and rare earth components. Estimates of the original quantities of sludge materials are given in Table II.8. Table II.9 provides a typical elemental analysis of Brazilian Monazite sludge (Mead et al. 1955). These results are based on the sample being dried at 110°C. This drying results in the removal of water. When the sample is heated to elevated temperatures, metal hydroxides and chlorides are converted to the oxides. The typical sludge lost additional weight amounting to 14% due to an oxidation at an elevated temperature referred to as ignition. These materials were contained in over 6,000 55-gallon drums and were delivered to Mound by railcar. Many of the drums were in deteriorated condition. One shipment was received by truck in April 1955 in particularly poor condition, indicating that significant spillage had occurred enroute (Scott 1955b). Some thorium metal scrap, machine turnings, and oxide were also received from Nuclear Metals, Inc. The thorium metal scrap consisted of thorium metal chips, a variety of alloys, and aluminum-clad thorium metal. Thorium alloys also contained uranium, aluminum, and iron. Thorium

Table II.8. Quantities of Thorium Sludges and Thorium-Bearing Materials Stored at Mound as Feedstocks for the Monex Process

Monex Feedstocks	Material Weight (lbs)	Thorium Content (kg)	Thorium Content (% dry weight)
Brazilian hydroxide sludge	2,700,000	270,013	>40
Brazilian oxalate sludge	286,000	36,876	~30
Domestic oxalate sludge	309,000	22,291	~20
Other material, miscellaneous	33,000		
Metal scrap	24,000		
Oxides and grinder sludge	78,000		
Indian nitrate	72,000		
Thorium, aluminum, and copper alloys	1543	656	43

Data from Nuclear Metals, Inc. 1955; MCC 1955b; McCarthy 1955

Table II.9. Typical Elemental Analyses of Brazilian Sludge

Element	Concentration (Weight %)	Element	Concentration (Weight %)
Aluminum	0.01 - 0.1	Lead	0.01 - 1.0
Calcium	0.1 - 1.0	Praseodymium	1.0 - 10.0
Cerium	<10.0	Selenium	Not Detected
Copper	0.001 - 0.01	Silicon	1.0 - 10.0
Erbium	Not Detected	Samarium	1.0 - 10.0
Gadolinium	1. - 10.	Terbium	Not Detected
Holmium	Not Detected	Titanium	7.0
Lanthanum	<10.	Thulium	0.1 - 1.0
Lutetium	Not Detected	Yttrium	1.0 - 10.0
Magnesium	0.01 - 0.1	Ytterbium	0.1 - 1.0
Neodymium	1.0 - 10.0	Radium-228	Not Analyzed
Thorium oxide[a]	45	Radium-224	Not Analyzed
Rare earth oxide[a]	15	Zirconium oxide[a]	1.4
Silicon dioxide[a]	4.4	Phosphorous oxide[a]	5.3
Titanium oxide[a]	7.0	Uranium oxide[a]	
Iron oxide[a]	4.3	Chloride[a]	1.0
Loss on ignition[a]	14		1.4

Data from Mead et al. 1955
[a]Percentages on dry basis at 110°C; MRC 1973a,d.

with aluminum and copper cladding was also part of the metal scrap inventory (Nuclear Metals, Inc. 1955). One shipment in January 1955 consisted of 45 kg of oxide and 25 kg of turnings (Waldfogle 1955). The drums shipped by railcar were unloaded in the old Warehouse 9. The drums were stored in many areas of the plant, including Warehouse 15, the Quonset hut, W Building, G Building (Scott 1955a), and many open areas (Figure 2.10).

Although the thorium refinery project was terminated, the drums of thorium residues continued to be stored at Mound. Because of the corrosive nature of these sludges, the drums leaked and frequent repacking was necessary. Typically, 20 to 40% of the drums were repacked annually. Initially, repacking of leaking drums took place in Warehouse 15, but the elevated radiation levels (radon?) forced the work outside to Area 3 and later to Area 9 (Figure 2.10). In 1961, a new bulk storage facility was proposed for containment of the sludge. This facility, known as Building 21, was completed in 1964, and most of the contents of the drums were transferred into the building at that time. By 1973, at least 117 55-gallon drums of thorium residue were still stored outside the building but were to be moved inside (Storey 1973a). Building 21 originally did not have any doors or windows and was referred to as a silo. The sectioned roof allowed the materials to be loaded. The oxalate sludge was stored in a separate room from the hydroxide sludges. By this time, the sludges had lost a significant amount of moisture; and, during the dumping of the material into the bin through a roof opening, significant emission of fugitive dust occurred, contaminating the surrounding area. The thorium sludges remained in storage in Building 21 until a decision was made to dispose of the material. General Atomic Company purchased the sludge and began packaging the material in 55-gallon drums and shipping it to its facilities in October 1974, completing the task in July 1975. Once the silo building was clean, it was used to store the drums of Cotter Concentrate.

2.5.1. Process Description

The preliminary design for the thorium refining process, the starting point for the developmental studies at Mound, was based upon pilot plant studies conducted at the National Lead Company of Fernald, Ohio, and the ORNL, where a thorium extraction process known as the Thorex process was developed. The background work conducted at these two facilities formed the basis for laboratory and pilot development studies for the Monex process conducted at Mound. The Monex process development work at Mound took place in the R Building in 1954 and 1955. The Monex pulse column pilot plant was installed in room 1-B of the SW Building. The pilot plant was constructed of laboratory glassware and 2-inch glass columns. A berm constructed around the pilot plant served the purpose of containing any spills.

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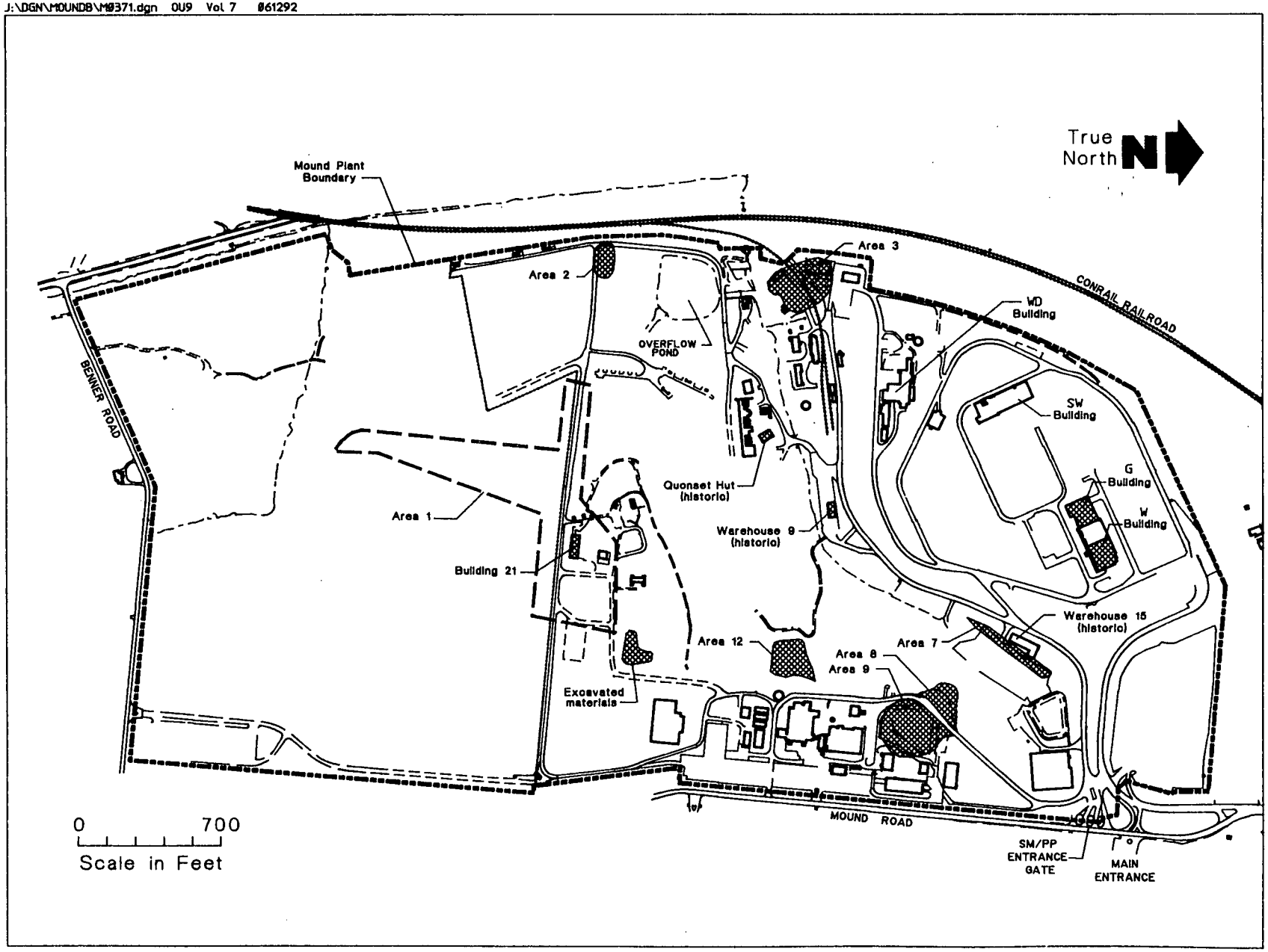

Figure 2.10. Thorium ore storage, disposal, and redrumming areas.

The process itself was designed to use the Brazilian Monazite sludge that had been produced by treating Monazite sand with caustic to crack the insoluble phosphate ore. The soluble sodium phosphate supernatant was removed, and the slurry was treated with hydrochloric acid to solubilize certain rare earth elements. The solids that remained after the rare earth elements were removed were called Brazilian Monazite sludge.

The Monex process was a solvent extraction process that relied on the stripping of thorium into an aqueous nitric acid phase. The first step was the efficient extraction of thorium from the thorium-containing sludges into a solution that was suitable as a feedstock to the process. Batch and continuous nitric acid digestions were studied in the laboratory to develop data and obtain feed solutions for batch countercurrent and pulsed column extractions. The extraction steps employed tributyl phosphate as a solvent. The countercurrent experiments used a kerosene-based diluent, and the pulsed columns used an oleum-treated Amsco, an aromatic hydrocarbon. From these studies, the normality of nitric acid in batch digestion solutions was determined.

The pilot plant actually used a pulsed column configuration. The feed solution was prepared in 100-gallon vessels. The feedstock was dissolved in nitric acid, the thorium and uranium were extracted in the tributyl phosphate, and the thorium was partitioned from uranium by stripping with nitric acid. The latter two steps were called a cycle, and two cycles were considered sufficient for purification (Mead et al. 1955). No information was given on the volumes of the pilot plant runs, although the available data suggest that a few pounds of sludge were probably all that were processed.

The feedstock preparation research included experimentation with all the thorium sludges on hand, including hydroxide, oxalate, and some sulfide. The countercurrent studies used a clarified feed, whereas the pulsed columns used a slurry. Recycled thorium metal, consisting of machine turnings and scrap, was also digested as feed. Most of the metal had a coating of machine oil that was removed. Trichloroethylene was typically used. Less than 100 g of metal appear to have been used in the experiments (Mead et al. 1955).

2.5.2. Waste Generation

The waste generated in association with the development of the Monex process can be characterized as an acidic alpha waste. For every gallon of Monazite sludge processed, the Monex process produced approximately 4 gallons of raffinate. This raffinate contained radioactive isotopes, daughters of thorium-232, that gave 2×10^4 alpha counts per minute/mL. When the raffinate was neutralized and filtered, residual amounts of thorium were recovered. The filtrate was an acid process waste and contained primarily radium-228 and radium-224. The radium present in the waste was treated with

barium chloride followed by a pH adjustment to 6. This step resulted in the precipitation of the radium isotopes. No analytical data were found to indicate the concentrations of radium-228 and -224 present in the raffinate or wastewater. This aqueous waste went to the 30,000-gallon influent tanks in the WD Building. It is not known whether it was treated or simply diluted and released to the Great Miami River. The tributyl phosphate and nitric acid wastes were probably drummed for shipment and burial offsite, but this has not been confirmed. The equipment used in the pilot plant, including the columns, glassware, pumps, and other equipment, was cleaned and subsequently used for the protactinium-231 separations (Meyer 1956c).

The production-scale thorium refinery facility that was planned for construction at Mound required extensive construction in the SW Building. Construction of the foundations for the refinery equipment was nearly complete in the west side of the SW Building when excavations for the refinery exposed a section of contaminated soil and gravel that had resulted from leakage of radium-actinium process wastes from the sump located on the west side of room SW-1-A. The sump served the "hot" side of the old cave in which the radium and actinium was processed. About 200 ft^3 of contaminated soil and gravel were excavated and dumped into an old septic tank. The septic tank was a remnant from the plant construction in the late-1940s and is currently included in Area 7 (DOE 1992g).

The majority of the waste generated by the thorium refinery project at Mound was associated with the storage of the 1,650 tons of thorium-containing sludges. Some of the drums in which the thorium was shipped were in poor condition when they arrived; many of the drums were apparently frozen when they were shipped and had thawed in transit, resulting in contamination of the interiors of the boxcars. These boxcars underwent decontamination procedures before being allowed to leave the facility. In some cases, the interior flooring and other contaminated material was removed, and some of the flooring was replaced.

Equipment necessary to conduct the redrumming was initially installed in Warehouse 15 (Figure 2.9), but the high levels of radon caused the operation to be moved outdoors (Thomas 1991). One report indicates that some redrumming took place by an AEC contractor other than MCC. The drums were washed, and the resulting "thorium decantate," amounting to 630 drums of wastewater, was diluted and released to the river in early January 1956 (Meyer 1956a). This release probably took place either to the storm sewer or the NPDES Outfall 001 pipeline to the Great Miami River.

The highly corrosive nature of the sludges resulted in drum leakage and subsequent soil contamination. The repacking of leaking drums became an ongoing activity. Somewhere between 15,000 and 20,000 steel drums had to be disposed of before the sludge was put into storage in Building 21 (Meyer 1979a). Corroded drums were collapsed and buried at Mound in the areas now known as Areas 2 and

7 (Figure 2.9). Used drums were not cleaned and contained residual amounts of the thorium sludges. Soils contaminated with thorium at the areas of redrumming and around the silo (Building 21) were removed to other areas and were generally dumped over the western slopes of the SM/PP Hill. The areas of redrumming are now known as Areas 3 and 8. Area 1 surrounds the old silo, and Areas 8, 12, and perhaps 7 received the contaminated soils (DOE 1992g). Equipment used during redrumming operations, including a flatbed truck and a conveyor belt, is known to have been buried in Area 7 (Figure 2.9). Nothing is known of the fate of the thorium metal. Mound reviewed the options for disposal of the thorium in April 1973 (MRC 1973a). This report indicated that some material had been sold prior to 1973. There is no specific mention of the thorium metal. An inventory of the thorium that was stored at Mound as of April 1973 does not include thorium metal. When Mound decided to sell the thorium residues, the invitation to bid, dated November 1, 1973, did not mention thorium metal available for sale (MRC 1973d).

2.6. THORIUM-230 (IONIUM) PROGRAMS

Ionium is an alpha-active thorium isotope with a half-life of 8.05×10^4 years. Ionium and thorium-230 are names that have been used interchangeably to identify this isotope. The interest in ionium goes back to 1946 (Peppard 1949), when a survey was conducted to identify sources of ionium. This survey looked at various fractions obtained from processing uranium and its ores to identify sources of ionium and protactinium-231 (Bruehlman 1947). In 1949, the ionium program reached a second milestone when a pilot plant was constructed at ANL to process 3,600 gallons of Mallinckrodt sparged turbid liquor from a material referred to as the airport cake, a raffinate produced by the diethyl ether solvent extraction of uranium (Peppard 1949). The material containing ionium was being produced at the Mallinckrodt Chemical Works uranium refinery in St. Louis, Missouri (Fariss 1955; Eichelberger and Scott 1956a).

In July 1955, Mound submitted a proposal to the AEC to design and install a facility that would be used for process chemistry development. The work would isolate ionium from raffinates produced at Mallinckrodt (McCarthy 1955). In November 1955, Mound received a directive to proceed with the design and construction of this facility, with a target completion date of February 1956 (Johnson 1955). The process chemistry research and development took place in the R Building. The larger columns required for production separation also were assembled in the R Building. Ionium was to be used as a tracer element in the Redwing test program, and kilogram quantities of ionium were needed for weapons diagnostic tests. Between April 6 and May 18, 1956, five shipments of a total of 400 g of ionium were made to the AEC (Haubach 1956a, 1956b, 1956c, 1956d).

7 (Figure 2.9). Used drums were not cleaned and contained residual amounts of the thorium sludges. Soils contaminated with thorium at the areas of redrumming and around the silo (Building 21) were removed to other areas and were generally dumped over the western slopes of the SM/PP Hill. The areas of redrumming are now known as Areas 3 and 8. Area 1 surrounds the old silo, and Areas 8, 12, and perhaps 7 received the contaminated soils (DOE 1992g). Equipment used during redrumming operations, including a flatbed truck and a conveyor belt, is known to have been buried in Area 7 (Figure 2.9). Nothing is known of the fate of the thorium metal. Mound reviewed the options for disposal of the thorium in April 1973 (MRC 1973a). This report indicated that some material had been sold prior to 1973. There is no specific mention of the thorium metal. An inventory of the thorium that was stored at Mound as of April 1973 does not include thorium metal. When Mound decided to sell the thorium residues, the invitation to bid, dated November 1, 1973, did not mention thorium metal available for sale (MRC 1973d).

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In July 1956, Mound was directed to produce an additional 500 g of ionium for the ORNL research stockpile and to refine the process chemistry for use in a future large-scale production program (Ager 1956). This required an additional supply of the Mallinckrodt feed solution, a delivery that was apparently never made. By November 1956, the remaining 73 L of feed had been processed to produce about 70 g of ionium (Eichelberger and Scott 1956c). Unfortunately, all of the undesirable impurities contained in the original feed solution were concentrated in the remaining solution. Forty-nine grams of the remaining ionium were shipped to the University of California Radiation Laboratory in December 1956 (Eichelberger and Scott 1957).

The ionium program was closely tied by chemistry and process development to the protactinium-231 program. In the late 1950s, capsules containing about 250 g of thorium oxide and apparently containing the remaining 22 g of ionium were sent to the MTR in Idaho for irradiation. This process was designed to produce protactinium-231 and protactinium-233 by neutron absorption by thorium-230 and thorium-232, respectively (Schuman 1960, 1961; Kirby 1960). The capsules were stored for at least a year in the reactor canal to allow the protactinium-233 to decay to a safe handling level. The capsules were returned to Mound, but it is not known if they were ever processed. They may remain in storage as research materials.

In the early 1960s, Mound conducted a search of ionium sources. Forty-nine samples from 17 uranium mills or processing sites were received and analyzed. Several samples of airport cake from the Mallinckrodt Chemical Works were used for comparison. Analysis of the samples by neutron activation analysis at ORNL indicated that the airport cake was the best source of ionium available (Eichelberger 1961b). These research efforts led to the procurement of additional quantities of airport cake some years later. The airport cake was also known as Cotter Concentrate and was processed for thorium-230 and protactinium-231 in the 1970s.

2.6.1. Process Description

Mallinckrodt raffinates that have been partially processed at the St. Louis uranium refinery were shipped to Mound in 55-gallon steel drums. This feedstock consisted of a caustic-neutralized fluoride slurry containing ionium, thorium-232, rare earths, scandium, uranium, and traces of protactinium.

The process equipment associated with separation and purification of ionium includes stainless steel storage tanks, mixers and mixing vessels, Pyrex glass contractors, mixer settlers, centrifuges, pulse columns, stainless steel process waste tanks, evaporator equipment, and Pyrex lines and valves for transfer of reagents and process liquids. The recovery of ionium began with the acidification of the Mallinckrodt material with nitric acid followed by centrifugation to remove solids. The supernatant

liquid was treated with aluminum nitrate to form a slurry that was removed in a mixer settler vessel. The supernatant liquid underwent a series of solvent extractions followed by aqueous scrubs. The solvent-solvent extraction steps used diethyl ether and pentaether (dibutoxytetraglycol). Aqueous scrub solutions contained nitric acid, ammonium nitrate, and ammonium hydroxide. The ionium was recovered from the process as the nitrate.

2.6.2. Waste Generation

The ionium process generated solid and liquid waste streams in the recovery of ionium from Mallinckrodt feedstocks. The solids and decant liquids from the centrifugation step were saved and processed to recover uranium and protactinium. The aqueous waste steam contained rare earths, scandium, and thorium. These waste steams could not be treated by the WD treatment facility to adequately decontaminate the waste effluent discharged to the Great Miami River. Therefore, the waste may have been transferred to the small waste evaporator treatment facility located in room 127 of the R Building. This facility, also known as the still, is described in the actinium-radium and reactor waste decontamination programs. The condensate from the evaporator was transferred to the WD Building for treatment, and the slurry from the evaporator was packaged in drums for off-plant disposal. This process used significant quantities of diethyl ether and pentaether.

Thirteen gallons of a solution containing 8 g of ionium leaked out of a drum in the high-risk corridor of R-121 where it was stored. The solution was washed to the WD Building influent tank where it was held and processed separately (Meyer 1957d). The solution was diluted and released to the river. The influent tank required subsequent cleaning and decontamination (Meyer 1958a).

At the completion of the 1956 production process, 250 gallons of organic waste, containing 1.232 g of ionium, were absorbed in sawdust, packed in 30-gallon drums, and shipped to ORNL for burial. One drum of the aqueous raffinate, precipitated with caustic and containing 0.473 g of ionium, was also shipped for burial (Eichelberger and Scott 1957). No information was found to indicate the disposition of the solid or sludge wastes from the process. The latter were probably also drummed and shipped for burial.

2.7. PROTACTINIUM-231

The need for protactinium-231 was generated in the early 1950s, when it was selected as a surrogate for protactinium-233 in the study of the physical and chemical properties of this element. Protactinium-233, an isotope with a half-life of 27 days, was to be created in the thorium-232 →

protactinium-233 → uranium-233 sequence, in the thorium breeder blankets of the breeder reactor program.

Programs at Mound involving the recovery and purification of protactinium-231 began in the early 1950s and continued intermittently to September 1979, at which time the demand for protactinium and thorium was significantly reduced. During this period, a number of separate programs were identified that separated and purified protactinium from a variety of source materials. Material processed came from the Mallinckrodt Chemical Works in St. Louis, Missouri; the AEC, Fernald Plant, Ohio; and the Cotter Corporation, Cannon City, Colorado. An attempt was made in the early 1960s to produce protactinium from irradiated thorium-230, but the materials were apparently never processed at Mound.

The first of the protactinium programs was initiated in 1954 at Mound at the request of the ORNL. The goal of the program was to isolate and purify 1 g of protactinium-231 from residues from previous uranium processing. The process chemistry research phase for this program took place in room 167 of the R Building. By October 1954, the procedures for separating the protactinium from the residues, sometimes referred to as raffinates, had been developed on a laboratory scale (Martin 1955). Some of the experimental work may have been done on residues supplied from Fernald Plant, Ohio. Equipment was then installed in room 145 of the R Building to process raffinate residues supplied by Mallinckrodt (MCC 1955 c,e). Batches weighing 5 kg each were run with a goal to separate milligram quantities of protactinium-231 and provide data for a small process plant. The pilot plant for this program was installed in the HH Building and completed in July 1955. Operations in HH Building were suspended in March of 1956 and moved to the SW Building. Equipment salvaged from the Monex thorium refinery pilot plant was adapted to the protactinium program (Meyer 1956c).

Approximately 80 drums, containing a total of about 20,000 pounds of residue, were shipped to Mound for processing. This feed material was referred to as the Sperry cake, Sperry filter cake, or Sperry press cake. This cake contained 0.1 to 0.2 ppm of protactinium in a matrix of iron, aluminum, calcium, magnesium, cobalt, and copper. When received, it appeared very inhomogeneous, and spectrographic analysis indicated that it was significantly different in composition from samples used during research phases. No two drums were alike. Since only about half of the quantity of the material was needed for 1 g of protactinium-231, individual batches were selected from the lot.

The first drum, containing 288 pounds of material, was processed in August 1955 (McCarthy 1955f). The extractions were very time-consuming because of the analytical procedures required for each step of the process. By August 1956, 700 mg of protactinium-231 had been recovered from 43 drums of raffinate. Fifty gallons of residual solids contained another 200 mg of protactinium-231 (Eichelberger and Scott 1956b).

After the first gram was successfully separated, work proceeded on the extraction of a second gram from the balance of the raffinate residues on hand. The gram of protactinium-231 had been requested in December 1954 by the AEC, Division of Research (Walker 1954). In researching the extraction process for the remaining, less desirable supply of the Sperry cake, it was found that the original sodium chloride process could be modified (Eichelberger and Scott 1956c). Experimental 1-inch columns were set up in room 1B of the SW Building for studying flow rates, extraction efficiencies, and other column parameters. The full-scale pilot plant was assembled in the HH Building, using 6-inch glass pipe columns. The plant was to be ready for operation by February 1957 (Eichelberger and Scott 1957), but general problems plagued the protactinium recovery and the fate of this program is not clearly known. Approximately 240 mg of protactinium-231 are known to have been recovered from the raffinates, residues, and analytical samples during the second attempt. The product was stored in approximately 140 mL of 50% diisobutyl carbinol in benzene (Eichelberger 1961a).

In the late 1950s, Mound submitted about 22 g of thorium-230, referred to as ionium, to the MTR in Idaho for transmutation to protactinium-231 by neutron irradiation. As of March 15, 1960, the ionium underwent neutron irradiation and was stored in the MTR canal, allowing the decay of protactinium-233 (from the irradiated thorium-232 [Schuman 1960, 1961; Kirby 1960]). The ionium remained in storage for over one year before it was shipped to Mound in lead casks. Some of the capsules swelled during either irradiation or storage and were probably never opened or processed. Although this program is no longer active at Mound, 10 or 11 lead capsules containing irradiated ionium have been stored as resource materials.

The last protactinium program carried out at Mound took place in the 1970s. The plan was to recover protactinium from the Cotter Concentrate and is described in a companion section of this report.

2.7.1. Process Description

The process used at Mound for the recovery of protactinium-231 was referred to as the sodium chloride process (NAS n.d.). The recovery of protactinium began with the dissolution of the raffinate in 2 N hydrochloric acid solution that was saturated with sodium chloride and contained titanium trichloride. The solution was boiled, resulting in the formation of a precipitate that contained

protactinium. The precipitate was separated from the supernatant liquid by filtration and was then digested with sodium hydroxide. The residue from the alkaline digestion step was treated with sodium hydroxide and 6 N hydrochloric acid. The resulting slurry was extracted with diisobutyl carbinal (DIBC) in Amsco kerosene. The protactinium was contained in the DIBC phase. In the next step, the DIBC phase was stripped with water containing hydrochloric acid and sulfuric acid. The protactinium was stripped from the acidic aqueous phase with DIBC. At this point in the process, the protactinium contained a solution of iron, niobium, and other metal impurities. These metals were removed in the protactinium purification step of the process.

Experiments continued on the efficiency of the protactinium-231 recovery process. After the initial project goals were achieved, the separation of the remaining raffinates posed a more difficult problem, because they had been highgraded and the remaining materials had lower protactinium concentration and higher quantities of impurities. Dissolution in nitric acid was tried, and it was found that nitric acid alone could not solubilize the protactinium; therefore, sulfuric acid was of prime importance. Efforts were taken to dissolve the raffinates directly and extract the resulting slurry. The pilot plant that was to have been assembled in the HH Building would have greatly decreased the time and labor involved with the extractions. Only the experimental column assembly in SW Building is known to have been used. In these experiments, sulfuric acid was made up with hydrochloric acid, and the raffinate was digested at fuming temperatures (about 230°C). Several extraction steps were apparently required, because the protactinium did not always come out in the first extraction, depending on the particular composition of the raffinate. The high iron content of the raffinates posed the most difficulty. It is not known whether this process was ever fully developed and used to process the remaining 43 drums of raffinate, but it does not appear so.

2.7.2. Waste Generation

The process equipment for recovery of protactinium-231 from uranium refining raffinate was located in the HH Building. Over 5 tons of the raffinate are known to have been processed to recover approximately 1 g of protactinium. The raffinate was dissolved in hydrochloric acid containing sodium chloride and titanium trichloride. The precipitate containing protactinium was separated by filtration, and the filtrate liquid was transferred to drums and stored. The precipitate, after treatment with sodium hydroxide and hydrochloric acid, underwent solvent extraction with DIBC. The acid aqueous phase from the extraction process was also drummed and stored. The protactinium was recovered from the DIBC and the solvent was recycled. The protactinium underwent purification resulting in a final acidic waste stream containing sulfuric, hydrochloric, and oxalic acids. The acid aqueous wastes collected were stored outside the HH Building in 200 55-gallon steel drums with polyethylene liners. It was originally planned that these materials would be neutralized and disposed of at the close of the

program. After a short period of storage, it was discovered that the liners were defective and the acid was eating out the drums and being spilled on the ground. Much of the material had to be redrummed. Since the waste contained quantities of radium-228 and its daughter products, it was deemed inappropriate to mix it into the polonium waste streams at the WD Building. The acid waste was finally disposed of by discharging it slowly into the Great Miami River so that the maximum permissible concentrations were not exceeded (Meyer 1957b). The discharge continued at least until December 1957 (Meyer 1958a). It is not known what happened to the used drums or where exactly the discharge took place, whether to a manhole in the storm sewer or a manhole to the NPDES Outfall 001 pipe to the Great Miami River. The disposition of 10 tons of raffinate that was not processed was not determined during the research for this report. Any residual solids generated by the process were probably drummed for off-plant disposal, as this was the general practice; however, no records were found.

In February 1960, 40-gallon drums of protactinium effluent (activity 0.01 Ci per drum) were separated from residue. The effluent was released to the "sewer in the lower area" and siphoned off at a rate of a liter per minute and diluted with rainwater at a rate of 150 gallons per minute. The residue was to be sent for offsite burial (MCC 1951-1961).

2.8. RARE ISOTOPE PROGRAMS

An important research and development program at Mound involved the production, separation, and purification of rare radioactive isotopes. This program, currently known as the Rare Isotope Program, has also been known as the Separation and Purification of Special Heavy Element Isotopes and Separations Technology. The isotopes that were processed included plutonium-238, protactinium-231, thorium-229, thorium-230, thorium-228, uranium-233, uranium-234, actinium-227, polonium-209, and radium-226. This work began at Mound in the mid-1950s (Miller 1955) and continued until 1985 (Figgins 1991). The separation processes were generally carried out in the SW, SM, and R buildings.

The Rare Isotope Program can be characterized as having numerous projects that are linked to the preparation of specific isotopes. The projects were started at different times during the 25-year period that the program was active, and they varied in size and duration. The source materials for the recovery of rare isotopes also differed. Protactinium-231 and thorium-230 were obtained from uranium-bearing ores or sludges. Uranium-234, a daughter product that "grows" as the plutonium-238 ages, was obtained from "milking" plutonium-238. Thorium-229 was obtained from milking uranium-233. The latter was produced by irradiation of thorium-232 to produce protactinium-233; the protactinium-233 then decays to uranium-233. An aged source was also needed to obtain uranium-233. Other isotopes were produced by irradiation of an appropriate target element.

Thorium-230, also known as ionium, was irradiated at the MTR in Idaho in an attempt to produce protactinium-231. These processes involved the use of only gram or milligram quantities of these isotopes each year.

The chemical processes for separating the desired isotope from its matrix were dependent on the isotope's chemical and physical properties. The chemical procedures used in processing rare isotopes included dissolution in strong acids, precipitation or coprecipitation, ion exchange, and solvent-solvent extraction. Each isotope presented a different degree of radiation hazard that, in turn, affected the scale of the process; the use of hot cells; the disposal and treatment of waste generated; and the disposal, storage, or treatment of starting or source materials.

To support laboratory- and pilot-scale isotope separation processes, analytical services such as x-ray diffraction, calorimetry, mass spectrometry, and wet chemical analysis, were performed to monitor and control the separation processes and to define the isotope purity in the finished product. The samples and sample solutions were, in most cases, returned to the isotope separation process for isotope recovery. After purification, the isotopes were shipped to the ORNL's Isotope Pool and were then sold to various clients for research purposes.

The larger and more extensive programs for plutonium, protactinium, thorium, and polonium are described in other subsections of this report. The following subsections provide summaries of the smaller programs.

2.8.1. Uranium-234

Plutonium-238, with a half-life of 87 years, decays by alpha emission to uranium-234. The uranium-234 was chemically separated from aged plutonium-238 at Mound over a 10-year period that began in 1962. Uranium-234 was used in conjunction with uranium-235 in fission chambers (detectors) for neutron flux measurements. The uranium-234 produced was shipped as the oxide to ORNL.

The production of uranium-234 took place in the R Building, and a satellite operation referred to as the solvent extraction system was housed in Room 1 of the SM Building. In the R Building, 13 alpha glove boxes were dedicated to the production of approximately 10 g of uranium-234 annually. The solvent extraction system continued to operate into the early 1970s.

2.8.1.1. *Process Description*

The recovery process of uranium-234 from plutonium-238 (Keister et al. 1978) was divided into three major chemical separation steps (Figure 2.11), and each step of the process was performed in a separate glove box line. The initial step removed the bulk of the plutonium by precipitation as the oxalate. The plutonium from returned heat source materials was dissolved in nitric acid followed by precipitation with dimethyloxalate. The plutonium oxalate was calcined at 450°C and returned to storage for future processing. The filtrate containing uranium-234 was concentrated by evaporation, and nitric acid was added with continued heating to decompose the oxalate. The resulting uranyl nitrate was ready to enter the intermediate step of the process. With the addition of aluminum nitrate to the uranyl nitrate and a pH adjustment, the resulting solution was transferred to an anion exchange column and the uranium-234 was eluted first with 7 N nitric acid. Next, the plutonium was eluted with 0.35 molar nitric acid. The uranium-234 went to the final separation step and the plutonium-containing fraction was sent to plutonium recovery. In the final separation of the process, the uranyl nitrate was converted to the chloride, and the resulting solution was transferred to a Dowex anion exchange column. Uranium was separated from plutonium and neptunium by elution with varying molar concentrations of hydrochloric acid. The uranyl chloride eluent from the resin column was treated with ammonium hydroxide to form a precipitate that was filtered, washed, and dried. It was then converted to uranium oxalate. The plutonium and neptunium elements were sent to respective recovery operations (Keister et al. 1978).

In SM-1, raffinate solutions generated by ion exchange column in the plutonium recovery operations were processed by the solvent extraction system. The uranium-containing fraction was sent to R Building for recovery and purification of uranium-234, and the waste was returned to plutonium recovery operations. The uranium-234, containing eluent from the ion exchange column, was extracted with tri-n-octylphosphine oxide (TOPO). The aqueous phase was returned to plutonium recovery, and plutonium contained in the TOPO was stripped with a carbonate solution and sent to R Building for processing and uranium-234 recovery. The TOPO remained in SM-1 and was reused in the solvent extraction process.

2.8.1.2. Waste Generation

Wastes associated with the processing of uranium-234 in R Building were identified to be aqueous wastes high in nitrate and chloride. They were returned to plutonium and neptunium recovery operations. The aqueous wastes containing aged plutonium-238 were stored in the R Building until such time that the plutonium recovery process became operational in the SM Building. At that time, the plutonium wastes were transferred to the SM Building for processing. Aqueous waste was also transferred from the R Building to the WD Building via a gravity-feed pipeline.

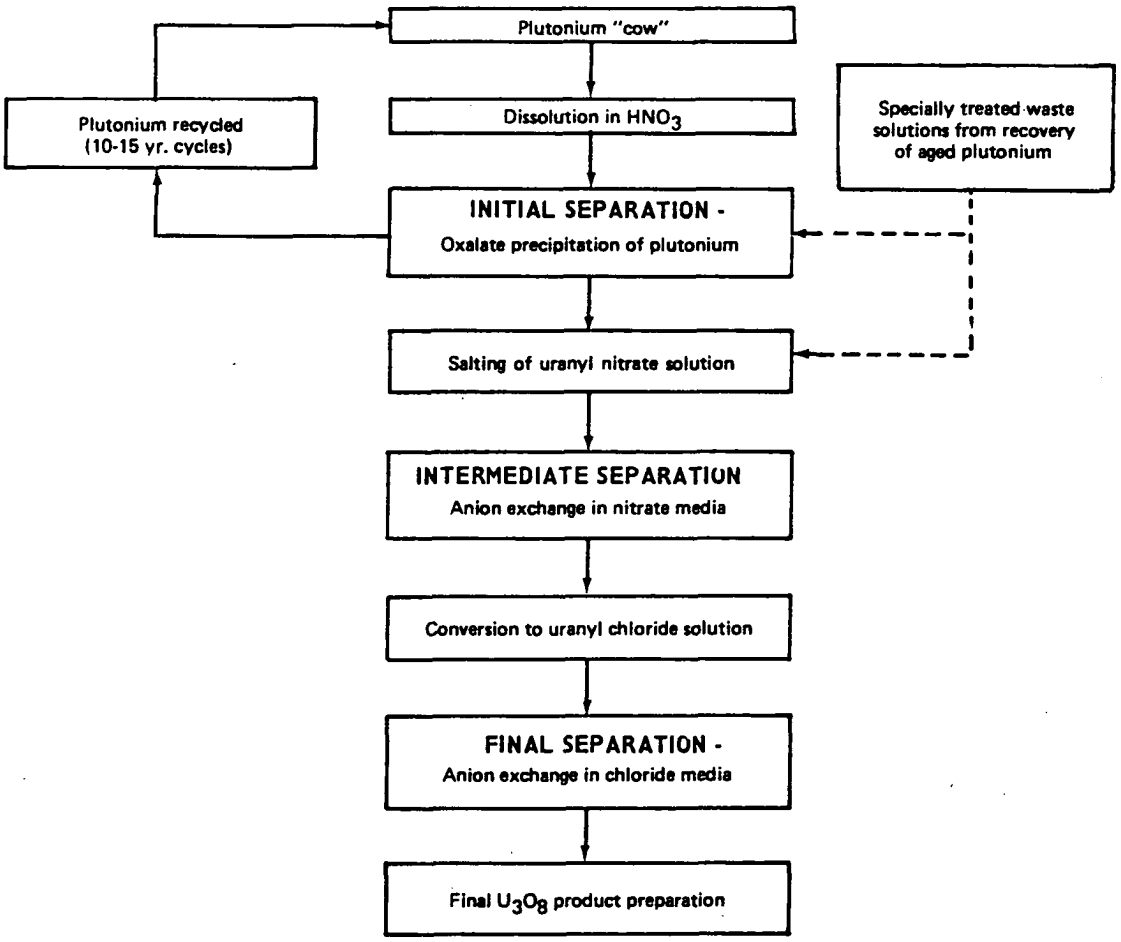


Figure 2.11. Chemical separation steps for recovery and purification of uranium-234 from plutonium-238 (Keister et al. 1978).

Solid wastes produced by the process included paper products, broken glassware, metal, spent ion exchange resins, rubber, and leaded gloves. These materials were placed into 30-gallon steel drums and then overpacked into 55-gallon drums and shipped off-plant for burial.

The SM uranium-234 recovery operation generated no aqueous wastes. The aqueous phase from the TOPO extraction was returned to the plutonium recovery process. Approximately 4 L of TOPO were used up to 20 times in the separation of uranium-234 from aged plutonium-238. The spent TOPO was placed in 1-L and 4-L plastic bottles, and Florco, a highly absorbent clay, was added to immobilize the TOPO. The plastic containers were then packaged into 55-gallon drums and shipped off-plant for burial.

2.8.2. Thorium-229

The interest in thorium-229 was as a source material for the production of francium-221, astatine-217, and other members of the 4n + 1 decay series. These isotopes were not readily available from other sources. Thorium-229 is the natural decay product of the uranium-233 that was produced via the thorium fuel cycle by the neutron irradiation of thorium-232. A kilogram of uranium-233 was received at Mound from Los Alamos National Laboratory in 1958 (Meyer 1958d). The uranium-233/thorium-229 project was initiated at Mound in 1966, and the work was performed in the hot cell facility in the SW Building. The project was initiated on a laboratory scale. During the course of this program, 1.5 kg of aged uranium-233 were processed to obtain 30 mg of thorium-229. This program was shut down temporarily for more than one year and then restarted with minor changes in process equipment and no change in process materials. This program was concluded in the mid 1970s.

2.8.2.1. Process Description

The process of separating and purifying thorium-229 from uranium-233 was based on laboratory-scale process development (Hertz et al. 1975). A small-scale separation was fully operational in the new hot cell facility of the SW Building. The processing of uranium-233 was conducted in two type A glove boxes and a fume hood interconnected on the north wall of SW-22. Additional laboratory equipment associated with this process was located on the laboratory benchtop in SW-140 and in the fume hoods in SW-132. The process began by dissolving the uranium-233 in nitric acid. The next step of the process involved the liquid-liquid extraction of the nitric acid solution with di-sec-butylphenyl-phosphorate and TOPO in diethylbenzene. The thorium was then stripped from the organic phase with 0.5 molar oxalic acid followed by a second strip of the organic phase with 8 molar nitric acid. A 50- to 75-g batch averaged 20- to 30-hr separation time (Hertz et al. 1975).

2.8.2.2. Waste Generation

Wastes associated with the production of thorium-229 were identified as aqueous and organic liquids, solids, and gases. All drains in the hot cell facility drained into a hot sump under the high-risk decontamination shower in SW-137. The sump was emptied by means of a steam jet syphon through a hot waste line to the WD facility. Organic liquids used in the solvent-solvent extraction process and small quantities of aqueous liquid that were too radioactive to handle by the WD facility were absorbed in Sorbal in small plastic or glass containers and consolidated with the solid waste generated in this process. The solid waste included Kimwipes, glassware, metal, latex and rubber gloves, and plastic, and was collected in plastic bags and placed in 30-gallon steel drums. When full, the drums were overpacked in 55-gallon steel drums and shipped to a burial site. The air from glove boxes was exhausted via the glove box in-line HEPA filter to the SW alpha area filter bank. After HEPA filtration, the air was discharged to the SW Building stack.

2.9. COTTER CONCENTRATE

In the processing of pitchblende ore to recover uranium, a residue was produced that was determined to contain significant quantities of protactinium-231 and thorium-230. This residue became known as Cotter Concentrate. The project to recover these isotopes from the Cotter Concentrate was undertaken in the early 1970s and was terminated in the late-1970s. It was generally part of the rare isotopes programs. The residue was known by a number of different names including Cotter Concentrate, St. Louis airport cake, or simply airport cake. The resounding usefulness of this material had been established many years earlier during the ionium (thorium-230) program. In the 1940s, the Mallinckrodt Chemical Works of St. Louis, Missouri, processed a Belgian Congo pitchblende ore for the recovery of uranium. This process involved dissolution with nitric acid followed by solvent extraction using diethyl ether. The raffinate from this process was limed, and the limed cake was then stored and became known as the St. Louis residues. The residue was then purchased by a St. Louis investment group that was going to further process the residue. This group went bankrupt, and the lending institution took over ownership of the material.

In 1968, the bank sold the residue to the Cotter Corporation of Cañon City, Colorado. Cotter processed the St. Louis residue to recover additional quantities of uranium and strategic metals such as cobalt, nickel, and copper. The Cotter process involved dissolution in sulfuric acid, followed by solvent extraction with di-2-ethyhexylphosphoric acid. From November 1972 until August 1973, Cotter added an additional step to the process at the request of Mound. This step involved a pH adjustment of the solvent extraction strip solution followed by filtration. This process change enhanced the concentrations of isotopes of interest to Mound (Hertz et al. 1983). This residue from

the filtration process contained thorium-230, protactinium-231, and uranium. At the end of the processing of the St. Louis residues by Cotter, 1,251 drums of material were collected and remained at the Cotter mill site. In 1975, the material was redrummed and shipped to the Mound. This material became known as the Cotter Concentrate.

The Cotter Concentrate consisted of a moist solid, with a water content as high as 50% by weight. The major constituents were thorium, uranium, and iron (Draper 1987). The concentrations of thorium-232 and uranium-238 were 10,000 ppm and 60,000 ppm, respectively. Thorium-230 and protactinium-231 were present at levels of 300 ppm and 0.5 ppm, respectively. Other elements present in the Cotter Concentrate included sodium, silicon, vanadium, lead, beryllium, magnesium, and silver (Watrous 1973). Rare earth elements may have been present, but no analytical data were available regarding speciation and concentrations. In 1985, five drums of the Cotter Concentrate were sampled and analyzed for EP Toxicity metals (Marple 1985). Selium was found to be present at concentrations ranging from 0.33 to 30.0 mg/L. The general composition of the Cotter Concentrate is shown in Table II.10. The composition varied from drum to drum.

The Cotter Concentrate was shipped to Mound in 1,251 55-gallon drums. The objectives of this program were to develop methods for the recovery of thorium-230 and protactinium-231 from the Cotter material and to design and construct a pilot plant facility that would process this material and furnish small quantities of these isotopes to the heavy elements isotopes pool at the ORNL. The concentrate acquisition, analysis, laboratory development, and pilot plant construction took place from 1970 to 1974. The pilot plant operation in SW Building ran from 1974 to 1979. During this period, 22 drums of Cotter Concentrate were processed to recover and purify 339 g of thorium-230 and 890 mg of protactinium. The purified radioisotopes protactinium-231 and thorium-230 were shipped to ORNL for sale. The drums of Cotter Concentrate were stored in Building 21, which had previously served as the silo for the thorium ores and sludges. To facilitate drum storage, the building was modified after the sludges were removed in 1975. In 1987, the entire lot of Cotter Concentrate was shipped from Mound to the NTS where it is stored as a resource material (MRC 1987).

2.9.1. Process Description

Three to four drums of the Cotter Concentrate were brought to the pilot plant facility located in the west section of the SW Building. Actual processing took place within the "hot cell" or "cave" that had been built to shield workers from penetrating gamma radiation. The drum contents were transferred to the acid digesters as the first step in the process. A flow sheet of the protactinium recovery process is shown in Figure 2.12 (Hertz et al. 1983). The process begins with the Cotter Concentrate being dissolved in concentrated nitric acid at 100°C, followed by dilution with water to 2 to 3 molar

Table II.10. General Composition of Cotter Concentrate

Element	Concentration (Weight %)
Sodium	>0.1
Iron	>0.1
Silicon	>0.1
Vanadium	>0.1
Molybdenum	>0.1
Aluminum	0.05
Titanium	0.04
Copper	0.02
Zirconium	0.02
Nickel	0.03
Beryllium	<0.005
Manganese	0.007
Magnesium	<0.005
Silver	<0.005
Uranium oxide	21,740 g/drum
Thorium-232	99.9 g/drum
Protactinium-231	0.060 g/drum
Thorium-230	11.1 g/drum
Average moisture content	47% (wt/wt)

Data from Watrous 1973; Rawlings 1951

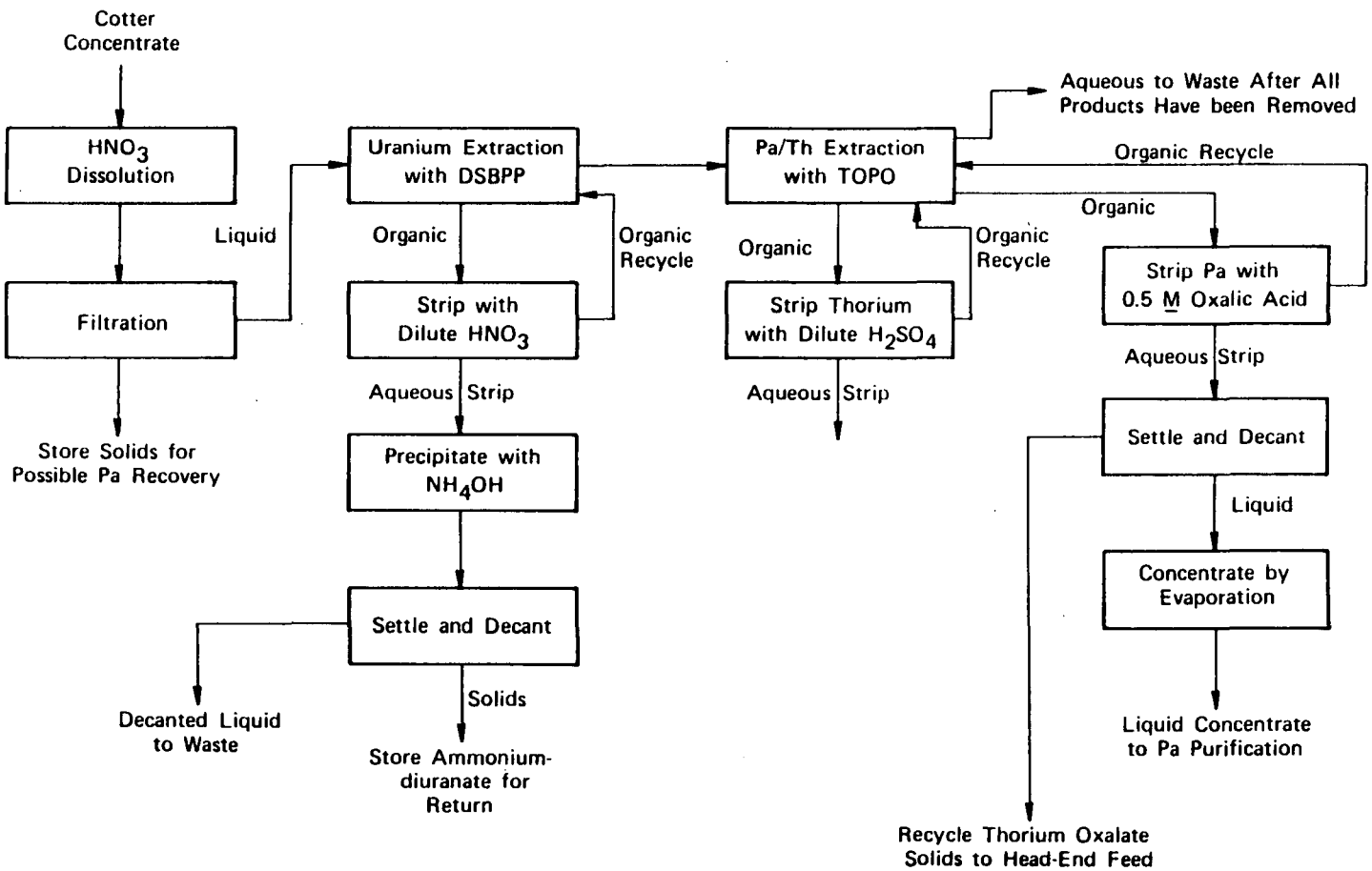


Figure 2.12. Recovery of protactinium-231 and thorium-230 from Cotter Concentrate (Hertz et al. 1983).

acidity and continued digestion. The solution was filtered, and the filtrate underwent a solvent-solvent extraction with di-sec-butylphenyl phosphonate (DSBPP) in carbon tetrachloride to recover uranium. The uranium was recovered from the organic phase by precipitation with ammonium hydroxide. The aqueous phase underwent a second solvent-solvent extraction with TOPO dissolved in carbon tetrachloride. Thorium was extracted from the TOPO solution into the organic phase and subsequently recovered with a 0.5 molar sulfuric acid solution. The thorium was then recovered from the sulfuric acid solution by precipitation with oxalic acid. The thorium precipitate was washed and calcined to obtain thorium oxide, which was then set aside. The protactinium was recovered from the TOPO solution with a 0.5 molar solution of oxalic acid. This oxalic acid solution containing protactinium was concentrated by evaporation in a still, and then the protactinium was precipitated as the phosphate by the addition of phosphoric acid. The protactinium-231 was then purified by treatment with a TOPO and di-2-ethylhexyl-phosphoric acid (DEHPA) mixture in a solvent extraction followed by DIBC extraction. The protactinium was stripped from the DIBC with oxalic acid and then recrystallized with sulfuric acid. Some uranium-233 was recovered from the DSBPP solvent extraction step. The residue was redrummed and returned to storage for future processing.

2.9.2. Waste Generation

The thorium program, involving recovery of protactinium-231 and thorium-230 from 22 drums of Belgian Congo material, resulted in an acid aqueous waste that was collected in an in-ground sump. The aqueous waste was then pumped to drums and trucked to WD Building for solidification. The solid residue was returned to 55-gallon drums for future processing.

Uranium was recovered from the DSBPP solvent extraction step. The processing of 22 drums of Cotter Concentrate generated five 55-gallon drums of uranium oxide. Protactinium and thorium were recovered in the second solvent extraction with TOPO and then selectively separated from TOPO with sulfuric and oxalic acids. The DSBPP and TOPO were recycled within the process, and the aqueous waste streams were sent to WD for solidification. These wastes are characterized as acidic containing sulfuric and oxalic acids. At some point, the organic solvents used in the extraction process became contaminated and were replaced. The spent solvents were packaged in 30-gallon drums with Florco adsorbent and then overpacked into 55-gallon drums and sent to Building 23 where they were staged for off-plant disposal.

No gaseous waste streams were generated during the processing of Cotter Concentrate.

2.10. STABLE ISOTOPES PROJECTS

The production of stable isotopes at Mound began in the SW Building in the 1950s and was transferred to the HH Building in the early 1960s, where it continues today. Production of stable isotopes also took place at the Los Alamos National Laboratory. The commercial sale of these isotopes is handled by the stable isotope sales organization at Mound. The isotopes find a wide variety of applications in agriculture, biochemistry, biology, medicine, and the nuclear industry. Stable isotopes available from Mound are listed in Table II.11. Helium-3 is used in the manufacture of neutron detectors and in dilution refrigeration systems used in extremely low temperature cryogenic investigations (Michaels 1991). Carbon-12, carbon-13, nitrogen-14, nitrogen-15, oxygen-17, oxygen-18, and calcium isotopes are used as tracers in biological and agricultural research and as diagnostic tools in medicine.

2.10.1. Process Description

The separation of isotopes involves physical processes such as thermal diffusion and cryogenic distillation. Other isotope separations involve chemical processes that rely on counter-current liquid extraction.

Helium-3 is a decay product of tritium and is separated from aged tritium by the use of chemical and physical adsorption. Isotopes of oxygen, carbon, and nitrogen are separated by the cryogenic distillation of nitric oxide and carbon monoxide. Thermal diffusion, a separation process developed and perfected at Mound, is also used to separate isotopes of xenon and krypton. The separation of halogen isotopes such as chlorine-35, chlorine-37, bromine-79, and bromine-81 involves the use of haloalkanes and halobenzene compounds in liquid thermal diffusion columns.

2.10.2. Waste Generation

No waste streams have been identified with the physical isotopic separation techniques such as cryogenic distillation, thermal diffusion, and use of selective membranes. Tritium separated from helium-3 is returned for further processing. The distillation process used to enrich the carbon-13 isotope produces a 90 L/hr discharge of carbon monoxide to the atmosphere (DOE 1979). Small quantities of organic solvents such as ethyl alcohol and 1,1,1-trichloroethane are used to clean process equipment. Used vacuum pump oil is stored in a 55-gallon drum and is picked up periodically by waste management personnel for disposal. Spent organic cleaning solvents are place in 5-gallon containers and also picked up by Mound waste management personnel.

Table II.11. Stable Isotopes Available from Mound

Isotope	Form Enrichment
CARBON-12	
Carbon dioxide	99.9%
Carbon monoxide	99.95%
CARBON-13	
Carbon dioxide	90%
Methane	90%
Barium carbonate	98 + %
Carbon dioxide	99%
Carbon monoxide	99%
Methane	99%
Carbon	99%
NITROGEN-14	
Ammonium sulfate (in 40% aqueous solution)	99.99%
Ammonium sulfate	(Bulk)
Ammonium nitrate (solid double label)	99.99%
Ammonium nitrate	(Bulk)
NITROGEN-15	
Ammonia	10%
Nitric acid (70 weight %)	10%
Ammonium sulfate	10%
Potassium nitrate	10%
Ammonium sulfate	60-85%
Potassium nitrate	60-85%
Mitrogen gas	98 + %
Ammonium sulfate	98 + %
Ammonia	98 + %
Nitric acid (40 weight %)	98 + %
Potassium nitrate	98 + %
Sodium nitrate	98 + %
OXYGEN-16	
Water	99.98%
Oxygen gas	99.98%
OXYGEN-17	
Water	20-35%
Water	36-50%
Oxygen gas	35-50%
OXYGEN-18	
Water	5-10%
Water	95 + %
Oxygen gas	95 + %
SULFUR-34	
Sulfur hexafluoride	10%
Sulfur dioxide	10%
Carbon disulfide	90%
Sulfur	90%

Isotope	Form Enrichment
SULFUR-36	
Carbon disulfide	3-7%
Carbon disulfide	15%
Carbon disulfide	30%
CHLORINE-35	
Sodium chloride	99%
CHLORINE-37	
Sodium chloride	95%
BROMINE-79	
Ammonium bromide	90%
BROMINE-81	
Ammonium bromide	90%
Helium-3	Feed Gas
Helium-3,	99.8%
Helium-3,	99.95%
Helium-3,	99.9995%
Neon-20	99.95%
Neon-21	90%
Neon-22	70%
Neon-22	99.9%
Argon-36	99.5%
Argon-38	95%
Argon-40	99.95%
Krypton-78	8%
Krypton-78	50%
Krypton-78	90%
Krypton-78	99%
Krypton-80	70%
Krypton-80	90%
Krypton-82	90%
Krypton-83	70%
Krypton-84	90%
Krypton-86	50%
Krypton-86	99%
Xenon-124	10%
Xenon-124	50%
Xenon-124	90%
Xenon-124	99%
Xenon-126	99%
Xenon-129	80%
Xenon-131	80%
Xenon-134	50%
Xenon-136	60%
Xenon-136	80%
Xenon-136	90%

2.11. REACTOR WASTE DECONTAMINATION

In 1948, at the direction of the Division of Engineering, AEC, the Waste Processing Committee was set up to survey the liquid waste disposal practices and disposal problems throughout the AEC facilities (AEC 1948). In August 1948, personnel from the AEC, MCC, Dow Chemical Company, and ANL met to address waste disposal problems and reviewed available waste treatment technologies (Haring et al. 1948). MCC committed to the AEC that they would be able to start work on crib wastes within a few weeks of the time MCC received authority to proceed with the work assignment. MCC indicated that process developmental and pilot plant work on crib waste could be carried out at Unit III of the Central Research Laboratories in Dayton. First- and second-cycle wastes and redox waste treatment investigations were proposed to take place at Unit III or at Mound (Haring et al. 1948). Since all operations ceased at Unit III in 1948, the proposed use of Unit III facilities to study reactor waste decontamination did not materialize. Research began on this project in R Building in late-1949.

In January 1949, Mound received a directive to undertake a long-range study of processes for the decontamination of radioactive wastes that were generated by plutonium production facilities at other AEC facilities. These wastes were generated in the separation of plutonium-239 from uranium-238. Fissionable material such as plutonium-239 is made by the neutron irradiation of uranium metal in production reactors at Hanford Reservation, Richland, Washington. Plutonium-239 is separated from the uranium and fission byproducts by one of several aqueous phase chemical processes. The Mound study was to investigate waste streams from three different types of processes. These included the bismuth phosphate wastes, tributyl phosphate wastes, and Purex wastes (Lowe et al. 1952). The Hanford bismuth phosphate process generated three different wastes that were identified as first cycle decontamination wastes, second cycle decontamination wastes before neutralization, and crib wastes. Crib wastes are second cycle wastes that have been neutralized.

At Hanford, the bismuth phosphate process and the redox process were used to separate the plutonium from the uranium and fission byproducts. These separation processes resulted in materials that were highly corrosive; had a high salt content; and contained nitrates, sulfates, phosphates, and chromates. Waste from the extraction step in the bismuth phosphate process contained uranium and most of the fission products. First decontamination cycle wastes are classified as strong-acid (~10N HNO_3) or low-acid wastes from product centrifugation. Second cycle decontamination wastes are identical chemically to first cycle wastes without the high activity coming from fission products. Crib wastes consist of wastes from decants of the second cycle decontamination wastes that have been neutralized, drain wastes, and scrubbing wastes. These wastes are discarded to the ground via cribs (AEC 1948). Cribs are porous wooden structures buried 20 to 30 ft underground. The wood structure acts as a wick and allows the waste to disperse into the surrounding soil.

The first objective of Mound program was to develop a process that would concentrate the radioactive constituents, effect a significant volume reduction, and render the remaining aqueous solutions of sufficiently low activity to permit their discharge to cribs or rivers (Lowe et al. 1952). The second objective of the program was to determine if large-scale processing results could be predicted by laboratory bench-scale batch experiments.

From 1948 to 1952, three different types of process wastes were studied in this program. These included bismuth phosphate wastes, tributyl phosphate wastes, and wastes from the Purex Process pilot plant at ORNL. These wastes were highly radioactive with abundant fission products and emitted beta and penetrating gamma radiation. Tables II.12 through II.15 report the activities of the Hanford first and second cycle bismuth phosphate, tributyl phosphate, and the ORNL Purex waste types, respectively. The rare earths were reported as a composite. No analytical data showing rare earth speciation were found.

Table II.12. Radiochemical Analyses of Hanford, Neutralized, First Cycle Wastes

Element	Waste A Age - 2 Months Received Nov. 1949 (cts/min/mL)	Waste B Age - 10 Months Received June 1950 (cts/min/mL)
Ruthenium	245,000	514,500
Cesium	130,000	2,428,000
Antimony, tellurium	1,000,000	1,346,000
Rare earths	5,700,000	170,500,000
Zirconium, niobium	85,300,000	1,603,000
Strontium	35,000	1,342,000
Yttrium	Not Determined	1,342,000
Alpha count	40	Not Determined
Gross beta	93,126,000	310,315,000
pH	6.1	0.1
Percent solids	11.3	12.1

Ref.: Lowe et al. 1951
cts/min/mL - counts/minute/milliliter

Table II.13. Radiochemical Analyses of Hanford Second Decontamination Cycle Waste Solutions[a]

Element	Crib No. 1 3-Year-Old Waste Solution (cts/min/mL)	Crib No. 2 2-Year-Old Waste Solution (cts/min/mL)	Crib No. 3 1-Year-Old Waste Solution (cts/min/mL)
Ruthenium	295	817	6,075
Cesium	205	175	1,080
Antimony, tellurium	80	346	3,240
Rare earths	-	157	10,880
Zirconium, niobium	5	53	2,140
Strontium	-	6	-
Plutonium	-	-	150[b]
Gross beta	800	2.000	29,000

Ref.: Lowe et al. 1951
[a]No corrections made for self-absorption of precipitation involved in the analyses.
[b]By alpha count
cts/min/mL - counts/minute/milliliter

Table II.14. Radiochemical Analyses of Oak Ridge Tributyl Phosphate Wastes

Activity	Cts/Min/mL
Gross beta	34,000,000
Ruthenium	3,310,000
Cesium	26,900,000
Antimony	145,000
Rare earths	3,300,000
Zirconium	430,000
Tellurium	53,000
Strontium	432,000
Niobium	72,000
Plutonium (alpha)	860
Acidity	2 molar

Ref.: Lowe et al. 1952
cts/min/mL - counts/minute/milliliter

Table II.15. Radiochemical Analyses of High-Acid Purex Waste

Activity	Waste Stream IAW (cts/min/mL)	IDW (cts/min/mL)	IIAW (cts/min/mL)
Gross beta	2.2×10^{10}	1.6×10^{6}	2.4×10^{7}
Cesium	1.5×10^{9}	7.4×10^{4}	2.7×10^{5}
Ruthenium	3.5×10^{9}	8.6×10^{5}	9.9×10^{6}
Antimony	5.1×10^{7}	1.5×10^{4}	4.6×10^{5}
Zirconium	1.4×10^{8}	5.1×10^{4}	2.2×10^{6}
Niobium	3.2×10^{9}	1.1×10^{5}	2.3×10^{6}
Rare earths	7.0×10^{9}	2.6×10^{4}	4.5×10^{5}
Strontium	5.3×10^{9}	1.0×10^{3}	7.8×10^{4}
Tellurium	3.8×10^{8}	2.2×10^{4}	7.5×10^{4}
Plutonium (alpha)	6.0×10^{5}	6.0×10^{3}	3.5×10^{5}
Iron content	0.1 mg/mL	1.0 mg/mL	4.0 mg/mL
Acidity	2m HNO_3	2m HNO_3	5m HNO_3

Ref.: Aponyi et al. 1953
IAW — waste stream from first column separation
IDW — waste stream from second column uranium purification cycle
IIDW — waste stream from second column plutonium purification cycle
HNO_3 — molar concentration of nitric acid
cts/min/mL — counts/minute/milliliter

As part of the process chemistry development phase of the program, Mound received first and second cycle wastes from Hanford. Two first cycle wastes were evaluated at Mound and are identified by their activity. The first waste showed an original activity of 90,000 counts/minute/milliliter (cts/min/mL). The second first cycle waste had an original activity of 312,000,000 cts/min/mL (Lowe et al. 1952). Mound began laboratory bench-scale experiments with the wastes in the winter of 1948-1949 to develop the process chemistry that would be transferred to a pilot-scale operation. Three shipments of Hanford second-cycle crib wastes were received by Mound in August 1948, March 1949, and December 1949 (Lowe et al. 1951). Project progress reports state that the first shipment was received in September 1948 (Yalman 1949, Mead 1949). At least one additional shipment of second-cycle waste, not neutralized, was reportedly shipped from Hanford in April 1949, but is not described in any of the project reports. The April 1949 shipment consisted of four 15-gallon samples in stainless steel containers, packed in sand and sawdust in 55-gallon drums (Hageman 1949). The volumes of the other shipments are not known. Two shipments of first cycle crib waste were reportedly received in November 1949 and June 1950 (Lowe et al. 1951), and their volumes are not known.

The decontamination studies also included three types of high-acid Purex wastes: fresh Purex process waste streams, evaporated and neutralized fresh Purex still-bottom residues, and wastes from processing 3- to 5-year-old Hanford uranium slugs. Purex wastes were generated at ORNL in a process involving the separation of plutonium from irradiated uranium slugs by a solvent exchange process. Mound's attention was given to the IAW waste stream from the first-column separation; the IDW waste stream from the second-column uranium purification cycle; and the IIAW waste stream from the second-column plutonium purification cycle (Table II.15). In the summer of 1950, 180 L of tributyl phosphate waste from pilot plant run HS 18 were shipped to Mound from ORNL. This waste was generated in the solvent extraction process for the recovery of uranium from stored metal wastes (Lowe et al. 1952). The radiochemical analysis of this waste is reported in Table II.14.

The bench-scale process chemistry research and development was performed in R Building (Bentz 1991) using mL aliquots of the sample wastes. With the completion of the research phase of the program, the resulting decontamination process was given the name Ferrous Sulfide, Ferrous Hydroxide, Calcium Phosphate Precipitation Process. A pilot plant was constructed based on this process in early 1952. Pilot plant feasibility studies were begun in June 1952, using a synthesized cold waste, and were completed in September of the same year. With the completion of the cold runs, the pilot plant was dismantled and moved to the SW Building (Vanden Bulck 1952). By the first of November 1952, the pilot plant was fully operational and the processing of hot waste began. Ninety-two gallons of neutralized waste from the Purex pilot plant were received at Mound for use in the pilot plant-scale studies. Prior to its use in the decontamination studies, this waste was stored in the Quonset hut (Bradley 1952e). The sample waste actually consisted of 80 gallons of supernatant liquid and 12 gallons of a basic sludge containing iron hydroxide and fission isotopes (Aponyi et al. 1953).

From November through mid-December 1952, four runs were completed in SW Building with feedstock made up of Purex process waste. In January and February 1953, two additional runs were conducted, at which time the supply of Purex waste was exhausted (McEwen 1953). At the conclusion of the sixth run, the pilot plant was dismantled and either shipped offsite for burial or reused.

2.11.1. Process Description

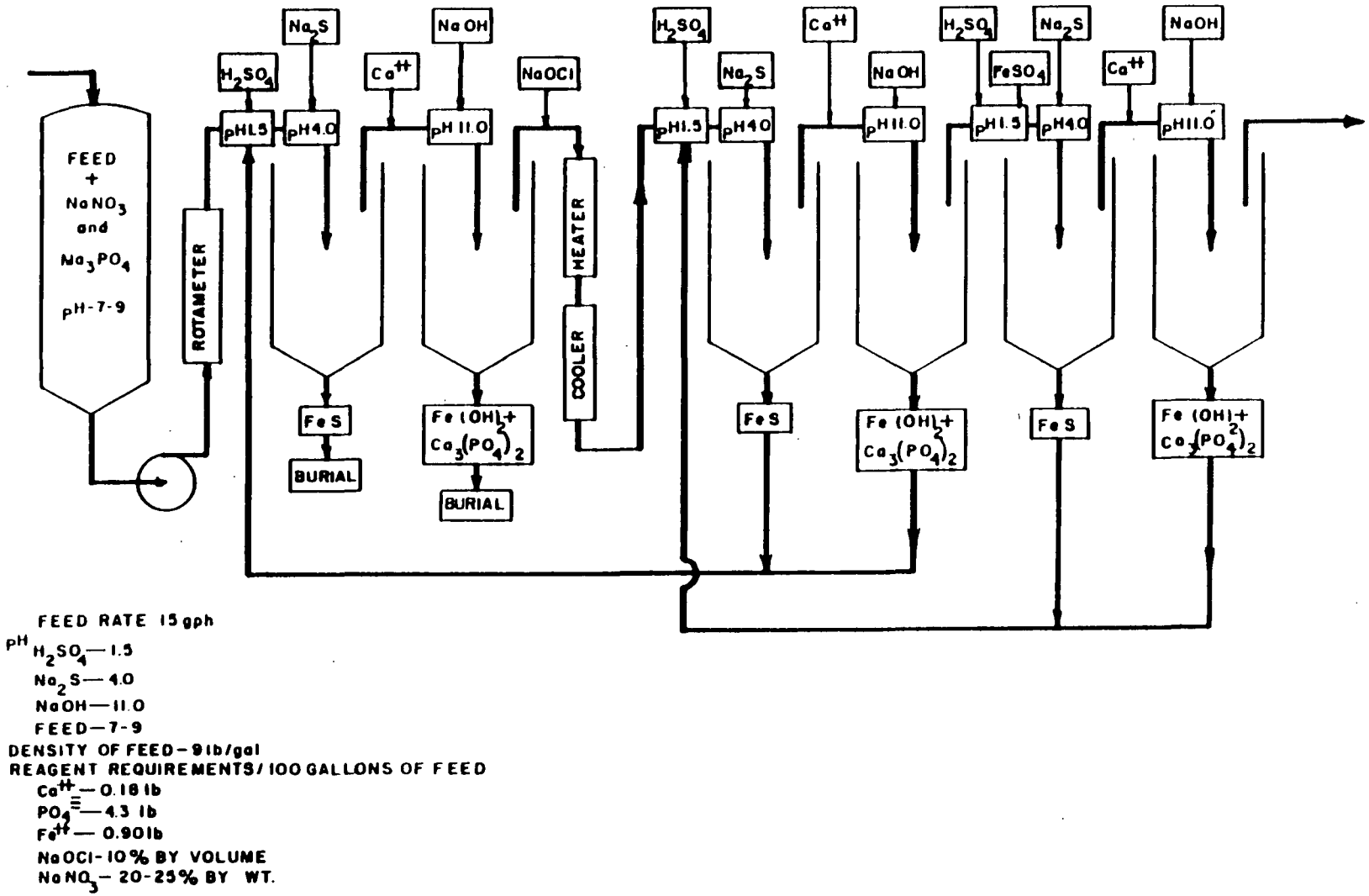
Laboratory experimentation to develop process chemistry for decontamination of reactor wastes took place in room 167 of the R Building (Yalman 1949). Because of the high activity of fission products contained in reactor-type wastes, the supply of Hanford waste was stored in lead casks in room 162. Mg quantity aliquots of the sample wastes were diluted with water and used in batch experiments. Experiments were conducted in laboratory glassware behind lead shields to protect the workers. The Ferrous Sulfide Process resulting from the laboratory experimentation was based on adsorption and/or

coprecipitation followed by clarification of fission products with ferrous sulfide, ferrous hydroxide, and calcium phosphate.

The Ferrous Sulfide Process pilot plant was probably initially assembled in the HH Building, but may have been in M Building. Research for this report was unable to determine the initial location. Trial runs were performed with a synthesized cold waste. After the completion of test runs and the necessary changes to the process equipment, the pilot plant was installed in room 1B of the SW Building, then known as the GP or general purpose building (MCC 1952-1957). The 92 gallons of Purex waste received from ORNL and stored in the Quonset hut were used to make up the feedstock for six trial runs. For the first two runs (H-1 and H-2), 1/2 gallon of the Purex supernatant liquid was diluted with water that contained 22% by weight sodium nitrate and 2% by weight trisodium phosphate. For trial runs H-3 and H-4, 40 gallons of Purex waste were diluted to 950 gallons with water containing 22% by weight sodium nitrate and 2% by weight trisodium phosphate. Half of this was used in run H-3 and the other half in H-4. For the fifth run (H-5), 40 gallons of Purex supernatant liquid and 4 gallons of hydroxide sludge were diluted to 950 gallons with the same diluent used for runs H-1, H-2, H-3, and H-4. For the sixth run (H-6), 450 gallons of feedstock remaining from H-5 were mixed with 60 gallons of raw waste from ORNL and then diluted with the same diluent as before to produce a feedstock of 1,000 gallons (Aponyi et al.1953).

The Ferrous Sulfide Process was a three-cycle process wherein the sample reactor waste was treated by precipitation and clarification. The flowsheet for the process is shown in Figure 2.13. Each cycle began with the addition of sulfuric acid to adjust the pH of the feedstock, followed by the addition of sodium sulfide. The ferrous sulfide precipitate that formed settled out in the clarifier and was withdrawn from the bottom. The clarifier overflow was treated with sodium hydroxide, ferrous sulfate, and calcium nitrate. The ferrous hydroxide floc and calcium phosphate precipitate settled in the second clarifier and was withdrawn from the clarifier bottom. This cycle was repeated twice. The sludge from the first cycle was pumped into drums for disposal, while that from the second and third cycles was pumped into holding tanks for recycle and analysis (Aponyi et al. 1953). The sludge from the clarifiers contained the fission constituents, and the supernatant liquid from the third cycle contained small quantities of the original activity of the sample Purex waste. The liquids were concentrated in an evaporator (McEwen 1951, Jackson 1953), and resulting solids were drummed for off-plant disposal.

From November through mid-December 1952, runs H-1, H-2, H-3, and H-4 were completed in the SW Building. No data are available for run H-4. The run reportedly got off to a bad start, and it was feared that the decontamination mechanisms may have been upset (Aponyi et al. 1953). In January 1953, the final run H-6 was performed. On January 20, 1953, however, a significant spill occurred when one of the holding tanks could not be drained because it was clogged with sludge. This spill and its cleanup necessitated the termination of the project. The equipment was dismantled and either boxed



FEED RATE 15 gph
pH H_2SO_4—1.5
Na_2S—4.0
NaOH—11.0
FEED—7-9
DENSITY OF FEED—9 lb/gal
REAGENT REQUIREMENTS/100 GALLONS OF FEED
Ca^{++}—0.18 lb
$PO_4^{\equiv}$—4.3 lb
Fe^{++}—0.90 lb
NaOCl-10% BY VOLUME
$NaNO_3$—20-25% BY WT.

Figure 2.13. Ferrous sulfide process flowsheet (Aponyi et al. 1953).

for off-plant disposal or decontaminated and reused as described below. The large 1,000-gallon tank was retained for use with the evaporator in the radium/actinium program. The spill is described below.

2.11.2. Waste Generation

The types of reactor wastes used in the decontamination studies at Mound included bismuth phosphate waste, tributyl phosphate waste, and Purex waste. These reactor wastes contained large quantities of dissolved salts resulting from processing reactor irradiated materials and from initial treatment operations such as neutralization of the acidic waste with caustic. Reagents such as nitric acid, sulfuric acid, bismuth phosphate, phosphoric acid, and sodium hydroxide were used in the uranium-plutonium separation, purification, and reclamation processes. Other reagents used in lesser amounts included chromates. The radionuclides present in these wastes included the starting materials, uranium-238 and plutonium-239, and a wide range of fission products. Short-lived isotopes, isotopes that have very short half-lives on the order of minutes, hours, and a few weeks, decay to stable isotopes. Long-lived fission products, radioactive isotopes with half-lives on the order of a few years to hundreds of years, presented a significant risk to the environment and human health. The radioactive isotopes referred to as fission products are beta- and gamma-emitters. These are radioactive isotopes that emit radiation in the form of gamma rays and beta particles. Laboratory experiments were conducted initially on a batch scale in the R Building and then on a pilot plant scale in the SW Building. When the pilot plant was operational, the laboratory continued to perform experiments duplicating process conditions and providing analytical support to the pilot plant.

The thrust of the process chemistry was to provide scavenging precipitates and adsorption processes to carry the fission isotopes with the precipitates and then remove them by clarification. The wastes from the research phase mirrored those from the pilot. To simulate the highly dissolved solids that characterized reactor material wastes, sodium nitrate totalling approximately 20% by weight was added to the feedstock. Sulfuric acid and sodium hydroxide were used to control pH in each of the settler tanks. Sodium sulfide, sodium phosphate, ferrous sulfate, and sodium hypochlorite were used to produce ferrous sulfide and ferrous hydroxide-calcium phosphate precipitates. These precipitates contained most of the fission isotopes. The radiochemical analyses performed to define the decontamination factors for the trial runs showed that cesium-137 and ruthenium-106 were not removed with the same efficiency as other fission products. The radiochemical analyses of the sixth-stage clarifier effluent for trial runs H-3, H-5, and H-6 are summarized in Table II.16 (Aponyi et al. 1953). The analyses confirm that cesium-137, strontium-90, and ruthenium-106 were contained in the process effluent.

Table II.16. Radiochemical Assay of Sixth-Stage Effluents

	Counts/ML/Minute		
Trial Run	Cesium-137	Strontium-90	Ruthenium-106
H-3	4,092	29	13,069
H-4	--	--	--
H-5	1,554	443	12,571
H-6	370	86	5,024

Ref.: Aponyi et al. 1953

Aqueous wastes from the laboratory experiments were collected beneath the lab benches and fumehoods in 5-gallon glass carboys and routed to a holding tank and then on to a small evaporator or still (Yalman 1949). The still received wastes from two projects, the reactor waste and the research phase of the radium-actinium program. The still had a capacity of about 3 gallons/hour. The sludges produced were packed in 30-gallon drums for shipment and disposal off-plant. These drums may have been stored at the old explosives bunker before shipment. The liquid condensate from the still was transferred to the WD Building through the old alpha wastewater pipeline from the R to the WD Building (Bentz 1991). No activity was observed from the still condensate (Yalman 1949).

In addition to solid and aqueous wastes, hydrogen sulfide was produced after the addition of sodium sulfide and acidification. The hydrogen sulfide was discharged through a ventilation system installed in the R Building for this purpose. Gaseous hydrogen sulfide also evolved in much larger quantities from the pilot plant at the same stage. A special ventilation system was installed to exhaust these gases.

No data or information suggested that run H-4 would not proceed as the others. The process was erroneously started cold and ran for 5 hours before the error was noticed. This was consistent with the first two runs, which also started with cold solutions to adjust the equipment. The lack of decontamination of run H-4 could have resulted in several hundred gallons of water with some elevated, but unknown, level of activity. This water was probably treated in the evaporator set up in room SW-1B.

Several spills were associated with the pilot plant. Small spills occurred in November 1952 (Bradley 1952h) and January 1953 (Bradley 1953a). Small spills that were easily cleaned occurred on the sides of the tanks on January 8 and 9 (Bradley 1953a). On January 20, however, a significant spill occurred when one of the holding tanks could not be drained because it was clogged with sludge. The sludge was discharged to the trench and sump in Room 1B. Gamma radiation readings of the sludge ranged

from 1.5 to 8 REM at 1-ft from the surface of the solution (Bradley 1953a). On January 26, the sludge was scooped out and put in 55-gallon drums. Eight drums were moved to Warehouse 13 for storage until a shielded shipping container could be fabricated. About 10 gallons of sludge from the sump were placed in a 30-gallon drum and mixed with sodium nitrate to maintain suspension. The sump and trench were decontaminated to 60 to 70 and 30 to 40 mREM, respectively (MCC 1952-1957).

The spill in Room 1B apparently necessitated the project termination. From February 4 to March 10, 1953, the pilot plant equipment was dismantled (Bradley 1953b). In addition to the 8 drums of sludge removed from the spill, 14 drums of sludge were emptied from the holding and process tanks. The settling and mixing tanks were moved to Warehouse 13 for storage, and the holding tanks were sent to the "lower storage area" (MCC 1952-1957). The storage areas are described in Section 5 of this report. The large 1,000-gallon tank and the liquid evaporator were retained in Room 1B for use with the radium/actinium program. At least some of the materials were loaded for off-plant shipment on February 18, 1953 (MCC 1952-1957).

Part of the ventilation and exhaust system on the east side of the GP Building, now known as the SW Building, was decontaminated after the dismantling of the pilot plant. Forty-four 55-gallon drums were filled with tiles and dirt from the exhaust duct and shipped to ORNL for burial in March 1953. Soil cleanup only included the loose surface and did not extend any deeper than a few inches. Residual levels at depth were as high as at the surface (MCC 1952-1957). Some of the exhaust duct remained in place and was not removed until the decontamination of the radium/actinium project (Meyer 1958a). Some of the underground duct may still be in place.

In Warehouse 13, some of the sludge drums leaked and were redrummed. These were apparently the drums of hot waste from the trench cleanup. Wipe samples on the floor where the leak occurred indicated 875 disintegrations/minute (d/m), and other areas were zero d/m. All of the drums were moved to Warehouse 9 for shipment off-plant by September 1953. The floor of the warehouse was then washed and scrubbed (MRC 1953-1957).

2.12. REACTOR FUELS PROGRAMS

Throughout the 1950s and 1960s, Mound conducted basic research into the chemical and physical properties of proposed reactor fuels. In 1953, Mound embarked on the first of the reactor fuels programs in support of the Aircraft Nuclear Propulsion Project (ANPP). The liquid-cycle reactor for the ANPP contained a liquid nuclear fuel that circulated through the reactor and heat exchanger, and the fluid operating a turbine was heated at the exchanger. The use of a fused-salt fuel system was considered for the reactor in this system. Mound was assigned to determine the phase relationships

and physical properties of components of these fuel systems (MCC 1954). Investigations conducted at Mound included differential thermal analysis, quenching and petrographic studies, x-ray diffraction studies, density and viscosity measurements, and optical thermal analysis. These studies involved some sample preparation; the use of physical methods; and the use of dry boxes for preparation, analysis, and handling of anhydrous salts. Dry box and glove box operations were used to safeguard the health of personnel performing these studies because the fused-salt fuel components included uranium fluoride, beryllium fluoride, and sodium beryllium fluoride.

Work on the homogeneous-type reactor began in the mid-1950s. A homogeneous reactor is one in which the fuel is evenly dispersed in the moderator. One of the major areas of research and development work associated with the homogeneous-type reactor was the development of satisfactory fuel systems. In 1952, Mound was responsible for measuring the physical properties of uranium and thorium solutions and slurries at elevated temperatures and pressures (MCC 1952b). This program used many of the physical measurement techniques applied in the ANPP, the major difference being the study of aqueous systems at high temperatures and pressures, as in the case of the homogeneous reactor, versus non-aqueous eutectic mixtures at high temperatures and pressures, as in the case of the ANPP.

The Civilian Power Reactor Program began in 1957 to develop reactors suitable for the production of power or heat for civilian use. The homogeneous-type reactor was selected for study. This program differed from the earlier homogeneous reactor program in that the fuel systems to be studied included solutions of uranium-233, uranium-235, and plutonium-239. The program at Mound began in early 1957 to investigate an aqueous system containing plutonium as a fuel for homogeneous reactors. Plutonium was also being considered for use as a fuel in fast-breeder reactors because of its high neutron capture efficiency. Mound had been given the responsibility for acquiring data on some of the proposed fuel systems. Research was initiated to determine the density, viscosity, thermal capacity, thermal conductivity, and phase equilibria of plutonium and plutonium alloys. Alloys of plutonium that were studied included iron, nickel, copper, cadmium, yttrium, and vanadium.

In 1961, Mound, in cooperation with Rensselaer Polytechnic Institute and Owens Corning Fiberglas, conducted experiments in the fabrication of plutonium-bearing glass fibers. The plutonium-bearing glass was being considered as a reactor fuel system.

With the exception of the plutonium alloy and glass fiber studies, all of the remaining reactor fuel programs at Mound involved physical testing and sample preparation. These programs were characterized as low-waste generating studies; and, in most cases, the materials under investigation remained unchanged.

2.12.1. Process Description

The processes involved in the study of physical properties of various reactor fuel systems included preparation of samples, measurements, recovery of samples, normal housekeeping in the laboratory, and disposal of waste materials generated from using analytical and experimental equipment. The work associated with these programs was performed in the R Building. Certain studies required the use of inert atmosphere such as argon and helium. Phase equilibria studies required the use of high-temperature furnaces and temperature measurement devices such as thermocouples and pyrometers and the use of thermal analysis, optical thermal analysis, and calorimetry. Since these studies involved materials containing beryllium, plutonium, uranium, and thorium, these experiments required the use of glove box operations. The fused-salt fuel studies involved preparing anhydrous compounds and conducting studies in dry atmosphere and, in some cases, in inert atmospheres.

High-temperature furnaces were used in phase equilibria studies and in the preparation of plutonium alloys and plutonium-bearing glass fibers. Other high-temperature studies involved the use of crucibles, generally made of platinum and tantalum, and foils made of noble metals and used as liners for crucibles. Physical measurements such as density, viscosity, and thermal conductivity were performed during these high-temperature experiments. Metallurgical studies included cutting and grinding sample specimens followed by polishing and, if required, etching the polished surface. The analysis that followed included photomicrography and the use of the microprobe for determining elemental composition of crystals and boundary regions. The studies involving aqueous nuclear fuel systems were performed at elevated temperatures and pressures. Measurements such as density and viscosity were made on various fuel systems. Analytical instrumentation used during these studies included x-ray diffraction and fluorescence, microprobe, petrographic, and spectroscopy.

2.12.2. Waste Generation

The reactor fuels programs generated wastes on a small scale because of the nature of the experiments that were conducted. The nuclear fuels systems studied contained fissile materials; and, therefore, the materials used in the experiments were packaged and returned for recovery of plutonium-239 and uranium-235.

Wastes generated during physical characterization studies included aqueous solutions of uranium, thorium, and plutonium; fused salts and salt mixtures containing sodium fluoride, uranium trifluoride and uranium tetrafluoride; oxides of uranium and thorium; and plutonium alloys and metals comprising alloys such as iron, nickel, copper, vanadium, cadmium, and rare earths. Ancillary wastes generated during these studies included refractory furnace materials, ceramic tubes and crucibles, platinum

crucibles and foils, sample holders, thermocouples, and inerting gases such as helium and argon. The analytical work performed on various reactor fuel systems generated solid and liquid wastes, including broken glassware; cleaning solutions and organic solvents such as ethyl alcohol, acetone, and isopropyl alcohol; etching solutions; abrasives used for grinding and polishing samples; and expendable miscellaneous items used in sample preparation and analysis. Other wastes generated during these studies included leaded gloves, latex gloves, Kimwipes, cloth, scrap metal and glass, and scrapped equipment. Line-generated solutions and solid waste went to plutonium and uranium recovery. Non-line-generated waste was packaged for off-plant burial.

2.13. NEUTRON AND ALPHA SOURCE PROGRAMS

Beginning with the Dayton Units, Mound produced alpha and neutron sources that were sold or leased to other government agencies and laboratories as well as industrial and university research organizations (MCC 1955a). These sources were used for biological purposes, instrument calibrations, oil and mineral well logging, mineral irradiation for activation analysis, reactor start-up, research on radiation shielding, scattering, diffraction, and diffusion of neutrons. In 1953, mock fission neutron sources were manufactured for nuclear submarine and commercial reactor applications. Special neutron sources were manufactured for General Electric's sodium-cooled nuclear reactor. Neutron threshold detectors made from neptunium-237, uranium-238, and plutonium-239 were also manufactured in the early 1960s (MRC 1961b).

Neutron production relied on the reaction of the alpha particles with other nuclei to produce a neutron flux. These small neutron sources largely used polonium-210. From 1956 to the early 1960s, some neutron sources were manufactured with plutonium-239. The low-gamma radiation intensity of polonium-210 made it especially attractive for handling and experimental purposes. The target materials included beryllium, boron, sodium, fluorine, and lithium. The polonium neutron sources typically contained less than 1 to 15 Ci activity.

By 1965, the commercial production facilities for neutron sources were transferred from Mound to MRC's commercial facilities in Dayton. The plutonium-239 source production was transferred earlier, but the exact date is not known.

2.13.1. Process Description

The first polonium-beryllium sources were made at the Dayton Project in 1945 by plating polonium on platinum or beryllium discs and sandwiching these between beryllium discs. The efficiencies were so low the technique showed no promise. The technique of electrochemically plating polonium onto

beryllium powder provided considerable improvement. The beryllium was shaken in a polonium nitric acid solution until 90% of the polonium was deposited.

Most polonium sources were made by a volatilization process, wherein the polonium was volatilized into a metal container, and loose or cold-pressed beryllium powder was added. The container was assembled and coated with nickel, which covers any contamination and seals the container. The assembly is heated to about 600°C to distribute the polonium. Powdered platinum was sometimes used as a plating medium for polonium, which was then covered with nickel before assembly. The latter reduced worker body exposure, but the volatilization temperatures were higher. Lithium and sodium sources were also made by the volatilization process. Boron sources, however, were made by sealing polonium and boron powder into metal containers and heating them to distribute the polonium. Boron sources developed only a 10 to 20% neutron efficiency, whereas the beryllium sources developed efficiencies of 75 to 90% (Moyer 1956).

Mock fission sources were made in the early 1950s to simulate the fission spectrum. Sodium fluoroborate and sodium fluorberyllate were commonly used salts. The polonium was prepared in an acid with the same radical as the salt, and the acid, typically hydrofluoric, was evaporated. Since the fluoroborates were unstable at high temperatures, evaporation was typically at 150°C in a platinum vessel, which was then cut or pressed into the shape of the finished source and plated with nickel (Watrous 1948).

Aluminum and brass containers were used early in the program, but most sources were contained in nickel, tantalum, or stainless steel. Some special sources required platinum or beryllium containers.

The plutonium-239 neutron sources were manufactured from metallic plutonium-239 received from other AEC facilities. The composition was about 94% plutonium-239 and 5% plutonium-240. The sources were made by breaking the metal into pieces and mixing them into a container with powdered beryllium. The containers were then welded shut and heated to several hundred degrees centigrade. Because of the long half-life of plutonium-239 (24,600 years), these sources produced an essentially constant neutron flux source with a long usable life.

2.13.2. Waste Generation

The fabrication of neutron sources involves machining targets and containment parts, assembling components, and welding closed source containers. The neutron source targets were machined from beryllium, boron, or lithium. Special techniques were used while machining beryllium metal to contain beryllium metal chips and fine particulates generated by cutting operations. Cutting oils containing

metal chips were filtered to remove beryllium. Most beryllium machining was dry, however, and an extensive dust recovery system was employed. The air from the immediate area of beryllium machining was exhausted to a filter system to remove fine particulate. The beryllium dust was recycled to the Brush Beryllium Co., Cleveland, Ohio.

The assembly of the alpha emitted and target material required an inerting atmosphere. The assembled sources were placed in tantalum or stainless steel containers that were welded closed using tungsten inert gas welding or electron beam welding.

Sources were shipped from Mound to customers in 55-gallon steel drums. The drums containing the source were initially filled with water. The water leaked from the drums on occasion and was later replaced with paraffin; however, the risk of fire from using paraffin resulted in replacement with discs made from a plastic material such as formica or melamine. These packing containers were returned to Mound and reused.

The plutonium-239 neutron source production operations generated some wastes that created historical environmental problems. The radioactive work areas and waste streams within the production area of the R Building were not well controlled. On one occasion in September 1960, radioactive waste that should have been placed in the controlled containers went into the ordinary trash. When the error was discovered through inventory control, the historic landfill was surveyed with radiation instruments and several square feet of contaminated soil were removed. A piece of plutonium-239 had apparently been burned with the combustible trash. Immediate steps were taken to correct the problem. All trash from the plutonium source production rooms was thereafter dealt with as radioactive waste and disposed of by drumming for off-plant burial (Garner 1991). Shortly thereafter, the entire plutonium-239 neutron source production program was transferred to the MCC commercial facilities in Dayton.

2.14. BIOLOGICAL STUDIES

Studies of the biological effects of polonium were initially conducted as part of the Dayton Project and moved to the B Building at Mound in 1949. Research work focused on the chronic and acute effects of polonium. Research on actinium metabolism and tumor incidence began in 1952 (MCC 1952b). This program largely involved experiments with rats, although other small animals were also used including dogs, cats, rabbits, and mice. By February 1955, the program was halted (MCC 1955d). By June of 1955, the program was entirely transferred to ANL. The experimental program conducted at Mound paralleled work performed at the University of Rochester (Fink 1950). The experiments at the University of Rochester dealt with polonium, radium, and plutonium. Overall, the experiments at

Mound and the University of Rochester provided analytical data of the minimum effective dose and permissive body burdens. The interpretations of safe occupational levels were largely determined from these and related experiments and the results of the bioassay programs conducted concurrently (Doty 1987).

2.14.1. Process Description

2.14.1.1. Polonium

Most of the biological experiments at Mound were conducted with rats (Sprague-Dawley strain) to determine the most sensitive criteria of biological polonium damage. These experiments focused on lifespan shortening and histopathological effects to vital organs, but also included liver and kidney function, body weight gain or loss, food and water intake, total and differential blood count, tumor indifference, and rates of growth. Polonium-210 in a phosphate-buffered neutral solution was used for intravenous, oral, and subcutaneous exposures. Studies of acute and chronic exposures required single polonium-210 doses of 35, 23, 8, 3.6, 0.9, 0.75, 0.5, and 0.25 μCi/kg of body weight and multiple polonium-210 doses of 2 μCi/kg, typically injected into the caudal vein or under the skin of the leg. Standard histopathological techniques were employed for animal sacrifice and dissection. Animals were sacrificed at intervals varying from 1 to 300 days after initial injection. Typically, two males and two females from each dose level were taken (including control groups), but many animals were taken immediately after their natural death or in moribund condition. Organs were fixed in solutions of formaldehyde. Thin sections were prepared for microscopic investigations and were stained with hematoxylineosin and Masson's trichrome. Special stains such as fat stains, reticulum stains, and glycogen stains were used as necessary. The organs examined included the kidney, liver, heart, lungs, lymph nodes, skin, brain, bone, and bone marrow. At the lowest dose levels, large groups (typically 40 males and 40 females at each dose level) were allowed to live out their life span virtually without disturbance except for feeding, watering, occasional weighing, and periodic inspection. This latter group was designed to yield data on chronic mortality, as some (typically 10 individuals) were maintained on an average body burden of 0.01 μCi/kg body weight through maintenance injections.

Tissues, excrement, and urine samples (and in some cases the entire animal carcass) were digested with mixtures of 70% perchloric and concentrated nitric acids over boiling water baths. Dry ignition was precluded by the volatility of polonium at elevated temperatures. Digestion of tissues to which known amounts of polonium had been added served as controls and tests for polonium volatilization. The highest temperature attained by the digestions was typically 200°C. Reactions were often very vigorous.

After digestion, the solutions were neutralized by the addition of aqueous sodium hydroxide. Concentrated hydrofluoric acid and water were added to bring the solutions to the 0.5 N needed for the polonium analysis. Methyl red and bromothymol blue were dissolved in a mixture of alcohol and water to provide a suitable indicator for the neutralization. The polonium content was determined by the plating of the hydrochloric acid solution onto silver foil by electrodeposition, and the polonium-210 content was measured by counting the alpha disintegrations.

2.14.1.2. Actinium

Most of the actinium research was conducted on rats and mice. The first serial sacrifices were in October 1952 after monthly doses of 2.0, 0.2, or 0.02 μCi of actinium equilibration mixture, an equilibrium mixture of actinium-227 and its daughter products thorium, francium, and radium (Anthony 1953). The research on hematological and pathological effects, as well as metabolic and toxicity reactions, followed procedures developed for polonium. Differences arose in the need to house animals treated with large doses because of the radiation dangers associated with the actinium decay chain. Fumehoods were installed to accommodate two colony cages (Davis and Rockhold 1951).

Special analytical procedures had to be developed to conduct the urinalysis of the actinium equilibration mixture, both in the laboratory workers and in the laboratory animals. Initial attempts used the method of separation by extraction in thenoyltrifluoro acetone. A procedure was developed at Mound for human urine, based on the quantitative insolubility of radium-barium nitrate. The radium isotopes were coprecipitated on barium nitrate and analyzed by alpha activity. The actinium and thorium were quantitatively coprecipitated on cerium phosphate (Kirby and Brobeck 1954). The quantitative analysis of actinium equilibration mixture in rat urine used a method of precipitated lead sulfate. The precipitate containing the activity was separated from the soluble urine salts by centrifuge. The lead was then removed by precipitation. The activity remaining in the solution was then determined by alpha counting (Rogers and Watrous 1954).

2.14.2. <u>Waste Generation</u>

Waste generated through the biological experiments largely included liquid laboratory wastes and solid animal carcasses. The liquids wastes included wash water and acids and soaps needed to clean the glasswares, as well as some liquid wastes from the digestions and neutralizations. These liquids were diluted and released to the WD Building through an underground line connected to the B Building. The connection of the B Building to the radioactive waste line system is generally not shown on current engineering drawings (DOE 1992a), but it is described as part of the original construction and operation

of the B Building. Some verbal reports of the earliest operations in the WD Building state that the odors of organic decay made it an area in which it was difficult to work.

Solid wastes from the experiments included animal carcasses and parts that were in some cases preserved in formaldehyde. These are reported to have been packaged and shipped off-plant for disposal (Meyer 1991).

2.15. LITHIUM PROGRAMS

Three projects involving lithium were conducted at Mound. In early 1955, the Livermore Project got under way in the M Building. This program was concerned with the production of lithium deuteride blocks that were pressed and then canned in metal containers. The start-up of the Livermore Project was scheduled for March 1955. In August 1955, 82 kg of lithium deuteride material were pressed, canned, and shipped to the Lawrence Livermore National Laboratory (MCC 1955f).

The second program involving lithium also occurred in the 1950s. This program involved the characterization of the chemical and physical properties of lithium deuteride. This was essentially a laboratory-scale program where experiments involved small quantities of material.

In June 1965, the third lithium project got underway at Mound. This project was concerned with the development of analytical methods for lithium hydride, deuteride, and tritide.

2.15.1. Process Description

All three programs required the use of dry box operations to eliminate oxygen and water vapor. The Livermore Project was located in the M Building; and some analytical activity associated with the third project, involving development of analytical procedures, was conducted there.

The dry box atmosphere was helium. A dewpoint of -77°F was required to prepare lithium material for pressing and canning. The helium gas was treated with a number of reagents that would remove water from the helium gas stream. These reagents included barium oxide, magnesium perchlorate, and lithium hydride. A uranium furnace, operating at 350°C, was also used to remove water vapor and oxygen from the helium process gas. This system was very effective and produced dewpoints as low as -100°F. The uranium furnace proved to be unreliable, because the gasket materials developed helium leaks at high temperatures.

The lithium hydride stability studies involved the use of furnaces capable of high-temperature operation under controlled atmospheres. These studies were also performed in a dry box. The development of analytical methods for lithium hydride, deuteride, and tritide focused on the following analytes: Kjeldahl nitrogen; total hydrogen, deuterium, and tritium; lithium isotopic ratios; carbon, hydroxide, chloride, oxygen, sodium, potassium, and calcium; and free and isotopic lithium (Rhinehammer 1965).

2.15.2. Waste Generation

Compared with the size of the programs, the wastes generated by them were few. Lithium metal, lithium hydride, deuteride, tritide, hydrogen, deuterium, and tritium represent the majority of the waste produced in these studies. The analytical methods development work used methanol, sulfuric and hydrofluoric acids, ethylbromide, Karl Fisher reagent, tin, mercury, hydrochloric acid, sliver nitrate, hydroiodic acid, barium hydroxide, and Nessler reagent.

Based on activity levels, tritium-contaminated aqueous wastes would be treated and disposed of as discussed in the tritium section. Gaseous waste containing hydrogen, tritium, and deuterium would be sent to the effluent removal system to recover tritium.

Lithium metal, lithium hydride, and deuteride are extremely reactive metals and had to be reacted with water to produce a waste that could be stored or undergo further treatment. The disposal of such wastes reportedly took place at Mound. In the mid-1950s, lithium hydride materials were reported as being disposed of by burning in the swampy area along the lower reach of the plant drainage ditch. The highly reactive materials were simply reacted with the water and allowed to burn. This area was referred to as Area C in the CEARP Installation Assessment (DOE 1986). After Building 34 was constructed in the mid-1960s, the disposal activity was moved to the standing water pond at the historic landfill site, known as Area B (DOE 1992g). Any associated contamination at these areas would be dependent on the effectiveness of the isotope separation operation.

2.16. DETONATORS AND EXPLOSIVES

In July 1955, plans and proposals were prepared for a detonator facility to be constructed at Mound. Plans were made to use Building I for explosive manufacturing, and Building B was to be used for inert manufacturing (Brawley 1955). In August 1956, Mound was directed to begin work on detonator assemblies required for the weapons program (MCC 1960). Thus began a long-lived program in the development and production of detonators, igniters, and actuators; in the research, development, and manufacture of pyrotechnic material and devices; and in the surveillance testing of explosive components. These programs involved research and development of plastic, adhesive, and ceramic

materials. Research, production, and testing included devices containing small quantities of energetic materials. The program began in the E, I, and SW buildings. In E Building, the plastics development program involved process improvement studies, new material investigations, evaluation of commercially produced plastic, and adhesive chemistry studies. In addition, detonator pilot plant operations and physical studies of high explosives were carried out. The detonator program was expanded into the SW Building in 1960. Explosive manufacturing was planned to take place in the I Building.

In 1961, the explosive program undertook the study of explosive purification. This program as conducted in Building 1 (Rhinehammer 1961).

2.16.1. Process Descriptions

2.16.1.1. Plastics Research

Plastics research at Mound conducted in the late 1950s and early 1960s was directed toward the development of a process for blending diallyl phthlalate powders and filler materials into resins whose chemical and physical properties met certain performance standards and could be molded easily. Asbestos fibers, micas and china clays, and man-made materials such as Dacron were evaluated. Various pigments such as titanium dioxide were also evaluated (Eichelberger 1961a). The process involved formulation, followed by injection molding and physical testing of the finished products. Testing included tensile strength, impact resistance, and residual volatile contents. Formulations typically included Dapon 35, ter-butyl perbenzoate, benzoyl peroxide, 10-undecenoic acid, and acetone. Typical batches ranged from 15 g to 15 pounds (Eichelberger 1961b).

2.16.1.2. Adhesives Research

In the early 1960s, research conducted on adhesives was directed toward the reevaluation of all previous work on polyurethane and polyurathane-epoxy copolymer systems. Dozens of formulations were studied throughout the program, including effects of polyol content on epoxy-modified polyurethanes and the effects of di-epoxide modifiers on polyurethanes and the adiprene-ferric acetyl acetonate-polyol systems. The polyols used were typically 1,3-butanediol, 1,4-butanediol, 1,2,6-hexanetriol, 1,5-pentanediol, and 1,1,1-trimethylolpropane. Normal formulations required 20 to 30 g of Adiprene resin and 0.02 to 0.2 g of catalysts. Many formulations of commercial adhesives and epoxy compounds were evaluated. Some required solvents such as methyl ethyl ketone. Other amine curing agents, such as 4,4-methylene-bis-(2-chloroanilene), also known as MOCA, were also used. The adhesive formulations were evaluated for elastomer properties, cure times, pot life, viscosity, and application characteristics (Eichelberger 1961b).

2.16.1.3. Transducers and Plastic Component Production

Mound produces transducers, plastic components, and inert plastic elements of detonators. Parts are cleaned in ultrasonic baths using trichloroethylene. Spent solvent is poured into a sink that drains to a waste solvent drum located in a shed attached to the building. Other organic solvents such as ethyl and isopropyl alcohols, toluene, and trichloroethane are also used for cleaning parts. Methyl, ethyl, and isopropyl alcohols are used to clean actuators parts. After use, they are transferred to waste drums located in an approved storage shed. Freon TF is also used as a cleaning and degreasing solvent, and the waste Freon is kept in a separate 5-gallon container in an approved storage shed.

Plastic molding activity also involves ultrasonic cleaning of components using Freon TE, Freon TF, and ethyl alcohol. Water from ultrasonic baths is drained to waste solvent drums stored in an approved storage area.

2.16.1.4. Pyrotechnic and Tape Development

Small quantities of pyrotechnic and explosive-containing wastes and organic solvent wastes are generated by pyrotechnic and tape development activities. Tape production involves a photoresist process, which generates aqueous waste streams containing sodium carbonate, ferric chloride, potassium hydroxide, and the photoresist that is chemically removed from the tape. These wastes are discharged to the sanitary sewer system. The tape is then plated with nickel. The plating solutions used in this process contain nickel sulfamate and sulfuric acid. After using the sulfuric acid cleaning solution and nickel sulfamate plating solution, they are returned to their original containers for reuse. Throughout this process, ethyl alcohol is used to clean tapes. Gold cyanide is used when tapes are gold-plated.

2.16.1.5. Energetic and Low-Energy Component Development

In this area, research and development work involves the use of primary, secondary, and special explosives to fabricate low-energy and energetic components. In addition to the explosive elements used in this activity, numerous organic solvents are used in small quantities. These solvents include ethyl and isopropyl alcohol, acetone, toluene, Freon, and trichloroethane.

2.16.1.6. Explosive Processing

Energetic materials may be classified as explosives, propellants, and pyrotechnics. Various high or secondary explosives, such as pentaerythritol tetranitrate (PETN), plastic bonded explosives (PBX), and tetryl, are used in development and manufacturing programs. The production of explosives involves a recrystallization process wherein the explosive is dissolved in a suitable solvent such as acetone or ethyl alcohol and water is added to the solution to allow fractional crystallization. The recrystallized explosive is filtered and washed with water. The major reagents used in this process are acetone, ethanol, dimethylsulfoxide, and dimethylformamide.

The management of waste energetic materials at Mound is described in *Destruction of Energetic Waste Materials* (EG&G 1990). This manual describes procedures for segregating wastes by groups, for packaging wastes destined for treatment in the retort, and for treatment by other thermal processes. Energetic waste materials are separated and classified into one of the following groups:

Group 1 contains explosive-contaminated flammable materials such as paper, wood, cardboard, plastic, air filters, etc.

Group 2 contains fabricated components and assemblies such as pellets, loaded cups, subassemblies, detonators, and surveillance-generated explosive waste.

Group 3 contains loose bulk materials such as PETN, PBX, hexahydro-1,3,5-trinitro-s-triazine cyclotetramethylene-tetranitramine (RDX), octahydro-1,3,5,7-tetranitro-1,3,5,6-tetrazocineyclo-tetramethylenetetranitramine (HMX), and tetryl.

Group 4 contains mild detonating materials, including mild detonating fuses and mild detonating cord.

Group 5 contains pyrotechnic powder and scrap or solid waste contaminated with pyrotechnic materials.

Group 6 contains hexanitrostilbene (HNS) and HNS-contaminated waste material.

Group 7 contains 2-(5-cyanotetrazolato)pentaamine, cobalt (III) perchlorate (CP), bulk CP, CP-contaminated materials, and CP components.

Group 8 contains thermite scrap and thermite-contaminated waste.

Group 9 contains primary explosives and primary explosive-contaminated waste.

Group 10 contains propellants and associated wastes.

Group 12 contains nonburnable explosive assemblies, such as timers.

Group 13 contains experimental and laboratory energetic material and explosive devices.

Group 14 contains waste energetic materials in solution/solvents.

Wastes belonging to Groups 1, 2, 3, 4, 7, 9, and 13, as described above, are destined for treatment in the retort.

2.16.2. Waste Generation

The majority of the wastes generated in association with explosive and related developmental and production activities are organic solvents and aqueous mixtures of these solvents. Organic solvents include trichloroethene; trichloroethane; methyl, ethyl and isopropyl alcohols; toluene; and acetone. Other chemicals include Freon TF, Freon TE, sodium carbonate, ferric chloride, potassium hydroxide, nickel sulfamate, sulfuric acid, and cyanide solutions. Metals involved include titanium, nickel, copper, and gold. Historically, the aqueous solutions containing organic solvents, mostly acetone, were released to leach pits and allowed to evaporate and disintegrate naturally. Since the mid-1980s, the solutions have been drummed and handled through the hazardous waste storage area. These solvent wastes are transferred to 55-gallon drums and 5-gallon cans and stored until the containers are full. Waste solvents are recycled or incinerated at off-plant facilities. Aqueous wastes containing ferric chloride and potassium hydroxide are allowed to discharge to the sanitary sewer system. Nickel and gold plating and wastes from photographic processing are collected and picked up by Mound waste management personnel for packaging and disposal. Photographic wastes receive pretreatment to recover silver before being picked up by waste management personnel. The organic solvent waste from the fractional crystallization of PETN, known as "27 waste solvent," was drained to an open trough, and the liquid was filtered. The filtrate was picked up by waste management personnel and handled as hazardous waste. Surplus explosives are burned in the thermal treatment unit.

The adhesives programs evaluated a wide range of chemicals including Adiprene 100, 167, 213; polyethylene glycol; MOCA; aliphatic epoxy resins; polypols including 1,3-butanediol, 1,4-butanediol, 1,2,6-hexanetriol, 1,5-pentanediol, and 1,1,1-trimethylolpropane; Versamid 140; Epon 812; dipentive dioide; and butanediol diglycidl ether, as well as other plastic polymers (e.g., 3,4-epoxy-6-methylcyclohexylmethyl-3,4-epoxy-6-methylcyclohexanecarboxylate and 1,4,5,6,7,7-hexachlorobicyclo-[2.2]-5-hepthane-2,3 dicarboxylic anhydride). Adhesive wastes were generally disposed of in the normal trash after testing, as were the excess volumes from production facilities. Solvent vapors were simply vented to the atmosphere.

2.17. CONTAINER TESTING PROGRAM

Mound historically shipped discarded quantities of solid low-level plutonium-238 waste for burial in drums authorized for shipment by the ICC Special Permit #4912, which expired on August 30, 1968. This permit provided for the shipment of up to 20 Ci/g of plutonium-238 contained in burnable and nonburnable waste material. Since discard of quantities greater than 20 Ci/g of plutonium-238 per container was economical and was authorized by the AEC's Albuquerque Operations office, a need existed for an approved container for these shipments. It was also known that testing would be required to assure compliance with AEC and DOT transport regulations, both for transport of quantities greater than 20 Ci/g and in order to obtain a permit to replace ICC Special Permit #4912 upon its expiration.

The testing program was directed primarily at providing an economical, disposable shipping container for plutonium-238 wastes shipped from Mound. In carrying out the testing program, a disposable container for shipment of small quantities of solid plutonium-238 compounds was also developed (Madding and Vallee 1968).

A test facility was constructed in the lower valley area of the plant, along the southern margin of the plant drainage ditch. The site had been a general residence area in the 1940s before the plant was built. Several houses that stood in the area were razed in the early 1950s. In 1965, Building 34 was constructed to support emergency fire fighter training. The container test equipment was placed in the open field area next to the training facility so the facility could serve dual purposes. The test facility included drop, burn, puncture, and submersion equipment.

2.17.1. Program Description

The container testing program consisted of performing four hypothetical accident tests on a single container, in the sequence given below. The successful completion of the test was determined by whether any radioactive material was released from the package, except for gasses and contaminated coolant containing very small quantities of radioactivity. A container was considered to have passed the test when there was no leakage of water into the space normally occupied by radioactive material. The required tests were as follows:

1) Free Drop - A free drop through a distance of 30 ft onto a flat, essentially unyielding, horizontal surface, striking the surface in a position at which maximum damage is expected.

2) Puncture - A free drop through a distance of 40 inches, striking the top end of a vertical cylindrical carbon steel bar at least 8 inches high and with a diameter of 6 inches, with a rounding of the top edge not to exceed a 1/2-inch radius. The bar was mounted on an essentially unyielding horizontal surface.

3) Thermal - Exposure for 30 minutes within a source of radiant heat having a temperature of 1,475°F.

4) Water Immersion - Immersion in at least 3 ft of water for 24 hours.

2.17.2. Waste Generation

Few wastes are thought to have been generated by this test program. Containers were probably not contaminated, because new containers were probably used for the tests. No radioactive materials were actually involved in the testing program. The used containers probably went to the historic landfill when the tests were complete.

3

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3. SUPPORT OPERATIONS AND FACILITIES: WASTE GENERATION

The support facilities at Mound have served the needs of a variety of programs that have come and gone at the plant in its more than 40-year history. Besides the basics, such as power and water, these support facilities have included plating and paint shops, maintenance shops, building heating and cooling, sanitary wastewater treatment, photoprocessing, analytical laboratories, D&D program, and the environmental monitoring program. The following subsections provide summary descriptions of the support facilities that generate significant volumes of wastes. These descriptions are not meant to be, nor are they, exhaustive. Figure 3.1 shows the locations of the support facilities.

3.1. PAINT SHOP

The paint shop, which began operating in 1963, is in the north-central portion of Mound, on the Main Hill (Figure 3.1). The shop is used for both maintenance and production parts painting. Maintenance work includes the painting of such items as racks and furniture. Production work includes the painting of metal shipping containers, styrofoam shipping trays, and test panels. All painting is done inside spray booths.

Until 1987, paint overspray was removed from the air using a water scrub and recirculation system. The water containing the paint contaminants was circulated through a vessel containing an Oakite powder to suppress the odor. Once a month, the Oakite and water solution would be drained from the vessel via an effluent line that discharged to the storm sewer; the plant drainage ditch; and, ultimately, the Great Miami River. The water scrub and recirculation system was then recharged with fresh water and Oakite. The waste products discharged to the storm sewer contained lead, dichloromethane, organic solvents, coal tar-based paints, chromates, toluenes, and aromatic solvents.

In 1987, the wet scrub paint removal system was replaced with a dry system using filters. Initially, a paper filter was used to remove the paint particles, but the paper filter was later replaced with a more durable paper and fiberglass filter. Upon replacement, the used filters are dried, bagged, and placed in the trash dumpster for disposal.

Other waste materials generated at the paint shop include unused paint, solvents, thinner, and solid trash. Florco is added to the leftover paint, and the mixture is placed in a spray booth and allowed to dry. The dried product is disposed of in the trash dumpster. The water-based and oil-based solvents and thinners are mixed together in a paint waste drum for disposal. The paint waste drum is kept on a concrete pad on the north side of the building. The drum is secured to the building, and the area is clearly marked. The waste liquids in the drum are picked up by Mound waste management personnel

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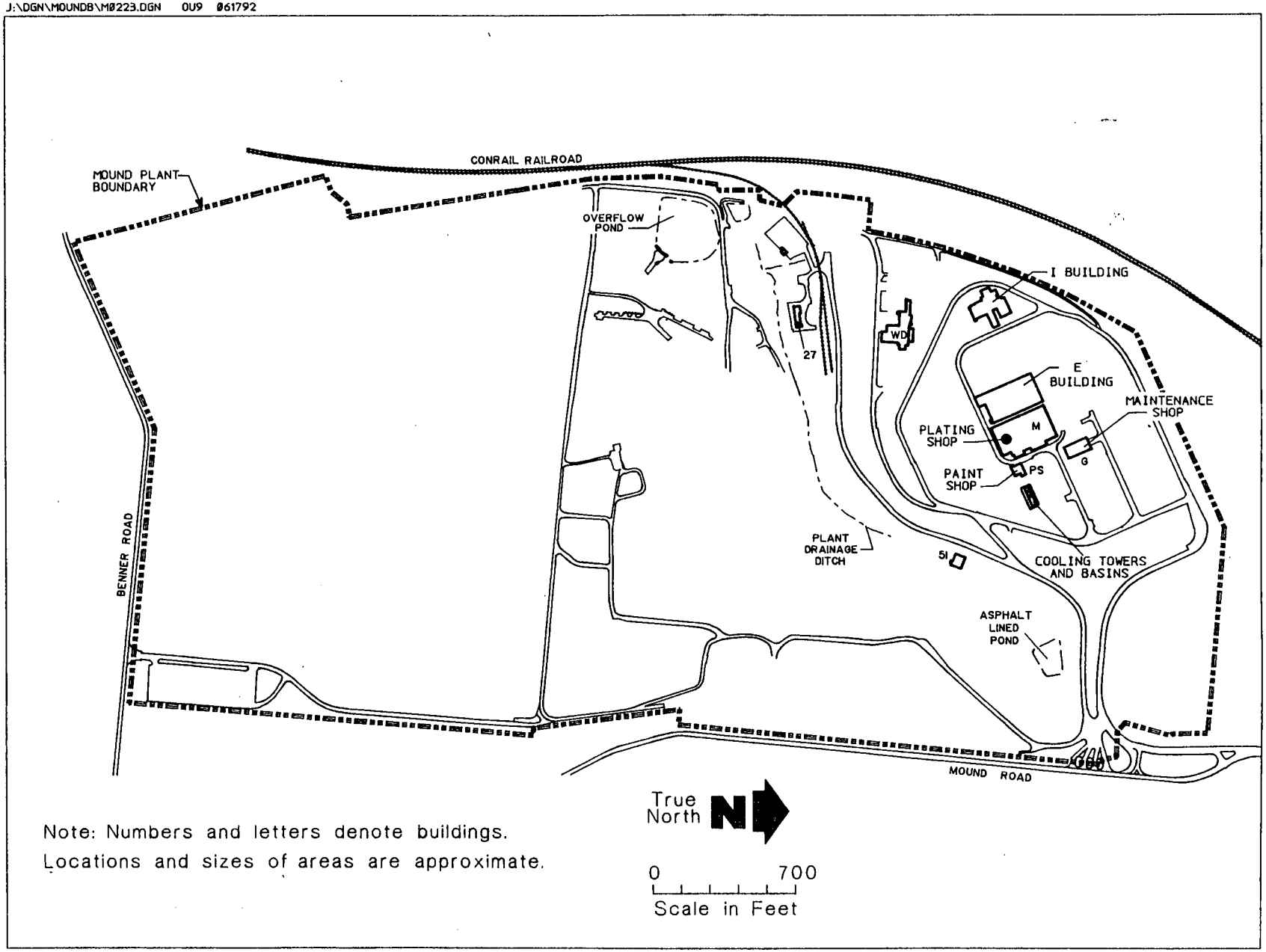

Note: Numbers and letters denote buildings.
Locations and sizes of areas are approximate.

Figure 3.1 Support facilities.

for disposal at an approved off-plant disposal facility. Approximately one drum of waste is generated every three months. Solid trash is placed in dumpsters for disposal. The paint shop is still in operation (Parrett 1991).

3.2. PLATING SHOP

The Mound plating shop started in the M Building in the late 1940s (Figure 3.1). Plating processes and metal purification experiments were performed there. The shop itself consisted of eight to ten 150-gallon plating solution tanks that were handmade from boiler plate steel (Shawhan 1991). Sulfuric acid anodizing solution wastes and sodium hydroxide cleaning wastes were regenerated on an infrequent basis. The plating solutions were reused and generally recycled; but, when necessary, they were dumped into a large underground tank. The tank consisted of a concrete vault structure west of the original M Building that connected to the plant sanitary sewer. Releases of solutions to the sewer would often affect the bacterial populations of the Old SD Plant (Thomas 1991). The cascade rinse systems also drained to the underground tank.

In 1962, a production plating shop and a general plating shop were installed in the M Building, and the old plating shop was dismantled. During the dismantling process, the plating solutions were removed from the equipment and neutralized. All of the old tanks and equipment were removed. The underground tank was retained and reconnected to the new equipment.

In 1981, a new production plating shop was built on the south end of the M Building. In 1985 or 1986, a new general plating shop was built next to it. The new shops were built to upgrade the old equipment and use modern technology. The old equipment still exists in the M Building, but has been cleaned out. The waste products were drummed and disposed of off-plant through the waste management system.

3.2.1. Process Description

The production plating shop was used to plate weapons parts and to develop weapons reserve products. Processes performed in the production plating shop included chrome, gold, cadmium, copper, nickel and silver plating, passivating, anodizing, and coating.

The plating process began with an etching of the component in hydrochloric acid, followed by a rinse, a nickel chloride strike, a primary and secondary rinse, a hand rinse, a cascade rinse, and a spray rinse using deionized water. The component was then immersed in the plating bath, and the rinses described above were repeated.

The passivating process consisted of a cleansing of the component in a nitric acid solution, followed by a primary and secondary rinse, a hand rinse, a cascade rinse, and a deionized water spray rinse. The object was then immersed in the passivating solution bath using a mixture of sodium dichromate and nitric acid. The bath was equipped with an ultrasound device. The series of rinses was then repeated.

The anodizing process involved cleaning with an Aceta 30 solution, conditioning in a nickel acetate bath, and application of the anodizing dye and a sealer.

The coating process consisted of cleansing the object in an alkaline solution, followed by nitric acid etching and subsequent immersion in an Alodine 1200S solution. This process was then followed by a series of rinses as described for the passivating process.

The general plating shop was used for tooling and fixture plating. Black oxidation was used as the plating process, which consisted of an electrocleaning of the object in an Oakite 190 solution, followed by an etching with hydrochloric acid and two tap-water cascading rinses. The object was then immersed in a caustic black oxide solution and rinsed again with two cascading tap-water rinses.

3.2.2. Waste Generation

Minor process changes have been made in the plating shops since they began operation. The cadmium and silver plating process has been eliminated, and the use of gold cyanide has been eliminated and replaced with gold arsenic. Wastes potentially generated in the plating shops include solutions of chromic acid, copper cyanide, Rochelle salt, sodium cyanide, sodium carbonate, electroless nickel, Woods nickel solution, Alodine waste, electrophoretic waste, dye, nickel acetate, passivating waste, sodium dichromate, acetone, isopropyl alcohol, ethanol, alkaline cleaner, freon, mixed acids (hydrofluoric, hydrochloric, nitric, sulfuric, and phosphoric), Oakite, sodium hydroxide, trichlorethene, sodium hydroxide, and potassium permanganate.

The sodium hydroxide solution and potassium permanganate were neutralized by mixing them together and then drained to the sanitary drains. In the old shop, the solutions went to the large underground tank (under the northwest corner of the M Building) and then to the sanitary sewer. A much smaller sump was installed in the new shops (under the southern end of the M Building), because the volume of waste solutions has been reduced. All other chemical wastes were drummed for pickup by Mound waste management personnel for disposal at an approved off-plant facility. Primary rinse solutions were recycled into the nickel strike bath or plating bath solutions as makeup water. Secondary and hand-rinse water were recycled for use in primary rinses. All other rinse water, including the cascade

rinses and the deionized water spray rinses, was disposed of in the sanitary sewer system. In 1989, the process of disposing of the sodium hydroxide and potassium permanganate solution in the sanitary sewer system was stopped. These solutions are now drummed and picked up by Mound waste management personnel. Currently, only the cascade rinse water drains to the small sump. The old tank is thought to still be connected to the sanitary sewer system as is the new sump. The old tank served as the sampling station for NPDES Outfall 001. The new sump in the production plating shop is currently sampled for that requirement.

Concrete containment pits with curbs are located under the plating shop process equipment to contain any spills or leaks. The pits are segregated so that acid materials do not mix with basic materials. Any material that collects in the pits is removed by pumping it into drums for disposal by Mound waste management. Floor drains within the building are connected to the sanitary sewer system. Administrative and physical controls prevent plating wastes from being disposed of in these drains (Johnson 1991).

When the original plating shop was dismantled in 1962, the plating solutions were neutralized and the solutes precipitated. The resulting wastes included sludges and a supernatant liquid. The liquid was released to the sanitary sewer through the old tank. The sludges were drummed in two 55-gallon steel drums and buried in the small parking lot on the northeast corner of the Main Hill. The old tanks were also buried at this location, as part of the expansion of the parking lot. This burial site is now known as Area F (DOE 1992g).

3.2.3. Vapor Degreaser

The vapor degreaser is in the plating shop in the M Building on the Main Hill (Figure 3.1). Small machined metal parts are cleaned by solvent vapors produced in the chamber of the degreaser. The fully enclosed metal chamber is approximately 3 ft long, 2 ft wide, and 4 ft deep and has a 15-gallon solvent capacity. The wastes produced in this unit are spent solvents. Spent solvents and vapors are retained in the degreaser cleaning chamber. The solvent used in the vapor degreaser is Perclene D. The unit began operating in the late 1970s and is still in use. Spent solvent is transferred to drums and transported to the hazardous waste storage area in Building 72.

3.3. MAINTENANCE SHOP

The Building G garage is used to maintain the automobiles, trucks, buses, and heavy-duty equipment used at Mound (Figure 3.1). The building is approximately 122 ft by 62 ft and is made of structural steel and brick with concrete floors. It has concrete floors and is located in the northwest corner of

the plant. The building contains a new parts storage area, offices, restrooms, and a custodial operations storage area. Maintenance operations include oil changes, antifreeze replacement, vehicle repair, and tire and battery replacement.

New oil is in 55-gallon drums and is pumped into a 65-gallon storage tank. Oil from the storage tank is metered through a discharge line directly into the vehicle crankcase. Used motor oil is drained from the crankcase into a temporary storage container and is then transferred into a 55-gallon drum. Antifreeze is received in 55-gallon drums and is pumped into a 65-gallon storage tank. The antifreeze is metered from the discharge tank directly into the vehicle radiator. Used antifreeze is placed in 55-gallon drums. The empty drums that contained the new oil and antifreeze are used to receive used materials of the same type. Failed vehicle parts are returned for redemption of the core charge. Parts that have no core charge, such as used filters, hoses, and spark plugs, are discarded as non-hazardous trash, which is transported off-plant for disposal.

Brake repair is now performed in confined conditions to prevent worker exposure to asbestos. A containment system with glove ports is placed around the wheel and maintained at a negative pressure. The containment system is connected to two HEPA filters. Asbestos or other dusts generated by the maintenance process are removed from the air by HEPA filters prior to discharge. Loaded HEPA filters are removed and packaged as asbestos waste.

A ventilation system contains the vehicle exhaust emissions inside the building. A hose is placed around the vehicle's tail pipe and when the vehicle is running, fans pull the exhaust fumes from the tailpipe and discharge them outside the building (Deel 1991).

Historically, the waste oils and antifreeze were disposed of in the historic landfill. A few tires and batteries were also dumped in the landfill, but most were sent off-plant for recycling. In the late 1960s, on-plant dumping was stopped, materials were collected for pickup by Industrial Waste Disposal, Inc., and shipped to an approved off-plant waste disposal facility (Vaughters 1991). Briefly, in 1972, waste oil was staged in a 1,000-gallon tank and burned in the incinerator in Building 51. Currently, the waste oil, used antifreeze, old batteries, worn out tires, and filters containing asbestos are placed outside the south side of the building. Mound waste management personnel collect these wastes weekly for proper off-plant disposal or recycling (Deel 1991).

Building G is also used to store janitorial supplies such as floor strippers, floor finishes, cleansers, deodorizers, hand soaps, sponges, and mops that are used throughout Mound. These materials are stored in locked cabinets and caged areas, because they do not generate any hazardous waste streams.

3.4. COOLING TOWER BASINS

Substantial volumes of water were used at Mound for the single-pass cooling of process equipment in Buildings E, SW, T, DS, HH, 38, and others. In the past, this cooling water was routed directly to the storm sewer system, which discharged to the Miami-Erie Canal via NPDES Outfall 002. The NPDES suspended solids limit set for this stream was frequently exceeded during heavy rainfall due to the additional storm water runoff containing high concentrations of silt. To remove the cooling water discharges from the storm sewer, closed loop systems using cooling towers were installed at the powerhouse for the major water users (Figure 3.1).

Specific information on the chemicals used in the recirculating cooling tower water prior to 1980 is not available. Typical cooling water treatment chemicals used in industry until the mid-1970s consisted of sulfuric acid and chromates. This type of water treatment was probably used at Mound. In 1980, Mound began using Nalco treatment chemicals to condition the cooling water. Nalco 2575, an organic treatment, was used as a corrosion inhibitor. Nalco 2575 contained a phosphorate base (scale inhibitor), tolytriazole (a copper corrosion inhibitor), polyacrylate, and a sodium chromate tracer. Sodium chromate was present in minor concentrations, totalling approximately 0.5 percent of the total constituents. Nalco 2532 and Nalco 2590 were the biocides used. Nalco 2532 contained bis(tributyltin) oxide, n-alkylidimethylbenzyl ammonium chloride, and potassium hydroxide; Nalco 2590 consisted of calcium hypochlorite.

In 1983, Mound changed from Nalco chemicals to Anco water treatment chemicals manufactured by Anderson Chemical Company. Anco CSA was used as the corrosion inhibitor and replaced Nalco 2575. Anco CSA basically consists of the same compounds as Nalco 2575; however, no chromates are present in Anco CSA. Microbicide 77 was used as the microbicide. Microbicide 77 consists of 5-chloro-2 methyl-4-isothiazolin-3-one and 2-methyl-4-isothiazolin-3-one. Anco Algaecide No. 1 was used as an algicide. This product contains 2-benzyl-4-chlorophenol and sodium hydroxide. Siltex was used as a micro-biodispersent and contained sodium polyacrylate.

Over the past few years, minor changes have been made in the compounds used in the cooling tower water. Presently, Ancocide 4020 (formerly called Microbicide 77) is used as the microbicide. Ancocide 4020 is added to the water as a biocide and contains aqueous glutaraldehyde. Ancosperse 3830 is added as a surfactant and contains polyalkylene glycol and n-alkyldimethylbenzylammonium chloride. Ancool 3310 is added as an organic treatment corrosion inhibitor and contains phosphorate, triazole, sodium molybdate, and sodium hydroxide (Mitchell 1991; Raker 1991).

Three cooling tower basins are installed to collect the cooled water from the 10 cooling towers and recycle it back into the plant cooling system. The cooling tower basins are below-ground concrete sumps and are provided with circulating pumps. The basins are covered with a concrete top and are on the north side of the cooling towers. Periodically, blowdown of the cooling water system is performed. The blowdown water is routed to the Mound drainage ditch. The area around the cooling towers and the basins is covered with asphalt to keep dirt and debris from entering the tower via the air draft. The start-up dates for the cooling tower basins vary. They are all currently in operation.

A cooling tower drum storage area is located near the cooling towers. The storage area consists of an asphalt pad on the south and west sides of the cooling tower. The pad is used as a chemical staging area. No containment system is present to control drum leakage or runoff. The pad is used to stage biocides, anticorrosion chemicals, boiler treatment chemicals, ethylene glycol, and other powerhouse water treatment chemicals contained in 55-gallon drums. The pad was built in the early 1970s and is still operational.

3.5. PHOTOPROCESSING

Photoprocessing activities are conducted at approximately 20 locations at Mound. The functional groupings of these activities are listed below:

- Product Development and Environmental Testing
- Manuals and Procedures
- Drawing Control
- General Analytical
- Advanced Devices Plastics (ADP) Operations
- Photography
- Instrumental Analysis
- Radiography (Industrial)
- Radiography (Medical)
- Classified Explosives Work

Specific wastes generated from the above activities include approximately 2,850 L (750 gallons) of spent fixer solution that are collected and stored on-plant for future recovery of silver using a recently acquired electrolytic unit, and approximately 2,850 L (750 gallons) of other photoprocessing waste consisting of developers, stop baths, bleaches, rinses, etc., that are collected for on-plant storage prior to transfer to an EPA-permitted vendor for transport and treatment/disposal.

In addition, very small amounts of photoprocessing waste are generated by X-ray film development. The X-ray film development is performed in Building DS, using a Hope processor, which uses Kodak chemicals (Kodak Industrex developer and replenisher, Kodak Industrex fixer and replenisher, Kodak

liquid developer system cleaner, and Kodak fixer wash system cleaner). These chemicals are collected in a waste can for pickup by Mound waste management personnel. In 1989, 4 gallons of photoprocessing waste were collected by Mound waste management personnel. In February 1990, a new Fuji processor replaced the Hope model. Different chemicals are now used, and Mound waste management is developing a plan for waste disposal.

3.6. ANALYTICAL LABORATORIES

The analytical laboratories support the research, production, and waste treatment operations at Mound. They also periodically participate in weapons components surveillance programs and the Safeguards Analytical Laboratory Exchange (SALE) program. The purposes of the SALE program are to verify standard analytical techniques used by other laboratories and to verify the radioisotope inventory.

3.6.1. Wastes Generated

The volume of waste generated by the analytical laboratories is very small. Solid wastes have included glass, paper, and plastic contaminated with plutonium-239, plutonium-238, uranium-235, uranium-238, beryllium, and mercury. The beryllium-contaminated wastes included glass, paper, gloves, and sample precipitates. Typically, less than 0.1 g of beryllium has been generated annually.

3.7. ENVIRONMENTAL MONITORING PROGRAM

The environmental monitoring program at Mound began with the bioassay program in 1948, managed by the health physics group. The program was conducted from 1948 to 1955 in the I Building, which was constructed to provide a facility separated from the other research and production activities to provide the low radioactive backgrounds necessary for low-level counting. Similar work had been conducted in the warehouse in Dayton, which was removed from the other Dayton units. In 1955, the low-level counting facilities were moved from the I to the T buildings, and in 1967, they were moved to a new isolation laboratory in the E Building, where they remain.

The environmental program was conducted by the health physics group and included worker urinalysis, air samples, surface wipe samples, and river surveys. Monitoring of the polonium levels in worker urine samples and in the environment was the focus of the work in the 1940s and 1950s. As other radionuclides came into use at the plant, the scope of the environmental program expanded; radium-226 was added to the urinalysis program in 1950, plutonium-239 in 1956, and plutonium-238 and tritium in 1958. Thorium was added in 1955 as part of the ionium and anticipated thorium refinery program, but was shortly terminated (Meyer 1956a). Radium-226 and plutonium-239 were phased

out in the late 1950s. Tritium and plutonium remain the principal focus of current surveys of both workers and workplace.

In addition to occupational monitoring, health physics personnel collected and analyzed surface water and silt samples from the Great Miami River and air samples from the surrounding areas to monitor the levels of radioactivity. Vegetation samples were collected beginning in July 1950 (Bradley 1950). From 1948 to March 1951, health physics information reports were published monthly by Mound. Reports through August 1951 contained only the number of samples collected. Polonium contamination in the Great Miami River during this time period was reported in annual summaries (Bradley 1951c). Beginning in September 1951, data summaries of the number of samples and maximum and average values of polonium in water, mud, and vegetation were reported. Beginning in March 1954, the health physics reports were published quarterly (MCC 1954c). Through 1953, the river monitoring program consisted of 175 mud and water samples per week, most of which showed no evidence of polonium except for the samples collected near the effluent points. About 70 air samples were collected per week in a rotational pattern and no correlation with wind directions was observed (Bradley 1953c). Based on the small fraction of permissible concentrations, a request was made in early 1953 to reduce the number of river locations sampled weekly to the immediate vicinity of the plant and to conduct air sampling only on a quarterly basis (Bradley 1953c). By 1956, 67 locations were routinely sampled for air quality.

Reports and data summaries have been published throughout the program. Reporting periods have varied over time. As described here, monthly information reports were published by the health physics group through March 1954 (e.g., Bradley 1954a); quarterly information and health physics reports were published until March 1959; quarterly environmental monitoring reports were published until 1963, when biannual reports began (e.g., MRC 1961a); the biannual reports were published until 1971 (e.g., Anderson and Sheehan 1968b); and since 1972, reports are published annually (e.g., Carfagno and Robinson 1975). Some of the monthly and quarterly reports issued by the health physics group contained data on weights of radioactive wastes shipped off-plant. These reports generally included sampling and analytical data summaries; concentration averages; and minimum, maximum, and background levels of radionuclides measured over the course of the reporting period.

The year 1959 was reportedly a year of transition (MCC 1960b) in which plutonium was added to polonium as the principal alpha contaminants in air. Tritium monitoring in air and water samples also began. The AEC required that all facilities publish an environmental monitoring report to the public (Springer 1960). It was directed that detailed reports, not involving the compromise of security information, would be disseminated to the public with sufficient explanation of data to be meaningful to a person without specific experience or training in radiation. The reports were to be written with

sufficient accuracy that well-informed persons would not consider the contents misleading. In addition to distribution within the AEC community, a 10-year summary report was transmitted to the Ohio River Valley Sanitary Commission and the chief sanitary engineer for the state of Ohio (Meyer 1959a). In 1960, MCC released a news report of the environmental radiation monitoring program and the availability of reports (MCC 1960a). By December 1963, plutonium surpassed polonium as the dominate alpha species in air emissions (Adams 1964). Plutonium was not reported in surface water until 1965 (Anderson and Sheehan 1966). The plutonium-238 isotope was not identified until 1967 (Anderson and Sheehan 1968a). Tritium was undetectable in surface water samples until late 1960 (MRC 1961a) and did not show up in air samples until sometime before January 1968 (Anderson and Sheehan 1968b). In 1969, pond water analysis was added to the monitoring program and the report. In 1971, the program was expanded to include area community drinking water supplies. Eight additional surface water and pond locations were added to the program. Since 1970, the annual reports were submitted to the Montgomery County Combined General Health District (Hebb 1970b). Beginning in 1972, reporting included nonradioactive water analyses such as those required by the EPA's Office of Water Programs (Carfagno and Westerdorf 1973). Summaries of sampling required by the NPDES permit have been included since 1975 (Farmer et al. 1976). The 1990 report included data compiled by the ER Program on groundwater monitoring and site hydrology (EG&G 1991b).

In 1970, the health physics group separated from the environmental monitoring group. The environmental program began managing the sample collections and counting laboratories, whereas the health physics group continued to monitor occupational radiation protection in the workplace. Since reorganizing, the environmental monitoring program has focused primarily on the collection and analyses of environmental samples. Like its predecessor group, the objectives of the environmental sampling and analysis program have been, first, to control all discharges to levels well within existing or proposed standards, and second, to collect and measure air, water, vegetation, foodstuff, and sediment samples collected from the environment at distances up to 48 kilometers (30 miles) from the plant. Samples are analyzed for radionuclides handled at the plant, including tritium, plutonium, and uranium. The last vestige of polonium in air outside of Mound was reported in the 1974 Annual Environmental Monitoring Report (Carfagno and Robinson 1975).

In 1973, in response to a request from the AEC, the environmental section at Mound produced an inventory of radionuclides both on and offsite for 1972 (Storey 1973b). This inventory included estimates of the amounts deposited over the years of operation and amounts remaining. Onsite estimates were hampered by the lack of soil core data. Although 15 areas had been identified (see discussion under D&D Program), the quantities of radionuclides were not known. The Nuclide Inventory Data Report is reproduced in Appendix B.

3.7.1. Process Description

The bioassay and environmental monitoring programs have used similar analytical techniques, although these have changed over the years as technology has advanced and the radioisotopes of interest have changed. The environmental monitoring program currently analyzes soil, air, water, and vegetation samples for plutonium-238 and tritium. Uranium has been measured in river water since 1978. Thorium is analyzed from on-plant soils as part of the D&D Program. Historically, the analyses included polonium-210, although the gross alpha analyses conducted in the mid-1950s would have included radium-226 and plutonium-239.

In the 1940s and early 1950s, urinalysis of polonium-210 was performed by plating the isotope onto nickel discs and counting the total alpha disintegrations. Similar methods were used for the determinations of polonium in environmental samples. A solvent extraction method using thenoyltrifluoracetone (Belcher 1952a) may have been employed for the actinium urinalysis in the early 1950s, in much the same manner as the analytical techniques used in the production process itself. A system for the urinalysis of actinium in humans used a method of coprecipitated barium-radium (Kirby and Brodbeck 1954). In the laboratory animals tested, a lead sulfate method was used (Rogers and Watrous 1954). The earliest tritium urinalysis used a process by which calcium carbide was used to generate methane into an ion chamber where the beta activity was counted by a vibrating electrometer.

The analytical procedures currently performed by the environmental control group on the environmental samples and bioassays are described in an *Environmental Analytical Procedures Manual* (EG&G 1991a). A summary of the most commonly used analytical procedures performed on the environmental samples and bioassays is presented below. A list of the reagents used in these analytical procedures is included in Table III.1.

Coprecipitation Anion Exchange Method

The coprecipitation anion exchange method is used to determine plutonium concentrations in water and uranium and thorium concentrations in urine. The procedure consists of a coprecipitation and an anion exchange separation and electrodeposition, followed by alpha pulse height analysis. To accomplish the coprecipitation of plutonium, the specific reagents used include nitric acid, iron (III), and ammonium hydroxide. For coprecipitation of uranium and thorium, the reagents include nitric acid, phosphoric acid, and ammonium hydroxide.

Table III.1. Reagents Used for Environmental Analytical Procedures

Acetone 28
Americium-241 or curium-244 standardized tracer
Ammonium hydroxide
Ammonium iodide
Ammonium sulfate
Ammonium thiocyanate
Anion exchange resin
Boric acid
Calcium nitrate
Dibutyl N, N diethlcarbamoyl phosphorate
Ethyl alcohol
Ethylene glycol
Ferric chloride
Hydriodic acid
Hydrochloric acid
Hydrofluoric acid
Hydrogen peroxide
Nitric acid
Phosphoric acid
Plutonium-242 solution
Scintillation solution
Sodium bisulate
Sodium hydrogen sulfate
Sodium nitrite
Sulfuric acid
Thorium-228 or thorium-229 standard solution
Toluene
Tritium water standard
Ultimate gold liquid scintillation cocktail
Uranium-232 standardized solution

Acid Leach Anion Exchange Method

The acid leach anion exchange method is used to determine plutonium concentrations in soil and fecal samples. The procedure consists of an acid leach and an anion exchange separation and electrodeposition, followed by alpha pulse height analysis.

For the plutonium analysis, the sample is acidified with nitric acid, and plutonium-242 is added as a tracer. Iron is added to the solution as iron (III), and the radionuclides are coprecipitated with the iron as ferric hydroxide by adding ammonium hydroxide. After decantation and centrifugation, the ferric hydroxide precipitate containing the radionuclide is dissolved, and the solution is acidified for anion exchange. The solution is poured through the anion exchange column, and any thorium present is removed with hydrochloric acid. The plutonium is eluted by reducing it to plutonium (III) with an iodide ion. The plutonium is then electroplated onto a stainless steel slide for counting by alpha pulse height analyses.

The method is modified for analysis of thorium and uranium by the addition of phosphoric acid during the initial acidification. The tracer isotopes used depend highly on the isotope of interest. Thorium-228, thorium-229, and uranium-232 are typical. The precipitations are facilitated by the addition of an alkaline earth phosphate instead of iron (EG&G 1991a).

Acid Dissolution Method

The acid dissolution method is used to determine plutonium concentrations in air and also uranium in soil and air. The current procedure involves decomposition of the filter sample by heating at 550°C, an acid dissolution, a coprecipitation, and an anion exchange separation and electrodeposition, followed by alpha pulse height analysis.

For plutonium analysis the procedure consists of adding plutonium-242 as a tracer, heating the sample to 600°C, and dissolution in nitric-hydrofluoric acid. Boric acid is added to complex the fluoride ion. Plutonium and iron hydroxide are coprecipitated and then dissolved in nitric acid, and the plutonium is oxidized to plutonium (III) with sodium nitrite and then passed through the anion exchange column. The solution is then electrodeposited onto a stainless steel slide for alpha pulse height analysis. The method for uranium requires modification from this scheme in that a uranium-232 tracer is used and precipitation is with the addition of ammonium hydroxide. If significant iron is present, an ether extraction is also required (EG&G 1991a).

Acid Leach Method

The acid leach method is used for the analysis of air filters for plutonium and uranium. The procedure consists of heating the filter(s) at 550°C for a minimum of 4 hrs, dissolving of the plutonium and uranium with an hydrochloric acid leach, and separating the isotopes by anion exchange chromatography. Plutonium is then eluted by reduction to plutonium (III) with the iodide ion, and uranium is eluted with hydrochloric acid. The solutions are then electrodeposited onto a stainless steel slide in preparation for alpha spectrometry. Specific tracer isotopes of plutonium-242 and uranium-232 are used for plutonium and uranium analyses, respectively.

Scintillation Counting

Tritium concentrations are measured in water, air, urine, and vegetation by analyzing the samples in a liquid scintillation spectrometer. Urine analyses require preparation of a 3-mL urine sample with 10 mL of a scintillation solution such as Ultimate Gold and are simply counted by liquid scintillation spectrometry, which measures the beta radiation. An external standard of barium-133 or radium-226 is also counted, and the results are compared through a quench curve. The quench curve is determined empirically by measuring various samples spiked with known amounts of tritiated water (EG&G 1991a). Quenching is a general term used to described the interference by the production of light in a scintillator.

Historically, p-dioxane (1,4-dioxane) was used for urine samples from the mid-1960s to 1980. In May 1980, Atomlight, also known as pseudocumene (1,2,4-trimethylbenzene), replaced p-dioxane in the scintillation cocktails. Atomlight was used until June 1990, when it was replaced by Ultimate Gold, a napthalene-based solvent. Until the use of Ultimate Gold, water analysis for tritium, scintillation counting required the use of Insta-Gel, a commercial product that was based on toluene or xylene and ethanol.

3.7.2. Waste Generation

Environmental sample analysis uses 7-cm^3 plastic vials containing 1 cm^3 of sample (potentially containing beta emitters) and 5 cm^3 of trimethylbenzene and scintillators. If the beta concentration is greater than 50 μCi/L, the contents of the vial are treated as radioactive mixed wastes. If the concentration is less than 50 μCi/L, the vial and its contents are treated as nonradioactive wastes. In 1989, a total of 21 gallons of radioactive mixed waste and 622 gallons of nonradioactive waste was generated. Radioactive mixed waste is sent to Building 23, and the nonradioactive waste is dumped to the sanitary sewer.

In addition, air sample filters and smear samples are counted as part of environmental sample analysis. After being analyzed, the dry samples are put in an LSA container. No more than two 55-gallon drums of LSA waste are generated by this operation annually.

Several reagents used for environmental sample analysis are ultimately discharged to the sanitary sewer line after use. These reagents and their estimated annual volumes include nitric acid (206 gallons/yr), hydrochloric acid (132 gallons/yr), ethylene glycol (55 gallons/yr), acetone (28 gallons/yr), ammonium hydroxide (18 gallons/yr), sulfuric acid (11 gallons/yr), sodium bisulfate (1 gallons/yr), phosphoric acid (0.5 gallons/yr), and hydroiodic acid (0.5 gallons/yr).

3.8. DECOMMISSION AND DECONTAMINATION (D&D) PROGRAM

The Mound D&D Program is an ongoing program that provides a coordinated system for funding and scheduling of the D&D of inactive radioactively contaminated areas of the plant (MRC 1978b). The program originated in 1949 with the deactivation of the Dayton units and has continued at Mound (Garner and Davis 1975) as projects were terminated and facilities were used for other projects. D&D activities at Mound include (1) the "old cave" in the SW Building, which had been used for processing radium-226 and actinium-227; (2) the T Building, which had been used for polonium processing; (3) the Waste Transfer System (WTS), which had piped liquid wastes from the SM Building and Building 38 to the WD Building; and (4) any other smaller projects (Combs et al. 1982). These activities required the development of many special tools, techniques, and procedures. Special techniques were developed in planning, exposure control, equipment removal, structural decontamination, and waste packaging (Hermetz 1982, 1986).

The decommissioning of the Dayton Project in 1949 required some areas to be decontaminated and packaged for burial at Oak Ridge before the facilities were demolished. In the case of Unit III, the old school was decontaminated and returned to the Dayton school board. Other buildings constructed on the site for the powerhouse and machine shops were demolished and disposed of at Mound. Much of the interior rooms, partitions, ceiling, walls, floors, and mechanical and electrical equipment at Unit IV had to be removed before the building was turned over to Maxon Construction Co. for demolition. At Unit III, 5,000 disintegrations per minute per 100 square centimeters (d/min/100 cm^2) was the cleanup target (Stoeckle and Hayden 1949). This corresponded to about 2.3 nCi/100 cm^2. Since Unit IV was to undergo complete demolition, a target of 50,000 d/min was used (Halbach 1950).

The D&D of radium-actinium areas in the old cave and the R Building took place over several years in the mid- to late-1950s. The cleanup of the actinium areas in the R Building actually began in March 1953 (Bradley 1953d) and was completed by January 1954 (Rogers and Watrous 1954). The drainage

trenches and the sumps in the cave were filled with sand and covered with a 3-inch layer of concrete (Meyer 1956a). High-risk wastes from the cave were stored in the R Building (Meyer 1957b). Equipment removal took place in phases (Meyer 1957b). The floor of the cave itself was covered with about 2 ft of sand, and a new concrete floor was poured over the sand (Meyer 1959a).

In 1968, the plutonium processing in SM Building came to a close and the first phase of D&D was undertaken. This initial phase of the program was completed in 1972.

The decommissioning of concrete surfaces such as walls, floors, and ceiling included treatment with a high-pressure stream of water. Painted walls, floor, and metal structural members were also treated with the ultra high pressure water. This procedure removed the contaminated paint, leaving a clean, bare metal surface. The large volumes of water generated by this procedure were sent to the WDA for processing.

Glove boxes, process equipment in the glove boxes, and fume and chemical hoods were decontaminated using water, detergent, and hypochlorite. Some process equipment was rinsed with acid solutions to recover plutonium. These wastes were sent to the plutonium recovery process in Building 38. The outside metal parts of glove boxes and hoods were cleaned with metal polish to remove the metal surface contaminated with plutonium. When glove box decontamination satisfied clean definitions, polyurethane was foamed into the glove box interior without removing any glove box equipment. The glove boxes were then packed into 4-ft by 4-ft by 7-ft wood containers, and the void space was foamed with urethane. These were shipped to Maxi Flats for burial.

During the D&D program, 6 kg of plutonium-238 were recovered from the SM Building. Estimates based on sampling in 1972 indicate that 1.5 Ci of plutonium-238 are under the SM Building and 9.7 Ci are in the area of the buried low-risk waste tanks (Flanagan 1976).

Until the 1970s, the principal concern of the D&D Program was buildings and structures and their decontamination for further use, although minor soil cleanups have occurred throughout the history of the plant. With growing environmental concerns, the D&D Program realized the need for decontamination of contaminated soils. A survey of known historical LLW burial sites was conducted in the early 1971 that resulted in the identification and general mapping of 15 areas known or suspected to be contaminated with radionuclides (MRC 1972). The original map produced during the initial compilation is reproduced in Appendix A of this report. Over the next 10 years, additional areas were identified and included in the radiological survey (DOE 1991c). The Site Survey Project collected and analyzed soil samples from known areas of contamination. The project was initiated largely by the needs of the D&D Program in order to estimate the quantities and types of radionuclides, the

volumes and locations of contaminated soil, and the costs of stabilizing or removing the contaminated soils (Stought et al. 1988). The project was the culmination of about 10 years of effort on the part of Mound to obtain funding for the study.

Two areas of contaminated soils were identified by the Site Survey Project as the priority areas for D&D removal, both associated with the WTS pipeline from the SM Building and Building 38 to the WD Building. One area was below the WD Building where the high-risk waste line had ruptured in 1969 and the other was the entire WTS pipeline itself. These areas are now referred to as Areas 14 and 19, respectively, and are described along with the other areas in the Site Scoping Report: Volume 3 - Radiological Survey Report (DOE 1991c). The Site Scoping Report provides a full tabulation of the Site Survey Project data (Stought et al. 1988) and reviews other data handling and analysis procedures within the context of the CERCLA requirements.

The current program started in 1978 after the plutonium-238 processing operations declined through the mid- to late-1970s. The 10-year plan included the complete removal of the SM Building and the entire WTS that ran from the SM Building to the WD Building, among other smaller projects (MRC 1978b). As described above, these areas were contaminated with plutonium-238 from the processing and recovery operations. The SM Building consists of offices, the plutonium processing areas, laboratories, maintenance shops, and building services. The WTS comprised about 2,650 linear feet of two 1-1/2-inch steel pipes at 6 to 25 ft below grade, an associated storage and pumping facility (Building 41), and associated soils. The D&D activities typically have been two-phased: (1) cleaning equipment, removing it from affected areas, and packaging it in approved containers for shipment off-plant; and (2) performing extensive structural decontamination on the affected areas to remove or seal contamination.

3.8.1. Waste Generation

The wastes generated by the D&D Program generally reflect the contaminants from the processes used in the facility being decontaminated as well as the waste produced by the work itself. Radioactive wastes from the D&D Program at Mound have generally been alpha- and tritium-bearing.

The D&D of the older Dayton facilities included the complete removal of Dayton Unit IV and removal of the smaller buildings at Unit III. Contaminated buildings, debris, and equipment were brought to Mound, because the short-lived polonium-210 isotope with a 138-day half-life would soon decay. Five "tropical huts" and the Quonset hut were moved from Unit III to Mound for the storage of contaminated materials (Bradley 1949). These huts were reassembled in the plant valley near where Building 3 stands today (see subsection 5.1). Records of the projects indicate that 100 truckloads of

contaminated scrape from Unit III (Halbach 1949) and 160 truckloads from Unit IV (Halbach 1950) were moved to Mound. It is unknown how much of this material was contaminated equipment and how much was just debris. Concrete and structural steel were disposed of on the west slope of the SM/PP hillside, now known as Area 10 (see subsection 6.1.1.5). Contaminated equipment was stored in warehouse 10 and in the tropical huts. Scrap wood and metal were stored in the open area behind the huts. The stored materials were periodically checked for contamination levels (Bradley 1952b).

By April 1953, the contamination level of equipment stored in warehouse 10 had sufficiently decayed to allow recovery. Wood and other combustible materials were destroyed in July 1955 by burning in the area adjacent to where they had been stored, now known as Area 13 (see subsection 4.18). Scrap metal was covered with fuel oil and also burned (Meyer 1955d). The tropical huts may have also been destroyed by burning at this time. What was left was buried in the historic landfill (Meyer 1955a), now known as Area B (see subsection 4.15). The disposal of all contaminated equipment and building materials from Units III and IV was completed by October 1955 (Meyer 1955f).

From 1953 to 1959, the radium-actinium processing facilities in the SW and R buildings were decommissioned and decontaminated. The R Building cleanup included removal of glove boxes and general decontamination of some of the actinium facilities. At least 18 boxes, size unknown, were filled with demolished equipment and furniture and shipped to ORNL for burial (Bradley 1953i). The high-risk drain trenches in rooms 121, 144, 146, and 148 were filled with vermiculite and covered with concrete (MCC 1953-1957). The entire concrete floor of R-160 was removed and repoured (Meyer 1955b). These facilities included the hot cell or "old cave" where the radium-actinium processing took place. The materials and equipment in the cave in SW Building were packaged for burial off-plant in boxes staged just south of the building. Some equipment was too large to send offsite. The crane and track mechanisms that had been used to move heavy containers within the cave were laid down on the concrete floor with the dismantled shielding from the cave itself and covered or entombed with several inches of concrete (Meyer 1955d; 1958d). This area is now known as Area 15 (DOE 1991c). Equipment continued to be shipped from the D&D of the radium-actinium areas until 1960 (Creamer 1964).

The tanks and evaporator units that had treated the wastes from the separation process were dismantled and stored out in the open behind Building 2 in the lower valley area of the plant until 1960, when they were shipped to ORNL for burial. During the Site Survey Project (Stought et al. 1988), the surface was screened for radioactivity and none was detected. However, the area is not discussed or mentioned in any detail (DOE 1991c).

During excavation work in 1957 on the west side of the SW Building, associated with the thorium Monex extraction process, soils and gravels contaminated with radium-226 and actinium-227 were discovered (Meyer 1956a). These soils were believed to have been contaminated by leakage from the high-level waste sump in the old cave that had previously been entombed. About 200 to 250 ft^3 of soil and gravel were excavated and placed in or near an old septic tank in the upper valley area of the plant. The septic tank is now included in Area 7 (DOE 1991c).

From 1971 to 1973, the portions of the T Building involved with polonium processing underwent D&D and were returned to other uses. Mechanical equipment, including ventilation parts and other service items contaminated with polonium-210, was removed, drummed, and shipped off-plant. Some of the low-level ventilation ducts may have been buried in the ravine in the upper valley, now included in Area 7.

Since the early 1970s, the D&D Program has involved the former plutonium processing facilities, including the SM and R buildings and Building 38. These activities have included D&D of glove boxes, conveyor housing, piping, service equipment, structures, soils, clothing, rags, Kimwipes, shoe covers, plastic, wood, and other miscellaneous debris. As of June 1982, more than 29,000 Ci of plutonium-238 had been removed in scrap and wastes (Combs et al. 1982). Starting in 1980, the only alpha-contaminated waste produced by Mound was from D&D operations (MRC 1983). By 1982, the in-line processing had ceased, and all remaining plutonium-238 residue in equipment undergoing D&D was treated as waste (MRC 1983).

Most of the TRU wastes were removed from Mound by the mid- to late-1980s, although in 1982 the definition of TRU waste was changed nationally from plutonium concentrations >10 nCi/g to >100 nCi/g (NCRP 1982). Currently, more than 95% of the wastes currently generated by the D&D Program are LLW, known as non-TRU alpha waste (EG&G 1989b). In the mid-1970s, hydraulic mechanical compactors were employed to reduce waste volumes; by 1975, compactors existed for both non-TRU alpha and LSA TRU compactible wastes. In 1975, a developmental program was initiated wherein a cyclone incinerator was used to burn the LSA TRU and non-TRU alpha wastes (MRC 1977a, 1978a). By the early 1980s, much of the LLW and some TRU wastes were soils excavated after the removal of the WTS pipeline.

3.9. UTILITIES

Two boilers in the P Building provide Mound with steam for heating buildings. These boilers are normally gas-fired and are capable of burning number 2 fuel oil as a backup. They are capable of producing 70,000 pounds and 85,000 pounds each of steam per hour at a gauge pressure of 125

pounds. Two water treatment processes are used at the plant. External water treatment consists of demineralization using a cation-anion zeolite exchange softener followed by treatment using a reverse osmosis system. The P Building utilities treat 200 million pounds of water annually (Brunner 1991). The water softening system consumes 50,000 pounds of sodium chloride per month for regeneration of the zeolite beds. The regeneration water and the backflush water from the reverse osmosis system are discharged to the storm sewer. The Main Hill storm sewer discharges to the Great Miami River through NPDES Outfall 001, and the plant drainage ditch discharges through NPDES Outfall 002.

The internal water treatment in the P Building consists of adding chemicals to the boiler feed water to prevent corrosion and scale buildup in the boiler and to control the solids content of the boiler water by frequent boiler blowdown. The volume of water generated from blowdown is equal to 1 to 2% of the feed water. The blowdown boiler water is discharged to the sanitary sewer system at Mound.

In 1980, the boiler feed water was treated with sodium sulfite 2548 to remove oxygen and with Transport Plus 2800 as a scale inhibitor. Steam line corrosion protection was achieved using octadecylamine and cyclohexylamine. Between 1983 and 1984, Mound changed vendors supplying water treatment chemicals. The oxygen scavenger named Ox-GPM contained sodium sulfite as the active ingredient. Braxon No. 2 is used as a scale inhibitor and the active ingredient is sodium phosphate. Korromeen is the trade name for the product currently used in the steam line for corrosion protection.

3.10. UNDERGROUND SEWER LINES

The underground sewer lines located throughout Mound convey storm, sanitary, and industrial wastewater from the various research, development, and production facilities to the treatment or disposal facilities. The pipeline construction materials vary, but include vitrified clay and cast iron or steel with diameters ranging from 4 to 10 inches. The older portions of the lines on the Main Hill primarily used vitrified clay. Most recent installations include flanged steel and continuous plastic. The Site Scoping Report: Volume 4 - Engineering Map Series (DOE 1992a) includes drawings of the digitized maps maintained by Mound. Table III.2 is a chronology of usage of the waste lines transcribed from a memo by a Mound employee (Hurwitz 1974). General descriptions of the system follow. Currently, all older, underground process sewer lines are being scheduled for removal by the D&D Program.

The storm sewer system includes both underground and surface runoff channels. On the Main Hill, storm water is routed through a series of underground pipes that drain to either the plant drainage ditch or the sanitary sewer pipeline. Historically, all storm water drained to the plant drainage ditch. In the

Table III.2. Hot Waste System Chronology

1947 - Present	Polonium-210 from H to T to WD, thence effluent to closed pipe to river.
1947 - 1953	Polonium-210 from B to WD, thence treated effluent to closed pipe to river.
1947 - 1956	Polonium-210 from T to HH to WD, thence treated effluent to closed pipe to river.
1947 - 1967	Polonium-210 from R to WD, thence treated effluent to closed pipe to river.
1967 - 1970	Polonium-210 from R to WDA, thence treated effluent to ditch.
1955 - 1967	Plutonium-239 from R to WD, thence treated effluent to closed pipe to river.
1967 - 1970	Plutonium-239 from R to WDA, thence treated effluent to ditch.
1970 - Present	Plutonium-239 from R to WD, thence treated effluent to closed pipe to river.
1959 - 8/67	Plutonium-238 from R to WD, thence treated effluent to closed pipe to river.
6/61 - 8/67	Plutonium-238 SM: High-risk to burial, low-risk treated at SM, effluent to ditch.
8/67 - 12/70	Plutonium-238 form R to WDA, thence treated effluent to ditch.
12/70 - Present	Plutonium-238 from R to WD, thence treated effluent to closed pipe to river.
8/67 - 12/70	Plutonium-238 from SM to Building 41 to WDA 2 lines: High-alpha immobilized and sent to burial. Low-alpha treated and effluent to ditch.
12/70 - Present	Plutonium-238 as above but low-alpha from WDA to WD; thence treated and effluent to closed pipe to river.
6/68 -	Plutonium-238 from Building 38 to SM, thence as above.
1958 - 1966	Tritium[a] from SW to storm drains after dilution, thence to ditch.
1960 - 1966	Tritium[a] from SW to WD, thence (diluted) to closed pipe to river.
1966 - 1971	Tritium[a] from SW to WDA, thence diluted effluent to ditch.
3/72 - 12/72	Tritium[a] from SW to WDA to burial via tank truck.
1973 - Present	Tritium[a] from SW to WDA, thence immobilization and to burial.

[a]Low-risk only. High always immobilized at SW and buried.

Table III.2. (page 2 of 2)

STORM SEWER SYSTEM CHRONOLOGY

1947	Original drainage system installed using closed drains around original buildings with discharge to natural open drainage ditch. Lower parking lot and adjacent areas drain off-plant via Mound Avenue.
1963	Drain line from vicinity of I Building tied through flow divider to outfall line dilute WD/SD effluent flow. Excess storm flow continues on to drainage ditch.
1957 - 1967	Local building drainage (following natural drainage) added as buildings were completed in Test Fire and SM areas.
1970	Weir and measuring station installed on drainage ditch near site exit.

SANITARY SEWER SYSTEM CHRONOLOGY

1947	All upper area (lettered buildings except OS) connected to original SD. Treated SD effluent to outfall to river. Various additions and reroutings have occurred including GS-1, 47, 28, M, 40, OS, B, RE, and 48.
1957	Building 2 - septic tank system
1959	Building 1 - settling basin only (no sanitary wastes)
1960	SM - septic tank system
1964	Building 3 - septic tank system
1966	Buildings 29, 36, 38 - septic tank system
1967	Building 37 - septic tank system
1968	Lower area plus SM area tied to lift station at Building 27, thence to SD
1968	Building 43
1969	Buildings 27, 44, 45, 46
1970	Buildings 42, 49, 50
1971	Sampling MH added to outfall line
1974	New sewage disposal plant to replace SD

Ref: Modified from Hurwitz 1974.

late 1960s, fear of chloride buildup in the plant effluent from the backwash of the zeolite water softeners in the P Building resulted in the routing of storm water runoff on the west side of the Main Hill to the sanitary sewer pipeline. An overflow diverter box was installed to permit normal flow to pass from the storm water channel into the sanitary sewer; but, during high flow events, the overflow is diverted to the plant drainage ditch. On the SM/PP Hill, storm water is now routed to either the asphalt-lined pond to the north or the overflow pond to the south. The ponds are part of the treatment system installed along the plant drainage ditch, designed to control suspended sediments in the plant effluent. These ponds are described in the treatment section of this report. Storm sewers from the SM Building were installed in 1960 when the building was constructed. Two storm water outfalls along the upper reach of the plant drainage ditch received treated wastewater from the plutonium facilities in SM. The plutonium wastewater treatment was moved to WDA Building in 1967, and the outfalls were abandoned in the late 1970s when the asphalt-lined pond was constructed.

The sanitary sewer system was largely installed during the initial plant construction, but has been modified and enlarged to accommodate the growth of the plant. Originally, all the buildings on the Main Hill were connected to the system of underground pipes that fed the old sanitary sewage disposal plant in the SD Building. The underground pipes on the Main Hill carried wastewater from laboratory toilets and showers, laboratory sinks, some of the laboratory and production area service sinks and floor drains, and photographic and plating processes. The sanitary sewer pipeline from the SD Building to the Great Miami River was shared with the WD Building. In 1975, a new sanitary wastewater treatment plant (Building 57) was constructed in the lower plant valley, and the old SD plant was abandoned (see treatment section for descriptions). The pipeline to the Great Miami River was slip-lined with continuous plastic in 1981 to preclude leaks. This pipeline was originally constructed largely of vitrified clay, but contained sections of steel and cast iron west of the plant, where it passed under the railroad and highway, respectively.

The sanitary sewer has received many contaminants from the laboratories and processes. The laboratories used strong acids and bases, volatile organic solvents, and heavy metal salt solutions from etching and plating. While most of these are currently contained and controlled, some solutions have been released to the sewer lines. In the 1950s, a plumber working in R Building created quite a stir when the torch he was using caused a small explosion in the pipe system. Several drain plugs were blown loose in adjoining rooms. Plant management immediately ordered all personnel to stop dumping flammable liquids down the drains (Garner 1991). The sanitary sewers in the SW Building washrooms were known to be contaminated as early as 1952 (Bradley 1952i). Photographic process areas may have released small quantities of silver, and the plating shops may have discharged rinse waters that contained heavy metals, acids and bases, and organics such as perchloethylene and acetone.

The process sewer lines were constructed to transfer radioactive waste solutions from the research and production facilities to the WD Building. These lines were originally constructed of in-ground, vitrified clay enclosed in concrete, but have been upgraded and expanded with steel pipe. Most recently, they were replaced by above-ground, continuous plastic. Historically, the WD Building received alpha wastewater from the H, B, R, and T buildings through 8-inch vitrified clay pipes. The HH Building transferred wastewater through a schedule 80, 3-inch steel pipe. The SW Building was tied into the system with an in-ground, 4-inch steel pipe at an unknown date. In 1967, the system was generally overhauled. A new 8-inch vitrified clay alpha wastewater pipe was installed from the H, SW, and R buildings to the WD Building, and a 4-inch, flanged steel pipe with a plastic lining was installed from the SW Building to the WD Building for low-level beta wastewater. Also that year, the WTS pipeline was installed from the SM Building and Building 38 to the WDA Building. Map locations and some of the construction details of the process or "hot waste" sewers are shown on Mound drawing No. 5-1398, included in Appendix A.

The WTS pipeline is of specific interest because leaks along its length have caused some environmental concern, and its D&D has created a considerable low-level waste stream. The pipeline system consisted of two flanged steel pipes that drained by gravity flow to two 2,000-gallon holding tanks at Building 41. A 1-1/2-inch pipe transferred high-risk wastewater generated within the process lines, and a 2-inch pipe transferred low-risk wastewater generated from showers and cleanup water outside the glove box systems. From Building 41, the wastes were pumped up the hill to the WDA Building through two 1-1/2-inch lines. The pipes were buried from 6 to 20 ft underground except where they passed over the plant drainage ditch.

Leaks in some of the pipes resulted in their abandonment. In 1969, the high-risk pipe in the WTS sprung a leak in the pressure system between the Building 41 pumphouse and the WDA Building. Contaminated dirt and soil overburden were excavated by the D&D Program in 1969, but the full extent of the resulting off-plant contamination in the Miami-Erie Canal was not realized until 1974 (Rogers 1975). The Miami-Erie Canal is currently in the ER Program as Operable Unit 4 (DOE 1992g). Other leaks in the WTS pipeline resulted in the high-risk pipe being abandoned and a high-risk waste solidification facility, known as WS, built in 1974. The original in-ground, low-risk pipe in the WTS pipeline was replaced in the late 1960s with an above-ground pipe of similar construction. To avoid interruptions to the plutonium production in Building 38 (also known as PP Building), a 2,000-gallon tanker truck was used to haul wastewater to WDA for processing. When the line was completed, the trucking operations ceased. The low-risk line was eventually abandoned in 1976, and the waste liquids have since been moved by truck. The entire length of the WTS has now been removed and is known in the ER Program as Area 19 (DOE 1992g, 1991c).

In 1975, the low-level wastewater beta line from the SW Building was found to be leaking and was abandoned and replaced. The new above-ground pipeline consists of a continuous 1-1/2-inch polyethylene pipe encased in a 3-inch pipe of the same construction (MRC 1983). In 1982, an above-ground alpha wastewater pipe from the R Building to the WD Building was constructed of a 2-inch polyethylene pipe encased within a 3-inch pipe of the same construction.

The 3-inch steel pipe from the HH Building to the WD Building has also been abandoned in place. Leaks along this pipe during the period of polonium processing created some soil contamination now known as Area 20 (DOE 1992g, 1991c). One leak was discovered December 23, 1954, and was cleaned up and repaired by December 28 (Meyer 1956a). Another leak was discovered and repaired during the summer of 1958. An area of 40 to 50 ft^2 appeared to be contaminated and was sodded to confine the activity (Meyer 1958c). The polonium production byproduct precipitation processes were moved from the HH Building to the T Building in 1959 (Meyer 1959a), at which time the 3-inch line was abandoned in place. One report (Biles 1973) suggests that the line was abandoned in 1954. No record could be found that the line may have been replaced.

In 1955, a leak was discovered in the 8-inch vitrified clay pipe from the south part of T Building to WD Building. This pipe was abandoned in place, and a new 5-inch steel pipe was laid directly on the concrete encasement (Biles 1973). In 1970, a leak was discovered in the 8-inch vitrified clay pipe from the north part of T Building to WD Building. This pipe was also abandoned in place, and a new 3-inch steel pipe was laid directly on the concrete encasement (Biles 1973).

3.11. GENERAL ALPHA WASTEWATER SOURCES

There are several potential sources of alpha wastewater at Mound, including the H, R, SW, SM, and WD buildings, Building 38, and the old alpha waste line. The SW and R buildings are addressed as the SW/R complex. Similarly, the SM Building and Building 38 now share the same system for the disposal of alpha wastewater and will be addressed as the SM/PP complex.

Floor drains in these buildings discharged materials to the alpha wastewater treatment system. Materials common to the building's floor drains include soapy shower water, mop and plutonium decontamination water, cleansers (Bowmans) and detergents, oils, paint, alcohol, and acetone. Approximately 200 pounds per year of acids (nitric, sulfuric, hydrochloric, and hydrofluoric) were discharged into drains from laboratory sinks (MRC 1985b). Sources from the individual buildings are discussed in the following subsections.

3.11.1. H Building Wastewater Sources

The H Building houses the laundry facilities for both uncontaminated (cold) and historically contaminated (hot) clothing for Mound. All of the water generated at the H Building from the laundry, the floor drains, and a sink is collected in a holding tank on the "hot side" of the building. The water then drains through a pipe to a lift station at the SW Building. From the lift station, the H Building water is pumped to the WD Building alpha wastewater influent tanks. The "hot" side of the facility is no longer in use (Hopkins, L. 1991).

Products used in the H Building that enter this waste stream include liquid soap that contains ethylene glycol monobutyl ether and sodium hydroxide, powdered soap that contains ammonium bicarbonate and sodium hexametaphosphate, and fabric softener (WESTON 1990).

3.11.2. SW/R Complex Wastewater Sources

Although the SW/R complex is mainly devoted to tritium processing, a small section, known as the alpha side, handled alpha-emitting radionuclides such as plutonium-238 and -239. The sink and floor drains from these laboratories are connected to a sump equipped with a steam lift pump that pumped the wastewater to the R Building and then to the WD Building alpha influent tanks. Mound personnel report that they have not been used in 3 to 4 years. (For the last several years that the area was in operation, the wastes were pumped from the sump to 30-gallon drums, then transported to the WD Building.) When the area was in use, it served as a research and development laboratory, mostly involving solvent extraction. Chemicals used included carbon tetrachloride, dichloromethane, trichloroethane, organophosphate, nitric acid, and sulfuric acid (WESTON 1990).

Yearly estimates of waste materials sent to the WD Building from the R Building laboratories included hydrogen peroxide; ammonium hydroxide; hydrofluoric, nitric, sulfuric and lactic acids (approximately 7 pints total); methanol, propanol, mineral oil, ethanol, acetone and trichlorethylene (approximately 5 pints total); sodium sulfite solution (approximately 1 pint); and 86 pounds of various chemicals including potassium and copper sulfates and carbonates and sodium hydroxide/lime (MRC 1985b).

3.11.3. SM/PP Complex Wastewater Sources

The piping, sumps, tanks, equipment, sinks, and other structures once present in the SM Building have all been removed by the D&D program. LLW alpha waste was historically generated in the SM Building as part of the plutonium processing operations, as described in subsection 2.2.2.

Wastewater sources include floor drains, shower water, sinks, and a laboratory still in operation in Building 38. Wastewater from these sources drains to two 500-gallon sumps in Building 38 (MRC 1985c). This sump water is then pumped to a 10,000-gallon tank on the west side of Building 38. From this tank, the water is pumped to a 5,000-gallon tanker truck, which transports it to the WD Building. At the WD Building, the tanker truck contents are pumped into the WDA Building tanks for treatment. The tanker truck transports waste approximately once per week. The hauling capacity of the truck is administratively limited to 3,500 gallons.

The laboratory still in operation in Building 38 performs a variety of analytical procedures, such as mass spectrometry, calorimetry, ion exchange, radiochemical separations, liquid scintillation, gamma spectroscopy, and plating of alpha samples for counting. With the exception of liquid scintillation vials, which are bagged for pickup by Mound waste management personnel as mixed wastes and sent to Building 23, all spent chemicals are assumed to be radioactively contaminated and are poured down the sink drains. The drains are connected to the Building 38 10,000-gallon tank. Chemicals used in the laboratory include acetone, nitric acid, sulfuric acid, sodium hydroxide, and acetic acid. Trichloroethane, once used in the SM/PP complex as a degreaser for metal parts, is no longer used (WESTON 1990).

3.11.4. WD Building Wastewater Sources

With the exception of the toilets, which are connected to the sanitary sewer system, all of the floor and sink drains in the WD Building are connected to the sumps in the basement of the building (Mills 1991). The basement and sub-basement each have sumps that are connected to the four 30,000-gallon influent storage tanks (Mills 1991). Similarly, the floor drains in the WDA Building are connected to a sump in the WDA basement. This sump is then connected to two 3,750-gallon tanks. These two tanks are pumped to one of the four 30,000-gallon WD alpha influent tanks.

There is a small laboratory in the WD Building where the alpha and beta waste streams are analyzed and a small amount of other work is done. The laboratory is used to perform pH analyses, sludge moisture analyses, and influent and effluent scintillation counts (Mills 1991). This laboratory is not used on a routine basis, but the sink is connected to the WD sumps described above. Hazardous compounds used in the laboratory include Instagel, which has a xylene base. This material is being replaced with nonhazardous Ultimate Gold (Klingler 1991). Liquid scintillation analysis is also performed in this laboratory, and a container of the cocktail mixture is kept in a fume hood. The container dispenses the amount of cocktail required for a scintillation vial. After use, the vials are bagged as mixed wastes for collection by the Mound waste management department and taken to Building 23 for storage.

3.11.5. Old Alpha Waste Line Wastewater Source

Before construction of the above-ground alpha wastewater transfer line, alpha wastes were transferred to the WD Building through an underground waste line, known as the old alpha waste line, which was connected to the SW/R complex and the laundry in the H Building. Although all of the drains and other connections to this line are believed to be plugged, a small amount of water from this pipe is still received at the WD alpha influent tanks, mainly after rains.

3.11.6. Building 23 Sump Wastewater Sources

Building 23 is adjacent to the WD Building and is used to store drummed radioactive and mixed wastes prior to shipment to an approved off-plant disposal facility. Several floor drains in the building collect any spills or leaks from the drums and are connected to the sump. If a spill occurs that is large enough to contribute to the sump, the sump will be sampled. Nonradioactive or clean material will be released to the sanitary sewer system. Contaminated material will be pumped to the WD Building alpha wastewater influent tanks.

3.12. GENERAL BETA WASTEWATER SOURCES

3.12.1. SW and R Building Wastewater Sources

The sources for the low-level tritiated wastewater generated in the SW and R buildings tritium complex are emergency (domestic) single-pass cooling water and tritium (hot) sinks in the decontamination area where tritium process equipment is cleaned. The equipment is cleaned using steam, biodegradable soap called Planisol M, and a window cleaner that contains isopropyl alcohol.

The sinks and drains in the mass spectrometry laboratory are also wastewater sources. An interview with Mound personnel in the mass spectrometry laboratory revealed that acetone and ethanol are used to clean the mass spectrometry equipment. The laboratory also includes a chilled water system, mostly closed, that contains ethylene glycol. There are no other contributors to the SW Building sump; the laboratories do not contain sinks, contain sinks with plugged drains, or contain sinks that are not connected to the SW Building sump and consequently to the WD Building beta waste line.

The wastewater from the SW Building is collected in two 125-gallon tanks that are discharged into two 3,750-gallon tanks, which serve as the beta wastewater treatment system influent tanks, in the WD Building (MRC 1979). The wastewater from the SW Building was pumped to the WD Building through an underground plastic-lined pipe with flanged fittings. In late 1975, the line was found to leak and

was immediately abandoned. In September 1977, a new continuous double line, consisting of 1-1/2-inch polyethylene pipe encased in a 3-inch polyethylene pipe located above-ground, was installed between the SW/R complex and the WD Building (MRC 1983). During the time the new line was being built, the tritiated wastewater was manually emptied from the 125-gallon tanks into 30-gallon drums with liners for transport to the WD Building for treatment (MRC 1979).

Approximately 30,000 gallons per year of the SW Building wastewater are pumped to the WD Building beta influent tanks. The sources for the tritium (beta)-contaminated water include tritium-process laboratories in the SW Building. No other buildings at the plant are connected to this system. However, it should be noted that the SW and R buildings are adjacent to each other and share several corridors and laboratories.

3.12.2. T Building Wastewater Sources

The other sources for the WD Building beta influent tanks are the tritium-processing laboratories in the T Building at Mound. Although similar functions are performed in the T and SW buildings, the T Building is not connected to the beta wastewater line to the WD Building because it was built much later, when Mound was concerned with the possibility of radioactive waste line breaks. Therefore, water from the T Building equipment decontamination and floor mopping is drummed in 30-gallon drums and transported directly to the WD Building, where it is pumped into the beta influent tanks. The only other potential source in the T Building is the sprinkler system. Floor drains are connected to a 15,000-gallon holding tank on the first floor. In the event of a fire, the water from the sprinklers would be collected in the first floor tank. The water would then be sampled, and clean water would be released to the sanitary sewer system, while tritium-contaminated water would be pumped into 30-gallon drums for transport to the WD Building beta influent tanks. The sprinklers have never been used. Most of the laboratories on the hot side of the building do not contain sinks, and the floor drains are plugged or are sloped toward a drain for use if the sprinklers are activated (WESTON 1990).

3.12.3. HH Building Wastewater Sources

Small quantities of very low-level tritiated wastewater were also generated from decontamination operations in the HH Building. This wastewater was collected in a small sump, transferred to a drum, and transported a short distance to the WD Building. At the WD Building, the wastewater was transferred to a 55-gallon drum where it was mixed with cement and solidified. The HH Building generated approximately 30 gallons of wastewater per year (MRC 1983).

3.13. WASTE TRANSPORT VEHICLES

Waste transport vehicles have been used since the 1950s. Currently, waste transport vehicles used at the site include hand carts, fork lifts, a modified step van, box vans, a cargo-bed truck, a stake-bed truck, and a tanker truck. The hand carts are used indoors to transport drummed hazardous wastes over short distances. The step van and box van transport explosive wastes in containers from various on-plant locations to Area H. Step and box vans are completely enclosed to prevent exposure of pyrotechnic waste containers to sunlight or precipitation. Drummed hazardous wastes are transported by a stake-bed truck and a cargo-bed truck to the hazardous waste storage area inside Building 72. Mixed wastes are transported to Building 23 (Klingler 1991). Drums are restrained on the bed of the stake-bed truck by removable sidewalls. Low-level wastewater from the SM/PP complex collects in a 10,000-gallon tank on the west side of Building 38 and is hauled from the tank to the WD Building by a 5,000-gallon tanker truck. Sources of this wastewater include floor drains, shower water, sinks, and laboratory drains. The wastewater may contain acetone, nitric acid, sulfuric acid, sodium hydroxide, and acetic acid, as well as plutonium and heavy metals as described in other sections in this report.

Historically, the plant used an old flat-bed truck for moving wastes around the plant site. This truck was used in the 1950s and 1960s for transporting casks of polonium from their unloading area along the railroad siding to T Building, moving radioactive wastes from HH Building to the Old Bunker site, moving drums from the Old Bunker site to Warehouse 15, and moving thorium drums around the plant to various areas and Building 21. This truck was eventually buried in the upper valley area, now known as Area 7 (DOE 1992g).

3.14. VENTILATION HOODS

Approximately 570 ventilation hoods are in service at various indoor locations at Mound. The start-up dates vary. Ventilation hoods are located over laboratory and process areas at the facility and are equipped with fans to accelerate discharge. Metal ducts convey the exhaust from the hoods through filters to the roofs of the buildings. The hoods are designed to collect and vent gases, fumes, and other particulate matter to the atmosphere. Many processes allow liquids to evaporate before disposing of towels and rags into proper containers. According to the site inspection, ventilated wastes include explosive gases, paint fumes, dust, acid gases, asbestos, and other chemicals (EPA 1988). Hazardous constituents of these waste streams include acetone, trichloroethene, benzene, tricholoromethane (chloroform), toluene, dichloromethane (methylene chloride), hydrofluoric acid, hydrochloric acid, sulfuric acid, nitric acid, 2-butanone, and asbestos (EPA 1988). Air releases are registered with the Regional Air Pollution Control Authority.

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4. WASTE TREATMENT FACILITIES

On-plant treatment of wastes generated by Mound production, research, and development activities has generally been limited to the processing of the liquid LLW from the polonium-210 and plutonium-238 processes, although other waste treatment processes such as incineration and liquid LLW solidification have been used. The liquid LLW from the polonium-210 and plutonium-238 processes was treated on-plant to produce a surface water effluent and solid LLW sludge. The solid LLW sludge was generally shipped off-plant, but was incinerated on-plant in the mid-1970s. Tritiated wastewater was historically diluted and released as a surface water effluent; but, since 1971, it has been solidified and shipped off-plant. Trial burns of a glass melter furnace were conducted in the mid-1980s as a mixed waste treatment process. The LLW sediments resulting from surficial erosion of plant soils are not truly treated, but are allowed to settle in the engineered ponds, reducing the suspended sediment load of the plant's surface water effluent. Hazardous wastes, some LLW wastes, and classified explosive wastes were historically destroyed by open burning. The following subsections provide detailed descriptions of these and other treatment facilities used over the history of Mound. Figure 4.1 shows the locations of the waste treatment facilities.

4.1. ALPHA WASTEWATER TREATMENT FACILITIES

4.1.1. WD Building

The central facility for the treatment of liquid radioactive wastes at Mound is the WD Building (Figure 4.1), which houses the alpha and beta wastewater treatment systems. The WD Building was constructed as part of the original plant design in 1948 and became operational in February 1949. It was originally designed to accept all liquid wastes generated from process operations and research activities; but, in practice, most wastewater was pretreated to remove the highest percent of solids possible or was treated independently of WD. Since its beginnings, alpha wastewater treatment has been the core of WD operations, supporting the polonium operations until 1971 and plutonium operations since. Alpha wastewater sources include the process operations in the SW and R buildings and Building 38 and the wastewater sumps in the WD Building. Historical alpha wastewater sources included the B, HH, H, and SM buildings. The beta wastewater facility was installed in the mid-1960s. Beta wastewater sources included the SW, R, T, and HH buildings.

The alpha treatment system has always treated only dilute low-risk wastewater. The low-risk wastewater originated outside the process glove boxes from sources such as floor moppings, and high-risk wastewater originated within the glove box systems. During the era of polonium production, the supernatant liquid from the coprecipitation processes in the HH and T buildings was piped to WD for

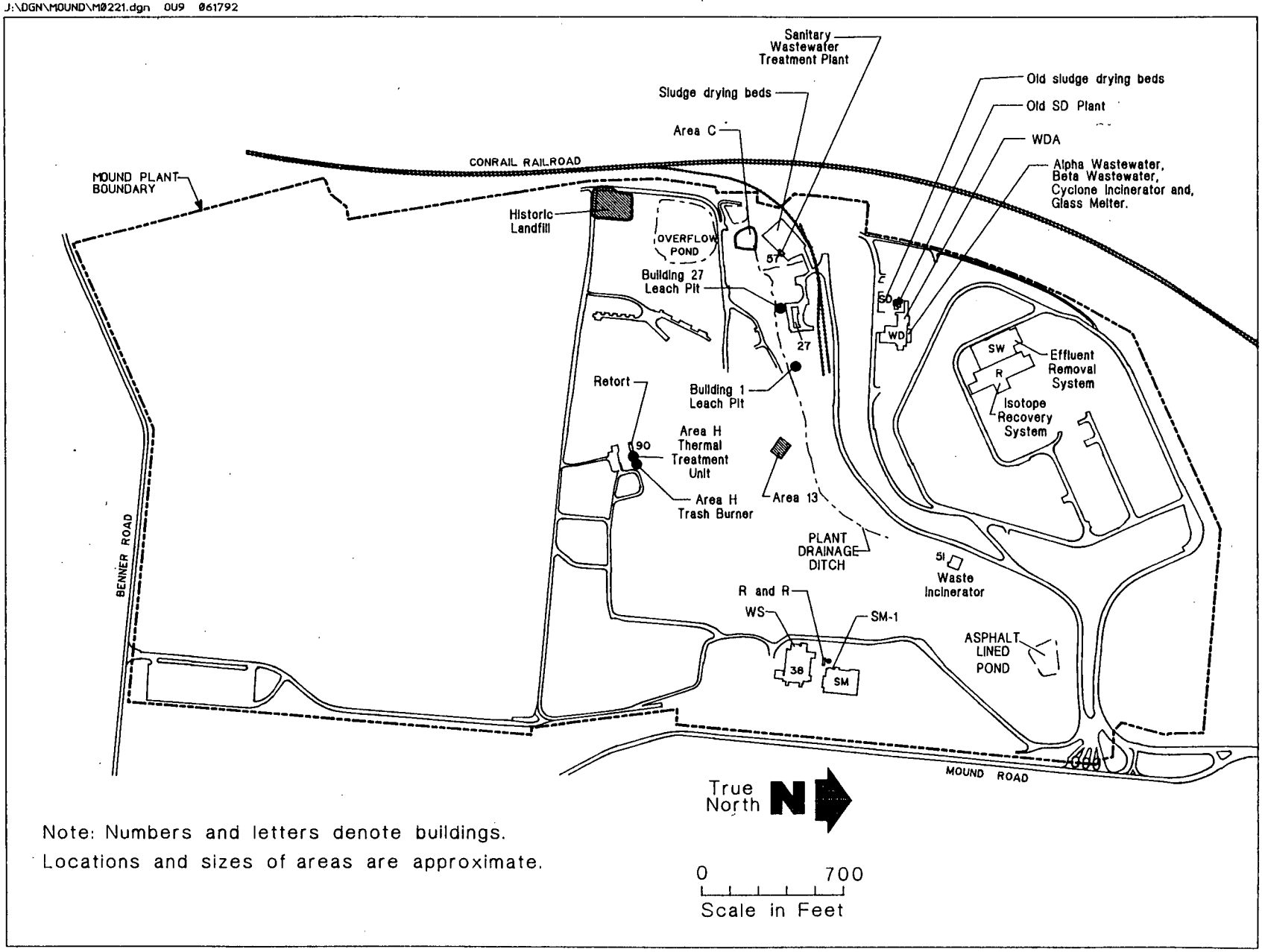

Figure 4.1 Waste treatment facilities.

further treatment before being released to the Great Miami River. The precipitation sludges were drummed directly in the HH Building. Other polonium wastewater sources included the R Building and the laundry in the H Building. When the plutonium production began in the SM Building in 1961, the wastewater treatment facilities in WD were augmented by a separate similar facility in the SM Building, described below. In 1966, the WDA was constructed to accept the plutonium wastewater from SM operations. Treatment of the low-risk plutonium wastewater at the WDA began in August 1967, upon completion of the WTS pipeline from the SM complex to WDA. The WDA facility was used for low-risk plutonium wastewater until 1971 when the polonium operations ceased and the larger WD facility was renovated for the treatment of plutonium wastewater.

Currently, low-risk plutonium wastewater from the D&D of the plutonium facilities is the main source of alpha wastewater. Both the high- and low-risk plutonium wastewater consisted primarily of plutonium-238 and plutonium-239 with americium-241, neptunium-237, uranium-235, and uranium-234 at trace concentrations.

4.1.1.1. WD Alpha Wastewater Treatment System Process

The low-risk alpha wastewater is treated in a precipitation, coagulation, filtration, and solidification process that has been the core of WD Building processing operations since it was built. The low-risk wastewater originates from the process operations in the SW, R, and H buildings, Building 38, and wastewater sumps in the WD Building. Historically, the WD Building received wastewater from the B, HH, and SM buildings.

Figure 4.2 shows the process flow for the alpha wastewater in the WD Building. The chemical extraction process was summarized by Althoff in 1968. There are four 30,000-gallon influent tanks constructed of epoxy-coated steel outside the north wall of the WD Building in a below-ground concrete vault (DOE 1991b). These tanks serve as feed tanks for the clariflocculators in the alpha wastewater treatment system. Alpha-contaminated wastewater is currently pumped into the tanks through pipelines from the H, R, SW, and WD buildings and is delivered by tanker trucks from the SM/PP Building complex. The pH is adjusted from 11.0 to 11.5 by the addition of sodium hydroxide to the tanks. Activated carbon, calcium chloride, and ferric sulfate are added in varying predetermined quantities to provide absorption, flocculation, scavenging, and phosphate precipitation. Two mixers are installed in each tank to provide agitation and keep the solids from settling. The wastewater is then pumped from the tanks to the clariflocculators (MRC 1983). The vault surrounding the four wastewater influent tanks is equipped with a visual leak detection system. The leak detection system is part of the original construction. Each influent tank is a steel tank within a concrete vault. A space between the two allows any leakage from the steel tank to collect in the sloped floor of the concrete tank and drain through an opening to a collection bottle inside the building. Any liquid leaking from

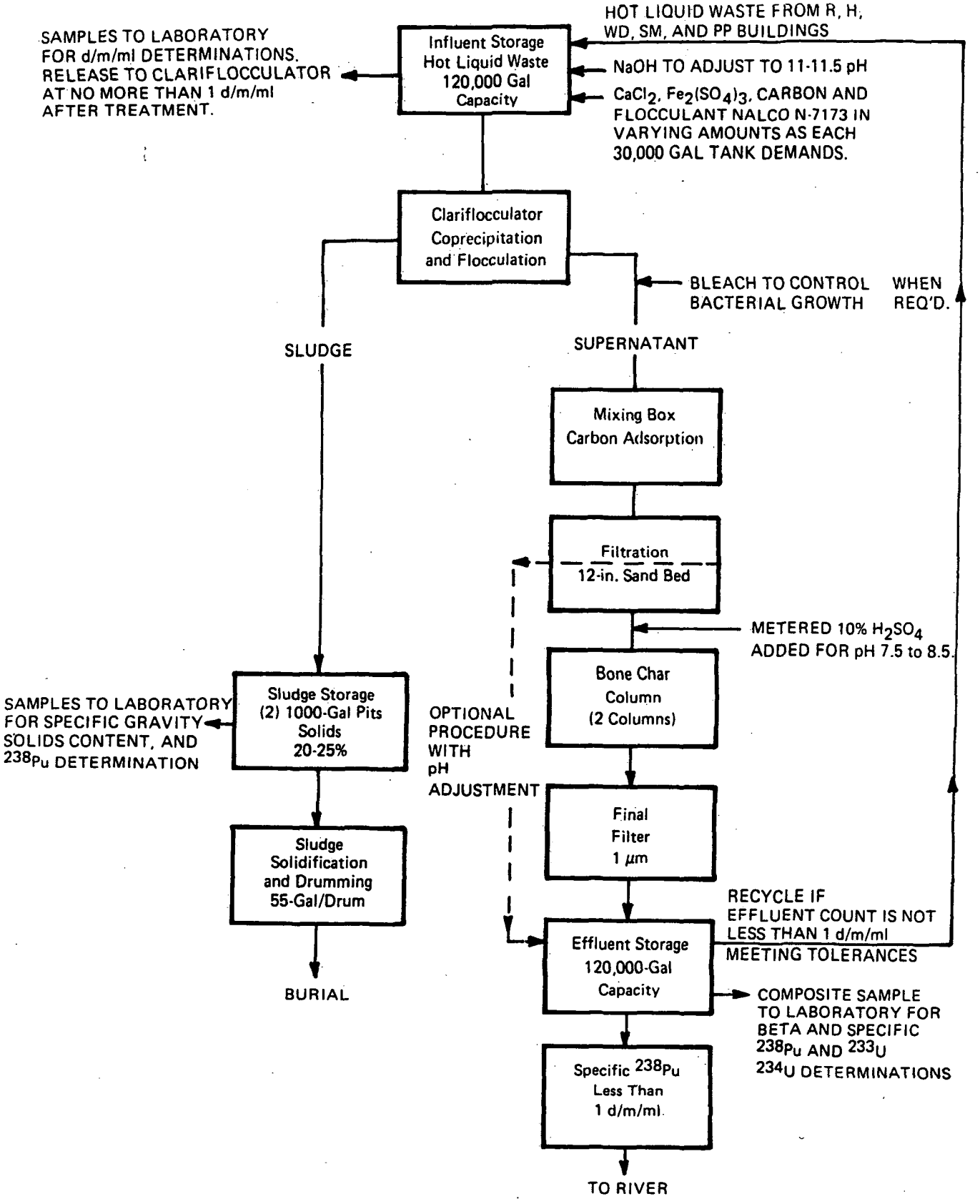

Figure 4.2. Waste disposal process flow diagram (MRC 1984b).

the tanks or pipes inside the vault is observed in the collection bottle. No leaks have ever been found (Mills 1991).

The heart of the low-risk alpha wastewater treatment system consists of two clariflocculators, two sand filters, two bone char columns, four effluent storage tanks, two sludge pits, and a sludge solidification and drumming unit. The bone char filters have been used for about the past 20 years. In 1973, Mound received a patent for the bone char filter process. The filters consist of natural calcium hydroxyapatite, a product prepared from cattle bones. Wastewater treated with additives (carbon, calcium chloride), flocculent (ferric sulfate, Nalco 676), and pH-adjusting chemicals (sodium hydroxide) is discharged into one of two 60,000-gallon clariflocculators for settling (DOE 1991b). The remaining clariflocculator is used as a standby unit.

The sludge from the clariflocculators is currently pumped into two 1,000-gallon sludge pits where it is sampled on a batch basis to determine activity level, specific gravity, and solids content. The sludge is then discharged to the sludge solidification and drumming unit where it is solidified with cement in 55-gallon steel (17C) drums lined with high-density polyethylene TRU liners. If the analytical results show that the sludge is non-TRU, the sludge is solidified with cement in 55-gallon (17H) drums with no liners. The solidified sludge is staged in Building 23 for shipment and off-plant disposal.

The supernatant from the clariflocculator is filtered through sand beds, a bone char filter, and a 1-micron filter prior to discharge into four 30,000-gallon effluent storage tanks (DOE 1991b). The effluent in the storage tanks is neutralized with sulfuric acid to a pH of 7 to 8 prior to being discharged to the Great Miami River. Effluent that does not meet discharge criteria is recycled back into the treatment system (MRC 1983). These tanks are currently provided with a visual leak detection system. Liquid that may leak from the tanks or piping inside the vault flows back into a container in the sub-basement inside the WD Building to provide a visual indication of a leak (Mills 1991).

All units of the treatment system are on the first floor of the WD Building with the exception of the sludge pits that are on the second floor. The sidewalls of the clariflocculators extend from the first floor to several feet above the second floor. All units are underlain with a concrete floor and are covered by the building roof.

4.1.1.2. WD Alpha Wastewater Treatment System: Historical Perspective

The WD facility began operation in February 1949 largely in support of the polonium processing operations. The treatment process had been researched through a pilot plant phase at the Dayton Project, but it took considerable effort before the treatment process was perfected. The supernatant

liquids from the polonium processes in the HH Building, as well as other wastewater from the research activities in the B and R buildings, were transferred through underground pipes to the WD influent tanks. Influent included organic chemicals with alpha and beta activity from chemical research, detergents from the laundry, digested tissue, animal hair, organic solvents from biological research, and process wastes (MCC 1952a). Samples of the tank contents were taken to determine treatment requirements. Tank contents were neutralized with sulfuric acid to a pH of 7.0 to 7.5 and treated with sodium sulfide, aqua regia, calcium chloride, and/or barium chloride solutions. The contents of the tanks were metered to the clariflocculators where aluminum sulfate and sodium hydroxide were added. The pH was maintained at 8.8. Solids precipitated out in the clariflocculators, producing a sludge blanket.

The sludge was transferred to two tanks where it was sampled and the solids content determined. Sludge under 5% solids was dewatered in Eimco rotary drum filters. Sludge over 5% solids was transferred to Pfaudler reaction vessels where the sludge was treated with bismuth trichloride in 6N hydrochloric acid and was contacted with hydrogen sulfide gas. The sludge was stirred in the reaction vessel and subsequently discharged to 30-gallon drums. The separable liquid was withdrawn by vacuum through a Moore-type basket filter and transferred into a holding tank. When the drum was full of dewatered sludge, it was sealed and shipped for off-plant burial (Stringham 1952). The filtrate was monitored and if the count exceeded 2,500 d/m/mL (i.e., 112.5 nCi/m/mL), it was recycled back to the Pfaudler reaction vessels. If the activity was low enough, it was mixed with water to dilute the acid and pumped to the Great Miami River for disposal (Huddleston 1953).

The supernatant from the clariflocculator was filtered through sand and transferred to the four 30,000-gallon effluent tanks. The filtered effluent was sampled and either recycled back into the influent tanks for reprocessing or diluted in a mix box with water and sent to the Great Miami River for disposal (Harris 1950b). The estimated activity level in the effluent was 12 to 13 d/m/mL (Mead 1950), or about 4.5 pCi/mL.

Operation of the WD facility from February 1949 to late 1950 proved to be very inefficient. By April 1950, it was apparent that the count in the effluent, particularly the beta activity, was not being reduced to a satisfactory level. An intensive series of pilot plant tests was conducted. Treating the influent was studied; influent tests included adding treatment agents (clay, iron, copper, powder, diatomaceous earth, bismuth-chloride) and filtering, distillation, coated filtering, multiple precipitations with bismuth-chloride, precipitation with bismuth-chloride and alum, displacement deposition on metals, and electrodeposition. None of these tests proved beneficial (Harris 1950a). Effluent from the clariflocculators was cloudy and contained considerable activity. From September 1950 to October 1950, the average activity in the effluent was 1,404 counts/minute/milliliter (c/m/mL) (630 pCi/mL).

The sand filters were not performing as efficiently as expected. They were caked in some areas, which allowed carbon and colloidal material to pass through. Average activity in the sand filter effluent during September to October 1950 was 264 c/m/mL (118 pCi/mL), which was an order of magnitude above the removal goal (Harris 1950b).

Pretreatment methods were inefficient and not successful in precipitating the activity. Some chemicals were added to the influent tanks through the tank top by hand. Control of the alum addition rate to the clariflocculator was performed manually and resulted in varying clariflocculator concentrations as the influent rate varied.

In October 1950, the Research Division took control of the WD facility from the Operations Division. A pretreatment technique was developed shortly thereafter, and the operation of the process became satisfactory (Huddleston 1953a). Undiluted contaminant concentrations in the process effluent were reduced to levels of 36 d/m/mL (16 pCi/mL) (Rauscher 1950).

Laboratory work continued on methods to improve the performance of the operation. Tests were performed on improving the sludge system efficiency, and various experiments were completed to increase volume reduction or remove activity from the sludge. Nitric acid was investigated as a replacement for hydrochloric acid to improve the sludge filtration characteristics and increase the volume reduction. Sludge freezing was investigated as a method to increase volume reduction by increasing the sludge-water phase separation. Tests were performed to determine the effectiveness of leaching the activity from the sludge using hydrochloric, nitric, or sulfuric acid, or aqua regia. High temperature, high vacuum volatilization, and the use of chelating agents (Versene and thenoyltrifloro acetone) were studied as alternative methods for removing activity from the sludge. It was found that if a stronger acid was used in the Pfaudler reaction vessel, a more dilute input slurry could be tolerated. In January 1951, the hydrochloric acid used in the reaction vessels was changed to sulfuric acid and the Eimco drum filters were bypassed (Rauscher 1950).

Process improvements continued. In 1954, an acid-carbon treatment and a pH change were implemented to reduce the quantity of suspended solids in the clariflocculator effluent prior to entering the sand filters. A slurry of activated carbon in sulfuric acid was added to the clariflocculator effluent. This process reduced the aluminum complexes in the carryover to the sand filters. The carbon acted as an excellent adsorbent for floc formation, and the change in pH helped in the formation of aluminum floc. Changes were also made in the treatment chemicals added to the 30,000-gallon influent tanks, such as the sodium hydroxide now added to adjust the pH and the ferric sulfate flocculent. As described above, in the early 1970s, bone char columns were added downstream of the sand filters to remove alpha activity.

Cleaning of the tanks and equipment in the WD Building has occurred several times. In 1953, decontamination work was conducted on the influent tanks. At least one tank had contained some actinium wastes. The interior was prepared for relining by wet sandblasting (Bradley 1953d). The overflow tanks on the sand filters were cleaned in 1954, and 30 drums of contaminated sand were shipped to ORNL for burial (Bradley 1954c). In 1956, the large clariflocculator tanks were emptied (Meyer 1956c), cleaned, and painted (Meyer 1957 c,e). In 1958, the influent tanks were again cleaned and repaired (Meyer 1958a). In 1964, the large tanks were again sandblasted and treated with epoxy paint. The sandblasting wastes were buried onsite in Area 6 (see discussion elsewhere in this report).

4.1.1.3. WD Building Wastewater Sources

<u>WDA Basement Wash Sump</u>

The WDA basement wash sump is a 600-gallon, polyvinyl chloride (PVC)-lined, steel tank. The sump collects alpha wastewater from floor and sink drains in the WDA and drains it to two 3,750-gallon alpha influent tanks, also located in the WDA basement, prior to draining to the 30,000-gallon alpha-wastewater influent tanks in the WD Building (DOE 1991b).

<u>WDA Alpha Influent Tanks</u>

The WDA alpha influent tanks are two 3,750-gallon, PVC-lined, double concrete/steel tanks that collect influent alpha wastewater from the WDA basement wash sump. The tanks drain to the 30,000-gallon alpha wastewater influent tanks in the WD Building (DOE 1991b).

<u>WDA Alpha Effluent Tanks</u>

Three 3,750-gallon, PVC-lined, steel WDA effluent tanks were formerly used to collect effluent alpha wastewater. Although still in place, the tanks were reportedly last used in 1975 (DOE 1991b).

<u>Building R Alpha Wastewater Tank</u>

The Building R alpha wastewater tank is a 500-gallon, double-walled fiberglass tank with the exterior set in concrete. The tank collects alpha wastewater generated in the R Building. After reaching a specified level, the wastewater is automatically pumped to the 30,000-gallon alpha wastewater influent tanks at the WD Building (DOE 1991b).

Building 41 Alpha Wastewater Tanks (Historical)

The Building 41 alpha wastewater tanks were two 3,466-gallon, PVC-lined, steel tanks that were part of the WTS from the SM Building to the WD Building. These tanks received wastewater via gravity flow. One tank received the high-risk wastewater and the other received the low-risk wastewater. From these tanks, the wastewaters were pumped through 1-1/2-inch, flanged steel pipes to the WD Building. The tanks and other equipment at Building 41 were taken out of service in 1982 and removed in October 1987 by the D&D Program (DOE 1991b).

SM Building Alpha Wastewater Tanks (Historical)

Four SM Building alpha wastewater tanks had capacities of 5,000, 3,000, 1,000, and 1,000 gallons. These tanks were used to collect alpha wastewater from the plutonium processing operations. The tanks drained by gravity flow to the Building 41 tanks as part of the WTS to the WD Building. All four tanks were taken out of service and removed in 1986 and 1987 (DOE 1991b).

HH Building Alpha Wastewater Sump (Historical)

The HH Building alpha wastewater sump is in the southeastern corner of the original HH Building. It was used for the collection of supernatant liquid from the polonium processing operations in the 1950s. This liquid was piped to the sump and then to the WD Building for treatment. The sump was the link to the 3-inch steel pipe from the HH Building to the WD Building. The sump would have received any wastewater within the HH Building that was destined for the WD Building, including process water from the Purex pilot plant (1953) and the protactinium-231 program (1956).

4.1.2. WDA Alpha Wastewater Treatment System (Historical)

The WDA alpha wastewater treatment facility was constructed in 1966 on the west side of the WD Building for the treatment of plutonium wastewater from the SM Building and Building 38 plutonium operations. The facility was designed as both a high-risk drumming station and a low-risk wastewater treatment system. The WDA facility replaced the treatment facilities in SM-1. In August 1967, the low-risk wastewater facility was first used in conjunction with the WTS pipeline (McMannon et al. 1967). The high-risk portion of the pipeline was not operational until April 1968 (MRC 1974d). In 1970, the WDA facility was placed in standby status, and the main facility in the adjacent WD Building was renovated for the processing of low-risk plutonium wastewater. Much of the WDA facility currently remains inactive, although some of the influent tanks have been used for collection of tritiated wastewater.

The WDA equipment and processes for low-risk plutonium wastewater were similar in operation to the WD facility, only smaller in scale. The four 3,750-gallon influent tanks fed two 6,000-gallon clariflocculator tanks that, in turn, fed through sand filters to three 3,750-gallon effluent tanks (Creamer 1964). Activity levels were measured in the effluent tanks; if activity was below the release limit of 5×10^{-6} μCi/mL, the effluent was discharged to the plant drainage ditch; if not, the water was recycled back through the system. The WDA effluent may have contributed small amounts of plutonium contamination to the drainage ditch (MRC 1974a).

After 1971, when the low-risk plutonium wastewater treatment was moved to the WD Building, the WDA alpha influent tanks were converted to use in the beta wastewater treatment. Two 3,750-gallon influent tanks were replumbed to accept tritiated wastewater, as described below.

4.1.3. SM-1 Alpha Wastewater Treatment Facility (Historical)

The SM Building (Figure 4.3) was constructed in 1960 to house the facilities for plutonium-238 production operations. The building included facilities for research and development, analytical laboratories, wastewater treatment, and plutonium recovery.

The SM Building consisted of a steel superstructure with fiberboard-cored aluminum panel walls. The building had a drop ceiling that concealed piping, ventilation ducts, process gas lines, building vacuum system lines, liquid waste transfer lines, and steam lines. In 1964, the SM Annex (SMA) was constructed with walls of concrete block on the north end. The plutonium production area contained over 500 linear ft of alpha glove boxes. The glove box and fume hood exhausts and the laboratory exhaust were handled by a set of HEPA filters. The SMA filter bank contained prefilters and one set of HEPA filters.

The SM waste treatment facility was located in room SM-1 and was used to process low- and high-risk wastes generated by plutonium production and plutonium recovery operations. The SM Building was phased out in 1967-1968 with the completion of a new plutonium facility in Building 38, also known as the PP Building (Flanagan 1976). Plutonium production in SM and SMA ceased at this time, and phase 1 of D&D of the building began in August 1968. The treatment plant was in operation from the start of plutonium operations in 1961 until the waste transfer pipelines were installed from the SM to the WDA buildings in 1967. Few records of the facility actually remain in existence. Much of the information for this report was obtained through personnel interviews, including interviews with process operators and supervisors, and from health physics and engineering records. All process records are believed to have been destroyed during the D&D of the SM Building, as they were found to be contaminated.

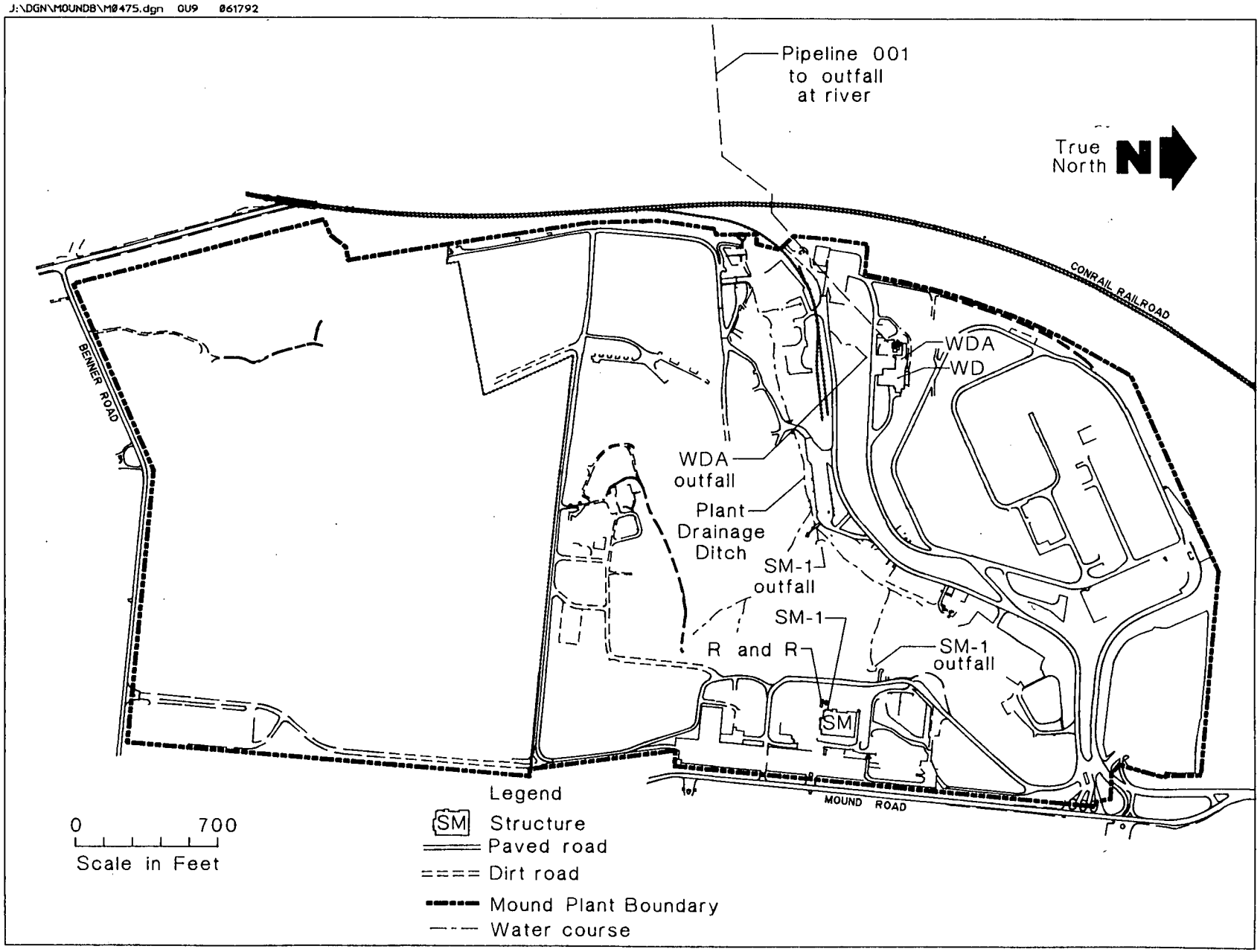

Figure 4.3. Historic and recent wastewater treatment facilities.

In the first few years of the SM Building's operations, all high-risk aqueous wastes were processed in SM-1 for possible plutonium recovery. Plutonium-bearing acidic solutions were accumulated in holding tanks in SM-1 and processed in a steam evaporator (Koble et al. 1962, Freeman et al. 1962). The evaporator condensate was then processed by an ion exchange column, and the effluent from the ion exchange column was treated as either low-risk waste or released to this storm sewer. This system was taken out of service in late 1962, and the processing of high-risk wastes was curtailed. When Mound began to distinguish between recoverable and disposable high-risk wastes, the plutonium aqueous recovery operations were moved out of the waste treatment area into the process area. In 1964, service lines were extended from SM-1 to the R and R Building, where solid materials were sorted into recoverable and disposable wastes. High-risk liquids generated by the sorting operations were transferred to SM-1 for processing (Garland 1992). No information was developed as to the characteristics of this waste and the quantity treated in SM-1. The disposable high-risk wastes were processed for offsite disposal, as described below.

The process for treating low-risk wastewater in SM-1 was nearly identical to the treatment process in WD. The low-risk alpha wastewater from plutonium-238 production and recovery operations was transferred to two 1,000-gallon underground influent tanks located on the west side of SM Building adjacent to SM-1. Wastewater was transferred from the influent tanks to a 1,000-gallon mixing tank in room SM-1. Calcium chloride and ferrous sulfate were added to the mixing tank followed by the addition of activated carbon. Sodium hydroxide was used to adjust the solution in the mixing tank to pH 11. A precipitate formed as a consequence of the pH change and the contents of the tank were transferred to a 500-gallon clarifier at a rate of approximately 3 gallons per minute. Water was drawn from the clarifier at a rate of 3 to 5 gallons per minute with a targeted output of 3 gallons per minute. When the sludge blanket in the clarifier reached the desired depth, the clarification process was stopped. The water from the clarifier was siphoned off, filtered using cartridge flow-through filters, and then pumped to a 1,000-gallon holding tank. The treated water in the holding tank was sampled and the activity of the water was determined. If the activity was below the RCG value of 5×10^{-6} μCi/mL, the treated liquid was considered suitable for discharge to the SM storm sewers and the plant drainage ditch. The SM-1 effluent may have contributed plutonium contamination to the drainage ditch (MRC 1974a). If the activity of the treated liquid exceeded the RCG value, the waste was returned to the first step of the treatment process and underwent a second cycle of treatment. Sludge from the clarifier was transferred and packaged in 30-gallon, poly-lined steel drums. The 30-gallon drums were overpacked into 55-gallon drums and staged in the SM drum storage area.

Room SM-1 was 23 ft long by 23 ft wide and housed most of the waste disposal process equipment. Much of the pumping and other ancillary equipment was housed in an 8-ft by 8-ft by 8-ft below-ground

equipment sump. A small 8-gallon waste sump in the floor of the equipment room sump collected aqueous wastes that leaked from the equipment or that resulted from spills and maintenance activities. During modifications in 1963, it was discovered that the plumbing of the 8-gallon sump pump was connected directly to the storm sewer. The plumbing was modified to route the sump output back to the low-risk influent tanks.

In addition to the two 1,000-gallon influent tanks, there were also two underground steel tanks along the south wall and near the southwest corner of the SM Building. One tank had a capacity of 3,000 gallons and the other, a capacity of 5,000 gallons. One tank received shower waste from the change room and the other received low-risk waste for subsequent treatment in SM-1. The shower water tank was installed in 1963 (McMannon 1963-1966). Prior to this, shower and perhaps other decontamination water was diluted and discharged to the storm sewer.

Utilities associated with the SM Building included a septic tank and associated leach field for handling sanitary waste. Two storm sewers were used by the SM Building to discharge storm water runoff and the treated effluent from the waste disposal facility (Flanagan 1976, Freeman et al. 1962). The SM-1 low-risk effluent was discharged to a 12-inch-diameter concrete storm sewer pipe, located along the south wall of the building, that extended west down the SM hillside to an outfall near the drainage ditch. The overflow from the two 1,000-gallon low-risk waste tanks drained to the northern line via a 4-inch sewer line that paralleled the north wall of the building and connected to a 24-inch diameter concrete storm sewer. This north storm sewer outfall was located south of Building 30 on the SM hillside, near the sanitary leach field, where it merged with the plant drainage ditch.

The south storm sewer system connecting to the SM-1 waste disposal facility was tested in February 1963 and found to be leaking in an underground section between SM-1 and the building stack (McMannon 1963-1966). No information was developed as to how or when the sewer line leak was repaired. On April 18, 1964, the south storm sewer again developed a leak in the same area. While digging in the area, a black material was encountered that was interpreted to have been activated charcoal used in the treatment of low-risk waste (McMannon 1963-1966). During the third week of April 1964, this same sewer line developed a leak again. No information was developed to indicate the extent of the leak or the corrective action that was taken to effect a repair.

4.2. ALPHA WASTE SOLIDIFICATION FACILITIES (HISTORICAL)

High-risk waste generated in the plutonium production operations has generally been packaged for shipment offsite. Beginning with startup of the SM operations, however, the high-risk waste liquids were processed for plutonium recovery. In 1963, Mound began to distinguish between recoverable

and disposable high-risk wastes, and the plutonium recovery operations were moved out of the waste treatment area into the process area. The disposable high-risk wastes have since been packaged for offsite disposal. The packaging operations moved to the WDA Building in 1968 and to Building 38 in 1974. Details of these activities are described in the paragraphs that follow.

The SM-1 waste disposal facility was also designed to process high-risk plutonium wastewater. When SM started plutonium operations in 1961 until late-1962, high-risk waste was treated by means of an evaporation and ion exchange resin column process. This waste was highly acid, containing nitric and hydrofluoric acids. The waste went to an evaporator (Freeman et al. 1962), and the condensate from the evaporator was passed through an ion exchange resin column and stored in a PVC tank. The contents of the tank were sampled and the activity was measured. If the activity was below the RCG value, the treated effluent in the tank was discharged to the storm sewer (Freeman et al. 1962). The residue from the evaporators was packaged in 30-gallon, poly-lined steel drums. Before 1963, these drums were probably saved for plutonium recovery, but no information is available as to drum disposition.

Beginning in 1963, the high-risk waste process was modified so that it was received in SM-1 in two 100-gallon spherical tanks (Garland 1992). Thirty-gallon, poly-lined steel drums were filled with Florco, a brand of highly absorbent Tennessee clay, and 10 gallons of high-risk waste were absorbed onto the clay. The drums were overpacked into 55-gallon steel drums and staged in the SM drum storage area, as described in subsection 5.1.14.

In 1967, a WTS consisting of a series of holding tanks, a pump station, and steel transfer pipes was constructed from the SM Building to the WDA Building. A 1-1/2-inch pipe was used to transfer the high-risk waste, and a 2-inch pipe was used to transfer the low-risk waste. The low-risk waste was directed to the alpha wastewater influent tanks, and the high-risk liquid was directed to a 3,750-gallon holding tank in the WDA Building. The high-risk liquid was then pumped from the holding tank to a drumming station where it was mixed with an absorbent and drummed for off-plant disposal. Vermiculite or Florco were used until the early 1970s and then Autodri or Sorbal were used. All of the latter were Fuller's earth-type materials. An evaporator and ion exchange system was planned to reduce the liquid volume, but the system never actually became operational. High-risk waste was drummed in WDA until 1974, when the WS Building, described below, was built. The drums were staged at Building 23 before shipment for off-plant burial (MRC 1973b).

Leaks in the WTS pipeline provided the impetus to construct a solidification facility nearer to the source. In 1974, the WS Building, on the west side of Building 38, became operational. The high-risk wastewater drumming operations were transferred from the WDA Building to the WS Building, and the

high-risk portion of the WTS pipeline was abandoned. At the WS facility, typically 10 gallons of high-risk liquid waste were mixed with about 150 pounds of absorbent, and the wash was double drummed with a 90-mil polyliner inside a 55-gallon steel drum. The drums were allowed to off-gas for 16 hours before the inner liner was epoxied closed and the drum was sealed (MRC 1976a). The WS operation was discontinued in late 1982 because the operation was no longer needed. The tanks, piping, and pump equipment were incorporated into the D&D activities of the former plutonium facilities.

4.3. BETA WASTEWATER TREATMENT SYSTEM

Historically, the tritiated wastewater received at the WDA Building was blended with raw water (using an in-line ratio controller) and discharged to the Great Miami River. The volume of raw water mixed with wastewater was selected so that the blended stream had a final tritium concentration of two-thirds the RCG (Anderson and Sheehan 1968b) when measured as oxide (i.e., 2 μCi/L). The stream was discharged into the old sewage treatment plant disposal line resulting in further dilution by other non-tritium streams as it was transferred to the river. This tritium disposal process was terminated in December 1971 when a tanker truckloading facility was completed at the WDA Building. The tritium wastewater was then loaded onto a truck for off-plant disposal.

The beta wastewater treatment system (Figure 4.4) became operational in March 1973 (MRC 1973b). The system currently consists of two influent tanks, a metering station, and a wastewater mixing/solidification unit in the WDA Building (Figure 4.1). Wastewater is piped into two 3,750-gallon tanks from which it is discharged to the metering station (DOE 1991b). The metering station transfers the wastewater at a controlled rate from the influent tanks to a 55-gallon drum in the mixing/solidification unit. The wastewater is mixed with cement and Florco in the drums and allowed to solidify. Mixing is performed with a mechanical mixer. Approximately 25 gallons of wastewater are mixed with 3 bags of cement and 2 bags of Florco (MRC 1983). The drummed waste is then sealed and surveyed for contamination before staging in Building 23 for off-plant disposal (MRC 1983). No wastewater effluent is produced by the treatment process.

The treatment units are on the second floor of the WDA Building and are underlain by a concrete slab. The influent tanks and metering station are enclosed to prevent releases to the floor. The treatment system began operating in 1973 and is still in service (MRC 1977a).

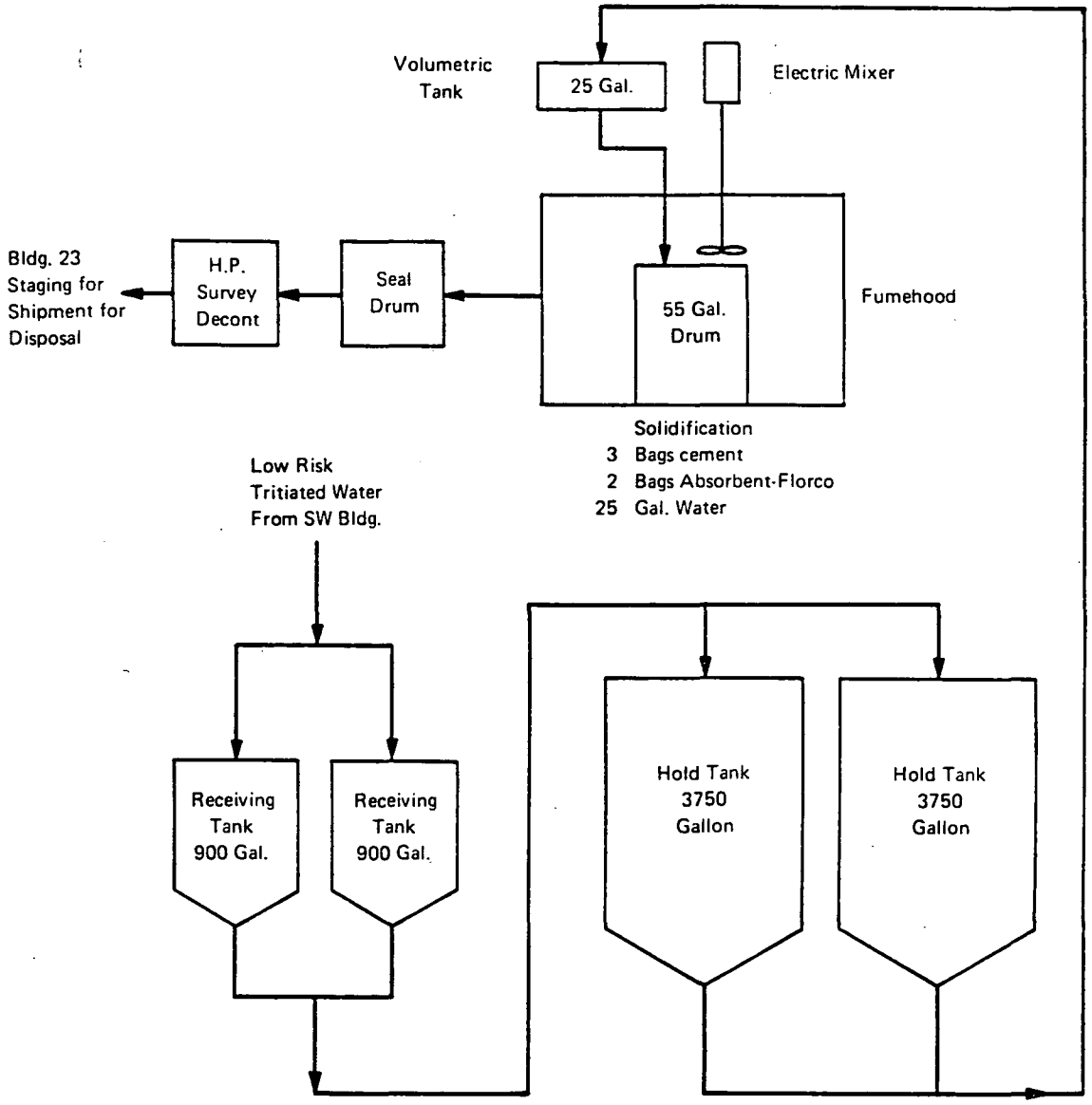

Figure 4.4. Flow diagram for low-level tritiated wastewater (MRC 1980).

The SW Building beta wastewater tanks are part of the beta wastewater system. The three tanks are steel and lined with stainless steel. One has a capacity of 200 gallons and the other two have capacities of 100 gallons each. The tanks collect beta wastewater generated from production processes in the SW Building and drain to the beta wastewater influent tanks in the WDA (DOE 1991b).

4.4. TRITIUM EFFLUENT REMOVAL SYSTEM (ERS)

The tritium ERS is in the SW Building (Figure 4.1). Tritium is handled at Mound at various locations in inert atmosphere glove boxes for processing and recovery, in analytical glove boxes, and in systems enclosed in high velocity furnace hoods. The ERS processes gaseous effluents from all glove boxes, pass boxes, vacuum pumps, and process lines to remove tritium prior to their release to the atmosphere. Figure 2.8 shows a flow diagram of the ERS.

The ERS contains a refrigerated filter system that cools the gaseous effluent to remove water and organics. The effluent is pumped into a pre-heater and platinum catalyst beds to oxidize tritium and tritiated organics. The stream is then treated by a molecular sieve bed to remove the tritium oxide.

The primary byproducts of this recovery system consist of tritiated water, oils, and solvents. These waste products are quantified, analyzed by colorimetry, and solidified by mixing with cement or being absorbed by vermiculite. The solidified wastes are then packaged for burial at an approved off-plant disposal area. The ERS system began operation in 1965 and has a capacity of up to 60 cubic feet per minute.

Separation of small amounts of tritium from stable isotopes in HH Building historically gave rise to a tritium-containing off-gas. This stream was vented to the atmosphere via the HH Building stack until 1970 when the practice began of collecting the gas in cylinders and transporting it to the ERS system for recovery. In 1972, a pipeline from the HH Building to the SW Building was installed to facilitate this transfer (MRC 1973b).

4.4.1. Isotope Recovery System

The tritium isotope recovery system is in the R Building (Figure 4.1). The process was originally located in the SW Building but was moved to its present location in the mid-1970s (Lamberger 1991). Figure 4.5 is a flow diagram of the isotope recovery system. Scrap from various DOE facilities is sent to Mound for the recovery of tritium. The recovery process consists of reacting the scrap in a heated vessel to drive off the tritium. These gases are purified by passing them through a series of carbon

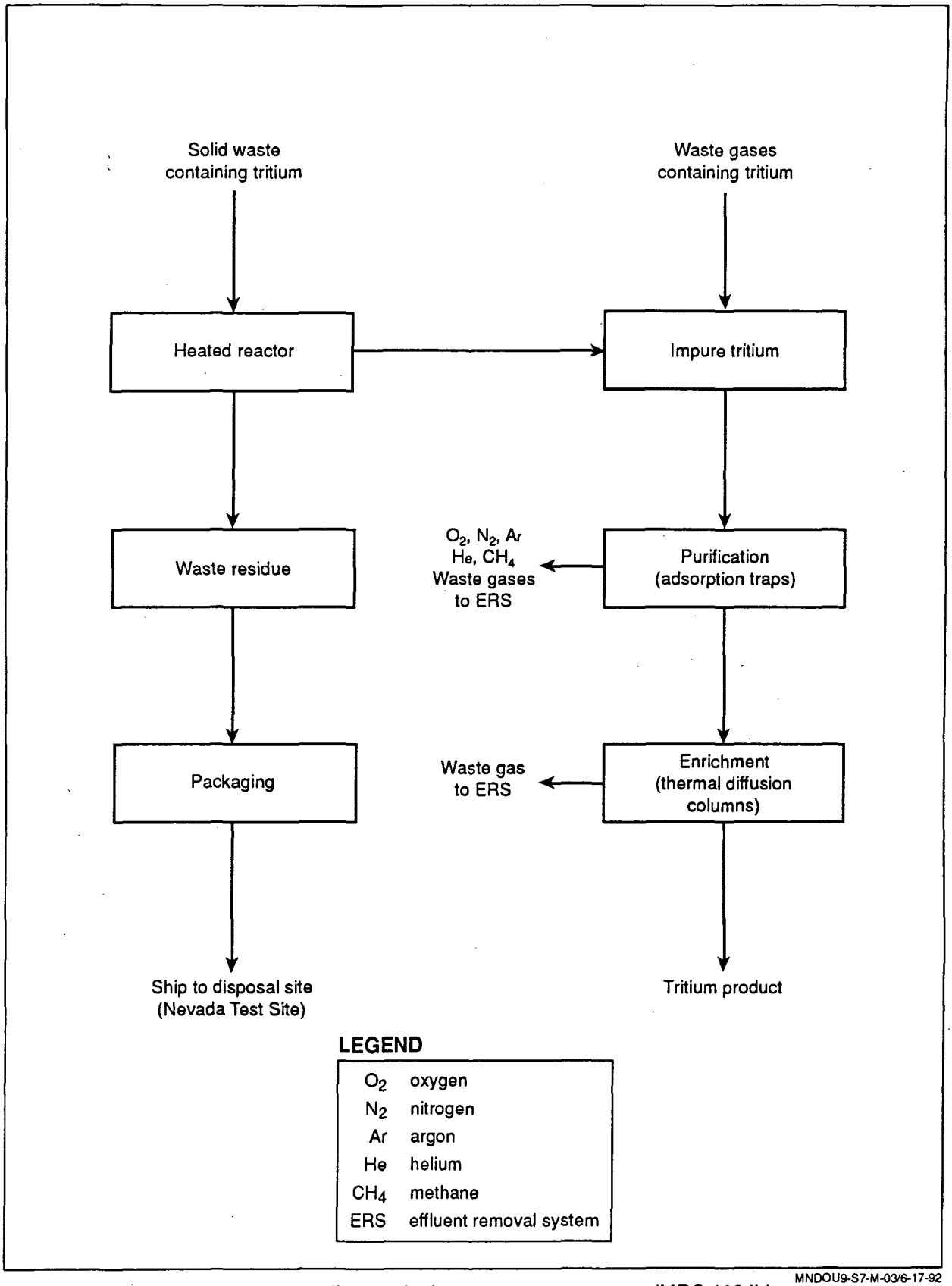

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Figure 4.5. Flow diagram for isotope recovery system (MRC 1984b).

and molecular sieve traps. The waste gases from this process contain small amounts of tritium and are sent to the ERS for treatment (Lamberger 1991).

After the process is completed, a lid is welded on the steel reactor liner containing the solid residues. The steel liner and its contents are assayed for tritium and packaged for disposal at an approved off-plant facility (Lamberger 1991). The isotope recovery system began operation in 1959 and is still active.

4.5. BETA WASTE SOLIDIFICATION FACILITY

The beta waste solidification facility is in the SW Building and is used for the packaging of waste liquids and solids for off-plant burial. The facility has been operational since the late 1960s (Davenport 1972; MRC 1976a). Wastewater and oils are initially pumped to holding tanks within the facility. The wastewater is then pumped to 26-gallon drum liners and mixed with cement and plaster to solidify it. The drum liners are packed in tar in 30-gallon drums and then placed with tar and vermiculite in 55-gallon drums for off-plant disposal. The waste oils (from vacuum pumps, diffusion pumps, and gearboxes) are mixed with vermiculite and double drummed. Solid materials from the tritium recovery operations are placed in stainless steel cans that are welded shut, submerged in tar, and double packaged in 30- and 55-gallon drums.

4.6. CYCLONE INCINERATOR (HISTORICAL)

The cyclone incinerator was in the WDA (Figure 4.1). The incinerator was used to burn non-TRU radioactive wastes (< 10 nCi/g) and non-hazardous wastes. The unit consisted of a single-stage cyclonic combustion chamber where the combustion air generated a high velocity swirling flow pattern that, in turn, created a high combustion efficiency. Figure 4.6 shows a schematic of the cyclone incinerator. Combustion gases from the incinerated waste were scrubbed in a vertical tank using a caustic spray solution. The gases were then subject to a wet scrubbing process using a venturi scrubber that neutralized any trace amounts of chlorine and sulfuric acid and removed particulates ≥ 0.3 μm. Gases and entrained droplets were routed to a cyclone demister where the droplets were removed. The gas was then routed to an exhaust blower for discharge. Centrifugal exhaust fans were used to pull the combustion air into the unit to maintain a negative pressure in the incinerator and off-gas treatment system (MRC 1983).

The cyclone incinerator was located indoors on the second floor over a concrete slab floor. Floor drains discharged floor washwater to a sump on the first floor of the building. The liquids were pumped from the sump to the alpha wastewater treatment system influent tanks.

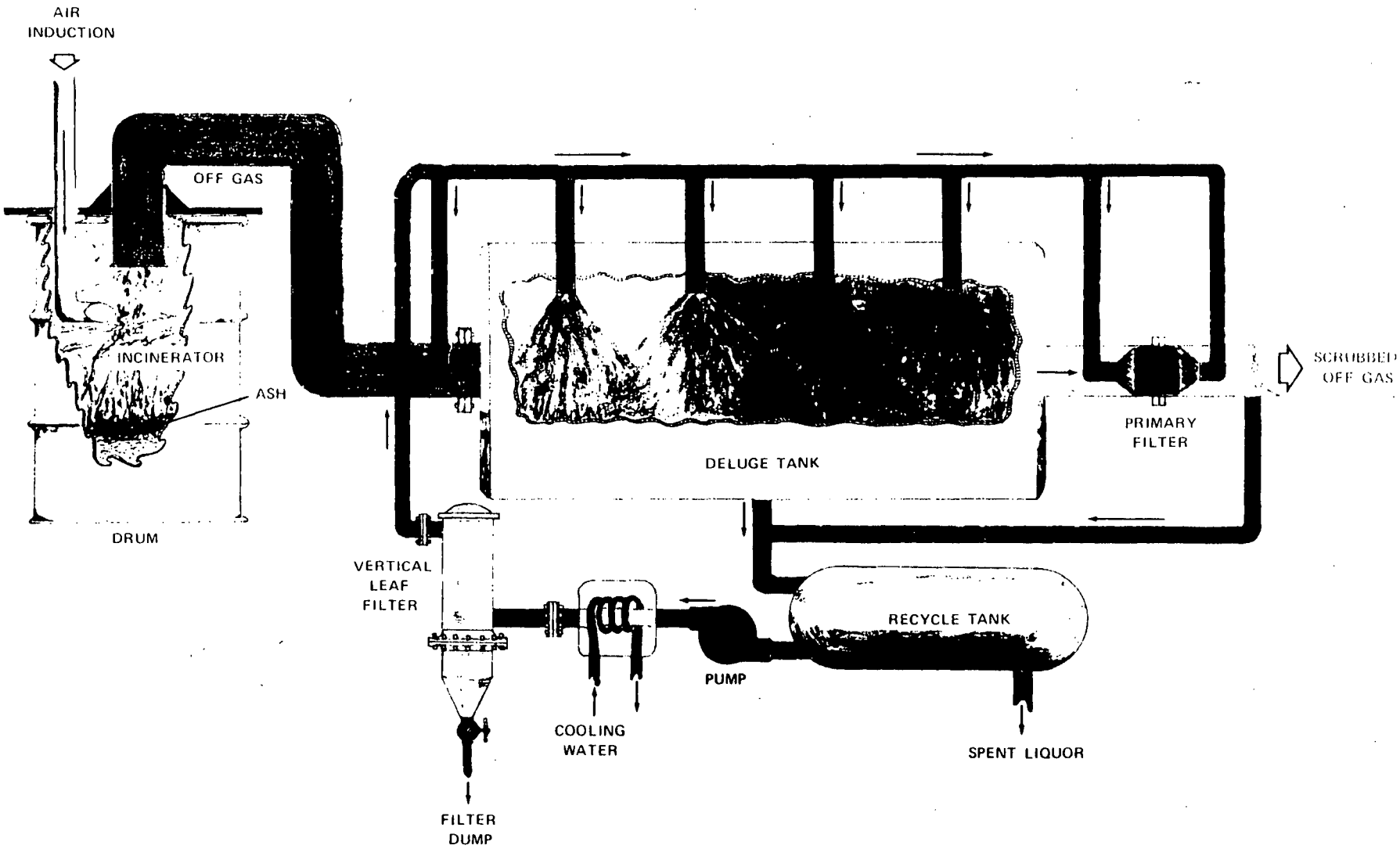

Figure 4.6. Mound cyclone incinerator (MRC 1976a).

The incinerator began operation in late 1975 to accumulate design data. The initial operation was performed using nonradioactive trash. In 1976, the incinerator was tested for the first time using radioactive alpha-contaminated (plutonium) solid wastes. In 1977, an extensive series of radioactive solid waste test burns were performed, and a continuous solid waste feed system was installed. The solid wastes processed through the incinerator consisted (by weight) of approximately 32% paper, 46% plastic, 16% rubber, and 6% metal (Bond et al. 1978). The incinerator was also modified to allow burning of liquids. Testing included the incineration of tributyl phosphate in kerosene and vacuum pump oils.

Testing of the cyclone incinerator for treating plutonium-contaminated wastes was continued throughout 1978. Also in 1978, the incinerator testing program began investigating the applicability of incinerating beta- and gamma-contaminated wastes. This work continued throughout 1979 and 1980. In 1981, the incineration testing program was canceled due to reductions in DOE funding (Klingler 1981). The incinerator was used sporadically thereafter to burn LSA non-TRU wastes generated at Mound. Ash from the incinerator was collected, placed in containers, and drummed or boxed for disposal at NTS. The incinerator was described in the January 1985 RCRA Part A permit application as changed to include the incinerator and the glass melter. In 1986, the incinerator was used to burn tritium-contaminated solid wastes such as shoe covers and chem wipes. Later that year, the incinerator ceased operation and was taken out of service. Mound requested the withdrawal of the incinerator from the August 1986 RCRA Part A application. The incinerator was dismantled in 1990 (Klingler 1991). The dismantled equipment was placed in boxes and is awaiting off-plant shipment for disposal. The off-gas treatment system was retained for use in the glass melter furnace.

4.7. RECOVERABLE PLUTONIUM WASTE INCINERATORS (HISTORICAL)

In 1965, when the SMA Building became operational, an in-line glove box incinerator was installed as part of the plutonium recovery process (McMannon 1963-1966). In 1967, when Building 38's plutonium processing facility became operational, a similar incinerator was installed in the plutonium recovery process glove box line. Each incinerator consisted of a large steel tub with a cover that was held in place with steel clamps. Each steel tub had a capacity of 10 gallons and was loaded with combustible waste. The cover was placed on the tub and clamped in place. The incinerator was fired with natural gas in the glove box, and the concentration of nitrogen and oxygen in the glove box was controlled so that the system was operating in an oxygen-starved condition. Under this operating condition, there was no open flame associated with the combustion process. The incinerator off-gas, consisting of a volatile and combustible pyrolysate, was scrubbed with a sodium hydroxide scrub solution and then filtered. The filters were made from a glass fiber/asbestos media. The filtered off-gas entered the building process exhaust system, was filtered again by the two stage HEPA filtration

system, and was discharged to the atmosphere via the SM stack. Combustible materials containing recoverable quantities of plutonium-238 that were treated in these incinerators included wood, neoprene leaded gloves, paper towels, rags, and glove box HEPA filters. The incinerator ash, containing plutonium oxide, was sent to the plutonium recovery process. No information is available as to the quantities of material processed.

4.8. GLASS MELTER FURNACE

The glass melter thermal treatment unit is located in the WDA building (Figure 4.1). The facility addition is 18 ft wide, 57 ft long, and 24 ft high. The foundation is poured-in-place reinforced concrete and the exterior walls are concrete block. The roof is built on a precast hollow concrete slab spanning the walls.

The glass melter furnace was manufactured by Penberthy Electromelt International and is a standard glass furnace that includes modifications requested by Mound relating to dimensions, waste feed techniques, and the location of feed and exhaust ports (Figure 4.7). The manufacturer was also asked to provide a gas-tight outer covering for control of fugitive emissions from the furnace (DOE 1990a).

The glass furnace is an elongated chamber (approximately 87 inches long by 27.5 inches wide by 30.5 inches high), constructed of Criteria 1 fused cast refractory manufactured by Combustion Engineering. The refractory is composed of alumins, zirconia, and silica. The floor of the furnace is fabricated with a depression at the feed end to provide a settling point away from the electrodes for any metal pieces inadvertently fed to the furnace. The upper walls are constructed of dense firebrick, and the ceiling is formed of cast refractory blocks. The entire furnace is lined with firebrick. The outer surface of the furnace is lined with 310 stainless steel separated from the firebrick by an air space. A water seal is provided as a pressure relief valve to the furnace. The chamber forming this seal is vented through HEPA filters to a building exhaust duct.

Wastes are added to the furnace through a port located in the ceiling of the furnace. Combustibles ignite immediately as they enter the furnace chamber. Solids and incompletely burned solids fall to the surface of the molten glass. The feed system consists of a hopper and 6-inch screw feeder, sized to deliver 23 kg/hour of shredded dry solid wastes to the melter furnace (Figure 4.6). The feed system screw shaft is water-cooled and has a nitrogen blanketing system in the hopper to prevent fires. A second feed system is available for feeding ion exchange resins and consists of a vibrating hopper and a 2-inch screw feeder. A third feed system consists of a drum and pump, feed cut-off system, and backflow preventer. This system is used to feed liquid waste into the glass melter. A fourth system is available and is used to feed sludge to the melter. This system consists of a drum and a progressive cavity pump (Klingler 1991).

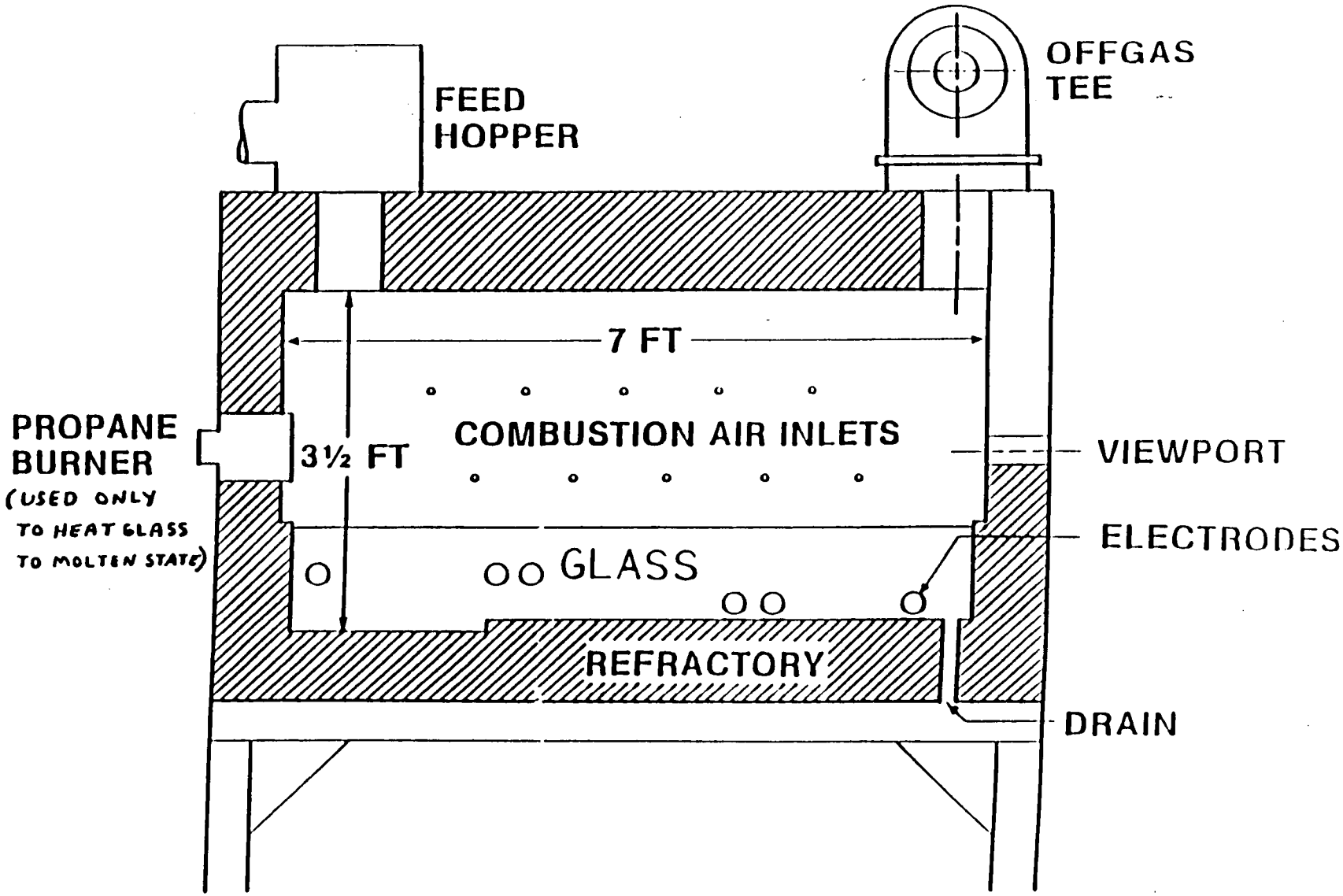

Figure 4.7. Schematic diagram of glass melter furnace (EG&G 1989b).

Combustion air is supplied through ports on both side walls of the furnace, and the air is induced by the off-gas system exhaust fans. The off-gases leave the furnace through an exit port located in the ceiling of the furnace on the end opposite the waste feed port. The off-gas handling system consists of a quench tank and venturi scrubber that combine to cool the gases to less than 180°F, remove particles, and neutralize acid gases generated in the combustion process. The off-gases are then directed through a cyclone demister and discharged through exhausters and HEPA filters to the atmosphere. Scrubber solutions generated by the quench tank and cyclone demister are recirculated with periodic blowdown to control salt buildup and tritium concentrations.

Prior to treatment of waste, molten glass is formed by the addition of glass frit and glass batch chemicals. These materials are then heated in the furnace chamber with a propane burner. When the glass reaches a molten state, the glass becomes conductive and a 150-kw joule-heater maintains the proper furnace temperature throughout the thermal treatment cycle. The propane burner is turned off and will only be used again when the furnace begins operations from a cold start. Two features make the joule-heated glass furnace attractive for waste treatment application: when waste is treated, toxic substances and radionuclides are immobilized by the molten glass bed; and the furnace chamber is maintained at a uniformly high temperature without dependence on open flame combustion (Klingler 1991). During operation, a pool of glass 12 inches deep, maintained in a molten state, covers the chamber floor (DOE 1990a). Ash from the incinerated wastes falls to the furnace floor and becomes incorporated into the molten glass.

The furnace is equipped to pour glass from the furnace into molds. The glass contains toxic metals and radionuclides that have been immobilized in the glass matrix. New glass frit and glass batch chemicals are added to the furnace to maintain a pool of molten glass 12 inches deep.

The glass melter has been used only as a test system and has never been used for waste disposal on a routine basis. Waste materials processed by the glass melter during testing included ion-exchange resins, simulated lab trash, filters, SD Building sludge, scintillation fluid constituents, acetonitriles, nitrate salt wastes, and trace quantities of cobalt, strontium, and cesium (Klingler 1991). The wastes treated in the future will consist primarily of radioactive wastes and oils, although some hazardous wastes may also be processed. The mixed wastes will consist of scintillation materials and solvents. Hazardous wastes will consist mostly of wastes containing solvents such as wastewater from Building 27 (Klingler 1991).

The glass melter began operation for testing in 1981. The glass melter is currently on inactive status and is awaiting approval of the environmental assessment. It was described in the RCRA Part A permit application, as revised in January 1985, and is included in the RCRA Part B permit application

submitted in November 1986 and resubmitted in October 1991. A trial burn plan (Cosmos 1989) has also been submitted to the EPA.

4.8.1. Glass Melter Feed Drum

The glass melter feed drum is in the WDA Building off-gas treatment room, room 11BB (Figure 4.1). The feed drum is approximately 15 to 20 ft from the melter furnace. A wall separates the feed drum from the furnace. The feed drum is a stainless steel, 55-gallon drum with a small progressive cavity feed pump. The feed pump is used to transfer liquid wastes from the drum, through 3/8-inch stainless steel tubing, to the glass melter furnace (Klingler 1991).

The feed drum sits on a stand on the floor of the building. Spilled material or leakage can potentially drain through a floor drain to the building sump and be pumped to the alpha wastewater treatment system (Klingler 1991). The glass meter feed drum is used for testing and feeds liquid solvents to the melter. The feed drum has been in place since 1981 and is still used as necessary.

4.8.2. Glass Melter Room Sump

The glass melter room sump is a 600-gallon, PVC-lined, steel tank on the south side of the basement of the WDA Building (Figure 4.1). Floor drains in the annex, including those in the glass melter and off-gas rooms, run to the sump. Exposed piping from the sump runs inside the building to the alpha wastewater treatment system influent tanks. The sump began operating in 1981 and is still in service. The sump was used to collect janitorial wash water from the floor of the glass melter room. The potential contaminants for the sump are wastewater sludge containing acrylonitrile, carbon tetrachloride, chlorobenzene, phenol, and water; acrylonitrile waste consisting of water spiked with acetonitrile and acrylonitrile; a cocktail consisting of kerosene, carbon tetrachloride, chlorobenzene, phenol, and xylene; and a spent solvent containing acetone, ethanol, dichloromethane, and water (DOE 1992g). There has not been a spill to the sump to date. The sump is pumped to the low-level alpha wastewater treatment system influent tanks (Klingler 1991). A radiation survey of the sump in 1992 revealed 65.7 pCi/g of thorium-232 and over 257 nCi/g of plutonium-238 in the sediment.

4.9. OFF-GAS TREATMENT SYSTEM

The off-gas treatment system was used for treating the cyclone incinerator off-gas and is currently connected to the glass melter furnace (Figure 4.1). This system is used to condition the combustion gases exiting the glass melter. The off-gas treatment system consists of a deluge tank, venturi scrubber, cyclone demister, scrubber liquor recycle tank, heat exchanger, and tube filter (Figure 4.8) (Klingler 1991).

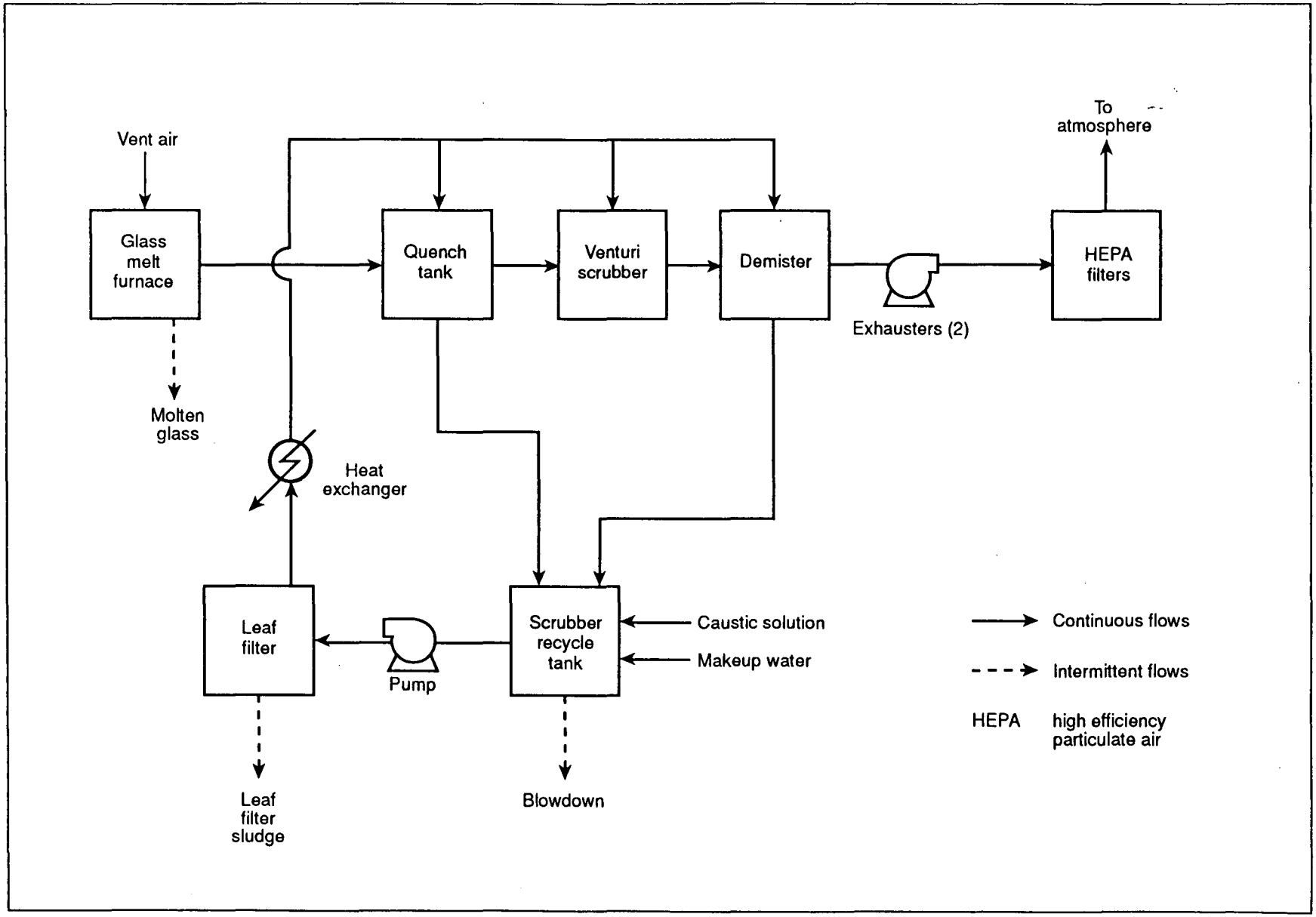

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Figure 4.8. Off-gas treatment system (Cosmos 1989).

Gases from the melter first flow into the deluge tank, which is a vertical steel tank. The deluge tank is approximately 3 ft in diameter and 8 ft high, equipped with full cone spray nozzles spaced along the vertical center line and at the tank top. High temperature combustion gases are introduced into the tank at its base, through an inlet in the tank side, and flow upward to exit at the top. A caustic solution is sprayed countercurrent to the rising gases. The tank walls opposite the gas inlet are kept wet by two additional spray nozzles. The tank drains at its base directly into the recycle tank upon which it sits (DOE 1990a).

The gases from the deluge tank enter a venturi scrubber where high energy wet scrubbing is completed. A slide assembly adjusts the venturi throat slit to change the gas pressure differential across the throat, which changes the gas velocity. Spray nozzles provide a caustic scrub solution to the venturi throat. The solution is distributed as finer droplets within the gas to capture and remove particles in the submicron range. The venturi throat opens to a ribbed cylinder. The high velocity gases are moved tangentially around the cylinder, and additional scrub liquid is added to the swirling gases. This motion agglomerates the small droplets and their captured particulates into larger droplets for removal (DOE 1990a).

The gases and their entrained droplets leave the scrubber and enter a cyclone demister. Droplets are centrifugally forced to the demister wall and are transferred to the demister's bottom by a coating of water sprayed on the demister's upper wall. Solutions from the demister and the venturi scrubber are sent to the recycle tank (DOE 1990a).

An iodine absorption filter was installed to remove iodine downstream of the cyclone demister during planned tests. The filter has never been used. Gases from the cyclone demister bypass the iodine filter and enter the HEPA filters for particulate removal. Gases leaving the system are routed via the building ventilation system to a filter bank prior to exiting from the building (EPA 1988). The filter bank is in a small enclosed structure on the WDA Building roof. The filter bank consists of several HEPA filters that filter additional particles from the gaseous effluent.

The recycle tank is used to make up the caustic scrub solution for off-gas treatment and receives the spent scrub liquor from the deluge tank, the venturi scrubber, and the cyclone demister. The recycle tank is equipped with water and sodium hydroxide supply systems, a pH probe, and a measurement device. The pH controller continuously monitors the pH in the tank and automatically controls the flow of caustics, using a metering pump to maintain the liquid at a pH of 8 to 10. The tank also serves as a reservoir to stabilize the rate of change in pH and temperature in the scrub liquor system. The recycle tank feeds the scrub system's centrifugal pump that delivers the solution to the deluge tank, the venturi scrubber, and the cyclone demister (DOE 1990a).

A tube filter is downstream of the recycle tank and filters out particles from the scrub solution prior to its addition back into the scrubbing equipment. Filter cake accumulates on the filter elements and is periodically removed. Sludge and spent scrub solutions are recycled to the glass melter chamber or immobilized in concrete (Klingler 1991). A strainer receives effluent from the tube filter and filters out iron chips (which could plug scrubber system spray nozzles) before the effluent is discharged to the deluge tank (Klingler 1991). The iron chips accumulate in the wastewater from the corrosion of the black iron pipes used in the wastewater treatment system. The strainer is a fully enclosed metal column, approximately 5 ft high and 6 inches in diameter.

Design changes made to the off-gas system to improve control and efficiency were completed in March 1988. The majority of the equipment in the glass melter off-gas treatment system is on the second floor of the WDA Building. The changes allow recycling of a portion of the off-gas exiting the fans back to the scrub tank. The system began operating in 1981 and is still in service.

4.10. WASTE EVAPORATION TREATMENT SYSTEM (HISTORICAL)

The waste evaporation treatment system was in the northern part of the east side of the SW Building. It was constructed in 1952 or early 1953 to treat high-level wastewater from the radium and actinium processing operations in the old cave. Aqueous wastes from two sumps adjacent to the cave were pumped to the treatment system.

The waste treatment system included an evaporator and three waste storage tanks. One tank had a capacity of 1,000 gallons and the other two tanks had capacities of 500 gallons each. Process waste was transferred from the sumps to these storage tanks and, in turn, to the evaporator. Water from the evaporator was routed through an ion exchange column to remove errant contamination before it was released to the plant sanitary sewer. The wet slurry or sludge from the evaporator was periodically transferred to 30-gallon steel drums. During this transfer operation, a larger quantity of particulate was created in the area because of high air velocities created by the process equipment. This particulate entered the building ventilation system located along the east wall. This ventilation system, in turn, was connected to an underground concrete duct. This duct work connected the building with the booster blower fan mentioned earlier and directed the air to the stack in the R Building. The particulate (containing radium, actinium, radon, and its daughter products) contaminated the ventilation system. As part of the D&D, the duct work and booster blower fan were decontaminated and removed from the building. The underground concrete duct appears to still be in place. It did undergo decontamination. At the conclusion of the radium-actinium program, the waste treatment process equipment was dismantled and stored temporarily on the ground behind Building 2 in the plant valley (Figure 4.9). It was shipped off-plant for burial in 1960.

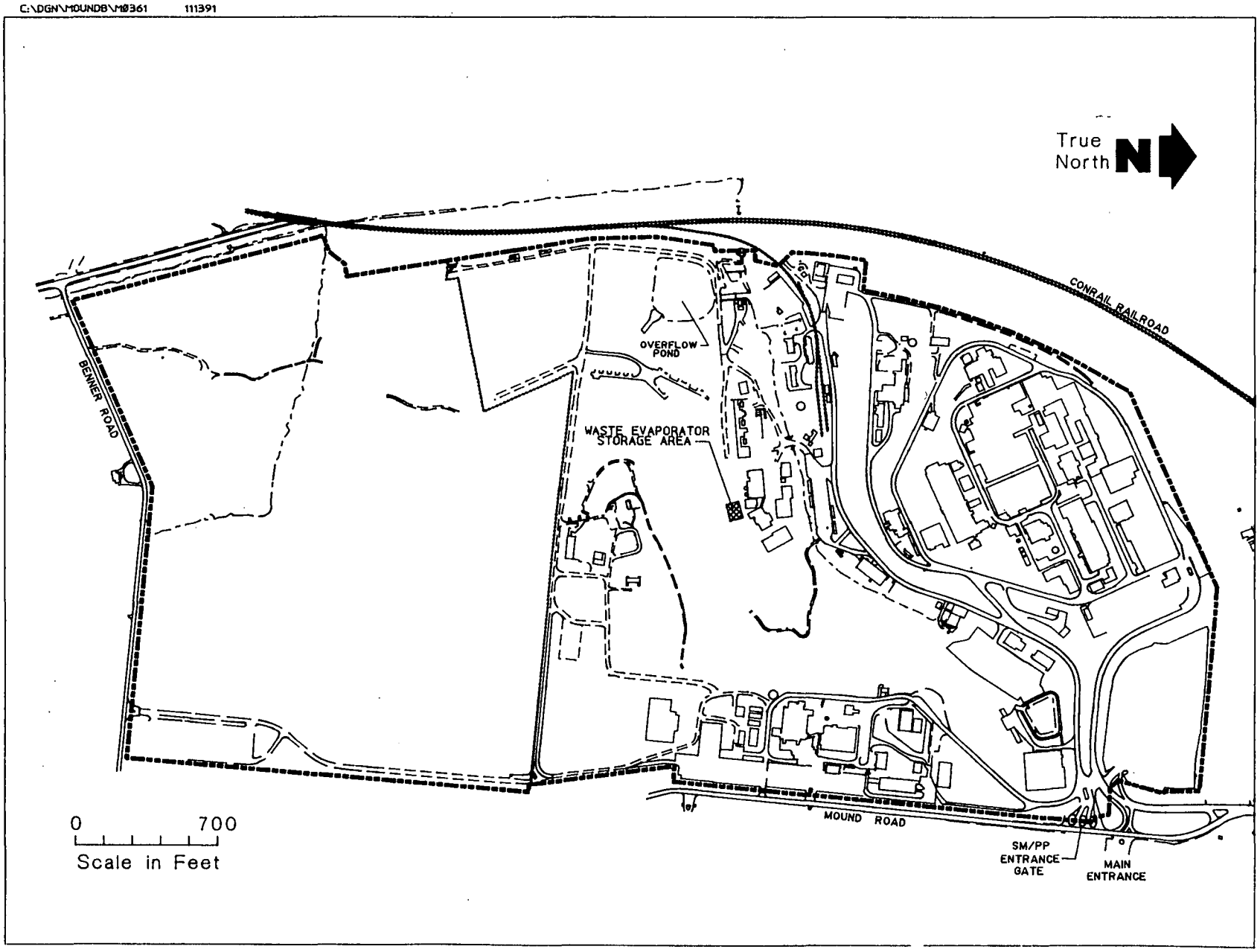

Figure 4.9. Approximate location where waste evaporator system was stored in late 1950s.

4.11. PILOT PLANT INCINERATORS (HISTORICAL)

In the late 1940s and early 1950s, Mound was among many AEC facilities that experimented with incineration of combustible solid radioactive waste. At least two pilot plant incinerators were built at Dayton and Mound to collect design data for use in selection and construction of a full-scale solid combustible waste incinerator.

In 1948, the disposal of contaminated solid waste from MCC's Dayton Units III and IV was accomplished by burial. Because of space limitations and the large expected increase in solid waste generation from the new Mound Laboratory, incineration was investigated as a volume reduction alternative. Test work was started on burning solid combustible wastes at Dayton Unit IV; and, in February 1948, a pilot plant was assembled and tested at Dayton Unit III (MCC 1949). This test incinerator and off-gas system was designed to collect data and determine decontamination factors. Data collected from a typical run indicated that the incineration process was approximately 99.7% efficient. Approximately 0.3% of the contamination in the solid waste feed was released in the off-gas. A typical run consisted of solid wastes contaminated with approximately 12.55 μCi of polonium-210. Liquid collected from the off-gas system contained approximately 26.1% of the solid waste feed contamination (Schauer 1948). It is not known how many runs or what quantity of contamination may have been treated with the incinerator, but the plant reportedly operated for about six weeks (MCC 1949).

Based on the pilot plant results, Mound installed and tested another pilot-scale incinerator sometime before early 1951 (Schauer and Schell 1952). This installation was in the HH Building (Bradley 1951b). The incinerator was a down-draft cylindrical incinerator approximately 10 inches in diameter and 24 inches high. The combustible material was placed on a perforated cast-iron grate inside the cylinder. The cylinder was placed inside a section of 12-inch steel pipe. Two nichrome heating elements were placed between the 10-inch cylinder and the 12-inch pipe to provide combustion energy. Air and/or oxygen to support combustion entered through four ports spaced 90 degrees apart above the grate. The ports were located so that the air entered tangentially to the cylinder to provide a swirling motion as the air passed through the burning material. Flue gases leaving the bottom of the incinerator passed through a counter-current spray washer to remove the larger fly ash and soot particles. The gases were then cooled in a heat exchanger and were passed through a vertical scrubber. From the scrubber, the gases were compressed and piped to a steam nozzle. In the steam nozzle, the gases were mixed with condensing steam. The particles in the off-gas were captured by condensing water droplets. The off-gas, steam, and entrained water droplets were transferred to a cooled expansion chamber followed by transfer to another heat exchanger for further condensation.

The off-gas was subsequently passed through a vertical scrubber, blower, and filter prior to exiting the stack.

Sixteen runs of 2 to 3 hours each were performed with this incinerator. Decontamination factors of 5×10^8 were achieved based on test data. Feed stock for the tests consisted of a synthetic waste with an alpha activity level of approximately 1×10^{11} d/m. It is not known what volume of feed material was treated in this incinerator nor what was done with the off-gas scrub solutions. It is not known when or how the unit was dismantled nor its disposition; it was gone by October 1951 (Bradley 1951b).

Design of a full-scale incinerator, based on the down-draft cylindrical pilot-scale model, was completed on October 31, 1952. By February 1953, the construction of the incinerator facility had been indefinitely deferred.

4.12. EXPLOSIVES WASTE TREATMENT

4.12.1. Area H Trash Burner (Historical)

The trash burner was located east of Building 90 in the open burning area (Figure 4.1). Trash was burned inside a 4-ft by 4-ft by 4-ft metal box. The metal box was inside an area enclosed by a chain-link fence and was covered with a screen gate to prevent release of large particulate material to the air. The floor of the trash burning unit was concrete. The trash burner was designed to burn up to 40 pounds of trash per event but more typically 5 to 6 pounds of material were burned at one time.

Waste materials disposed of in the trash burner included mild detonating fuses, pyrotechnic materials, components containing small amounts of explosives, tissue and cardboard contaminated with explosives, and thermite powder. The trash burner was also used to flash large detonating devices that did not fit into the retort or thermal treatment unit and materials containing organic solvents such as acetone and Freon (EPA 1988). The major products from the burning of the explosive wastes were carbon dioxide and water vapor with minor quantities of carbon monoxide, nitric oxide, nitrous oxide, and nitrogen dioxide (DOE 1979). Ash from the burner was placed in 55-gallon drums for disposal (DOE 1992g). The trash burner began operating in the 1950s and was dismantled in 1988.

4.12.2. Area H Thermal Treatment Unit

The thermal treatment unit is east of Building 90 in the open burning area (Figure 4.1). The unit consists of a 55-gallon drum placed in a larger diameter base that contains antifreeze and water to allow cooling of the drum base during burning. The drum and cooling system are within a 10-ft by 10-ft by 10-ft cubicle consisting of steel-plate, sand-filled walls, 4-inches thick, with an open expanded

metal screen roof (DOE 1990a). The floor of the cubicle is constructed of sand with the thermal treatment unit sitting on firebrick. Dampers are at the base of the walls for air inlet. An expandable metal screen door is available to allow entry into the cubicle.

The thermal treatment unit is operated in a batch mode with a complete thermal cycle required to treat a discrete quantity of explosive waste. The unit has a capacity of approximately 5 pounds of energetic materials per burn (DOE 1990a). Excelsior and waste are placed in the unit and then triggered remotely from Building 13. Instruments to monitor head temperature, cooling bath temperature, and other process parameters are also located in Building 13 (DOE 1990a), and measurements are recorded every few minutes.

The thermal treatment unit is used to burn explosive wastes including contaminated trash, fabricated explosive components and assemblies, loose bulk high-explosive powder (PETN, PBX, RDX, HMX), mild detonating cords and fuses, pyrotechnic powders, and pyrotechnic-contaminated wastes, HNS and HNS-contaminated wastes, 2 (5-cyanotetrazo)latopentaamine cobalt (III) perchlorate wastes, thermite-contaminated wastes, and solid primary explosives (DOE 1990a). Virtually no ash residue remains after burning. In the case where metal assemblies are burned, the resultant ash contains metal components but is suitable for disposal as a nonhazardous material. The treatment unit began operating in 1968 and is still in service.

4.12.3. Retort

The retort began operations in 1984 and is still in service. This thermal treatment unit is located in the burn area and is attached to the east side of Building 90 (Figure 4.1). It is installed on a 4-inch-thick reinforced concrete slab floor and is located within an enclosure consisting of 12-inch-thick reinforced concrete walls. The enclosure is approximately 30-ft long by 15-ft wide and is covered with a metal screen. The retort is a 3-ft diameter by 9-ft long rotating cylinder and can be described as a rotary kiln. The unit is propane fired at one end. The waste feed entrance and the exhaust stack are located at the opposite end of the retort. The retort is heated to approximately 800°F; and, when it reaches this temperature, waste energetic materials are fed to the retort by means of a conveyor. The combustion reaction renders the explosive wastes nonreactive and results in both solid and gaseous byproducts. The gaseous byproducts consist of carbon monoxide, carbon dioxide, water, nitrogen, and various oxides of nitrogen. Other gaseous emissions that are expected from the retort are products of incomplete combustion. Particulate emissions can contain metals that are constituents of primary explosives used in detonators. Asbestos fiber emission may also occur when diallyl-phthalate-based plastic components are treated in the retort.

Solid byproducts from the retort include ash, metal parts, traces of incompletely oxidized wastes, and metals from primary explosives. Asbestos and fiberglass used as filler material may also be present in the ash.

The energetic waste destined for treatment in the retort is stored primarily in Magazine 53. Energetic materials are placed in wax-impregnated paper containers with snap lid closures. The energetic materials are transferred to the Building 90 blockhouse where they are packaged into impregnated wax containers. The paper containers are then taken from the blockhouse and placed on the retort conveyor, maintaining a waste feed rate of one container entering the retort every 30 seconds.

The conveyor moves the waste to the entry port of the retort. The entry port connects to the front cover assembly of the unit by means of a downward sloping feed tube that directs the wax paper containers into the retort where they undergo thermal destruction. A screw feeder moves the burning material along the inside of the rotating drum. This screw feeder mechanism provides the residence time and mixing to assure complete destruction of the explosive wastes. The retort process variables are monitored and recorded throughout the thermal treatment process, and automatic controls maintain a relatively constant temperature in the retort combustion chamber. The gaseous products of combustion, generated by the propane burner and by the energetic waste material, exit through an exhaust port and are directed to the retort stack. The stack discharges combustion products to the atmosphere.

Access to the retort interior is at the propane burner end of the retort chamber, and the residue is removed manually and drummed. Some wastes, such as detonators, contain metal parts that may be classified. These are treated separately from other waste energetic materials.

4.12.4. Biodegradation Unit

The biodegradation unit is stored in the pyrotechnic waste shed east of Building 90 in the open burn area (Figure 4.1). The unit consists of a small portable steel cylinder approximately 1 ft in diameter and 2 ft high. The unit is mounted on legs and is placed inside a 30-inch-wide by 30-inch-long by 6-inch-high metal tray. Screens are at the top and bottom of the cylinder. The unit was designed and fabricated at Mound and is used to destroy soapy water solutions by evaporation/burning (Klingler 1991). The soapy water solutions are generated from cleaning equipment and utensils in pyrotechnic and explosive operations. The solutions contain trace amounts of pyrotechnic and explosive compounds. In use, a filter is placed over the top screen of the unit, and the soapy water is poured onto the filter to allow evaporation of the wastewater. The unit is removed from the pyrotechnic waste shed, and the small amount of solid residue is then burned in place (DOE 1990a). The unit began operating in 1975 and is still in service.

4.12.5. Area I, Buildings 1 and 27 Leach Pits (Historical)

This site consists of two leach pits located southwest of the Main Hill, in the western portion of Mound (Figure 4.1). The Building 1 leach pit is an open-topped impoundment near the plant drainage ditch west of Building 1. The Building 27 leach pit is an inactive, open-topped impoundment east of the sanitary wastewater treatment system. The leach pits were used for the disposal of liquid wastes generated from a high explosive process. Solvents, mostly acetone, and wastewater were discharged to the pits where infiltration/evaporation would occur.

The Building 1 leach pit was used for the biodegradation of trace explosive nitrate compounds and the evaporation of acetone and ethanol in wastewaters generated in Building 1 (Janowiecki 1991). The leach pit is triangular, approximately 75 ft long on two sides and approximately 50 ft long on one side. The pit was formed by removing soil to a depth of approximately 5 ft. The sides and bottom of the pit are not lined. Three pipes run to the pit: one to transport routine discharges from Building 43, one to carry Building 43 overflow, and one to carry liquids from the Building 1 sump and storm drains. A standpipe in the north end of the pit was used to route excess liquids to the plant drainage ditch. The pit received approximately 260 gallons of acetone and approximately 1,000 gallons of wastewater containing dissolved explosive nitrate compounds per year (EPA 1988). In 1985, discharge of wastewater from Building 1 was discontinued and the soil in the leach pit was excavated. The pit was filled with gravel and currently receives storm water runoff from Buildings 1 and 43 (Way 1991).

The Building 27 leach pit received wastewater containing acetone, ethanol, and explosive nitrate materials from the Building 27 sump. The pit is approximately 30 ft on each side and 3 ft deep. The sides and bottoms of the pit are not lined (EPA 1988).

The soils in the Area I leach pits were sampled during Stage 1 of the remedial investigation initiated under CEARP. The analytical parameters included volatile organic compounds, base-neutral acid extractables (BNA), and the explosives RDX, HMX, and PETN. Refusal depths for a hand auger occurred at 1 ft in the Building 1 pit and 1.5 ft in the Building 27 pit (DOE 1987).

All constituents were reported at less than the method detection limit in the eastern pit. In the Building 27 pit, one sample contained RDX at 6.85 ppm and bis(2-ethylhexyl) phthalate at 14 ppm. Also in the Building 27 pit, a number of "tentatively identified compounds" were reported in the BNA analysis. These are compounds other than those on the Hazardous Substances List. The tentatively identified compounds were apparently organic acids associated with the abundant natural organic material; i.e., decomposing vegetation, found in the Building 27 pit (DOE 1987).

Both leach pits began operating in the early 1960s. The Building 27 leach pit was taken out of operation in 1985. The Building 1 leach pit is still in operation but is used only for the collection of storm water runoff (Janowiecki 1991).

4.12.5.1. Building 1 Sump (Historical)

The Building 1 sump is a partially covered, inactive pit, approximately 4 ft long by 4 ft wide by 3 ft deep, on the west side of Building 1 (Figure 4.1). It is concrete-lined and covered with a metal lid. The sump was put into operation in the early 1960s. The sump's function was to collect wastewater from Building 1, filter it to remove contaminants, and discharge the effluent to the Building 1 leach pit. The sump was dredged every three to four years, and the sludge and filters were destroyed on-plant by open burning in Area H (Way 1991). The wastewater discharged into the sump contained small amounts of dissolved explosives (ppm, g per year) and acetone (4 m^3 per year). The sump discharged filtered wastewater by gravity to the leach pit (EPA 1988). In September 1985, the sump was emptied and cleaned; and in November 1985, all input lines to the sump were capped (Way 1991). The volume of wastewater generated in Building 1 has been reduced, and liquid wastes are now drummed for off-plant disposal (Way 1991).

4.12.5.2. Building 27 Sump (Historical)

The Building 27 sump is a partially covered, inactive pit near the south side of Building 27 (Figure 4.1). It is approximately 6 ft long by 3 ft wide by 4 ft deep. It is lined with concrete and covered with a metal lid. Operation of the sump began in the early 1960s, and it was taken out of service in 1985. The sump was used to collect wastewater from Building 27, filter the wastewater to remove suspended particulates including explosive nitrate compounds, and discharge the effluent to the Building 27 leach pit. Sump effluent was discharged by gravity through an underground pipeline. The leach pit is approximately 200 ft west of the sump. The sump was dredged every three to four years to remove accumulated sludge. This sludge and the spent filters were destroyed on-plant by thermal treatment. Wastewater currently generated at Building 27 is drummed and temporarily stored at the Building 27 solvent storage area. The solvents are subsequently taken to Building 72 where they are stored until shipped to an approved off-plant disposal facility (Ball 1991). No releases have been documented other than discharge to the leach pits. The sump wastewater contained ethanol, acetone, and dissolved explosive nitrate compounds (EPA 1988).

4.13. HISTORIC LANDFILL (AREA B)

The Area B Historic Landfill is in the southwestern portion of Mound (Figure 4.1). An old gravel excavation and the area just north of it were used for landfill and burning of solid and liquid chemical wastes. When Mound first opened in 1948, a small trash incinerator was located just south of the landfill. This small incinerator proved too small and the practice of burning trash at the landfill site was adopted. A burn cage in the landfill area was used for the open burning of trash and garbage from plant operations. The burn cage consisted of an open wire mesh structure to catch ashes from the burned wood, paper, and other combustible materials (DOE 1991a).

Nonradioactive liquid wastes such as trichloroethene, carbon tetrachloride, benzene, alcohol, acetone (in paints), photoprocessing solutions, and polychlorinated biphenyl (PCB) oils were routinely brought here for disposal. The materials were dumped on the ground or their containers were stacked and ignited. Fuels may have been added to the liquids to assist with their combustion. The practice of open burning in the historic landfill was halted in June 1970 (Wolfe 1973a). Liquid wastes were then staged for off-plant disposal; the disposal of solid wastes continued until 1975. Additional information is given in the waste disposal section of this report.

4.14. BUILDING 51, WASTE INCINERATOR (HISTORICAL)

On April 24, 1970, the Montgomery County, Ohio, General Health District passed regulations requiring conformance to certain air pollution standards on the same date. Mound disposal practices of open burning of solvents and combustible solids would not comply with these regulations (Neubert 1970). Mound decided to incinerate its wastes in order to come into compliance with these regulations.

The waste incinerator was constructed inside Building 51 (Figure 4.1). Building 51 is on an area of extensive fill on the western flank of a ravine in the upper valley area of the plant. Building 51 appears to lie on the southern border of an area of debris disposal within the fill (DOE 1992c). Construction of the incinerator was begun on August 25, 1970. The first test burn was conducted on August 30, 1971. Several operating problems were encountered. Additionally, a test conducted on October 12, 1971, indicated that particulate emissions were too great and that the incinerator could only burn 3,000 pounds of combustibles per hour rather than the designed 5,000 pounds per hour. The report submitted by Bowser-Morner, the company performing the stack tests, indicated that particulate emissions were below allowable levels (Delany 1971), but the test did not conform with federal regulations (Kozuszek 1971). On January 7, 1972, the AEC accepted the incinerator (Werner 1972b). A permit to construct and operate the incinerator was granted on March 24, 1972, by the Montgomery County Air Pollution Control Section (Clark 1972).

The incinerator itself consisted of primary and secondary combustion chambers that had a rated capacity of 5,000 pounds per hour. The combustion chambers were lined with refractory brick. The primary chamber was 222 inches long, 81 inches wide, and 176 inches high. The secondary chamber was 61 inches long by 81 inches wide by 176 inches high. Forced air for combustion was supplied to the grates at a rate of 5,100 cfm.

A liquid waste oil and solvent disposal system, including the Building 51 waste oil storage tank, a heater, and a pump, was connected to the incinerator (MRC, n.d.). The 1,000-gallon underground storage tank was constructed of steel. The incinerator was designed to handle the combustion of the 27 gallons of oil and 16.2 gallons of solvents, typically toluene, acetone, ethanol, and methahol, per day (Russell 1969).

Several problems plagued the use of the incinerator for destruction of solvents and oils. In September 1971, the first load of waste oil and solvent was emptied into the 1,000-gallon holding tank. Problems were encountered when debris in the drums, including rust flakes and rags, clogged the filler funnels and hampered filling. It was noted that 11 drums, approximately 530 gallons of waste oil and solvent, were selected for disposal and added to the 360 gallons of fuel oil that were in the tank (Russell 1971). The plan was to continue to dispose of the accumulated wastes, as well as to continue the weekly collections. It is not known how much actual incineration of waste oils and solvents was done after this. However, in January 1972, a test burn of approximately 80 gallons of waste oils and solvents was conducted (Werner 1972a). The intent of the test burn was to collect data and identify the problems so that corrective actions could be taken. It was established that no future burns would take place until several modifications were made.

Numerous design and construction problems and variances were blamed for the poor performance of the incinerator throughout its life. These problems included misapplication of the cyclones (Werner 1972a, Westendorf 1973). Structural defects also effected the operation of the incinerator (Russell 1971). The problems associated with the cyclones created high particulate content in the recirculated scrubber water. This high particulate content caused the cooling spray nozzles to clog. When the nozzles clogged, the maximum scrubber inlet temperature (800°F) was exceeded, and the furnace effluent was sent directly to the stack without emission control (Werner 1972b). Pressure buildups in the incinerator were common. These pressure buildups caused improper burning and fire to enter into the loading hopper. Control of the charging ram (part of the feed system) was another design flaw that created a major safety hazard (Werner 1972a). The recirculated water was initially discharged to the storm drains. Since the recirculated water became very acidic, it was eventually treated at the SD Building (Russell 1972).

The incinerator was used to burn nearly all of the plant's nonradioactive solid wastes and some liquids including paints, oils, and solvents on an experimental basis (Thomas 1991), but most liquids were shipped off-plant for disposal. In an effort to reduce waste disposal costs and find a better way to handle wastes, the "Mound Laboratory Solid Waste Reclamation and Recycling Program" was created. All wastes previously incinerated were eventually handled under this program. The incinerator was operated under interim status from December 30, 1973, to February 15, 1974, when it was completely shut down (Garbe and Wolfe 1974). With the exception of a few janitorial items, the incinerator was disassembled, and removed from Mound on May 22, 1979 (Schroeder 1979, Balsmyer 1979). The tank was removed in November 1990 (Burdg 1991). Soil sampling was performed as part of tank removal. Maximum concentrations of approximately 35 to 560 ppm total petroleum hydrocarbons and 200 ppm trichloroethene were found in the samples.

4.15. AREA C, LITHIUM BURN AREA (HISTORICAL)

Area C is adjacent to the plant drainage ditch in the lower valley area (Figure 4.1). In the late 1950s and early 1960s, the area collected and ponded stagnant water. It may have been about 150 ft in diameter, but its dimensions were irregular. Area C lay just north of the old hand-dug well in the area occupied by several old farm buildings that predated Mound, as shown on the historical topographic map of 1946 (DOE 1992b).

This swampy area was used to destroy small drums of lithium hydride that came from a research project on the Main Hill. Three to four 20-gallon drums a month were destroyed by burning (Meyer 1991). The water assisted and facilitated the reactions. No radioactive materials were associated with the process (Garner 1991). No other disposals are known to have occurred in the area. In 1964, when Building 34 was constructed, the area was filled and regraded, and the burning activity was relocated to the area of standing water in the bottom of the old landfill (Area B).

The ER Program has in the past assumed that Area C occupied a larger area than it probably occupied. A magnetic survey and two ground-penetrating radar surveys (DOE 1990b) covered much larger areas than had been described by Mound personnel during research for this report (Garner 1991). The multiple reflectors observed in the magnetic survey probably relate to the older farm buildings that were razed in the 1950s. The older buildings and the old hand-dug well are apparent in the historical topographic map of 1946 (DOE 1992b). The hand-dug well was in the approximate location now occupied by the fire fighter training pits, built in the late 1960s or early 1970s (DOE 1991d).

4.16. AREA 13, POLONIUM-CONTAMINATED WOOD FROM DAYTON UNIT IV (HISTORICAL)

Area 13 is northeast of Building 49 in the Test Fire Area, in the south-central portion of Mound (Figure 4.1). In 1950, wood contaminated with polonium-210 from Dayton Unit IV was deposited in Area 13. Wood from the walls was not contaminated and was sold for salvage. The flooring, however, was too contaminated to remove from the plant. In July 1955, the wood flooring and other combustible materials were burned. Metal and other non-combustible materials were saturated with fuel oil and burned (Meyer 1955a, 1955d, 1956b). Residue was surveyed for radioactivity in August 1955. No alpha activity was detected, but some beta or gamma contamination was detected (Garner 1991). The residual material was moved and buried in the southern part of the Historic Landfill (Meyer 1955a,e). The 1982 to 1985 radiological site survey of Area 13 detected low levels of plutonium-238 in soils, but no thorium activity.

4.17. SOLID RADIOACTIVE WASTE COMPACTORS

Two solid radioactive waste compactors were located in Building 38 (Figure 4.1). The first compactor became operational in July 1974. Its purpose was to compact radioactive wastes containing less than 10 nCi/g of TRU radionuclides. The second compactor became operational in December 1974. This unit was used to compact solid wastes containing greater than 10 nCi/g of TRU radionuclides. The second compactor was enclosed in a specially designed room that allowed containment of any radioactivity released from the compaction process. The room was also designed with special features to allow simplified decontamination in the event of a radioactive release. The compacted waste was either shipped for off-plant burial or sent to INEL for 20-year retrievable storage (McClain 1975). These compactors were removed from service and dismantled in 1987 (Geichman 1991).

Compactors currently operating are in the T Building and the SW/R Building. Compatible LSA beta wastes are placed in plastic bags, inserted into 55-gallon drums, and reduced in volume through compaction. Another compactor is installed in the WD Building for the compaction of alpha wastes (MRC 1987).

4.18. HH BUILDING

The HH Building has served as a general purpose building over the life of the plant, having served originally as a waste treatment facility and more recently as a process facility. The building was constructed in 1948 to treat the concentrated solutions from the polonium operations. Design of the building, equipment, sumps, and piping was determined early during plant design and was based on experience in operating the Dayton units (Mead 1947). From 1949 to 1960, aqueous waste containing

bismuth chloride and aluminum chloride, generated by the polonium project in the T Building, was transferred to the HH Building for treatment. This transfer took place via four 2-inch Pyrex pipes that ran through a 6-ft concrete culvert that connected the two buildings. Caustic was added to the bismuth and aluminum decanning waste streams to bring the pH to approximately 12. The aluminum decan solutions produced a gelatinous hydroxide precipitate with many short-lived gamma-emitting isotopes produced during the irradiation. These precipitates were reportedly moved to the old explosives bunker for storage before shipment offsite. The bismuth waste stream precipitate was separated by filtration, and the filtrate was transferred to the 30,000-gallon influent tanks in the WD Building through a 3-inch iron pipe (Mead 1947). The bismuth sludge was drummed at the HH Building in 55-gallon drums and moved to the Quonset hut for storage.

The HH Building has also served to house many process operations including the incinerator pilot plant in 1951, bismuth recovery in 1951-1952, and perhaps the Purex pilot plant in 1953, the protactinium-231 separation activities in 1956, and stable isotope separations since the early 1960s.

In the early 1960s, the stable isotopic project was transferred to the HH Building. The raw gas facility and the processing of tritium to recover helium-3 are now housed in the HH Building. Prior to 1970, tritium gas produced by the helium-3 recovery process was vented to the atmosphere via the HH stack. After 1970, tritium gas was collected in tanks and transferred to the SW Building where the gas was processed in the tritium ERS. The use of gas cylinders was discontinued in the 1970s when a pipe was constructed between the HH and SW buildings and the waste tritium stream was piped to the ERS for tritium removal.

Tritiated wastewater is generated in the HH Building associated with tritium processing. This tritiated wastewater is transferred to the WD Building in 30-gallon drums, and the aqueous waste is transferred to 55-gallon drums and solidified for off-plant disposal.

4.19. WASTEWATER TREATMENT PLANT

The Wastewater Treatment Plant is southwest of the Main Hill, on the southwestern edge of the plant (Figure 4.1). The current activated sludge sanitary plant that serves the site has a capacity of 130,000 gallons per day. The treatment plant receives sanitary wastewater from restrooms, laboratory sinks, production and plant service areas, photographic processing areas, plating shops, and water softener backwashes. There are strict administrative controls to prevent anything but sanitary wastes from being discharged to the sanitary sewer system. Components of the facility include the grit chamber, comminutor, equalization basins, aeration basins, clarifiers, sand filters, chlorine contact chambers, and sludge press.

The grit chamber is the first component of the treatment plant and is located outdoors, east of the storm water retention basins. The chamber is an open-topped unit approximately 10 ft by 10 ft by 10 to 12 ft deep. The chamber's sides and bottom are made of 12-inch-thick concrete. It receives wastewater by gravity flow through a below-ground pipe. Heavy solids settle out in the grit chamber and are collected and dewatered prior to transport to an approved off-plant disposal facility. Overflow of the grit chamber is prevented by metering the influent flow. Wastewater from the grit chamber is transported to the comminutor.

The comminutor is an outdoor, open-topped, in-ground unit located east of the storm water retention basins. The unit's bottom and sides are lined with concrete. The comminutor receives the wastewater and reduces the size of floating or suspended solids to improve the treatment system's efficiency. The comminutor is approximately 5 ft on each side and 10 ft deep. Wastewater from the comminutor flows to the four equalization basins.

The equalization basins are in-ground, open-topped units with metal sides and bottoms. A typical basin is 12 to 15 ft on each side and approximately 10 ft deep. The basins homogenize the incoming liquids, keep solids in suspension, and maintain aerobic conditions by mixing the wastewater. Wastewater from the basins is discharged to the aeration basin.

In the past there was an east and a west aeration basin. To improve aerobic conditions, the east basin was converted to a sludge holding tank. Currently, wastewater from the equalization basins is discharged to the west aeration basin. Sludge from the west basin is discharged to the east aeration basin where the material is aerated. The basins aerate the effluent to improve its treatability, degrade organic constituents, and promote uniform distribution of suspended solids. The basins are approximately 40 ft long by 20 ft wide by 10 ft deep. Wastewater from the west aeration basin is discharged to the clarifiers.

The two clarifiers are in-ground, open-topped, and rectangular in shape and have metal sides and bottoms. The clarifiers remove the settleable solids and floating material to reduce the overall solid content of the wastewater. The sludge from the clarifiers is removed, dried in the sludge filter press, and shipped to an approved off-plant disposal facility. The units are approximately 20 ft long, 10 ft wide, and 10 ft deep. Effluent from the clarifiers is discharged to the sand filters.

The two sand filters are located in a small building west of the clarifiers. The filters are cylindrical units, fully enclosed, and are approximately 12 ft high and 4 ft in diameter. The filters are above-ground and are constructed of metal. Wastewater is pumped through the filters to reduce the concentration of suspended solids. The filters are operated one at a time and are backwashed when

they become loaded with solids. The backwash effluent is discharged to the communitor (Raker 1991). Filtered effluent is discharged to the chlorine contact chambers.

The two chlorine contact chambers are the final treatment step in the wastewater treatment plant. The chambers are outdoor units, rectangular, with open tops. The units are approximately 3 ft long by 3 ft wide by 10 ft deep. Chlorine is added to the wastewater in these units to disinfect them prior to discharge. Effluent from these units is discharged to the Great Miami River via NPDES Outfall 001. Flow measurement is performed using a Parshall flume. The sanitary sewage disposal plant began operating in 1975 and is still in use.

In addition to the units described above, the R Building sanitary waste collection tank and the Building 37 sanitary waste tank are associated with the sewage disposal plant. The R Building sanitary waste collection tank consists of a 500-gallon, unlined, stainless steel tank used to collect sanitary waste in the R Building. The tank was originally constructed because of a planned operation in the building that could have potentially caused the wastewater to become radioactively contaminated, had it been initiated. The tank was pumped to the SD Building for sanitary waste treatment (DOE 1991g). The Building 37 sanitary waste tank is a 500-gallon, unlined, steel tank that serves as a lift station for sanitary wastes received from Buildings 37 and 88. The wastes are then pumped to sanitary waste treatment facilities at the SD Building. Originally, this tank was placed to receive radioactively contaminated wastes; however, the tank never received them (DOE 1991b).

Historically, a sanitary septic tank located southwest of Building 30 served the SM Building. This tank is believed to have been constructed as a concrete vault, about 15 ft by 8 ft, but of unknown volume, that served the SM leach field downslope of the tank. Discharges to the tank took place from 1960 when it was built to 1964 when it was taken out of service and the sanitary sewer connected to the sewage disposal facility. Overflow of the alpha wastewater system in SM-1, described elsewhere, may have contributed plutonium contamination to the tank and leach field. The D&D of the SM leach field originally included the removal of the tank, but the tank could not be located when excavation started. The tank may have been removed during an earlier construction project in the area.

4.19.1. Sludge Drying Beds

The sludge drying beds are in the southwest area of the plant near Building 57 (Figure 4.1). They received sludge and grit from the grit chamber and clarifiers in the sanitary sewage disposal plant. The drying beds are approximately 40 ft long by 20 ft wide by 3 to 4 ft deep. The sides and walls of the beds are constructed of concrete. Three perforated drainage pipes are partially embedded lengthwise in the bottom of each bed. Sand and gravel covers the pipes. Drainage water from sludge drying was

collected by the perforated pipe and added back into the wastewater influent stream upstream of the equalization basins (Raker 1991). The sludge and grit placed in these beds was dried naturally and then removed from the beds and placed, with an absorbent, in large plywood boxes for shipment to an approved off-plant disposal facility. The dried sludge contained plutonium and other radionuclides but did not constitute a RCRA hazardous waste, nor did it have hazardous waste characteristics (EPA 1988).

Originally, there were four sludge drying beds. In late 1989 or early 1990, two of the beds were removed and replaced with a filter press for the removal of water from the sludge. The remaining two beds were scheduled to be dismantled in June and July 1991 (Raker 1991). The beds became operational in 1975 and were taken out of service when the filter press was installed.

4.20. OLD SEWAGE DISPOSAL FACILITY - SD BUILDING (HISTORICAL)

The old sanitary sewage disposal facility in the SD Building is just west of the WD Building and was first used in 1948 (Figure 4.1). It was taken out of service in 1975 when it became too small and was replaced by a new sanitary sewage disposal plant. The plant consisted of a pump room, primary settling tank, aeration tank, digester, chlorinator, and effluent baffle chamber. The system treated sanitary wastewater and some process effluent from the facility. Sources of wastewater included restrooms, showers, laundry facilities, lab sinks, and rinse water from a metal-finishing operation. All treatment units were open-topped, in-ground structures. The sidewalls and bottoms were in-ground structures constructed of 12-inch-thick reinforced concrete. The entire plant was approximately 44 ft long by 47 ft wide. Treated effluent was discharged to the Great Miami River through NPDES Outfall 001. The sludge from the treatment plant was routinely spread around various open field areas of Mound. The sludge was spread over the ground in the area around Building 87 and was dumped in piles in the area around Building 34, as well as over many grassy areas at the plant. In the 1960s, it was found that the sludge was slightly radioactive and open disposal was stopped. The sludge was then packaged for shipment to an approved off-plant disposal facility (Thomas 1991).

The area surrounding the old sewage disposal facility was contaminated with polonium and perhaps cobalt when a waste line broke near Building 48 in December 1970. The radioactive waste that leaked from the line cross-contaminated the sewage treatment process, causing the destruction of the bacterial population. To accommodate the process flow that resulted from the interruption of the SD Plant, water and sludge were pumped into a pit dug to the west of the SD drying beds (DOE 1991c). Other debris, old pipes, etc., may have been added to the pit. Plutonium contamination is also present in this area from the 1969 rupture of the WTS pipeline from SM/PP to WD Buildings.

4.21. MOUND'S SOLID WASTE RECLAMATION AND RECYCLING PROGRAM

In 1968, Mound made a decision to dispose of all noncontaminated solid waste in an onsite incinerator and landfill operation. Mound's incinerator operation consistently failed to meet air pollution standards. The life of the onsite landfill had dwindled to less than eighteen months (Garbe 1973a). In May 1973, Mound conducted a study with the objective of finding an up-to-date practical disposal method. Approximately 90% of the material disposed of in the incinerator consisted of waste paper that could be sold to nearby paper mill for recycling. The remaining plant wastes could be salvaged at a nearby reclamation plant. The waste was segregated into separate categories of glass, metal, plastic, wood, and paper fibers to be reused in the making of new products.

The reclamation and recycling program was implemented in three phases:

Phase I (implementation date - August 1, 1973)

The salvage and sale of white, high-quality waste paper resulted in a 10% reduction in the incinerator waste load.

Phase II (implementation date - December 30, 1973)

After removing the white, high-quality waste paper, the remaining plant waste was divided into two categories: (1) low quality mixed waste paper (cardboard, colored paper, carbon, wax-coated, etc.), and (2) general waste (garbage, cans, glass, metals, wood, etc.). In Phase II, salvage operations were confined to the recovery of only that waste generated in buildings not involved in explosive or radioactive operations. Phase II expanded the program to 80% of the total solid waste recycled. The incinerator and landfill were operated on an intermittent basis pending Phase III of the program.

Phase III (implementation date - February 15, 1974)

The remaining 20% of solid waste, (non-contaminated waste from work areas adjacent to operations involved with radioactive and explosive materials) was salvaged in Phase III of the program. Phase III completed the plan for a plant-wide recycling program. At that time, all normal onsite incineration and landfill operations ceased (Garbe and Wolfe 1974).

As an interim measure, ash generated from incineration operations was incorporated into the reclamation and recycling program (Garbe 1973b).

By May 1974, Mound was salvaging approximately four tons of white, high-grade paper; and 15 to 16 tons of mixed paper each month. An additional 15 to 16 tons of general waste were transported to the reclamation facility for salvage offsite each month.

The economic advantages were indicated by a reduction of $51,000/year in waste handling costs. A net cost of $2,000/year to dispose of 300 to 400 tons of waste was incurred. By phasing out the incinerator, an estimated $450,000 did not have to be spent to upgrade the operation to meet pollution standards. This program also made land space available by eliminating the need for a landfill (Garbe and Wolfe 1974). The program continues today.

4.22. DREDGE SPOIL DRYING BEDS (HISTORICAL)

The dredge spoil drying beds were originally placed around the edge of the asphalt-lined pond. The dredge spoil drying beds are open-topped wooden structures, approximately 6 to 8 ft wide and 3 ft deep. The wooden beds consisted of an upper bed lined with plastic canvas that drained to a lower bed of sheet metal. Wet sediments dredged from the asphalt-lined pond were placed in the upper bed, and excess water that drained to the lower pan was allowed to drain back to the pond. The dredge spoil material contained low levels of radioactivity. Dredge spoil was packaged for offsite disposal. The beds were moved for storage to the southeast of the Main Hill in the parking lot of Building 57, next to the sludge drying beds (Figure 4.1). The beds have also been used to dry sanitary material from the sludge drying beds. The dredge spoil drying beds were first used in the mid-1980s and are not now in use.

5

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5. WASTE STORAGE AREAS

The production, research, and development activities at Mound require the temporary storage of solid and liquid LLWs, solid TRU radioactive wastes, explosives wastes, radioactive mixed wastes, and hazardous chemical wastes. No high-level wastes (wastes from spent fuel rods) have ever been generated at Mound. The following subsections describe the individual storage areas currently and historically used for these activities. Figure 5.1 shows the locations of the waste storage areas.

5.1. RADIOACTIVE WASTE STORAGE AREAS

Radioactive wastes have been packaged and stored at Mound for off-plant disposal since the facility began operations in 1948. Radioactive wastes have been the primary waste streams from plant operations. Historically, drummed wastes were staged temporarily in the operating areas and moved by health physics personnel to storage warehouses before shipment. Wastes with high gamma radiation levels were staged at the old explosives bunker or Quonset hut to avoid worker exposures. The old warehouses were replaced by more modern facilities in the 1960s and 1970s. When the waste management section of the plant was established in 1972, radioactive wastes remained the primary concern. Procedures were implemented that established the maximum allowable amount of radioactive waste that could be staged at various collection points, thereby assuring minimum operating levels (Davenport 1972).

Solid LLWs currently comprise 95% of the total volume of radioactive waste generated annually (EG&G 1989b). Liquid LLWs are treated on-plant, and the solid treatment residuals are stored and shipped from either the WD Building or the Building 31 staging areas. LLW and TRU wastes are currently stored on-plant and are awaiting transportation to off-plant storage or disposal facilities. Radioactive mixed wastes are also being stored on-plant and are awaiting approval for on-plant treatment.

5.1.1. WD Building Drum Staging Area

The WD Building Drum Staging Area is a concrete pad, approximately 50 ft by 50 ft, on the south side of the WDA Building on the Main Hill, in the west-central portion of Mound (Figure 5.1). The pad slopes to the south and has no curbing. The area began operating in 1981 and was taken out of service in 1990. The wastes stored there were primarily solidified plutonium sludge from the alpha wastewater treatment system. A 1988 inspection found stains on the pad extending into soil south of the pad (EPA 1988). The drums have been removed and there are no further plans to store drums there. The area is also used for the storage of boxes of LSA D&D wastes. Semi-truck trailers with drummed radioactive wastes are also currently stored there (Mills 1991). The drums in this area are periodically shipped to the NTS for disposal.

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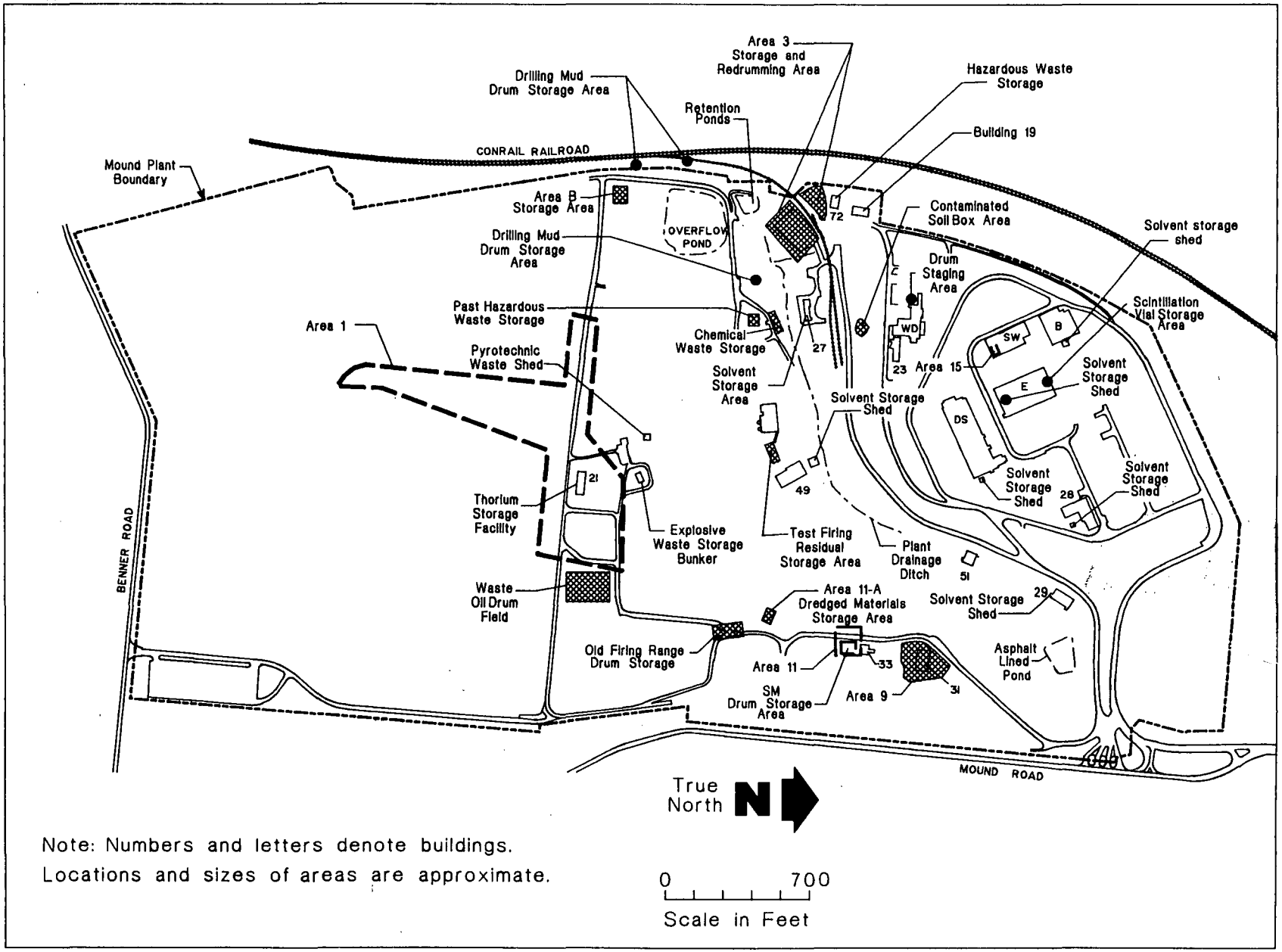

Note: Numbers and letters denote buildings.
Locations and sizes of areas are approximate.

Figure 5.1 Waste storage areas.

A leaking drum of radioactive waste was reported in 1974 on an area on the south side of the WD Building (MRC 1974b). A 55-gallon TRU package, containing high-risk immobilized plutonium-238, released waste, which migrated downslope toward the plant drainage ditch along a series of flumes and ditches. The leak was quickly contained and decontamination activities removed contaminated soil, sediment, and water. A sampling program initiated the day the leak was found showed that little radioactive material was released off-plant through the plant drainage ditch outfall.

5.1.2. Radioactive/Mixed Waste Storage Area

The Radioactive/Mixed Waste Storage Area is in Building 23 on the Main Hill, just east of the WD Building (Figure 5.1). Building 23 was designed and built in 1966 as an interim storage facility for packaged radioactive wastes prior to off-plant shipment (MRC 1978b). The stored wastes contained primarily plutonium-238 and tritium. The plutonium-containing wastes included

- sludge from liquid waste treatment, which was solidified and stored in drums;
- acid/caustic liquid wastes absorbed with inert clay and packaged in drums; and
- solid waste from glove box operations packaged in drums or boxes.

The tritium-containing wastes stored here included

- liquid wastes solidified in cement/plaster-of-paris mixture and packaged in double drums, and
- solid wastes packaged in drums or boxes.

Virtually all of the radioactive mixed waste currently handled on-plant consists of scintillation vials from biomedical assay. Scintillation vials contain tritium mixed with a trimethylbenzene cocktail and mixed radioactive corrosive wastes. Glass or plastic vials are generated in analytical laboratories. They are placed in cardboard boxes or plastic bags by the generator, picked up by Mound waste management personnel, and consolidated in steel drums for storage in Building 23.

All radioactive mixed waste is stored in Building 23, mostly contained in new 55-gallon DOT-approved steel drums (17H). Most of the drums contain loosely placed individual plastic or glass scintillation vials; approximately 25% of the drums contain vials surrounded by absorbent. Drums of mixed waste are segregated from drums of solid radioactive waste and are marked "Radioactive LSA." They each have a unique identifier showing an identification number that corresponds to a written record indicating date received, origin, description, isotope present, and other relevant information.

Closed containers of mixed waste are transported from the laboratory generating the material to Building 23, using a box-type or flatbed truck with rails. The truck is marked "Dangerous." Mixed waste is not transported off-plant; such waste is stored pending completion of waste characterization and identification of an acceptable waste treatment/disposal option. One hundred 55-gallon drums were stacked three-high during the 1988 site inspection (EPA 1988). Building 23 is one-story, 30 ft by 117 ft, and constructed of concrete block walls. The storage area is 30 ft by 40 ft with a concrete floor sloping to a 3-ft diameter, 6-ft deep concrete sump. The sump is not double contained. The sump has a sump pump with a flex-hose that can route the liquids to the storm sewer if clean or to WD Building or drums if contaminated (Hopkins, D 1991). An automatic sprinkler system is in the interior of the building, and two loading docks are on the front side of the building. The site inspection (EPA 1988) reported a release of tar-like substance near the radioactive waste drums in the northeast corner of Building 23, but the source of the leak was unidentified. The tar-like substance was later identified as a non-hazardous/non-radioactive material and was disposed of accordingly (Hopkins, D 1991). Approximately 85 gallons of scintillation vial wastes (and associated packaging materials) are generated annually.

5.1.3. Building 31, Contaminated Material Storage Building

The Building 31 Contaminated Material Storage Building (Figure 5.1) was built in 1966 and is located on the SM/PP Hill, (MRC 1978c). The building was originally used to store recoverable plutonium wastes that had been moved from the SM storage field east of Building 21 (McMannon 1963-1967). It is now used for interim storage of packaged radioactive waste waiting final disposition. The building is a one-story, sheet-metal building occupying 6,100 ft^2. The radioactive waste storage room was originally divided into three bays, but has been converted to a single large bay. The floor is a concrete slab with no drains or sumps or curbing. The waste is normally noncombustible equipment or soil contaminated with plutonium-238 or tritium. Waste stored in Building 31 is packaged in either drums or boxes that meet LSA or TRU criteria (Davis 1991).

5.1.4. Area 3, Thorium Storage and Redrumming Area (Historical)

Area 3 is in the lower valley area southwest of the Main Hill (Stought et al. 1988) and includes Buildings 19, 42, 55, 57, and 72 (Figure 5.1). These buildings serve various purposes, including salvage operations, effluent monitoring, sewage treatment, and hazardous waste storage. In 1954 and 1955, about 6,000 55-gallon drums of thorium sludge were delivered by rail to Mound (MRC 1973a; Meyer 1979a). Some thorium drums were stored in Area 3 for prolonged periods during which time exposure to the elements and internal exposure to corrosive solutions necessitated frequent redrumming (MRC 1973a). Leakage and redrumming operations resulted the release of thorium into

the soil. In 1965, the thorium-contaminated soil was reportedly excavated and the area backfilled with clean soil (MRC 1985a; Stought et al. 1988). This claim could not be verified through research for this report. The Mound Site Survey Project (1982-1985) (DOE 1991c) analyzed soil samples from Area 3 and found elevated concentrations of plutonium and thorium (maximum plutonium-238 concentration of 50.60 pCi/g and maximum thorium concentration of 5.30 pCi/g). The plutonium contamination may have resulted from runoff from the rupture of the WTS line between the WD Building and the SM/PP area complex in 1969 (DOE 1991c). Building 72 is currently used to store drums of hazardous waste prior to shipment for off-plant disposal. Wastes stored in this area may include organic solvents (e.g., acetone, isopropanol, methanol, trichloroethene); waste oils; paints and thinners; spent plating solutions containing chrome, cadmium, nickel, and copper; photoprocessing wastes; and polymer wastes (EPA 1988).

5.1.5. Area 9, Thorium Storage and Redrumming Area (Historical)

Area 9, the former Thorium Storage and Redrumming Area, is located under and around Building 31 (Figure 5.1). Building 31 was constructed in 1966 (MRC 1985a) and is on the eastern border of the site on the SM/PP Hill. It is currently used to stage both alpha and beta solidified and packaged wastes prior to shipment to off-plant disposal locations. In 1954 and 1955, 6,000 55-gallon drums of thorium sludge were delivered to Mound (MRC 1973a; Meyer 1979a). Some of these drums were stored at Area 9, and prolonged outside storage and internal exposure to corrosive solutions necessitated their frequent repackaging to ensure containment of the ore residue. Redrumming was initiated in April 1966 (Meyer 1956d). It became routine to repackage 20 to 45% of the drums annually. Drums were eventually moved to Area 1 where the thorium sludge was removed and placed in Building 21 (Thorium Sludge Storage Facility) beginning in July 1964. In 1965, an area of approximately 40,000 ft^2 was excavated from Area 9 and backfilled with clean soil to remove thorium-contaminated soils, which were subsequently deposited in Area 8 (MRC 1985a; DOE 1991c). The area is currently covered with asphalt. Low levels of plutonium and thorium contamination were detected in soils in this area (maximum plutonium-238 concentration of 8.15 pCi/g and maximum thorium concentration of 12 pCi/g) during the 1982 to 1985 Radiological Site Survey (DOE 1991c).

5.1.6. Building 21, Thorium Sludge Storage Facility (Historical)

Building 21 is southeast of the Building 90 blockhouse in the southern portion of Mound (Figure 5.1). Building 21 became operational in July 1964 (MRC 1973a), but is currently empty and is to be decommissioned. The building is 112 ft by 36 ft by 14 ft high and is completely enclosed with the walls and roof constructed of iron and steel (MRC 1973a). It was constructed on concrete with a 10-inch-thick floor and 14- to-16-inch-thick walls, which were intended to act as cantilevered retaining

walls. The retaining walls and floor were designed to ensure liquid tightness (MRC 1973c). Drums containing thorium sludge were moved from Area 9 and other locations at Mound to Area 1, Bulk Transfer of Thorium Drums. After 1964, the thorium was removed from the drums staged at Area 1 and placed in Building 21 in bulk form. Since the building was constructed with no openings in the walls for emptying the drums, the thorium was emptied from the drums through the roof by removing the roof panels. The building had two bays to segregate thorium hydroxide and thorium oxalate. A total of 1,338 drums of oxate sludge was dumped into the small bay and 3,576 drums of hydroxide sludge were emptied into the larger bay (Meyer 1979a). The thorium sludge was sent to Mound for the planned separation and recovery of the contained thorium using the Monex process; but the concept of recovery was eventually dropped. The thorium sludge was sold to the General Atomic Company (Meyer 1979a) for reclamation and was removed between October and July 1975 (MRC 1974e; MRC 1975b).

Following removal of the thorium, the building was cleaned and used as a staging area for drums of Cotter Concentrate (Stought et al. 1988). Cotter Concentrate is a high-level waste resulting from uranium milling and contains uranium decay products such as thorium and radium. The Cotter Concentrate was stored in approximately 1,258 drums in Building 21 (Meyer 1979a). In 1987, these drums were shipped to the NTS. A November 1970 soil survey for thorium-230 and thorium-232 concluded there was no evidence of loss, leakage, or buildup of thorium in the vicinity of Building 21. A 1973 alpha monitoring survey of the structure and surrounding area showed radiation levels sufficiently high that health physics precautions restrained personnel from entering the area (MRC 1973a).

5.1.7. Area 1, Bulk Transfer of Thorium Drums (Historical)

Area 1 is in the south-central portion of Mound (Figure 5.1). The area consists of 400,000 ft^2 surrounding Building 21 and includes two drainage pathways (DOE 1992g): one about 300 ft long extending into the new Mound property, and one about 600 ft long extending west along the north side of the access road.

Area 1 was used as a staging area for thorium drums transferred from Area 9, Thorium Storage and Redrumming Area, and possibly other areas on the facility. The thorium in the drums was removed and placed in bunkers in Building 21 following the building's operational date of July 1964 (MRC 1973a). Building 21 had no openings in the walls to allow the emptying of the thorium into the bunkers. The building had removable roof panels and the thorium was dumped into the bunker through the roof (Meyer 1991). Approximately 136,000 ft^2 of soil north of Building 21 became contaminated from this process (DOE 1992g), and in 1966 the contaminated soil was excavated and transferred to

Area 8 and Area 12, Contaminated Soils from Areas 1 and 9 (Stought et al. 1988). A November 1970 survey for thorium-230 and thorium-232 in surface soils and core samples showed no trend in contamination, and readings were within statistical limits of background (MRC 1973a). It was concluded that there was no evidence of loss, leakage, or buildup of thorium in the vicinity of Building 21.

In 1967, a portion of Area 1 was used to stage plutonium-238 waste packages destined for recovery. The area was referred to as the SM field area and is discussed in the section on the SM Drum Storage Area.

A radioactive site survey from 1982 to 1985 (Stought et al. 1988) showed that soils were contaminated with high levels of thorium and plutonium-238 (maximum thorium concentration of 54.3 pCi/g and maximum plutonium-238 concentration of 34,000 pCi/g). That same study alluded to the natural movement of contamination during periods of rain and possible migration of contaminants between 1976 and 1985 into adjacent areas to the south.

There was insufficient sampling for adequate characterization of the vertical extent of contamination (DOE 1991b). A drainage channel to the west was excavated and covered with concrete in 1989. Much of the soil was transferred to the banks of the channel.

5.1.8. Contaminated Soil Box Storage Area (Historical)

The Contaminated Soil Box Storage Area is located south and slightly east of the WD Building (Figure 5.1) (DOE 1992g). In 1969, a radioactive waste line from the SM Building to the WD Building broke and contaminated an area (Area 14) southwest of the WD Building with plutonium. The contaminated soils were excavated from Area 14 in 1974 and placed in wooden boxes for disposal at the NTS (Black 1974). The boxes of soil were decontaminated and screened for surface contamination before they were removed from Area 14. Soil samples from the Soil Box Storage Area collected in 1984 showed some elevated levels of plutonium-238 (DOE 1991c).

5.1.9. Area 21, Old Explosives Bunker (Historical)

The Old Explosives Bunker (Area 21) is on the south central slope of the SM/PP Hill at an elevation of approximately 885 ft (Figure 5.2). This bunker was accessed by a dirt road and was used for the storage of explosives during plant construction in 1947 and 1948. There were originally two bunkers: a large one for explosives storage and a small one for detonator storage. These bunkers were also known by the term dynamite caves (Bradley 1953h) and dynamite shacks (MCC 1953-1957). The

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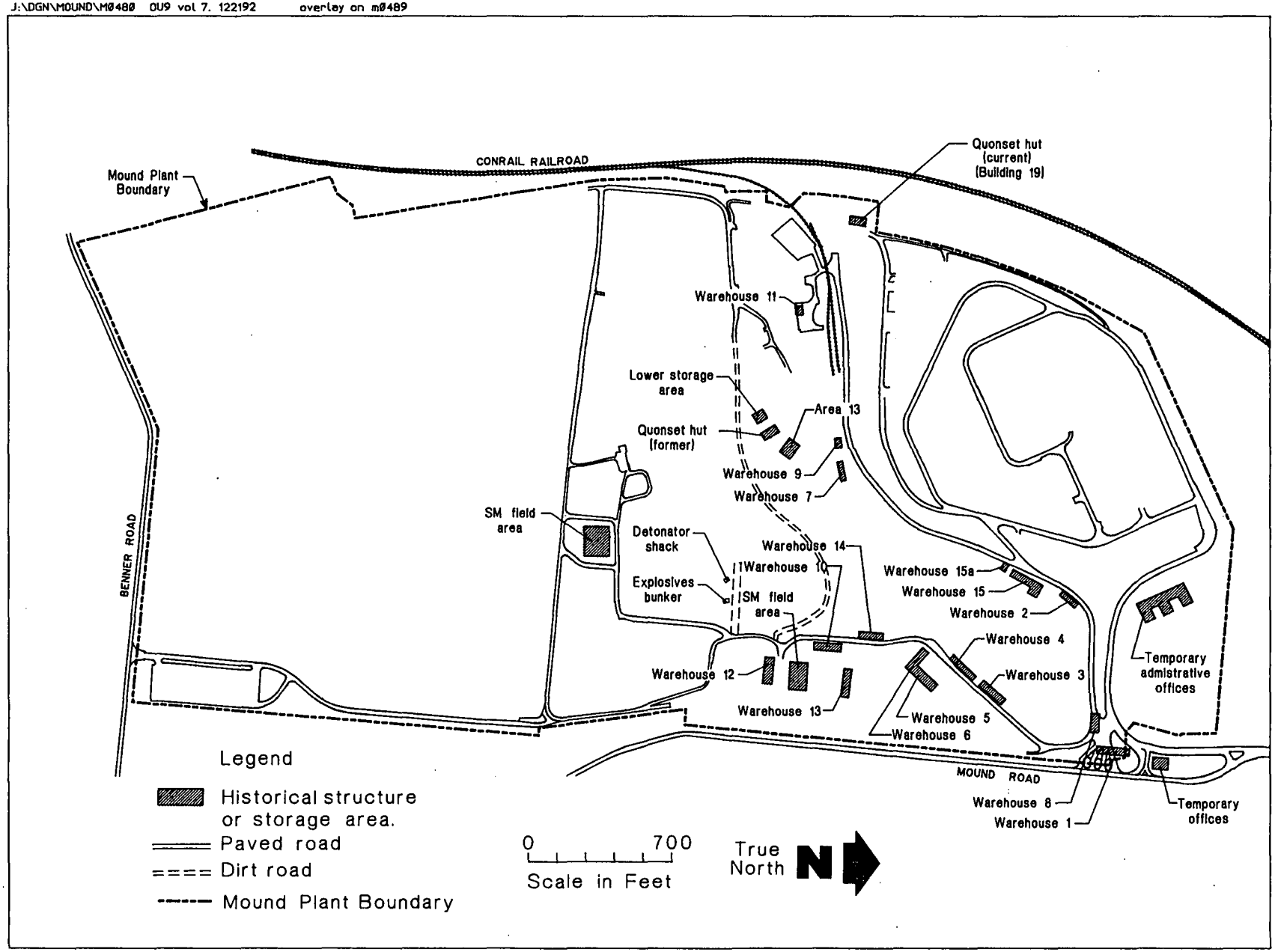
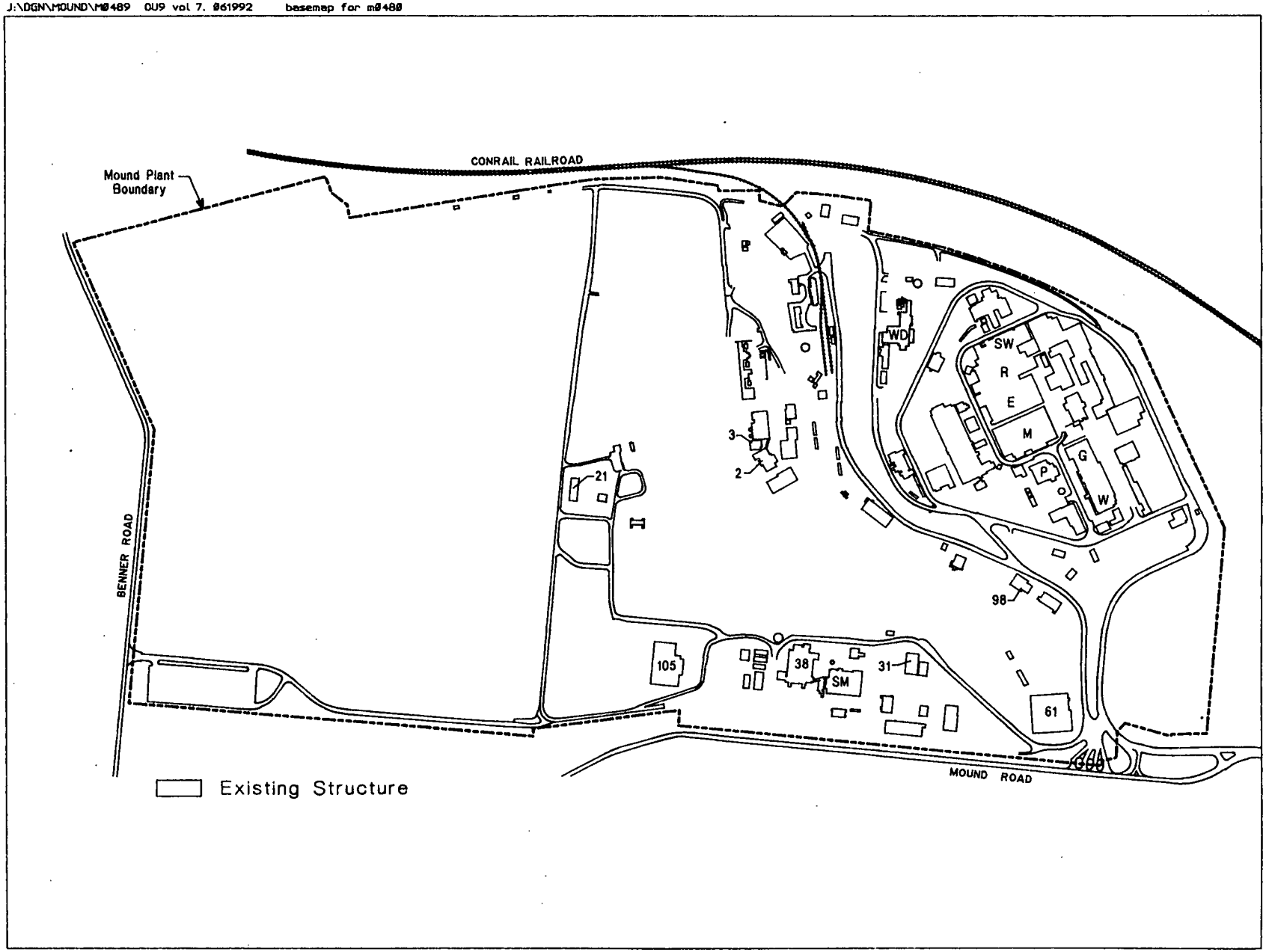


Figure 5.2. Historic buildings, structures, and storage areas.

J:\DGN\MOUND\M0489 OU9 vol 7. 061992 basemap for m0480



larger explosives bunker, also known as shack #2, is the one that probably received the greatest use by Mound. The smaller detonator bunker was also known as shack #1. The bunkers were constructed of heavy timbers tied together with steel cables. The floors are believed to have been packed earth. The only current visible sign of the location of the explosives bunker is the residual steel cables that are partly buried. No sign of the detonator shack is apparent.

In the 1940s and 1950s, the Old Explosives Bunker was used extensively for storage of wastes that had high gamma radiation. The isolated location of the bunkers on the far hill of the plant (now the SM/PP Hill) allowed these materials to be stored away from the operational areas. During the era of polonium processing, 20- and 30-gallon drums containing the residual sludge from the bismuth decanning processes in HH building were moved by truck to the bunkers. The sludges contained high levels of short-lived, gamma-producing radionuclides. Storage of these sludges at the bunker site allowed the radiation levels to subside before they were shipped off-plant for disposal (Garner 1991). The drums were trucked from the bunker to the Quonset hut, or later to Warehouse 15, for loading onto trucks and shipment to ORNL for burial.

In the early 1950s, the K-65 residues used in the radium-actinium project were stored in the explosives bunker in lead casks. Plant workers would remove small quantities of the residue for processing. This activity resulted in the bunker being called by the name "the radium shack." At the conclusion of the radium-actinium project, the ion exchange resins containing approximately 10 g of radium were stored at the bunker (Schauer 1953). High-risk wastes from the radium-actinium program were probably also stored here. In July 1952, 37 20-gallon drums of liquid waste were removed from shack #1 and placed in sawdust in 55-gallon drums. These drums showed no external alpha radiation and an average gamma radiation of 150 mR/hr. The drums were moved to Warehouse 7 (MCC 1951-1956). Some wastes were moved to the Quonset hut in July 1953 for shipment offsite (Bradley 1953h).

Drums stored in the shacks were surveyed in June 1953. The highest readings were 7.5 R/hr in shack #2 and 10 R/hr in shack #1 (MCC 1953-1957). The source of these drums could not be determined from the existing records, but was probably the radium-actinium program. In August 1953, radiation surveys of surface and air contamination levels on and around drums of waste in storage indicated drum leakage. The problem was suspected to be mainly residual thorium from the purification and separation processes of the radium/actinium program. The drums were moved to the Quonset hut for shipment offsite (MCC 1953-1957). It is not possible from the available information to know exactly how many and what the sources were of the drums stored in the old bunkers. Subsequent surveys in September 1953 indicated little wipeable contamination in Shack #1 (probably the smaller of the two) and none in Shack #2. No direct readings could be taken in Shack #2 because of the high gamma level inside the shack (MCC 1953-1957). Shack #2 may have still contained waste drums at

that time. No other historical data or references to these shacks or bunkers could be found during the research for this report.

The Site Survey Project (DOE 1991c) reportedly located the area through its gamma surveys of the plant. Cesium-137 was found in the area at levels of 31 pCi/g measured in a core from 60 inches deep (DOE 1991c). It is speculated that wastes from the reactor waste pilot plant were also stored at the explosives bunker site, but limited data indicate that at least the incoming casks were stored at the Quonset hut (Bradley 1952e). There is no recent information on the adjacent detonator shack.

5.1.10. Old Warehouses (Historical)

Numerous wooden buildings were built by Maxon Construction Company during the initial phase of plant construction in 1947. These temporary buildings included warehouses for shipping and storing construction materials and equipment and supplies, as well as for use as office space (Figure 5.2). Several of the warehouses were retained by Mound after plant construction to provide enclosed storage. Warehouses numbered 1 through 8 and 11 and 12 (Figure 5.2) were apparently demolished in the early 1950s. There are no records that indicate that these 10 structures were ever used by Mound. The temporary office buildings (Figure 5.2) in the north parking lots were also demolished during this time period. Warehouses 9, 10, 13, 14, 15 and 15a were used to stage or store radioactive wastes for shipment offsite. The records of use of these building are sketchy and fragmented.

Two structures for unloading boxcars were located along the south side of the railroad siding south of the present Building 22 (Figure 5.2). The larger of the two was Warehouse 7, located at the far end of the siding; the smaller was Warehouse 9. These were sometimes referred to as the old railroad warehouses. Both buildings were wooden structures with elevated wooden floors and with docks along their north sides. Warehouse 7 is not known to have been used by Mound. Warehouse 9 had a heavy floor structure and was apparently used to ship and receive drummed radioactive materials. Until December 1954, Warehouse 9 served as the central point of waste shipments (MCC 1951-1956). In September 1953, drums of waste from the Purex pilot plant were moved from Warehouse 13, where they had been stored, to Warehouse 9 for shipment to ORNL for burial (MCC 1953-1957). In 1955, Warehouse 9 was used for the unloading of thorium drums for the planned thorium refinery. The drums were moved by truck to other areas of the plant for storage. Neither of the old railroad warehouses was used for unloading of the lead casks used to ship radioactive materials into Mound; the casks were too heavy and required crane unloading along the siding. Warehouse 9 was last used December 7, 1954. Warehouse 15A was used thereafter for waste shipments (MCC 1951-1956). Review of photographs indicates that it was gone by August 1962. It was probably sold for salvage

and, as with many of the old warehouses, the flooring was too contaminated to remove from the site and may have been burned in place. The site of Warehouse 9 currently lies under a paved parking lot.

Warehouse 10 was located on the SM/PP Hill in an area now partially occupied by Building 38 (Figure 5.2). Warehouse 10 was used in the early 1950s to store materials contaminated with polonium-210 from the Dayton units (Bradley 1953e). Over the years much of the radioactivity died away and by August 1956, the materials were either cleaned and sold for salvage or shipped to ORNL for burial (Meyer 1956b). The building itself was sold for salvage, but the flooring was too contaminated and was burned in place during the fall of 1956 (Meyer 1956e, 1957a).

Warehouse 13 was located on the SM/PP Hill in the area now occupied by the SM Building (Figure 5.2). It was a wooden structure and probably had a concrete floor. During the mid-1950s, Warehouse 13 was used to store waste materials from the radium/actinium program and the Purex pilot plant (Bradley 1953f). In 1952, materials contaminated with low levels of radioactivity from the radium/actinium program were placed in Warehouse 13 until they were moved to the Quonset hut for shipment offsite (Bradley 1952f). These were probably solid wastes of some sort, as all liquids were processed in an evaporator (see project descriptions in this report). In March 1953, eight 55-gallon drums of sludge with high gamma radiation (1.5 rem), along with miscellaneous tanks, pipes, and valves from the Purex pilot plant, were moved to Warehouse 13 for storage (MCC 1952-1957). By September 1953, the sludge drums were moved from Warehouse 13 to Warehouse 9 for shipment offsite. One of the drums apparently leaked and the contents were redrummed in Warehouse 13. The floors of Warehouse 13 were scrubbed (MCC 1953-1957). No record was found of the decommissioning of Warehouse 13, but it is noted during a review of photographs that the building was gone by August 1956. The floor remained and was used as a pad for storage of thorium drums in 1959.

Warehouse 14 was located on the SM/PP Hill, on the west side of the access road just south of the present Building 30 (Figure 5.2). It was a wooden structure and probably also had a concrete floor. Very little is actually known about this structure. A logbook entry on August 30, 1958, indicates equipment destined for disposal was stored in Warehouse 14 (MCC 1951-1961). No other data were given. Another log book entry, dated January 18, 1966, indicates that WD sludge was moved to the Warehouse 14 area, behind the SM Building (MRC 1961-1968). In January 1966, drums of apparently recoverable plutonium-238 and contaminated trash were to be moved from Warehouse 14 to the new storage Building 31. Contaminated trash was apparently stored since May 1965 (McMannon 1963-1966). There are no records of the decommissioning of Warehouse 14, but it is noted during a review of photographs that the building was gone by March 1968. The floor is still present.

Warehouses 15 and 15A were located along the upper reach of the plant drainage ditch, in the approximate position of the present Building 98. Warehouse 15, the larger of the two with 6,000 ft^2, lay northeast of Warehouse 15A (Figure 5.2). These two warehouses were shown in the historical maps of the upper valley compiled in the Photo History Report (DOE 1992c) but were not labeled. Both structures were wooden construction. Warehouse 15 had a concrete floor and Warehouse 15A had a wooden floor. Because of their ease of access and location, away from the Main Hill, these warehouses were used as general storage areas for radioactive wastes and for truck loading facilities. Warehouse 15 was used as a general storage area for plant operations (office supplies, furniture, etc.). In the mid-1950s, thorium redrumming operations were conducted in Warehouse 15, but were moved outdoors because of elevated radiation levels, possibly radon. Logbooks indicate that, from December 1954 (MCC 1951-1952) through the mid-1960s, Warehouse 15A served as one of the general sites for storage and loading of radioactive waste for offsite shipment (MRC 1961-1968). Radioactive trash, plutonium sludge from SM, polonium sludge from WD, and waste from other operations were picked up from the process areas and stored until loaded into vans for shipment offsite. The floor of the warehouses were typically scrubbed with solutions of dilute hydrochloric acid to remove contamination. In April 1965, the waste storage and loading operations were transferred to the newly constructed Building 23. Both Buildings 15 and 15A were sold for salvage in the mid-1960s. The floors may have remained in place until they were bulldozed into the ravine in the early 1970s. The site of warehouse 15 is currently occupied by Building 98. The site of warehouse 15A is currently occupied by the paved parking entrance adjacent to Building 98. The ravine fill east of the old warehouses is included in the ER Program as Area 7 (DOE 1992c).

5.1.11. Lower Storage Area (Historical)

The lower storage area was an open storage area located behind what is now Building 2 in the lower valley area; the lower storage area was originally behind the Quonset hut (Figure 5.2). The area was used from 1955 to 1960 to store the waste evaporator equipment that had been removed from room SW-1B as part of the D&D of the radium-actinium operations. The equipment consisted of several waste liquid holding tanks and the evaporator itself. The equipment was decontaminated, capped, and stored in the open field. No data are known to exist on the level of decontamination, but a personal interview suggested that the equipment was washed externally until no wipeable levels were observed (Garner 1991). Also stored in the area were the holding tanks from the Purex pilot plant. These tanks were dismantled in March 1953 and stored in the lower area (MCC 1952-1957). Their final disposition was not determined, but they may have been shipped offsite in 1960 with other equipment. In January 1959, equipment from the decommissioned HH sludge facility was stored in the lower area (MCC 1951-1961). This equipment was probably also shipped offsite in 1960, but no record of shipment was found. The ground surface of the storage area was surveyed by radiological field

instruments during the initial phases of the Site Survey Project (Stought et al. 1988), but nothing was detected (Garner 1991).

5.1.12. Quonset Hut Storage Building (Building 19)

The Quonset hut is a one-story, corrugated-metal building originally erected at Dayton Unit III during the Manhattan Project. During the D&D of the Dayton units, the Quonset hut was moved to Mound for equipment storage. It was first erected in the plant valley in the area now occupied by Building 3 (Figure 5.2). During the 1950s, the Quonset hut was used for the storage of radioactive wastes from polonium and may have served to store other radioactive wastes, such as the shipments of Purex wastes for the reactor waste research program (Bradley 1952e). From 1949 to 1954, the bismuth chloride residues from the polonium project were moved from their staging area in T Building to the Quonset hut for storage. By August 1953, over 600 30-gallon drums were stored on a high density concrete pad at the Quonset hut (Bradley 1953h). Shipments of these drums to ORNL for burial began in April 1954 (Bradley 1954a; 1954c) and were completed by September 1954 (Bradley 1954d). Low-risk and high-risk wastes from the radium-actinium program, which had been stored in Warehouse 13 and the explosives bunker, respectively, were moved to the Quonset hut for shipment offsite (Bradley 1953h). In 1957, some damaged thorium drums were also stored in the Quonset hut (Meyer 1957b). It is apparent that some time after this, radioactive wastes were stored or staged at other buildings such as Warehouse 15 for shipment offsite. When or how this happened is unknown. In 1963, the Quonset hut was moved to its present location and now serves as the salvage and surplus sales facility (Figure 5.2).

5.1.13. SM Drum Storage Areas (Area 11 and Others)

Associated with the SM Building plutonium operations were several drum storage areas. These areas were located on the SM/PP Hill adjacent to the SM Building (Figure 5.2). From 1961 to 1966, at least three areas west, south and southwest of the SM Building were used for open storage of drums and boxes of plutonium wastes. The plutonium wastes included materials destined for plutonium recovery and well as disposal. In 1966, the use of open the open storage areas was curtailed and the plutonium waste packages moved to Building 31.

From 1961 to 1963, significant quantities of solid recoverable plutonium waste was generated that did not go to the plutonium recovery because methods and facilities for recovery did not exist. Plutonium wastes were packaged into 30-gallon poly-lined steel drums and saved for future processing. These 30-gallon drums were stored along the west side of SM Building, in the vicinity south of Building 33. This storage area is known as Area 11 (DOE 1991c). In June 1964, these drums were moved

to the open field area south of the SM Building. At least one of the drums was found to be rusted through and was overpacked into a 55-gallon drum. The integrity of the other drums was also questionable because of their rusty condition and an extensive effort of overpacking the 30-gallon drums into 55-gallon drums in the field was started in January 1965. By March 1965, 557 drums had been repackaged. The roadway around the west side of the SM Building was resealed in April 1965 to contain the contamination from the leaky drums (McMannon 1963-1966).

In May and June 1965, approximately 485 drums of plutonium contaminated trash was moved from the area directly west of SM to Warehouse 14 and the open area east of the former location of Warehouse 14. The latter probably includes Area 11. The entire roadway west of SM Building was resurfaced with blacktop in October 1965 to contain the plutonium activity (McMannon 1963-1966).

In preparation for the construction of Building 38 and the water tower, the drums containing recoverable materials stored in the open field south of SM were moved further south in the same area and were moved again in November 1965 to a prepared gravel pad in the field area adjacent to Building 21 (Figure 5.2). Approximately 1687 55-gallon drums and 100 boxes materials destined for plutonium recovery were moved to the gravel pad (McMannon 1963-1966). Due to weathering, some of the boxes collected rain water or water condensate and leaked plutonium to the soil. This area is included in Area 1.

The waste packages remained at the gravel pad location until April 1966, at which time the drums and boxes were transferred to the SM Drum Storage facility in Building 31. The relocation of the recoverable waste packages was completed in April 1966. Only one drum was found to be contaminated during the move and was sent to the R and R Building for processing. Drums of recoverable materials that had been stored in Warehouse 14 were also moved to Building 31 during this time period (McMannon 1963-1966). The gravel pad was still used in the late 1960s for staging of radioactive waste before offsite shipment.

Areas 1 and 11 were sampled for plutonium activity as part of the Site Survey Project (Stought et al. 1988). In Area 1, plutonium contamination up to 34,000 pCi/g was found at the surface. This area was reportedly scraped and backfilled at some undetermined time. Resampling of Area 1 in 1989 indicated a maximum plutonium concentration of 40 pCi/g (DOE 1992h). Sampling of Area 11 by the Site Survey Project (Stought et al. 1988) indicated 870 pCi/g plutonium at 18-inches below the surface. More recent sampling indicated 64 nCi/g plutonium (DOE 1992h). The area now identified as Area 11 includes the area west of the road (DOE 1991c, 1992h) that may actually include the area formerly occupied by Warehouse 14.

5.2. EXPLOSIVES WASTE STORAGE AREA

Small volumes of explosives and pyrotechnic wastes are generated at Mound and are temporarily stored until treated on-plant or shipped off-plant for disposal.

5.2.1. Test Firing Residual Storage Area

The test firing residual storage area is inside Building 2 in the test fire area, in the central portion of Mound (Figure 5.1). It began operation in 1956 and is still in service. It is used to store residuals generated during the test firing of detonating devices. Wastes include both unexploded detonation devices and explosion residuals that consist primarily of aluminum residue. Wastes are stored in 30-gallon drums on a concrete floor, but no physical descriptions of the area are available. Wastes are transferred to the open burn area for treatment. No releases have been documented.

5.2.2. Explosive Waste Storage Bunker

The explosive waste storage bunker, also known as Magazine 53, is in the open burn area (Area H), in the southern portion of Mound (Figure 5.1). It began operation around 1970 and is still in service. It is used primarily for temporary storage of containerized explosive waste prior to thermal destruction. Classified, non-explosive wastes were stored in the bunker during the 1988 visual site inspection (EPA 1988). Detonators, high explosive powder, detonating cord, pyrotechnic powders, hexanitrostilbene, and primary explosives are stored in drums on the floor of the bunker. The bunker is approximately 15.5 ft long by 10 ft wide by 10 ft high. The walls and ceiling are constructed of corrugated, 10-gauge, Armco multiplate, and the end walls are made of reinforced concrete approximately 12 inches thick. Compacted earth fill surrounds the bunker on three sides with 2 ft of fill cover on the top of the bunker. The uncovered front wall has a metal door for access.

5.2.3. Pyrotechnic Waste Shed

The pyrotechnic waste shed is northwest of Building 21 in Area H in the southern portion of Mound (Figure 5.1). The start-up date is believed to have been 1975 and the area is still in service. The shed is a temporary storage area for pyrotechnic powders and pyrotechnic-contaminated wastes. Contaminated trash and pyrotechnic wastes are saturated with mineral oil, double-bagged, and sealed in a metal can. The facility personnel indicate that "pyrotechnical components are stored in non-propagating trays inside of a metal suitcase." All wastes are enclosed in drums. The shed is constructed on a 15-ft by 9-ft concrete pad, has 7-ft-high chain-link fence side walls, and is covered by a roof made of 18-gauge galvanized corrugated steel. The shed also contains the Biodegradation

Unit, which is a portable steel cylinder (1 ft in diameter by 2 ft high) mounted on legs and placed within a 30-inch by 30-inch by 6-inch-deep metal tray. No releases have been documented and no spills were observed during a 1988 inspection. Pyrotechnic waste materials are stored here until they are burned in the retort or open burned (Vinings 1991).

5.2.4. Building 27 Drum Storage Area

The Building 27 drum storage area is on the south side of Building 27 in the test fire area, in the west-central portion of Mound (Figure 5.1). It began operation in 1985 and is still in service. The drumming and storage activities replaced the former process of releasing the liquids to a sump and leach pit. Wastewater containing acetone, ethanol, and explosive constituents generated in Building 27 is temporarily stored in this area in 55-gallon drums with lids. Drummed wastewater is transferred weekly to the hazardous waste storage area in Building 72 (MRC 1983). The Drum Storage Area consists of an uncovered outdoor concrete pad and has no secondary containment controls.

5.3. HAZARDOUS WASTE STORAGE AREAS

All hazardous waste currently generated at Mound is temporarily stored and shipped off-plant for treatment or disposal. The following subsections describe the present and past areas used for the staging and storage of hazardous chemicals. The hazardous wastes storage area (Building 72) and the satellite areas are included in Mound's RCRA Part B Permit application filed with the EPA Region V in November 1986.

5.3.1. Hazardous Waste Storage Area

The hazardous waste storage area is located at Building 72, in the west-central portion of Mound (Figure 5.1) (EPA 1988). It began operation in 1986 and is still in service. Wastes generated at several Mound locations are picked up weekly by a waste transport vehicle and transported to the area (MRC 1983). Wastes are contained in sealed 35- and 55-gallon drums of both metal and plastic construction. Wastes stored in the area include combustible and flammable liquids and waste oils, solvent-containing wastes, ignitable wastes, plating wastes, photoprocessing wastes, polymeric wastes, and toxic wastes. Wastes are shipped off-plant for disposal every two to three months (Klingler 1991). Building 72 is 60 ft by 40 ft, constructed of a curbed concrete floor covered by a metal grate. The floor consists of three bays that are curbed and sloped to confine spills. The building is enclosed on three sides with metal walls and is covered with a metal roof. The roof was moved from the past hazardous waste storage area building.

Adjacent to Building 72 are the outdoor hazardous waste storage area and the empty drum storage area. No releases from these areas have been documented. The outdoor waste storage area has not been used for waste storage since late 1989. The empty drum storage area is still in service (Klingler 1991). The outdoor waste storage area is outside the east and south walls of Building 72, adjacent to the empty drum storage area. Sealed 55-gallon drums containing waste oil were stored at the east side of Building 72, on an asphalt pad surrounded by a concrete curb 6 inches high. The pad is sloped to two catch basins at the east end of the storage area that discharge to the plant drainage ditch, retention basins, and through the NPDES Outfall 002 to the Great Miami River. Drums were stacked two-high on wooden pallets and were periodically transported off-plant for disposal. Waste oil has not been stored there since late-1989. No releases were documented, but stains were noted on the asphalt pad during the site inspection (EPA 1988). Sealed empty 55-gallon drums that formerly contained hazardous wastes are stored on their sides in the empty drum storage area and are covered with a canvas tarpaulin.

5.3.2. Empty Drum Storage Area

The empty drum storage area is outside the northeast corner of Building 72, adjacent to the outdoor hazardous waste storage area (Figure 5.1.). Sealed empty 55-gallon drums, which were formerly used for storage of hazardous wastes, are stored on their sides and covered with a canvas tarpaulin. The area consists of an asphalt pad surrounded by a 6-inch high concrete curb. The pad is sloped to two catch basins at the east end of the storage area that discharge to the plant drainage ditch, the retention basins, and on through the NPDES Outfall 002 to the Great Miami River. No releases were documented, but stains were observed on the asphalt (EPA 1988). The area on the east side of the building was once used to store both oils and empty drums (Carfagno 1989).

5.3.3. Scintillation Vial Storage Area

The scintillation vial storage area is in Room 143 of Building E on the Main Hill, in the northern portion of Mound (Figure 5.1). The start-up date is unknown. The area is still in operation, and is used for the temporary storage of vials of scintillation liquid composed of radioactive materials (tritium) mixed with solvent (trimethylbenzene cocktail) with a radioactivity level ranging from greater than 50 μCi/L to less than 50 μCi/L (DOE 1992g). The vials are closed plastic containers with volumes ranging from approximately 40 mL to 250 mL. Vials are stored in two approximately 20-gallon metal drums that sit on a concrete floor. Filled drums are transferred to the radioactive/mixed waste storage area in Building 23.

5.3.4. Building 28 Solvent Storage Area

The Building 28 solvent storage area is a sheet metal building on a concrete pad located on the east side of Building 28, on the Main Hill, in the north-central portion of Mound (Figure 5.1). Historically, waste solvents were pumped from Building 28 into drums located on a concrete pad on the south side of the building. There was no curbing or controls to contain releases. In 1990, a solvent storage building was constructed to contain the drums. Solvents used in Building 28 are now stored in the new building. The solvents consist of alcohol, acetone, and dichloromethane. The alcohol and dichloromethane are pumped from drums into Building 28 through stainless steel lines. The acetone is stored in bottles. Once used in the building, the solvents are returned through copper lines to waste drums in the solvent storage shed. The drums are equipped with sensors to automatically shut off the solvent flow when full (Koons 1991). Drummed waste solvent is transferred as required to the hazardous waste storage area in Building 72 near the western edge of the Mound boundary (MRC 1983). In 1989, approximately 800 gallons of waste solvents were generated in Building 28 (Fentiman 1990).

5.3.5. DS Building Solvent Storage Shed

The DS Building solvent storage shed is on the east side of DS Building on the Main Hill, in the north-central portion of Mound (Figure 5.1). The shed was built in the early 1970s and is still in operation. The shed is a completely enclosed structure of approximately 10 ft by 10 ft, with a 12-ft ceiling equipped with a fan for ventilation. It has a concrete floor and a sealed drain with an unknown point of discharge, although a storm drain is near the shed. The concrete floor is curbed and covered with a metal grate. The curbing was not installed until 1987, at which time the drain was sealed. Historically, solvents were stored in 5-gallon cans within the building and picked up and delivered by laborers. The shed now receives waste solvent from the DS Building and also contains product-grade solvent to be used in the building. Waste solvent is pumped from the DS Building into sealed 55-gallon drums in the storage shed through automatic discharge hoses that are equipped with automatic shutoff devices. During a 1990 site visit, two drums of waste solvents composed of 1,1,1-trichloroethane, trichlorofluoromethane, and trichloroethene; and product-grade solvents including one drum of 1,1,1-trichloroethane, two drums of trichlorofluoromethane, and one drum of ethyl alcohol, were found (DOE 1992g). Drummed waste solvent is transferred as required to the hazardous waste storage area in Building 72 near the western edge of the Mound boundary (MRC 1983).

5.3.6. B Building Solvent Storage Shed

The B Building solvent storage shed is on the east side of the B Building on the Main Hill, in the north-central portion of Mound (Figure 5.1) (Becker 1991). The shed was built in the early 1970s and is still in use. Before the shed was built, solvents were stored within the building, typically in 5-gallon cans. These were picked up and delivered by laborers. The automatic system now in use was not installed until the late 1970s.

The B Building solvent storage shed receives waste solvent from B Building and also contains product-grade solvents to be used in the building (DOE 1992g). Waste solvent is pumped from Building B into sealed 55-gallon drums in the storage shed through automatic discharge hoses equipped with automatic shutoff devices. During a 1990 site visit, it was found that the storage shed contained three drums of waste flammable liquid and product-grade solvents including two drums of trichloroethene, four drums of trichlorofluoromethane, two drums of ethyl alcohol, and two 5-gallon drums of clean oil (DOE 1992g). Other solvents routinely stored here include methyl and isopropyl alcohol, acetone, trichloroethene, dichloromethane, and toluene (Fentiman 1990). Several drums were found outside the solvent storage shed including one DTE heavy oil, several drums that had or did contain unspecified flammable materials, one drum of hydraulic fluid, and one drum of Sunthene 410 (Sunoco). Drummed wastes are placed outside the shed only as a temporary measure during unloading and pickup (Becker 1991). Drummed wastes are transferred weekly to the hazardous waste storage area in Building 72 near the western edge of the Mound boundary (MRC 1983). Approximately 1,300 gallons of waste solvents were generated in 1989 (Fentiman 1990).

The shed is a fully enclosed structure approximately 20 ft by 10 ft with a 12-ft ceiling. It has a concrete floor covered with a metal grate. Curbing was installed in 1987 and 1988. No releases were documented and no evidence of spills was observed. A drain connected to the plant's storm sewer was sealed prior to 1988. Old, unused, above-ground lines running to and from the storage shed, are being dismantled (Becker 1991). Thus far, three of the unused lines contained chemicals, one contained alcohol, and two contained trichloroethene.

5.3.6.1. B Building Temporary Drum Storage Area

The B Building temporary drum storage area is adjacent to the B Building solvent storage shed on the east side of B Building, on the Main Hill, in the northwest portion of Mound (Figure 5.1). Storage began in this area in 1988. It was intended for temporary storage, and it is not still in use. Waste solvents, waste oil, and trash from E and B buildings were stored here. The areais

approximately 15 ft by 15 ft. Twenty-six sealed 55-gallon drums were stored in this area during the 1988 visual site inspection (EPA 1988). The area is an open concrete pad without curbing.

5.3.7. SW Building Drum Staging Area

The SW Building drum staging area is near the SW Building, on the Main Hill, in the northwest portion of Mound (Figure 5.1). The start-up date is unknown and the area is still in service. The area was intended for storage of asbestos material but is currently used for storage of hazardous wastes in sealed 55-gallon drums. The area is an uncurbed concrete pad sloping downhill and surrounded by metal grid sidewalls. Two sealed waste oil drums, one fiberpak drain, and one antifreeze drum were observed outside the walls of the staging area during a 1988 inspection. No releases were documented and no spills were observed during the inspection.

5.3.8. Building 49 Solvent Storage Shed (Inactive)

The Building 49 solvent storage shed is 120 ft north-northeast of Building 49, in the south-central portion of Mound (Figure 5.1). The shed is a metal structure constructed in 1985 and used as a solvent supply and storage facility until late 1990 (Hatfield 1991). The shed measures 8 ft by 12 ft with a 10-ft ceiling and is equipped with a ventilation fan and a metal-grid floor with an underlying catch basin (Brewer 1991). The solvent shed was taken out of service as a satellite solvent supply and storage facility in late 1990 (Hatfield 1991). This solvent storage shed was not described in the RFA (EPA 1988).

Timer assembly and inert transducer encapsulation operations, which were moved to Building 49 during the late-1960s and were conducted there until late-1990, formerly took place in Building E (Fentiman 1990; Hertenstein 1991). Operations in Building 49 included the degreasing of metal parts using solvents (trichloroethene, isopropyl alcohol, ethyl alcohol, Freon, and hexane) stored in the solvent shed. Trichloroethene, isopropyl alcohol, and ethyl alcohol were primarily used to clean parts and were stored inside the shed in 55-gallon drums (Fentiman 1990). These solvents were piped directly from the drums into Building 49. The spent solvents were poured into a drain, piped back to the solvent shed, and contained in a 55-gallon waste drum (Fentiman 1990; Brewer 1991). Freon and hexane were occasionally used for cleaning parts and were stored in the shed in 5-gallon cans. Waste Freon and hexane were put in separate 5-gallon cans and also stored in the solvent shed. All solvents were picked up by Mound waste management personnel and transferred to the hazardous waste storage area in Building 72 (Fentiman 1990). The major portion of parts cleaning operations was moved to the Building M plating shop in late 1990. Currently, operations at Building 49 include limited ultrasonic cleaning of parts using Freon TF; however, the solvent shed piping system is no longer used for the

inflow and outflow of solvents. Supply Freon TF is pumped from a 55-gallon drum (located inside the shed) into a 5-gallon can and transported to Building 49 where it is stored for use. Both supply and waste Freon are stored in a fire-proof cabinet. Approximately 2.5 gallons of waste Freon are generated from the ultrasonic cleaning operations per year. The waste Freon was picked up by Mound waste management personnel as needed. Two sealed 55-gallon drums containing ethyl alcohol are currently staged in the solvent shed (Hatfield 1991).

5.3.9. Old Firing Range Drum Storage Area (Historical)

The old firing range drum storage area is just west of Building 105, in the southeastern portion of Mound (Figure 5.1) (DOE 1991a). The area was in operation from about 1970 to 1974. It was used for the collection and staging of liquid chemical wastes until they could be transported off-plant for disposal; it was the first staging and storage area used for such purposes when the historic landfill (Area B) was closed to open burning. Its operation was concurrent with the limited operation of the Building 51 waste incinerator. Most hazardous wastes generated during this time were collected weekly and consolidated at the old firing range drum storage area, although some waste solvents were incinerated. In September 1971, of the approximately 50 55-gallon drums of oil and solvent that had accumulated, 530 gallons were transferred to the incinerator for disposal (Russell 1971). Another test burn was conducted in January 1972, in which 80 gallons of waste oils and solvents were burned (Werner 1972a). The destruction of waste oils and solvents by incineration was generally not successful and is described in subsection 4.14. In 1974, the hazardous chemical staging activities moved back to the area of the historic landfill and the old firing range drum storage area was abandoned.

The area was approximately 100 ft by 100 ft, and photographs show that 100 to 500 drums were stored in the open on bare ground. Historic photographs reveal oil sheens of undetermined origins. No radiological contamination was detected during a 1988 Mound Site Survey (DOE 1992g). The area is sparsely vegetated and partially covered by the intersection of the new paved road and a dirt road.

5.3.10. Area B Drum Storage Area (Historical)

The Area B drum storage area was located at the site of the historic landfill (Figure 5.1). It was used in the mid-1970s to stage and temporarily store hazardous chemical wastes before they were shipped off-plant for disposal. The area replaced the old firing range drum storage area for this activity. The waste chemicals were typically picked up weekly by waste management personnel and transferred from small laboratory vessels to 55-gallon drums. The drums were placed in open-topped, steel dumpsters that could be moved around to allow the solid waste landfill operations to continue

concurrently (Vaughters 1991). The chemical waste staging activities in Area B were moved to the chemical waste storage area in 1976 to allow the construction of the overflow pond and site sanitary landfill.

5.3.11. Chemical Waste Storage Area (Historical)

The chemical waste storage area was in the central part of Mound along the southern margin of the lower reach of the plant drainage ditch (Figure 5.1). This area was used to stage hazardous chemical wastes before they were shipped off-plant for disposal. The area replaced the Area B drum storage area in 1976 and was itself replaced by the construction of the past hazardous waste storage area structure (old Building 72) in 1982. The old Building 72 was constructed adjacent to the chemical waste storage area.

The area appears from photographs to have been located along the access road and was probably about 50 ft wide by 200 ft long. The location and extent of this storage area are graphically displayed in the Site Scoping Report: Volume 6 - Photo History (DOE 1992c).

It is unknown whether the drums stored in the area were stored on the ground or were elevated. The drainage in the area probably did not allow water to pond as it had in the old firing range drum storage area, so the drums may have been placed directly on the ground. In all probability, the types and quantities of wastes were similar to those stored at the past hazardous waste storage area and the waste oil drum field.

5.3.12. Waste Oil Drum Field Area (Historical)

The waste oil drum field area is an inactive unit located approximately 250 yards southeast of the open burn area and due west of Building 100, in the southern portion of Mound (Figure 5.1). It was used for temporary drum storage between the decommissioning of the past hazardous waste storage area in 1986 and start-up of the hazardous waste storage area (Building 72). It was closed during the last quarter of 1986. Approximately 200 drums were observed in an open field east of the burn area in August 1986. Half the drums were marked as containing waste oil, and the remainder were identified as plating shop waste, explosive/solvent waste, herbicides, mixed laboratory chemicals, photographic waste, batteries, kitchen grease, epoxy resins, ethylene glycol, scintillation vials (less than 50 μCi/L), and other chemical wastes (EPA 1988). The drums were removed from this area shortly after August 1986. The area was approximately 50 ft by 100 ft (DOE 1992g), and the 55-gallon drums were stored on skids above the soil. During an August 1986 inspection, it was found that the soil at the south end of the drum area showed evidence of leakage from waste oil drums, and dark stains could be seen on

the ground throughout this area. Storm water runoff from the area probably flows westward toward the overflow pond.

5.3.13. Past Hazardous Waste Storage Area (Historical)

The past hazardous waste storage area is the former location of Building 72 and is immediately west of Building 87, in the test fire area of Mound (Figure 5.1). The building began operation in 1982, and the Ohio EPA approved the closure plan August 8, 1985. The building was used for storage, prior to off-plant shipment, of combustible and flammable liquids and waste oils, solvent-containing wastes, ignitable wastes, plating wastes, photoprocessing wastes, polymeric wastes, and toxic wastes generated at the facility. Wastes were stored in sealed 55-gallon drums. The storage structure was a 60-ft by 40-ft covered structure (Building 72) with a concrete floor that was divided into four drum storage bays to segregate incompatible wastes. Three of the bays were 13 ft by 40 ft. The fourth bay measured 24 ft by 9 ft and was used to hold defective containers and to prepare waste containers for off-plant shipment. The bays had sloped floors and 6- to 15-inch dikes. The expansion of Building 87 required removal of the structure. During closure, the concrete floor was broken up and disposed of and soil samples were collected and analyzed for contamination by halogenated volatile chemicals (DOE 1992g). Contaminated soils were identified, excavated, and shipped off-plant for disposal. Additional soil samples were collected from newly exposed soil, but no contamination was found. The building was dismantled and moved to its present location in early 1986. During the time it took to move the building, the contents were staged at the waste oil drum field.

5.3.14. Building E Solvent Storage Shed (Historical)

The Building E solvent storage shed was on the south side of Building E, on the Main Hill, in the north-central portion of Mound (Figure 5.1). The start-up date is unknown. It was taken out of service in April 1988 when the new addition to E Building was completed. The shed was used for the temporary storage of waste solvents (most likely ethanol, methanol, and trichloroethene) generated in Building E. Waste solvent was pumped from Building E directly into 55-gallon drums inside the shed. Filled drums were transferred weekly to the hazardous waste storage area in Building 72, near the western edge of the Mound boundary (MRC 1983). The shed was a metal-roofed and walled structure with a concrete floor and a surface area of approximately 144 ft^2. The concrete floor was sloped to a drain that routed spilled materials to storm sewers and to the plant drainage ditch. During operation, the unit had no curbing or other structures to contain spills. The building and pad were removed to allow construction of the E Building addition. During dismantling operations, soil contaminated with trichloroethene was discovered around the floor drain. The soil was excavated to a depth of approximately 10 ft, drummed, and shipped off-plant for disposal (DOE 1992g). Analysis for Freon,

acetone, tricholoroethene, dichloromethane, isopropyl and methyl alcohols, and 1,1,1-trichloroethane indicated no results above the 1 ppm detection limit (Gloeckler 1988). The quantity of solvents used in the E Building has since been reduced. Since the removal of the solvent storage shed, these solvents are kept inside the E Building in appropriate cabinets (Pardieck 1991).

5.3.15. Building 29 Solvent Storage Shed (Inactive)

The Building 29 solvent storage shed is on the west end of Building 29, in the north-central portion of Mound (Figure 5.1). The solvent storage shed is a stand-alone building, approximately 11 ft wide by 10 ft high, and is constructed with sheet metal walls and roof. It is placed on a concrete pad. The floor is contained on three sides by a 4-inch-high curb, the remaining side of the floor is uncurbed.

Construction and operation of the solvent storage shed began in 1972. Acetone stored inside the shed in 55-gallon drums is pumped from the drums through transfer lines into Building 29 where it is used. Spent solvent is pumped from Building 29 back into the solvent shed and into drums for disposal. Acetone is the only solvent that has been stored in the shed for use in Building 29. A 55-gallon drum of propanol was delivered by mistake and is currently stored in the shed. However, Mound personnel indicated that acetone is the only solvent intentionally used and stored in the shed.

Prior to construction of the shed, acetone was stored in drums in Room 7 of Building 29. The acetone was used in the building. Waste acetone was drummed for disposal. The drummed waste was picked up by waste management personnel.

The solvent storage shed became inactive approximately two years ago when the process using acetone in Building 29 was shut down. The shed is in a standby mode and may go operational depending upon future plans. This shed was not described in the RFA (EPA 1988).

5.4. STORM WATER RETENTION AND DISCHARGE SYSTEM

The Storm Water Retention and Discharge System (SRDS) consists of three engineered structures constructed along the plant drainage ditch to control the movement of surface water and sediments contaminated with low-levels of plutonium-238. The SRDS surface impoundments include the asphalt-lined pond, the retention basins and weir basin, and the overflow pond. Surface water and sediment samples were collected from the surface impoundments of the SRDS in 1987 as part of the DOE Water and Sediment Sampling/Analysis Program performed by International Technology Corporation (IT 1987). A description of each impoundment and a summary of analysis results are presented in the following sections.

5.4.1. Asphalt-Lined Pond

The asphalt-lined pond is an open-topped pond located west of Building 61, in the northeast corner of the plant (Figure 5.1). The pond began operating in the 1970s and is still in use. It is approximately 150 ft by 150 ft and 10 to 12 ft deep, with a nominal capacity of 1.5 million gallons (EPA 1988). The pond receives wastewater from the SM/PP Hill storm sewers, SM/PP hillside runoff, and non-contact cooling water. A controlled outlet and emergency overflow spillway that drain to the Mound drainage ditch prevent overflow. The pond's bottom and sides are covered with a layer of asphalt, The pond provides temporary storage, flow equalization, and retention time for removing suspended solids prior to discharge to the drainage ditch. Wastewater flows by gravity into and out of the pond. Approximately 5 ft of freeboard are maintained by a gravity-fed discharge at the south end of the pond. Cracks in the asphalt liner were observed during the removal of vegetation from the north end of the pond during the summer of 1991.

The sediment depth and activity level are measured occasionally. Sediment buildup in the pond is minimal. Sediments have been removed from the pond only once during its operation, in 1982 (Carfagno 1991). The sediment was cleaned out of the pond, dewatered onsite in the dredge spoil drying beds (see treatment subsection 4.22), and packaged for off-plant disposal. The water removed from the sediments was placed back in the pond. The sediments removed from the pond were found to contain plutonium, radium, and uranium.

Water and other sediment samples have been collected from the asphalt-lined pond. Five full-column water samples were composited to form one sample for laboratory analysis (IT 1987). Twenty sediment plugs were composited to form one sample for laboratory analysis (IT 1987). The samples contained low-level radioactivity in excess of the as low as reasonable achievable (ALARA) cleanup level of 100 pCi/g. The samples were tested for RCRA Extraction Procedure (EP) toxicity parameters that include arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Barium was found in the pond water and sediment leachate samples at concentrations of 0.016 mg/L and 0.40 mg/L, respectively. These concentrations are below the maximum contaminant level (MCL) of 1.0 mg/L for drinking water and the EP toxicity level of 100 mg/L for leachate from soils. Sample concentrations for all other parameters were below laboratory detection limits.

5.4.2. Retention Basins and Weir Basin

The retention basins are in the southwestern corner of the plant and consist of an open-topped impoundment with earthen sides and bottom that is partitioned into three basins by concrete dividers (Figure 5.1). Rainfall runoff and facility effluents from the plant drainage ditch flow into the

northernmost basin, discharging to the south basin and finally to the west basin. Each of the three basins is irregularly shaped. The northeastern basin is approximately 20 ft by 40 ft, the southern basin is 60 ft by 75 ft, and the western basin is approximately 45 ft by 140 ft.

The normal pool elevation in the basins is controlled by a standpipe in the west basin that discharges basin effluent to a connected weir basin. The capacity of the retention basins is estimated to be 230,000 to 260,000 gallons at normal pool elevation and 400,000 to 450,000 gallons at maximum pool elevation. The standpipe maintains approximately 2 ft of freeboard on the basins. During times of excess rainfall or when the plant drainage ditch effluent carries a high suspended solids load, the wastewater stream is diverted to the overflow pond for storage and clarification.

Water and sediment samples were collected from nine locations around the periphery of the northeasternmost retention basin. The water and sediment samples were composited to form one sample for each medium for laboratory analysis. The sample analysis included RCRA EP toxicity parameters. Barium was found in the basin water and sediment leachate at concentrations of 0.023 mg/L and 0.31 mg/L, respectively. These concentrations are below the MCL of 1.0 mg/L for drinking water and the EP toxicity level of 100 mg/L for leachate from soils. Sample concentrations for all other parameters were below laboratory detection limits (IT 1987).

In the event the retention basins fill to capacity, excess wastewater will discharge over a concrete spillway in the west basin to the weir basin. The spillway outlet terminates at the weir basin, which is the location of NPDES Outfall 002. The basin is roughly circular in shape with dimensions of 40 ft by 40 ft. A weir wall divides the weir basin into an upper and lower half. The weir wall contains a weir plate outlet (NPDES Outfall 002) that directs discharge from the upper weir basin into the lower weir basin when water in the upper weir pool reaches a specified level. As required by the NPDES permit, Outfall 002 is monitored for pH, suspended solids, and total toxic organics (EG&G 1989b). Mound also monitors the outfall for plutonium-238. Two underground concrete culverts direct discharge from the lower weir basin to the Miami-Erie Canal. Discharge then moves along an unused portion of the canal into the Great Miami River. The basins receive approximately 410,000 gallons of process water per day.

5.4.3. Overflow Pond

The overflow pond is in the southwestern corner of Mound and is used to control excess storm water runoff to the Miami-Erie Canal (Figure 5.1). The overflow pond began operating in 1979 and is still in use. It is approximately 300 ft by 300 ft, is built with earthen dikes, and has a 5,000,000-gallon capacity. The pond is lined with at least 3 ft of natural clay-bearing glacial till that was tested for

conformance with geotechnical specifications before and during construction (DOE 1991a). In the construction of the overflow pond, glacial till was excavated and used for construction of the surrounding road embankments. On the east side, the pond embankment was benched into the hillside. Areas with steep slopes and areas of potentially concentrated runoff were lined with riprap, asphalt, or concrete for erosion protection. On the north and west sides, the road was elevated and constructed to specifications for water impoundment. The north side contains an overflow channel from the plant drainage ditch and the low-flow retention basins (DOE 1991a). The pond was constructed in the location of the past landfill. Wastes from the landfill were excavated and placed in the Lined Landfill to the south. A portion of the wastes from the past landfill still remains below the overflow pond.

The purpose of the pond is to retain storm water flows, settle sediment, and support compliance with the NPDES discharge standards for suspended solids. The pond receives storm water runoff and cooling water blowdown from the plant drainage ditch. During a 6-month period following construction of the site sanitary landfill, leachate from the landfill dripped into the overflow pond (DOE 1991a).

The pond is designed to retain all facility effluents for five days in the event of a contaminant release. The retention time in the pond allows for settling of 95% of all silt. The overflow pond effluent is discharged through a standpipe in the northwest corner of the pond to the Miami-Erie Canal and the Great Miami River through NPDES Outfall 002.

Water and sediment samples have been collected from the overflow pond. Five full-column water samples were composited to form one sample for laboratory analysis; fifteen sediment plugs were composited to form one sample for laboratory analysis. The samples contained low-level radioactivity that probably resulted from surface erosion of soils within the watershed as well as erosion of the sediments along the plant drainage ditch. The sample analysis included RCRA EP toxicity parameters. Barium was found in the pond water and sediment leachate samples at concentrations of 0.028 mg/L and 0.52 mg/L, respectively. These concentrations are below the MCL of 1.0 mg/L for drinking water and the EP toxicity level of 100 mg/L for leachate from soils. Sample concentrations for all other parameters were below detection limits (IT 1987).

5.5. DRILLING MUD DRUM STORAGE AREAS

The drilling mud drum storage areas were located near the three groundwater monitoring wells (151/44-1, 152/46-2, and 153/55-2) adjacent to the overflow pond, in the southwestern portion of Mound (Figure 5.1) (DOE 1992g). The areas were used from the summer of 1987 to approximately 1989. The cuttings (i.e., muds) from cable-tool drilling rig operations were stored in 55-gallon sealed

drums. The cuttings contained barium, an additive used in well construction. Approximately 12 drums were stored outside on bare soil at each storage area. The drums were disposed of at an approved off-plant disposal facility following chemical analysis (Klingler 1991).

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6. WASTE DISPOSAL

This section describes Mound's current and historical waste disposal practices. The following descriptions of waste disposal activities are grouped according to radioactive, explosive, hazardous, and general debris waste forms. Historical practices and historical disposal sites are distinguished from current or ongoing activities. Estimates of quantities of wastes buried or disposed of are provided where they are known. Summaries of quantities of radioactive wastes are provided for the 1970s and 1980s, and summaries of quantities of hazardous wastes for the 1980s are also included.

6.1. RADIOACTIVE WASTE DISPOSAL

Radioactive wastes have continued to be the dominant waste form from Mound since its beginnings in the late 1940s. Most radioactive waste has been shipped off-plant for disposal, although some materials containing residual levels of radioactivity have been buried on-plant. Because Mound has not had the capacity nor the inclination to dispose of radioactive waste on-plant, it has been instrumental in research and development of waste containers, packaging materials, shipping and transportation requirements and guidelines. The following subsections summarize the types, locations, and quantities, if known, of materials known to be buried on-plant and the types, quantities, and destinations of materials shipped off-plant.

6.1.1. On-Plant Radioactive Waste Disposal

Throughout the history of Mound, very little radioactive waste has been disposed of on the plant site. Only materials containing residual radioactive wastes have been buried on-plant. No radioactive waste from any of the research or production activities has ever been disposed of on-plant. The types of radioactive materials disposed of on the plant site generally consist of five groups: 1) debris from the demolition of the Dayton units containing residual levels of short-lived isotopes of polonium-210, 2) used drums and soils contaminated with low levels of thorium from the failed thorium refinery project, 3) cleaning residues such as the sand from the sandblasting of the WD Building tanks, and 4) soils and gravels containing residual levels of radium and actinium from the excavation next to the old cave in SW Building.

In 1972, partially in response to the newly organized waste management program, a concerted effort was made to identify the areas where residual materials had been buried or otherwise disposed of on-plant. Few records had been kept on the types and quantities of wastes disposed of; researchers relied largely on the memories of long-term employees. This information resulted in the production of a site

map of the hot waste burial areas (Hebb 1972), dated February 15, 1972. A copy of the "hot waste burial sites" map (Drawing No. SK-2281) is provided in Appendix A. The areas identified included only those areas with radiologic contamination, which were assigned numbers. These numbered area designations (e.g., Area 2, Area 10) are retained for use in the ER Program (DOE 1992g) and this report. Fifteen areas were first identified in 1972, and an additional eight areas have been identified since (DOE 1991c). The initial identification of the radiologically contaminated areas was followed by the need to sample and confirm the levels of contamination. Ten years passed from the time the contaminated areas were identified until the sampling was funded and performed. In 1982, the Site Survey Project (Stought et al. 1988) began a three-year effort to conduct radiological surveys and sample analyses of the identified areas of contamination. The results of the Site Survey Project are referred to in this report and detailed in the Site Scoping Report: Volume III - Radiological Survey Report (DOE 1991c).

In 1984, the ER Program, then called the CEARP, conducted an installation assessment under contract to the DOE, Albuquerque Operations Office. Under the CEARP installation assessment, 10 areas that had potentially released contaminants to the environment were identified. These areas were designated by letters (e.g., Area B, Area J). These area designations are also retained in the ER Program (DOE 1992g) and are used in this report.

6.1.1.1. Area 2, Thorium- and Polonium-Contaminated Wastes (Historical)

Area 2 is south of the overflow pond along the west-central border of the plant (Figure 6.1). The area forms part of the historic landfill, but was distinguished in the 1972 map of hot waste burial areas (Hebb 1972). The area received several different lots of residual materials in the 1950s and 1960s. In 1955, wood ash and debris from a fire that had consumed the polonium-contaminated flooring from the Dayton units (Area 13) was buried along the southern margin of the historic landfill. The burial occurred in an irregular trench, 12 to 14 ft deep, which was covered by a few feet of soil (Thomas 1990). Between 1955 and 1964, some 2,000 to 5,000 crushed 55-gallon drums were also buried. These drums were the remains of the thorium repackaging operations that occurred in Areas 1, 3, and 9. The drums were empty, but probably contained residual thorium sludge materials. In 1965, sandblasting sand from the cleaning operations within the WD Building were buried in the southern parts of the historic landfill. The sandblasting operations were part of the cleaning of the large clariflocculator tanks used for processing wastes from polonium production (Garner 1991).

Area 2 is believed to occupy about 15,000 ft^2 and is at least partially covered by the site sanitary landfill constructed in 1977. Results of a magnetic survey conducted in Area 2 in 1990 indicated that some of the burials may lie under the present position of the road intersection (DOE 1990b). This is

J:\DGN\MOUND8\M0222.dgn OU9 062392

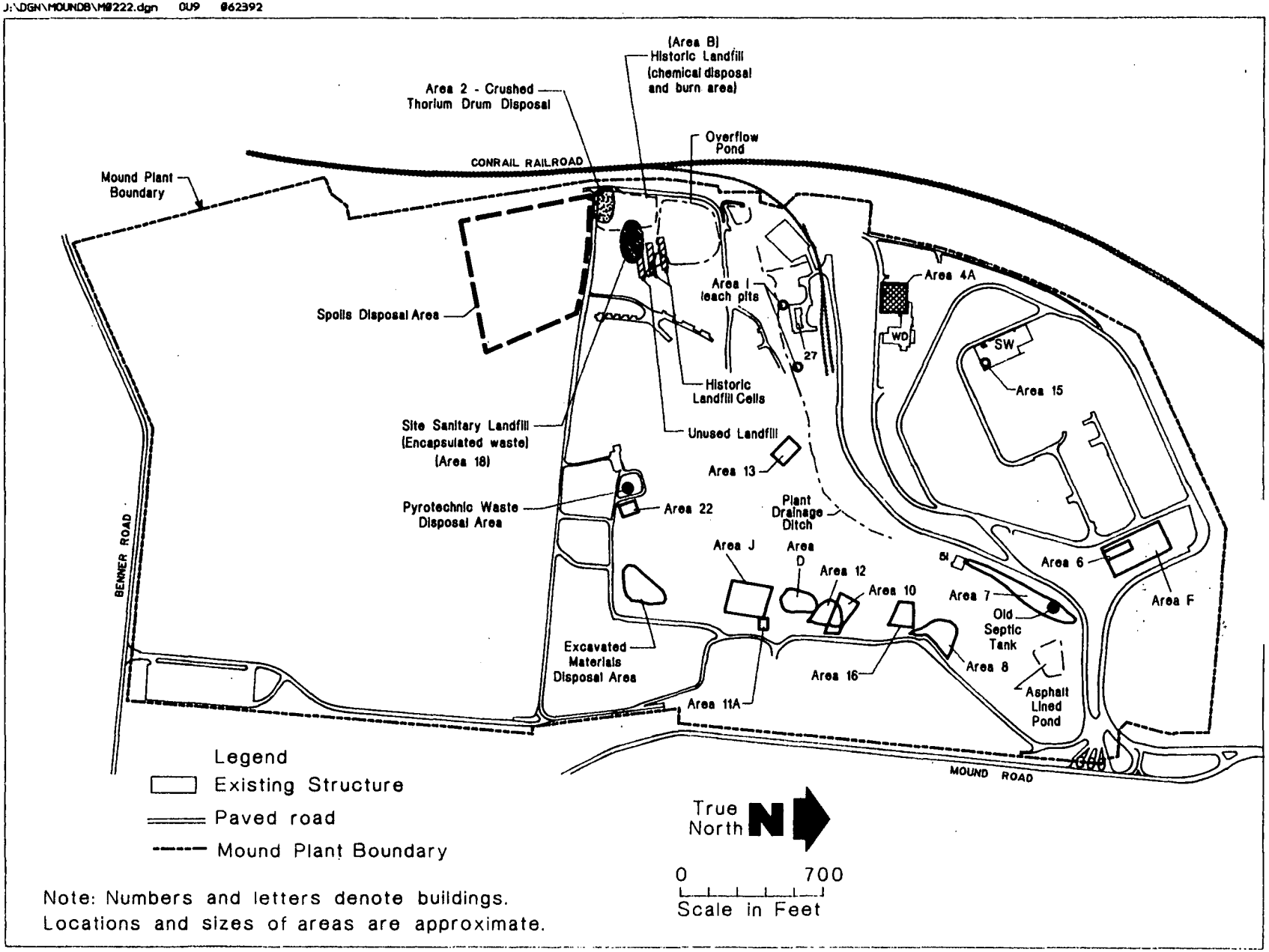
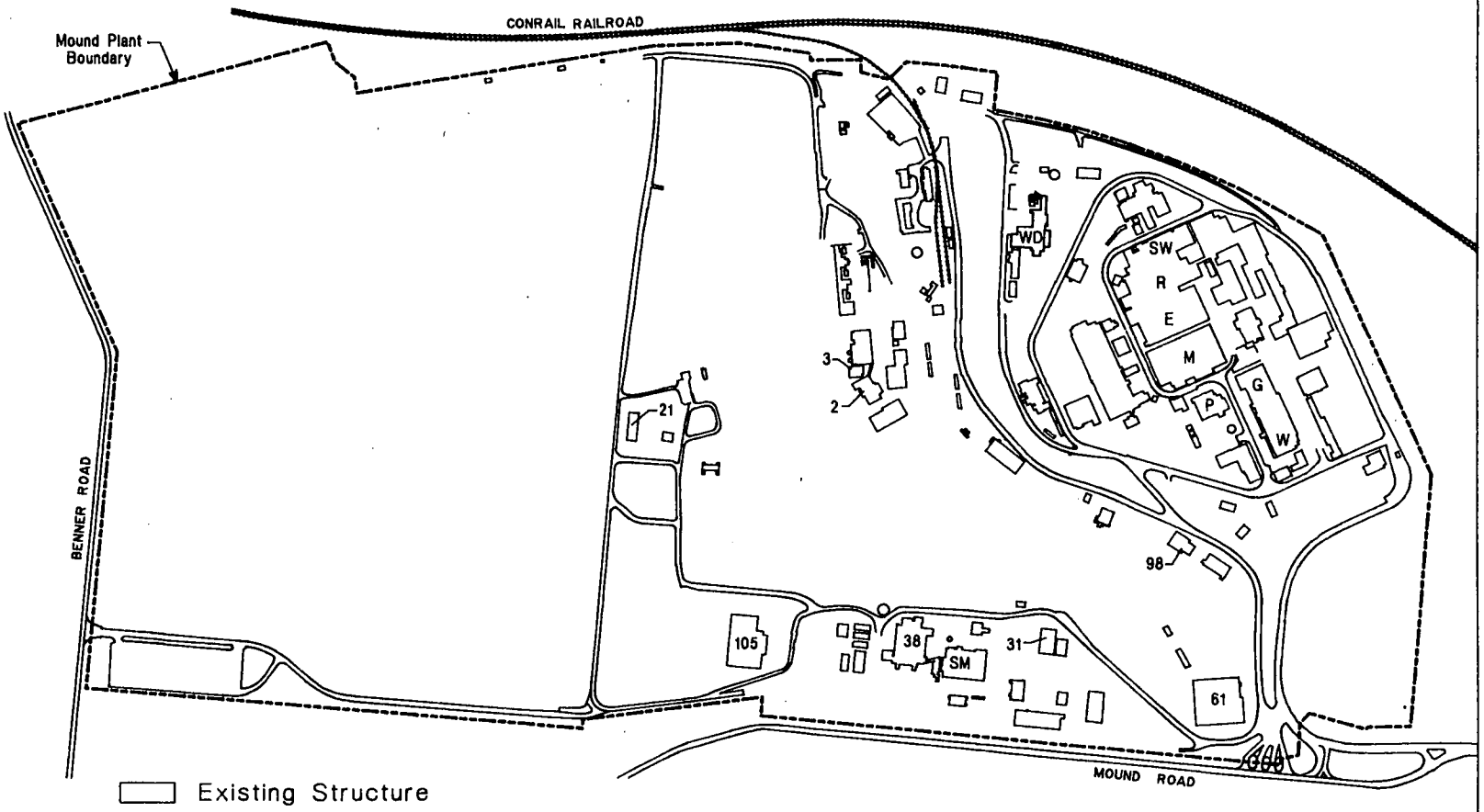


Figure 6.1 On-plant waste disposal areas.

J:\DGN\MOUND\M0489 OU9 vol 7. 061992 basemap for m0222



also supported by the interpretation of historic aerial photographs, which indicate that the historic landfill may have occupied areas presently under the paved roads (DOE 1991f).

Area 2 was investigated for radiological contamination during the Site Survey Project (DOE 1991b). The maximum concentration of plutonium-238 was 17.1 pCi/g in a sample taken at a depth of 18 inches. The maximum thorium concentration detected was 3.31 pCi/g at a depth of 108 inches. Neither of the two boreholes in the area appear to have been located to exactly penetrate the thorium drums (DOE 1991b).

6.1.1.2. Area 6, Polonium-Contaminated Waste (Historical)

Area 6 is southeast of the GH Building on the Main Hill, in the northern portion of Mound (DOE 1991b) (Figure 6.1). The area is currently a parking lot and may overlap Area F, the chromium trench. In 1964, at least three 55-gallon drums of polonium-contaminated sand were placed in this area. The sand was contaminated during cleaning (sandblasting) of the metal framework of the WD Building sand filters. The sand was originally contained in drums that were placed in Area 6, in a 100-ft by 40-ft trench. The trench was covered with up to 30 ft of clean fill dirt before the parking lot was built. The trench may also contain a polonium-contaminated washing machine (Thomas 1991). Polonium has a half-life of 138.4 days and is no longer present due to radioactive decay. The 1982 to 1985 Radiological Site Survey (DOE 1991c) detected low levels of radium-226 (all below 1 pCi/g) in soil samples at various depths.

6.1.1.3. Area 7, Thorium, Polonium, and Actinium Wastes (Historical)

Area 7 is in the northeast portion of Mound, southwest of the asphalt-lined pond (Figure 6.1). The area encompasses about 140,000 ft^2 and is currently covered by a paved parking lot constructed in 1984. Buildings 51, 66, and 98 are also located over the area, which originally formed the upper reach of the plant drainage ditch. Many years of debris disposal and infilling have buried the original ravine (DOE 1992c).

Area 7 has been the site of extended disposal of residual materials including thorium, polonium-210, and some actinium-227. The thorium repackaging operations that extended from the mid-1950s to the mid-1960s generated between 15,000 and 20,000 steel drums. It is estimated that between 10,000 and 15,000 of these drums were crushed and buried along the western part of the original ravine. The remainder are probably buried in Area 2. This disposal tended to create usable land along this part of the ravine. In the Site Scoping Report: Volume 3 - Radiological Survey Report (DOE 1991c), it was reported that 2,500 drums were buried in Area 7, but that number fails to account for

the continued replacement and repacking of the drums over the 10-year time span. The best current estimate is that the majority of these drums were placed in Area 7 (Meyer 1991; Garner 1991) and the remainder in Area 2. Also associated with the thorium project was a flatbed truck and a conveyor belt device used in the repackaging operations. This truck was previously reported to have been buried in the early 1950s and to have been contaminated with polonium-210 (DOE 1991c). It now appears likely that the dominant contaminant was thorium-232 from the repackaging operations and that the truck could not have been buried until that operation was completed in the mid-1960s (Garner 1991).

In either 1959 or 1960, concrete, soil, and gravel excavated from the west side of the SW Building were dumped in an old septic tank in the northern part of what is now included in Area 7 (DOE 1991c). The septic tank was installed for use during plant construction, but was abandoned during the 1950s. The contaminated materials contained radium-226, actinium-227, and thorium-228, which probably originated from a leaky sump (MCC 1953-1957) associated with the "old cave," now known as Area 15. The dirt and gravel were excavated in 1955 as part of the construction of the thorium refinery project (Meyer 1955c). The volume of material involved is estimated to have been about 100 to 150 ft^3 (Garner 1991). The septic tank appears to have been drilled, and core samples were collected during the Site Survey Project (DOE 1991c). Residual actinium-227 was detected at a concentration of 1,400 pCi/g at a depth of 144 inches (DOE 1991c).

In the mid-1960s, materials contaminated with polonium-210, including an exhaust system from the remodeling of T Building and a large stainless steel washing machine, were also buried on the side of the ravine. Smaller items contaminated with polonium-210 may also have been buried (Garner 1991).

During the research for this report, one unusual entry was noted in the logbooks maintained by decontamination workers. The log records that on April 29, 1965, seven 30-gallon drums [sic] of dirt were removed from road below Warehouse [sic] 15A (MRC 1961-1968). Warehouse 15A was used during this time period for a storage and shipping point for radioactive trash and wastes. No other information was obtained for this activity.

During the early 1970s, it was rumored that some of the trash from the historic landfill was excavated and removed to the ravine (DOE 1991a). This rumor has been difficult to substantiate; but, if true, it would suggest the possibility that some hazardous chemicals could have been relocated from the historic landfill to Area 7. Area 7 was identified as a historic burial site for materials containing residual radionuclides. The original map compiled during that early effort (Hebb 1972) is reproduced in Appendix A. Some errors were apparent on the original map. For example, the thorium contamination was listed as thorium-228 when in fact thorium-232 was the dominant isotope in the thorium sludges.

Later versions of the map appeared in the waste management site plans of the mid-1970s (e.g., MRC 1974c) with the correct thorium-232 isotope identified.

The contamination levels within Area 7, reported as a result of the Site Survey Project investigation, are plutonium-238 and thorium concentrations of 7.40 and 20.52 pCi/g, respectively, in surface samples (DOE 1991c). Other radionuclides detected included radium-226 (2 pCi/g), cesium-137 (1.2 pCi/g), and tritium (5.23 nCi/L).

6.1.1.4. Area 8, Thorium-Contaminated Soils from Areas 1 and 9 (Historical)

Area 8 is northwest of Building 31, on the SM/PP Hill in the eastern portion of Mound (Figure 6.1), and encompasses approximately 25,000 ft^2 (MRC 1985a). Area 9 and Area 1 were contaminated by the repackaging of the thorium-232 sludges in 1965 and 1966. When these areas were scraped to remove the surficial contamination (in 1965), the soils were disposed of in Area 8 and Area 12. During the 1982 to 1985 Radiological Site Survey (DOE 1991c), plutonium-238 was detected at a maximum concentration of 24.4 pCi/g in a surface sample; all other surface samples were less than 10 pCi/g. The maximum thorium concentration was 254.3 pCi/g in a subsurface sample at a depth of 80 inches.

6.1.1.5. Area 10, Debris from Dayton Units (Historical)

Area 10 is west of Building 30, on the slope of the SM/PP Hill, in the east-central portion of Mound (Figure 6.1) (DOE 1991c). It was used for the disposal of concrete contaminated with polonium-210 from the Dayton operations. The concrete was deposited in 1950 and, because of the short half-life of polonium-210 (138.4 days), is no longer radioactive (DOE 1992g). One hundred and sixty truckloads of debris were brought to Mound from Dayton Unit IV (Halbach 1950), and 100 truckloads were brought from Unit III. It is unknown how much of this was stored in Warehouse 10, the tropical huts, or dumped in Area 10. Many of the temporary buildings at Unit III were also razed and brought to Mound when that facility was decommissioned. Some more recent concrete disposal may also have occurred, but nothing is known for certain. The area is estimated to be approximately 150 ft by 100 ft. The single surface soil sample collected from Area 10 during the 1982 to 1985 Radiological Site Survey had a plutonium-238 concentration of 11.8 pCi/g and a thorium concentration of less than 2 pCi/g (DOE 1991c).

6.1.1.6. Area 12, Thorium-Contaminated Soil from Area 1

Area 12 is west of Building 38, on the SM/PP Hill, in the eastern portion of Mound (Figure 6.1) (DOE 1991c). In 1965, soil contaminated with thorium-232 was transferred to Area 12 from Area 1, when

the latter was scraped to remove the surface contamination. Soil contaminated with thorium-232 and plutonium-238 from the SM Building was deposited over the area in 1965 (DOE 1992g). In addition, the pipelines that carried low- and high-risk radioactive wastes from Building 38 to the WD Building passed through this area and could be a source of contamination. The 1982 to 1985 Radiological Site Survey found maximum plutonium-238 and thorium concentrations of 313 pCi/g and 189.9 pCi/g, respectively, at a sample depth of 54 inches. The area encompasses approximately 19,000 ft^2 (MRC 1983). When the WTS pipeline was removed by the D&D Program, soil overburden containing low-level thorium contamination was removed to a site south of the area now called Rader's Hill.

6.1.1.7. Area 15, Entombed Old Cave (Historical)

Area 15 is room 219 (referred to as the old cave) in the SW Building, on the Main Hill, in the northern portion of Mound (Figure 6.1). The approximately 1,000-ft^2 room was a hot cell used for the processing of radium-226 and actinium-227 from 1952 to 1954. In 1955, the contaminated room and equipment underwent D&D. Most equipment was packaged and shipped offsite for burial. Larger items, including a crane, crane tracks, and the cell walls and shielding, were laid down on the floor and covered with several inches of concrete (Garner 1991). Three sumps were also entombed. These were filled with sand and covered with 3 inches of concrete in 1955 (Meyer 1955d). A construction drawing of the original foundation and drainage plan, depicting the sumps layout, is included in Appendix A. The entire east side of the original SW Building was entombed, including room 1-A where the cave was located and room 1-B where the waste treatment evaporator was located. Two feet of sand were laid down room 1-A in 1959 and covered with concrete (Meyer 1959a).

Because this area was sealed, no radiological samples were collected from the equipment or concrete during the 1982 to 1985 Site Survey Project (DOE 1991c). Currently, a stack from the room is monitored by Mound and releases about 1 Ci of radon-222 per year. Radon-222 is a decay product of the residual radium-226. Residual radium-226 and actinium-227 may lie beneath the old cave room in a wastewater sump, which is known to have leaked contaminants into the area west of the sump, that drained the hot side of the cell. Concrete, soil, and gravel removed in 1955 were disposed of in an old septic tank in Area 7.

6.1.1.8. Area 16, SM Building Sanitary Sewage Septic Tank and Leach Basin (Historical)

Area 16 is below Building 30, on the west side of SM/PP Hill (Figure 6.1). The area covers approximately 15,500 ft^2 (MRC 1983). The SM Building was built in 1960 and served as the nuclear processing facility for plutonium-238 until 1967. The SM Building septic tank and leach basin were used from 1960 to 1963 or 1964 until the building was connected to the site sanitary sewage disposal

system. The septic tank and leach field were connected to the toilets within the building. Process wastewater, floor drains, and sink drains were treated by a wastewater treatment system within room 1 of the SM Building. In 1967, the process wastewater was disconnected from the SM treatment system and was piped to WDA Building for treatment. The leach field may have received contamination from mop and wash water during decontamination operations. The septic may have been removed in the late 1970s, but no data are available. The leach field was undergoing excavation in 1991 by the Mound D&D Program.

The Mound Radiological Site Survey (DOE 1991c) showed the maximum plutonium-238 concentration to be 144 pCi/g at a sample depth of 36 inches and a maximum thorium concentration of 3.46 pCi/g at a sample depth of 36 inches. The contamination may have originated from surface water runoff from the storm sewer outfall or from contaminated floor mop water that was disposed of by pouring down the SM Building toilets (WESTON 1990). An area at the lower part of the slope may also be contaminated as a result of receiving drainage from this storm sewer or Area 16 (DOE 1992g). Recent sampling found this lower area to have contaminant concentrations (plutonium and thorium) of 6 to 8 nCi/g. The total size of the area could potentially be as high as 125,000 ft^2 (Geichman 1991). The septic tank and leach basin are currently undergoing excavation as part of the D&D Program.

6.1.1.9. Area D, Acid Leach Field

The Area D acid leach field is west of Building 38 on the upper slope of the SM/PP area, in the eastern portion of the plant (Figure 6.1). The leach field was installed to catch spills from the plutonium processing facility. Tanks inside Building 38, which contained nitric acid or caustic solutions, were surrounded by a metal tray to catch leaks or spills. In the event of a leak or spill, the liquid was collected by the tray and routed through a pipe to the acid leach field. The leach field, which was placed in service in 1967, was approximately 10 ft by 10 ft and filled with limestone to neutralize any acid routed to it. In 1987, the acid and caustic tanks routed to the leach field were taken out of service and the pipeline was capped (Davis 1991). Discussions with Mound personnel indicated that no significant spills or releases were ever discharged to the leach field. A single core sample taken from the area during the 1982 to 1985 Radiological Site Survey (DOE 1991c) found no significant thorium or plutonium contamination (0.98 pCi/g of plutonium-238 and less than 2 pCi/g of thorium).

6.1.1.10. Area 22, Orphan Soil from Other Areas

Area 22 is just east of Building 53, in the southern portion of Mound (Figure 6.1). It consists of many piles of excavated soil. Soil contaminated with polonium-210 from a waste line break west of the HH Building and from other sites was deposited there in 1985 (DOE 1991c). A 75-ft by 150-ft area has

been roped off. The 1982 to 1985 Radiological Site Survey (DOE 1991c) found soils contaminated with low levels of plutonium-238 (1.67 pCi/g), cesium-137 (7.0 pCi/g), and radium-226 (0.7 pCi/g), and an elevated concentration of cobalt-60 (143 pCi/g).

6.1.1.11. Spoils Disposal Area

The spoils disposal area is southeast of the overflow pond, in the west-central portion of Mound (Figure 6.1). It was put into operation in 1985 and is still in service. The area is used to dispose of uncontaminated soil and concrete removed during plant construction operations. Soil is dumped onto the ground and graded slightly to the west. All soils removed during construction are screened for plutonium-238 and thorium-232 by the soil screening facility prior to transfer to the area. Maximum activities must not exceed 25 or 5 pCi/g, respectively. In late 1986 or early 1987, soil removed from the Building G garage area was deposited in the spoils disposal area. The soil was contaminated with gasoline and was stockpiled for volatilization of the gasoline prior to transfer to the spoils area (Burdg 1991). The area is 300 ft by 300 ft by 10 ft and is divided into three cells with a total capacity of 350,000 yd^3. It is surrounded by a ditch to prevent rainfall run-on. The 1982 to 1985 Mound Site Survey (DOE 1991c) found surface soils to be contaminated with low levels of plutonium-238 at a maximum concentration of 8.30 pCi/g measured in a surface sample. No thorium activity greater than 2 pCi/g was measured.

6.1.1.12. Excavated Materials Disposal Area

The excavated materials disposal area is south of the water tower at the bend in the road, in the southeastern portion of the plant (Figure 6.1). The area is also known as Rader's Hill. The area partially overlaps the area formerly occupied by the old firing range and is south of the area used for storage of waste chemicals, known as the old firing range drum storage area. The area contains the overburden soil excavated to expose the WTS pipeline in the mid-1980s. The excavation on the western slopes of the SM/PP Hill penetrated the southern margin of what is known as Area 12, where thorium-contaminated soil was disposed of in the mid-1960s. The soil in Rader's Hill is probably contaminated with thorium. The volume of soil is probably on the order of several hundred cubic yards. Analytical data indicate thorium levels about 2 pCi/g.

6.1.2. Off-Plant Radioactive Waste Disposal

Off-plant shipment of wastes from the production, research, and development activities at Mound has dominated the radioactive waste management programs. Because Mound has not had the capacity nor the inclination to dispose of radioactive waste on-plant, it has been instrumental in research and

development of waste containers, packaging materials, and shipping and transportation requirements and guidelines.

6.1.2.1. Transportation Requirements

Beginning with the Dayton units, Mound shipped radioactive wastes by truck to ORNL, Tennessee. Shipments were regulated by the ICC under Special Permit #4912. In the early 1950s, all shipments were made in trucks owned by the AEC, but commercial trucks were used beginning in January 1954 (Meyer 1956c). The ICC Special Permit #4912 expired August 30, 1968. In order to continue shipments, Mound had to comply with the pending requirements of the DOT.

The DOT imposed new regulations on package specifications and shipping requirements, including material characteristics, radiation exposure, labeling, handling, and contamination. Packaging requirements generally fell into two classes: Type A and Type B. In addition, the quantity of radioactive material was classified by "large quantity" and LSA.

All packages are limited by the concentrations and physical forms of the isotopes. LSA waste packages are the least restrictive in terms of package integrity, but the most restrictive in terms of their radioactive contents. Type A packaging requirements, which relate to preventing the loss or the dispersion of the contents and retaining the containers' shielding properties, are outlined in 49 CFR 173. Type A packages must retain their integrity after being subjected to a series of tests and environmental conditions considered representative of normal transportation and handling conditions. Type B packages, used for transporting high-activity materials, must meet the standards of Type A packages and the requirements for hypothetical transportation accidents also outlined in 49 CFR 173. To comply with these regulations in the late 1960s, Mound conducted a package testing program (described in Section 2).

Shipments since 1970 have generally been by railroad (Heitkemp 1969; Schneider et al. 1981; Edling 1973b). Waste shipments were packaged in the ATMX railcar and the Super Tiger container. Only a few shipments used the Super Tiger; most shipments of TRU wastes used the ATMX railcar (Edling 1973a). The ATMX railcars were used under the DOT Special Permit #5948, extended to the DOE for shipment of government TRU wastes (DOT 1972).

The ATMX railcar was a fully enclosed car designed to meet all American Association of Railroads and ICC standards. It was intended to provide the maximum practical structural and fire resistant qualities in order to prevent or minimize damage to the contents in the event of a train wreck and offered many safety devices, including interlocking couplers to prevent uncoupling in case of a derailment (Schneider

et al. 1981). The ATMX-500, unlike the ATMX-600 series railcar, was not designed for ease of load handling and variable load characteristics, but was originally constructed for shipments of special weapons materials. The use the cars for shipments of waste packages required internal modifications, which Mound performed (McDonald 1971). Shipments of radioactive wastes using the ATMX railcar continued from 1970 through the late 1980s.

6.1.2.2. Off-Plant Shipment of Radioactive Wastes

From the operations of the Dayton units to the operation of Mound until 1964, all radioactive wastes were shipped to ORNL for burial. Shipments were made in trucks owned by the AEC until January 1956, when commercial trucks were used (Meyer 1956c). Radioactive wastes generated during this time period consisted of bismuth chloride sludge from the polonium production; uranium sludges from production of thorium (ionium) and protactinium extractions; waste sludges from the radium-actinium process evaporator; sludges from the Purex waste pilot plant; sludges produced from the waste treatment processes in the WD facility; solid wastes from the D&D of the Dayton facilities and the old cave, among others; and other miscellaneous wastes generated by research and development activities.

Few records of this time period have been found concerning waste shipped for disposal. The health physics group generally monitored all waste packages and shipments for radioactivity levels. Some of the health physics monthly and quarterly reports include data on waste shipments. For example, during the first quarter of 1956, three truckloads, 25,000 to 30,000 pounds of waste each, were shipped to ORNL for burial (Meyer 1956c). No effort was made during research for this report to compile these data. A proposal for remodeling activities of the WD Building contains some data on the volumes of wastes shipped for burial at ORNL (Creamer 1964). These data are shown in Table VI.1. The data from 1956 to 1963 were reported simply as solids or liquids. The liquids were actually absorbed onto sawdust or vermiculite.

Beginning in 1964, Mound began using commercial burial sites for unclassified wastes instead of AEC facilities. Old and possibly incomplete records show that between February 1964 and February 1969, 133 shipments containing 33,478 ft^3 of waste were sent to ORNL (Hopkins, D 1991). From November 1964 until June 1976, Mound shipped approximately 800,000 ft^3 of LSA waste to Nuclear Engineering Co., Maxey Flats, Kentucky. Records are available for these shipments (Hopkins, D 1991) but were not reviewed for this report.

Table VI.1. Historical Shipments of Radioactive Wastes 1956-1962

	1956	1957	1958	1959	1960	1961	1962	1963
Liquid	4.5	4.5	3.2	3.2	6	6	8.6	16
Solid	14	15.5	15.5	20.8	26.8	19.4	21	24

Ref.: Creamer 1964
Values in thousands of cubic feet
Note: 1960 included 9,200 ft^3 of material removed from the old cave area.

Beginning in January 1970, the DOE required that TRU wastes be segregated from LSA wastes. TRU wastes were defined as having activity levels >10 nCi/g (AEC Manual Chapter 0511). Prior to this date, all TRU waste was disposed of with the LLW at ORNL and Nuclear Engineering Co., Maxey Flats, Kentucky. The DOT packaging and shipping requirements led to the use of special shipping containers and use of railroads as well as trucks. From January 1970 to June 2, 1972, 31 shipments, containing 41,640 ft^3 of TRU waste, were shipped via ATMX railcar to Nuclear Fuel Services, Inc., West Valley, New York (Hopkins 1992a).

In August 1973, Mound was directed to include its plutonium-238 in the TRU waste category (Wolfe 1973c). Plutonium-238 had generally been exempted from TRU classification before this period (Wolfe 1973b). The new classification created serious financial implications, as TRU wastes had to be packaged in containers that would withstand burial for up to 20 years retrievability (Wolfe 1973b). Packaging requirements included not only those of the DOT, but also the requirements of the receiving storage facility (Wolfe 1973d; Donnelly 1973). The site chosen for by the AEC for retrievable storage was the National Reactor Test Station in Idaho (Wolfe 1973a), which became the INEL. The implementation of the TRU waste requirements was generally postponed until full funding was obtained (Adams 1974). Between January 1974 and June 28, 1974, a total of six shipments, containing 7,957 ft^3 of possible TRU waste, were shipped via ATMX railcar to National Engineering Co., Richland, Washington, for burial (Hopkins 1992a).

Beginning in February 1975, all TRU waste was shipped via ATMX railcar to INEL for retrievable storage (MRC 1975a). Approximately 141,000 ft^3 of waste was shipped until January 1988, at which time the governor of Idaho closed the site for all wastes originating outside the state. Records of these shipments are available (Hopkins, D 1991) but were not reviewed for this report. Since January 1988, Mound has accumulated approximately 900 ft^3 of TRU waste and is storing it on-plant awaiting shipment to INEL or the WIPP (Hopkins 1992a).

LLW generated at Mound continued to be shipped off-plant for burial through the 1970s and 1980s. Beginning in July 1976, Chem-Nuclear Systems, Inc., Barnwell, South Carolina, was used for burial until the last shipment during December 1979. During this period, 78 shipments, containing approximately 112,000 ft^3 of waste, were sent. Beginning in August 1976, LLW containing high-activity tritium was shipped to Reynolds Electrical and Engineering Co. at the NTS (Hopkins 1992). On January 22, 1980, Mound began shipment of all LLW to Reynolds. Available records indicate that Mound has shipped approximately 1,189,000 ft^3 of waste to Reynolds up to April 30, 1990, at which time all shipments were stopped pending a new application approval. LLW is currently accumulating at Mound; as of the end of May 1991, there were approximately 121,000 ft^3 of waste awaiting shipment (EG&G 1991c).

Since 1972, Mound has published the amount and types of alpha- and tritium-bearing wastes shipped off-plant in the annual Waste Management Plans (e.g., MRC 1975a). Because of TRU waste definitions, the types and categories of wastes have changed over this reporting period. Table VI.2 summarizes the amounts of radioactive wastes shipped off-plant in the years 1972, 1975, 1981, 1984, and 1988. The quantities for the years 1972 and 1975 are grouped by type of radionuclides (i.e., polonium and tritium wastes and plutonium wastes and activity levels were not noted). The production of polonium largely ended in 1972, but polonium remained in the alpha waste streams until 1974, because the D&D Program was generating waste from the cleanup of T Building. The decrease in TRU wastes after 1973 was attributed to the completion of the D&D of SM Building equipment in July 1973 (MRC 1974c).

Table VI.2. Published Annual Volumes of Radioactive Waste 1972-1988

	1972	1975	1981	1983	1984	1988
FP/IA	31.9	12.4	-	-	-	-
TRU	59.4	50.7	24.4	8.6	2.9	1.4
LLW	-	-	22.1	40.0	89.9	218.6
LSA	-	-	8.6	14.0	20.0	56.6

Ref.: MRC 1972, 1975a, 1981b, 1983, 1984b; Geichman and Jaeger 1988
Values in thousands of cubic feet.
FP/IA: Fission Product/Induced Activity - contains polonium and tritium
TRU: Transuranic: contains plutonium-238 and plutonium-239 at ≥10 nCi/g before 1982 and ≥100 nCi/g after 1982.
LLW: Low-level waste contains plutonium-238 at <10 nCi/g before 1982 and <100 nCi/g afterward; also known as non-TRU waste.
LSA: Low-specific activity; historically used for all low-level radioactivity including plutonium-238 at < TRU value and tritium concentrations at <0.3 nCi/g.

There were no published records of quantities of radioactive wastes between 1976 and 1980, but records have increased in detail through the 1980s. Since 1980, the only alpha-contaminated wastes have been from the D&D operations of the former plutonium processing facilities. In the early 1980s, alpha wastes were separated into in-line TRU wastes, other TRU wastes (greater than 10 nCi/g), and non-TRU wastes (less than 10 nCi/g). The ash, precipitate, and other materials containing recoverable plutonium from the in-line recovery processes were sent to SRP. The non-TRU wastes were compacted by mechanical means (MRC 1981b). By 1982, the in-line processing of plutonium wastes ceased, and all the remaining plutonium-238-contaminated equipment was shipped as waste (either TRU or non-TRU) to INEL or NTS.

In late 1982, the level for non-TRU waste (essentially LLW) was raised to 100 nCi/g (MRC 1983) in response to the National Council on Radiation Protection and Measurements' recommendation to the NRC (NCRP 1982). The changes in the relative quantities of LLW and TRU wastes between 1981 and 1984 (Table VI.2) indicate the consequences of the change. The quantity of LLW generated in the 1980s reflects both the increased volume of soil excavated by the D&D Program and the effects of the increased cutoff limit for non-TRU waste to 100 nCi/g. The volumes of TRU waste from 1981 to 1988 indicate the long-term trend of decreasing quantities of TRU waste generated by the D&D Program at Mound. The LSA wastes shown for 1988 include solidified tritium wastewater and WD Building sludge not included in the D&D Program.

6.2. EXPLOSIVES WASTE DISPOSAL

Explosives waste disposal has been an integral part of the normal Mound explosive production operations since the mid-1950s. Since that time, explosive wastes have been burned on-plant in an isolated area chosen for personnel and property safety.

6.2.1. Pyrotechnic Waste Disposal Area (Historical)

Use of the pyrotechnic waste disposal area (Figure 6.1) began in 1975, and wastewater was last deposited in this area in 1985. The solution was poured directly onto the soil without prior treatment. The area is reported to be adjacent to the southern fence line of Area H, but the exact boundaries of the disposal area are unknown. Wastewater was also reportedly disposed of along the western fenceline, behind the retort (Vinings 1990). The area is thought to cover approximately 150 ft by 150 ft (22,500 ft^2). At the pyrotechnic waste disposal area, small amounts of waste solvents (primarily acetone) and dissolved pyrotechnic materials, including potassium perchlorate, were mixed with water and filtered. The filtrate was poured onto the ground for treatment by natural biodegradation. These solutions were disposed of in this manner because it was thought that inorganic salts in the solutions

would not be removed by sanitary wastewater treatment plant. The amount of waste materials deposited ranged from 5 to 20 gallons per year (DOE 1992g). For acetone, the amount treated annually was far below the 24-hour reportable quantity of 5,000 pounds (EPA 1988).

6.2.2. Area I Building and Building 27 Leach Pits (Historical)

The Area I and Building 27 leach pits (Figure 6.1) have been used historically for the treatment or disposal of explosives waste liquids. These leach pits received wastewater with dissolved explosives (typically ppm quantities) and acetone. The aqueous solutions were allowed to evaporate and disintegrate naturally. Since the mid-1980s, the solutions have been drummed and stored at the hazardous waste storage area.

6.2.3. Summary of Explosives Waste Disposal

The explosives research and development activities at Mound typically produce small volumes of waste solids and liquids. Solid waste explosives, including mild detonator cord and fuse, PETN, PBX, RDX, HMX, tetryl, and triaminatrinitrobenzene; explosive components; and explosive-contaminated trash, are burned or treated on-plant. Liquid wastes are dominated volumetrically by water with dissolved explosive wastes and acetone. Other organic solvents are used in the processes and include trichloroethene; trichloroethane; methyl, ethyl, and isopropyl alcohols; and toluene. Other chemicals used in these processes include Freon TF, Freon TE, sodium carbonate, ferric chloride, potassium hydroxide, nickel sulfamate, sulfuric acid, and cyanide solutions. Metals involved include titanium, nickel, copper, and gold. Two historic memos refer to the disposal of explosive waste and include titanium trifluoride (100g), copper cyanide (0.5 pint), and chromic oxide-sesquioxide (5 pounds), along with many other small volumes of chemical wastes. The titanium trifluoride was neutralized with ammonium chloride and siphoned down a drain with excess water (Schneider 1979; Vaughters 1979). The volumes of explosive wastes and chemicals are not reported separately, but are included in the annual estimates of hazardous wastes described below.

6.3. HAZARDOUS WASTE DISPOSAL

Hazardous chemical wastes have been disposed of both on- and off-plant since operations began in the late 1940s. In the early 1950s and perhaps later, liquid chemical wastes containing radioactive material were segregated with all radioactive waste. In some cases, chemical liquids may have been disposed of down the drains to the WD Building alpha wastewater treatment system. No systematic program appears to have existed for the disposal of non-radioactive waste chemicals. In the mid-1960s, Mound engineering and safety personnel recognized the problem of chemical disposal and

began an informal program to collect and dispose of the waste chemicals in the historic landfill, now known as Area B (DOE 1992g), in a more systematic fashion. The organization of the waste management group focused on the processes of chemical waste disposal in 1972. In 1982, guidelines for disposal of chemical wastes were firmly established (Vaughters 1982), beginning the procedures that are followed today.

6.3.1. Historic Landfill (Area B)

The Area B, historic landfill is beneath the overflow pond and site sanitary landfill, in the west-central portion of Mound (Figure 6.1) (DOE 1991a). It includes Area 2, the WD Building filter cleaning waste and thorium drum area. The area was used as a general disposal area for Mound from 1948 until the construction of the overflow pond and site sanitary landfill in 1977. The area occupies approximately 4 acres. During plant construction (1947 to 1948), gravel was excavated from the area for construction purposes, creating a wide depression 4 to 6 ft deep, principally in the southern part of Area B. From 1948 to 1954, only nonradioactive solid and liquid wastes were reportedly disposed of in Area B. Waste consisted of administrative and laboratory trash that included paper, glass, wood, plastics, kitchen garbage, and bottled urine samples. Some of the waste was burned in a cage to control fly ash in the east-central portion of the area. From 1954 to 1970, the area may have received solid and liquid wastes containing beryllium, mercury, tricholoroethene, carbon tetrachloride, evacuated nickel carbonyl gas cylinders, benzene, alcohol, acetone, photoprocessing solutions, plating materials, small quantities of PCB oils, and other laboratory, office, and kitchen wastes. Paper and liquid wastes were generally burned, but other liquid wastes were simply dumped on the ground. These wastes are believed to have been essentially nonradioactive, as radioactive waste was generally closely monitored.

Some LLW is known to have been buried at the historic landfill. In 1954, a trench was dug on the southern boundary of the area, and residual steel and metal debris from the burning of the Dayton units were buried there. Wood and scrap metal contaminated with polonium-210 were burned elsewhere in Area 13, and the residual materials were brought to the historic landfill and buried (Meyer 1955e, 1956b). The trench was later filled in. From 1955 to 1964, between 2,000 and 5,000 empty 55-gallon drums containing residual thorium were crushed and deposited in a depression in the southwest corner of Area 13. The drums were covered with 1 to 2 ft of soil. Information in the Site Scoping Report: Volume 6 - Photo History Report (DOE 1992c) indicates that at least some of the historic landfill and perhaps the thorium drum disposal area overlap what is now the road intersection. In March 1964, sand contaminated with polonium-210 from the cleaning of filters in the WD Building (MRC 1961-1968) was deposited in the southwest corner of Area B. The area where the thorium drums and polonium-contaminated sand were dumped is now known as Area 2. The only other routine radioactive waste disposal known to have occurred in the historic landfill is disposal of dredgings from

the Parshall flume. The flume was installed on the lower reach of the plant drainage ditch in 1971 to monitor the water level. The flume was unable to handle the capacity of the stream and would, on occasion, require cleaning of the sediment that accumulated. This sediment was screened for radioactivity and dumped in the old landfill. During excavation for the site sanitary landfill (see below), this sediment was incorporated randomly into the structure.

Only one accidental disposal of radioactive materials is known to have occurred in the historic landfill. In February 1960, a plutonium-239 button, or part of one, was accidentally burned as ordinary trash. The item came from the plutonium-neutron source laboratory in R Building, which manufactured neutron sources for commercial use. The button consisted of 8 g of plutonium-239 metal that appeared to have been completely burned upon investigation. Thirty-five 55-gallon drums of soil were excavated as part of the cleanup; all of the contamination is believed to have been identified at the time by health physics personnel (Meyer 1960). Corrective actions were taken in the laboratory to ensure that type of accident did not recur (Garner 1991).

Burning of waste in Area B ceased in June 1970 due to an Ohio State ban and Montgomery County Combined General Health District regulations (Wolfe 1973a; Neubert 1970). From 1970 to 1973, solid wastes were placed in east-west trending trenches, compacted with a bulldozer, and covered with about 4 ft of soil as the cells were filled (Garbe 1973a). Records indicate that 2 to 10 tons of refuse were generated daily in the early 1970s (Hebb 1970a; Judd 1972; Monnin 1970). Burial of combustible wastes was replaced by incineration, which was, in turn, replaced by Mound's Solid Waste Reclamation and Recycling Program. Some wastes that could not be handled in Mound's Solid Waste Reclamation and Recycling Program may have been placed in the historic landfill after February 1974. The solid waste typically consisted of plastic bags containing paper, plastic, glass, cloth, other unknown laboratory and office trash, food scraps from the cafeteria, and plastic sample vials containing urine and liquid scintillation "cocktails." Since they were no longer burned, hazardous liquid wastes were collected and staged at the old firing range drum storage area and disposed of off-plant.

Unverified rumors indicate that sometime during 1972 to 1973, soil materials may have been excavated from the west-central portion of Area B and placed in a ravine along the upper reach of the plant drainage ditch in what is now known as Area 7, perhaps to facilitate the construction of a parking lot (DOE 1991a).

Some of the solid waste from Area B was excavated and placed into the lined site sanitary landfill constructed in 1977 and 1978 (DOE 1991a). The unburned solid waste placed in the landfill cells of the early 1970s was excavated along with some of the burned materials. Most of the older burned trash in the central area of the historic landfill was not excavated. From the eyewitness accounts and

historical aerial photographs (DOE 1992c), the heart of the historic landfill appears to have been in the southwestern part of what is now known as Area B. Very little of this area was excavated during construction of the site sanitary landfill (see below). The residual debris from the Dayton unit fire and the thorium drums, buried in trenches in the southern part of Area B, were not excavated. The as-built drawings of the overflow pond and site sanitary landfill, included in Appendix A, show that only a few inches of burned debris were excavated in the area near the present road intersection. The historical data indicate several episodes of disposal and burial occurred that are not shown on these drawings.

6.3.2. Site Sanitary Landfill, Area 18 (Historical)

The clay-lined site sanitary landfill is south of the overflow pond, in the southwest corner of Mound (Figure 6.1). It was constructed in 1977 during the excavation of the overflow pond. The site sanitary landfill was constructed to contain solid waste relocated from the historic landfill. Construction drawings of the site sanitary landfill and the overflow pond and cross sections of the areas excavated are included in Appendix A.

The site sanitary landfill was constructed with a 14-ft-thick clay liner consisting of on-plant virgin clay materials. The clay liner was compacted to 95% of maximum dry density to ensure a high quality seal and integrity over time. Clay berms were constructed on the landfill to prevent runoff from pooling on the top of the landfill and to direct it to the overflow pond. A leachate collection system was constructed consisting of two 6-inch perforated drain pipes running along the length of the top surface of the bottom liner (Burdg 1991). The drains in the landfill allow for drainage of any landfill liquids into the adjacent overflow pond. Five french drains were installed 2 to 25 ft below the landfill liner (DOE 1991a), partially in a fine gravel/sand layer and partially in a silty clay layer, to drain moisture from under the site sanitary landfill to ensure soil slope stability.

The site sanitary landfill cap, which consists of a minimum of 3 ft of low-permeability clay, was designed to minimize infiltration of precipitation and snowmelt into the landfill and its subsequent flow through contaminated soils and debris, thereby reducing leachate generation. In addition, the cover prevents direct contact with potentially contaminated surface soils and controls contaminant migration by air, surface water, and sediment pathways.

The base, berms, and liner of the landfill were constructed entirely of virgin, high-grade clay excavated from undisturbed slopes east and north of the historic landfill. The geotechnical studies conducted as part of the preliminary engineering activities (Dames and Moore 1976; Cowherd 1975) indicated enough high-quality clay existed on-plant to avoid the need for additional materials. Clean fill and trash-filled excavations within the pond area had been identified from the soil borings. Clean fill was

defined as soil without visible trash or debris. However, the chemical content of the clean fill was not analyzed. Trash, excavated from the previously identified areas and compacted into the liner in 1-ft lifts, consisted of burned and unburned debris mixed with surrounding soil. A thin (less than 2-ft) layer of burned trash was excavated on the west side directly beneath the landfill site. The base and berms of the landfill were compacted to 95% dry density. As the construction of the landfill progressed, the clay material was compacted to 95% of maximum dry density to form the low-permeability liner. The liner was designed to be a minimum of 5 ft thick, but is closer to 14 ft thick (DOE 1992g). Before adding trash, the liner was surveyed for interior dimensions, and the two 6-inch perforated drain pipes were installed to drain any liquid into the new overflow pond to the north. As the construction neared the top of the designed landfill, the trash was overlain by high quality clay that was compacted to 95% of maximum dry density so that the liner completely surrounded and covered the trash. The compacted liner material extends to the surface of the landfill.

Approximately 18,000 yds^3 of trash were moved into the engineered landfill. Only sanitary trash, such as paper, plastic bags, office trash, and kitchen garbage, was placed in the landfill along with scintillation cocktails and other lab trash. The excavation and removal of the trash was continually monitored by industrial hygiene and health physics personnel. Some materials were removed and disposed of by waste management personnel or radiation workers. Waste management removed several drums of dark liquid sludge presumed to contain hazardous waste. When they were analyzed, however, they were deemed nonhazardous. It is not known if any analytical reports were retained. Health physics personnel also removed a small (less than 5-gallon) container of soil with a radiation level above 100 pCi/g, probably plutonium-238. This soil was placed in the dredged material disposal area (Area 11A) (Figure 6.1) on the SM/PP Hill (Burdg 1991). According to personnel accounts, some of the trash was saturated during excavation and the leachate collection system drained liquid into the pond for six months afterward. Samples of this leachate were collected; however, results of analyses are not known. No known drainage has occurred since the initial six-month period (DOE 1991a).

The site sanitary landfill has sometimes been referred to as the Area 18, site sanitary landfill and cover. This designation refers to the possibility that sediments containing low-level plutonium contamination dredged from the old Parshall flume on the lower reach of the plant drainage ditch were placed in the historic landfill. During construction of the site sanitary landfill, these sediments were incorporated into the structure, possibly into the cover. It is most likely that they were randomly incorporated. The report of the installation assessment (DOE 1986) included information that sanitary sludge was used as cover material, but this claim cannot be substantiated (Burdg 1991).

During construction of the overflow pond, slightly more material was cut from the area than was needed. The extra material was used on the east side and top of the site sanitary landfill. The height

of the landfill is within design specifications; however, the east slope is more gradual than specified because of the extra fill placed there. The height of the landfill was surveyed and checked for settling a year or two after construction; although no known written report exists, a verbal report suggests little or no settling occurred (DOE 1992g). During the 1982 to 1985 Radiological Site Survey (DOE 1991c), the maximum plutonium-238 concentration found in the core samples taken at the site sanitary landfill was 3.71 pCi/g at a sample depth of 126 inches. The maximum plutonium-238 concentration measured in the surface samples was 0.98 pCi/g. No thorium concentrations above 2 pCi/g were detected in any of the Area 18 samples (core or surface).

6.3.3. Area F, Chromium Trench (Historical)

The chromium trench is beneath an asphalt parking lot on the Main Hill, just south of the GH Building in Area F (Figure 6.1). Area 6 is within Area F's boundaries. In 1963, approximately 110 gallons of chromium plating bath solution treated with sodium bisulfite were disposed of in a trench in this area. These wastes were deposited onto the ground surface in the trench with no apparent release controls. The disposal actions occurred only in 1963 when the old plating lab was replaced by a new facility. No formal closure was undertaken.

There is a low to moderate potential for the contamination from the chromium plating bath solution disposal particles to reach the underlying groundwater. No release controls were used, but the area is capped with asphalt. The amount of chromium placed in Area F was substantially below the 24-hour reportable quantity of 1,000 pounds. It is thought that the small amount of residual chromium would not likely pose a health hazard (DOE 1992g).

6.3.4. Summary of Hazardous and Mixed Waste Disposal

Hazardous and mixed wastes are generated by the production, research, and development activities at Mound. Few waste generation records exist for the period preceding the waste management program that began in the 1970s. Records for the justification for the waste incinerator indicate that approximately 250 gallons of waste oils and solvents were generated each week in the early 1970s (Ashby 1973). In 1969, a total of 12,449 gallons of liquid waste oils and solvents were destroyed (Hebb 1970b). Beginning in July 1970, chemical wastes were collected and disposed of off-plant by private contractors, including Industrial Waste Disposal, Inc., of Dayton, Ohio, and Industrial Waste Disposal Liquid Waste, Inc., of Tremont City, Ohio (Storey 1970). The chemical wastes were disposed of in Ohio, Kentucky, or Michigan. From 1971 through 1973, some liquid chemical wastes were disposed of by burning in the waste incinerator. Although several test burns were conducted (Russell 1971; Werner 1972a), it is not known how much of the accumulated wastes were actually treated in

the incinerator. Since 1981, chemical wastes have been handled by Triangle Resource Industries, Inc., of Greenbrier, Tennessee. Estimates of the types of wastes generated historically can only be based on the types and quantities of wastes generated currently and in the recent past. Documentation of the actual annual quantities and types of hazardous and mixed wastes generated by plant activities have improved through the 1980s, as illustrated in the following subsections.

6.3.5. Pollutant Inventory Program - 1971-1975

The Pollutant Inventory Program, which was active from 1971 to 1975, required data on the radioactive and nonradioactive pollutants released from ALO facilities, including Mound, via liquid and air discharges. This program was implemented to substantiate the fact that each ALO facility was being operated without significant adverse effects upon the environment.

In general, except for sanitary sewage data, total quantities of all pollutants discharged were reported. Each report provided complete information on the source (building), nature, type (airborne or waterborne), concentration (airborne $\mu g/m^3$), quantity (waterborne lbs/month), and total annual quantity of both radioactive and nonradioactive pollutants. A data package reporting types of nonradioactive pollutants being discharged was submitted in August 1971. Data packages were submitted that reported all of the radioactive and nonradioactive pollutants discharged for the calendar years of 1971, 1972, 1973, 1974, and 1975 (Donnelly 1971; Adams 1971).

Copies of the data packages for 1972, 1973, and 1974 are included in Appendix B. Products of combustion (nitrogen, carbon, and sulfur oxides), and solvents (ethanol, methanol, trichloroethene, and acetone) were the primary airborne contaminants reported. Metals and typical NPDES parameters (biological and chemical oxygen demand, suspended solids, chlorides, and fluorides) were reported for waterborne contaminants.

The concentrations that were provided for airborne pollutants were calculated values and represented average concentrations for each building for a one-month period. These data were obtained by reviewing the disposition of materials in use in the buildings; for example, the total quantity of a material introduced into the building, the amount of this material in the product, and the amount of this material that could be released to the atmosphere.

The concentrations that were provided for waterborne pollutants were obtained from the analyses of two on-site continuous composite sampling stations. Liquids discharged to the environment from the laboratory flowed through these continuous composite sampling stations. The samples from the two on-site stations were combined to reduce the number of analyses (Storey 1971).

6.3.6. Summary of Nonradioactive Wastes - 1980 to 1984

The 1980 Waste Management Site Plan (MRC 1980) provided summary descriptions of nonradioactive waste streams from Mound. These descriptions were updated in the 1983 Waste Management Site Plan (MRC 1983), as described below.

6.3.6.1. Sanitary Wastes

The sewage treatment plant in the lower area, Building 57 (Figure 4.1), of Mound provided secondary treatment of biologically extended aeration type with disinfection. The plant treated an average of 133,000,000 L (35,000,000 gallons) of wastewater per year. In 1983, the volume was reported to be 167,200,000 L (44,000,000 gallons).

6.3.6.2. Solvent Wastes

Operations at Mound, excluding those required for processing explosives, used approximately 15,900 L (4,200 gallons) of organic solvents annually. This remained unchanged in 1983. The most widely used organic solvents were acetone, ethyl alcohol, trichloroethene, toluene, Freon TE, and Freon TF. Used solvents were accumulated for disposal in 2-gallon or 5-gallon safety cans and 55-gallon drums. A commercial industrial waste disposal firm disposed of these accumulated wastes. Fifty-seven hundred L (1,500 gallons) were estimated to have evaporated during 1979 while being used in fume-hood-protected operations and were released as airborne material. An estimated 480 L may have been released as liquid effluents. In 1983, 3,800 L (1,000 gallons) were estimated to have evaporated while 400 L were released as liquid effluents. The estimated volumes released annually in the liquid effluent resulted from discards into laboratory sinks and fume hoods from intermittent use of small quantities not feasible for accumulation and collection. The sinks, fume hoods, and such disposal points were part of the sanitary waste system, and discharges received treatment in the sanitary waste disposal plant. The effluent from the treatment plant was monitored. The nonvolatile solvents were detected by the oil and grease analysis, and the biodegradable solvents (acetone and alcohol) were included in the biochemical oxygen demand analyses. Neither of these parameters exceeded NPDES limits. A commercial service disposed of the accumulated liquid waste.

6.3.6.3. Other Liquid Wastes

Annual estimated accumulations of waste cutting oils (automotive, etc.), discarded paints and thinners, and waste caustic solutions amounted to about 3,785, 3,785, and 946 L, respectively. These estimates did not change in 1983. The liquid wastes, along with solvents, were collected and

disposed of by contract. Disposal services for spent plating-bath solutions of chromic acid, cadmium cyanide, nickel sulfate, nickel chloride, black oxide, and copper cyanide were handled by a commercial industrial waste firm. First rinse and cleanup wastes from the preparation of fresh plating baths were used in the makeup of new baths; therefore, these chemical solutions were never introduced to the facility effluent stream.

Waste PCBs might have been generated from any of 19 transformers located throughout the facility; other sources included capacitors, fluorescent light ballasts, storage cans, microwave ovens, and electronic equipment. PCBs used in transformers are controlled through monthly inspections (for leaks or spills) performed in accordance with procedures detailed in Maintenance Index No. 3021 and the Emergency Planning System Handbook. (The Toxic Substance Control Act lists 4.54 kg/24 hours as the hazardous quantity for PCBs) (MRC 1983.)

6.3.6.4. Photoprocessing Waste

There were 20 plant locations generating photoprocessing waste (spent fixer solutions and waste photographic film) in FY80 and FY82. The functional groups are listed below.

- Product Development and Environmental Testing
- Radiological Health
- Manuals and Procedures
- Drawing Control
- General Analytical
- Photography
- Metallography
- Industrial Analysis
- ADP Operations
- Radiography (Industrial)
- Radiography (Medical)

Note: Precious metals recovery, as detailed in 41 CFR Part 101-42, continues to be an ongoing endeavor at Mound.

Approximately 2,850 L (750 gallons) of spent fixer solution were generated annually from the aforementioned locations; silver content may have ranged from 120 mg/L (0.01 oz/gallon) for microfilm to 7,600 mg/L (0.9 oz/gallon) for industrial x-ray. Reclamation was accomplished by refining (contractor) or by electrolytic recovery. About 770 kg (1,700 lbs) of used film were generated annually, but nearly 70% of this film was retained as records and stored in files; therefore, only about 227 kg (500 lbs) were available for reclamation. Approximately 2,850 L (750 gallons) of the remaining photoprocessing waste solutions (developers, stop, bleaches, rinses, etc.) generated annually from the same locations were treated by the secondary treatment facilities (WD and SD Buildings) or collected and packaged for disposal by a liquid waste disposal contractor. These estimates did not change in the 1983 report (MRC 1983).

6.3.6.5. Solid Wastes

Explosive wastes were generated from no less than 22 buildings throughout the facility; these wastes consisted of small amounts of mild detonating fuse, pyrotechnic materials, rejected components containing small amounts of explosives, and operational wastes such as tissue and cardboard that had been contaminated with explosives or pyrotechnics. It was estimated that the total amount of explosive and pyrotechnic waste generated did not exceed 398 kg (875 lbs) per year. These estimates increased to 873 kg (1,920 lbs) in 1982 (MRC 1983).

Classified wastes resulting from destructive testing and burning of explosive devices were drummed for off-plant burial.

6.3.6.6. Paper Wastes

Approximately 700 office workers (as defined by EPA guidelines) generated nearly 200 tons of paper waste annually; 40 of the 200 tons were salvaged and sold as part of the high-grade paper recovery and recycling program. Another 200 to 250 tons of low grade waste paper mixed with trash were buried in 1979 and 1982, respectively, at a local sanitary landfill company licensed by Montgomery County and approved by the Ohio EPA.

Two-hundred tons of wood and metal wastes were generated per year. Fifty percent of the yearly scrap was segregated on-plant and sold periodically to salvage dealers.

6.3.6.7. Garbage

Garbage was generated from two sources at the facility: the main cafeteria (C Building) and the SM cafeteria (Building 44). About 150 to 200 tons of garbage were generated from these two buildings per year. Garbage was disposed of by contract with a local sanitary landfill company licensed by Montgomery County and approved by the Ohio EPA.

6.3.7. Summary of Hazardous Waste Generation - 1983

The Mound Implementation Plan (MRC 1984a) of DOE Order 5480.2 included actual and estimated annual quantities of hazardous wastes generated in 1983 and 1984. These estimates were more detailed than those previously available. Table VI.3 is excerpted from that plan.

6.3.8. Summary of Hazardous Wastes - 1988 to 1989

As part of an effort to reduce the environmental impact of its operations, Mound is evaluating technologies that may be used to reduce hazardous wastes. As one of the first steps in that process, a site-wide survey was conducted to determine what wastes were being generated. Although the survey is still in progress, some preliminary results are available. Overall, it is noted that the hazardous waste streams are generally small in comparison to the LLW. In most cases, the technical staff responsible for operations that generate the larger hazardous waste streams are studying methods to reduce the volumes. The waste streams surveyed are summarized in Table VI.4. A total of 42 waste streams were identified (Fentiman 1990). Emphasis was placed on the larger streams that are routinely generated, but information was included on the smaller streams as it became known. Explosive wastes were not quantified, and gaseous effluents were not considered.

6.3.9. Summary of Mixed Wastes - 1989

Mixed wastes are those that are both hazardous (as defined by RCRA) and radioactive. They fall under the jurisdiction of both the NRC and the EPA. These two agencies have not yet coordinated their efforts to regulate mixed wastes. As a result, their regulations are inconsistent and/or contradictory. Since no disposal site can satisfy all the regulations governing mixed wastes, none is operated for general use. Mound's mixed wastes are being stored in Building 23, awaiting disposition of the RCRA Part B permit application.

Table VI.5 summarizes the inventory of mixed wastes stored in Building 23 as of the end of 1989. The table shows only the types of wastes and the number and types of storage containers. It would

Table VI.3. Actual and Estimated Annual Quantities of Hazardous Wastes Generated - 1983 to 1984

Waste Description	Process/Source	Annual Quantity	
		FY83	FY84 (est)
Organic solvents such as acetone, ethanol, trichloro-ethlene, toluene, Freon TE, and Freon TF	Various cleaning operations, excluding those required for processing explosives	3,944 gal	6,000 gal
Waste oils	Machining operations, hydraulic systems, pump oils, used motor oil	1,879 gal	2,400 gal
Discarded excess paints and thinners	Paint shop, outdated paint, cleaning solutions from painting operations	215 gal	250 gal
Waste caustic solutions	Plating operations and other sources	50 gal	100 gal
Spent plating-bath solutions of chromic acid, cadmium cyanide, nickel sulfate, nickel chloride, electroless nickel, black oxide, and copper cyanide	Plating shop	83 gal	200 gal
Waste PCBs	From transformers, capacitors, storage cans, microwave ovens, and electronic equipment; also, bulk waste from various site operations	0	0
Photoprocessing wastes such as spent fixer solution, used film, developer, stop, bleaches, and rinses	From various functional groups including Product Development and Environmental Testing, Manuals and Procedures, Drawing Control, General Analytical, Photography, Industrial Analyses, Industrial Radiography, and Medical Radiography	539 gal	800 gal

Table VI.3. (page 2 of 2)

Waste Description	Process/Source	Annual Quantity	
		FY83	FY84 (est)
Explosive wastes consisting of small amounts of mild detonating fuse, pyrotechnic materials, rejected components containing small amounts of explosives, and operational wastes such as tissue and cardboard that have been contaminated with explosives or pyrotechnics; also, bulk high explosives/pyrotechnics	Generated in production areas in 22 buildings throughout facility	350 kg	350 kg
Radioactive mixed wastes	Biomedical assay	2,800 gal[a]	2,000 gal
Laboratory wastes	Lab R&D and analytical work	900 lb	1,000 lb

Ref.: MRC 1984a
[a]Includes 36 55-gallon drums of oil and 15 55-gallon drums of scintillation vials.
PCB - polychlorinated biphenyl
R&D - research and development

Table VI.4. Summary of Hazardous Waste Streams - 1988 to 1989

Waste Stream	Waste Stream Description	1988 Volume[a]	1989 Volume[a]
1	"27" Solvent[b]	9,625 gal	4,400 gal
2	Wastewater and coolant	2,420 gal	2,750 gal
3	Waste oil	2,479 gal	2,407 gal
4	Ferric chloride	1,540 gal	2,239 gal
5	"B" solvent[c]	1,595 gal	1,336 gal
6	Potassium permanganate/sodium hydroxide (plating)	0	1,070 gal
7	Scintillation vials (nonradioactive)	652 gal	853 gal
8	"28" solvent[d]	1,210 gal	825 gal
9	Photo waste	784 gal	634 gal
10	Resin wastes	280 lb	433 lb
11	Dye waste (plating)	495 gal	425 gal
12	DAP (with or without asbestos, fiberglass, or both)	1,130 lb	406 lb
13	Nickel sulfamate waste	125 gal	383 gal
14	"E" solvent[e]	394 gal	301 gal
15	Paint waste (some with water)	818 gal	290 gal
16	Asbestos	295 gal + 65 lb	275 gal + 10 lb
17	Acids[f]	354 gal	244 gal
18	Mixed solvents (unspecified)	35 gal	225 gal
19	Freon (some with water)	195 gal	218 gal
20	Alcohols[g]	292 gal	204 gal
21	Gel degreaser	0	165 gal
22	Nickel acetate (plating)	110 gal	165 gal
23	Dry ink	63 lb	157 lb
24	Acetonitrile	0	150 gal
25	Nickel cleanup waste	346 gal	145 gal
26	Acetone (may contain water)	82 gal	124 gal
27	Tires	76 tires	121 tires
28	"I" solvent[h]	325 gal	110 gal
29	Hydraulic fluid	165 gal	110 gal
30	Wood's nickel solution (plating)	85 gal	105 gal
31	Electrophoretic (plating)	190 gal	105 gal
32	Nickel waste	706 gal	104 gal
33	Batteries (acid-lead)	131 batteries	77 batteries
34	Alkalies[i]	120 gal	75 gal
35	Alcohol and acetone	0	72 gal
36	Alcohol and trichloroethylene	25 gal	60 gal
37	Trichloroethane	213 gal	57 gal

Table VI.4. (page 2 of 2)

Waste Stream	Waste Stream Description	1988 Volume[a]	1989 Volume[a]
38	Stoddard solvent (new)	0	55 gal
39	LIX solvent	0	55 gal
40	Oil and water	495 gal	55 gal
41	Oil and solvents	55 gal	55 gal
42	Nickel chloride	0	55 gal

Wastes for which 1989 Volume was Less Than 50 Gallons but Greater Than 10 Gallons	
Alodine waste	Maleic anhydride
Copper cyanide	MOCA waste
Dichloromethane	Oakite
Electroless nickel	Passivating waste
Lead waste	
Wastes for which 1989 Volume was 10 Gallons or Less	
Acetone and absorbent	
Acetone and asbestos	Gold waste
Acetone and trichloroethane	Grease
Alcohol and ethyl acetate	Isocyanate cleanup material
Alcohol and freon	Mercury
Alcohol and trichloroethane	Methyl ethyl ketone
Aluminum waste	Nitric acid and nickel
Benzene	Nitric acid and zinc chromate
Blankrola	Oil cleanup material
Carbon disulfide	Oil and mercury
Chromic acid	Propylene glycol
Cyclohexane	"R" solvent[k]
"DS" solvent[j]	Sodium dichromate
Ethyl acetate	Tricholoromethane
Ethylene glycol	Trichloroethene
Formaldehyde	Zinc chromate

Ref.: Fentiman 1990

[a]All volumes are approximate. Waste cans and drums are often not full when they are picked up. Sometimes an estimated volume of waste is recorded on the pickup sheet and sometimes the container volume is used.

[b]Contents include acetone, acetonitrile, ethyl and isopropyl alcohols, toluene, dichloromethane, and water.

[c]Contents include ethyl, methyl, and isopropyl alcohols; acetone; trichloroethene; trichloroethane; dichloromethane; and toluene.

[d]Contents include isopropyl, diacetone, and ethyl alcohols; dichloromethane, and acetone.

[e]Contents include ethyl and isopropyl alcohols, dichloromethane, trichloroethane, and Freon.

[f]Contents include hydrochloric, sulfuric, nitric, and phosphoric acids.

[g]Contents include ethyl, methyl, isopropyl, and diacetone alcohols.

[h]Contents include ethyl and isopropyl alcohol and trichloroethane.

[i]Contents include sodium, potassium, and ammonium hydroxide.

[j]Contents include ethyl and isopropyl alcohols, acetone, toluene, Freon, trichloroethane, and trichloroethene.

[k]Contents include unspecified solvents; some may be halogenated.

MOCA - 4,4-Methylene-bis-(2-chloroanilene)

Table VI.5. Inventory of Mound's Mixed Wastes - 1989

Type of Waste	Storage Containers	
	Number	Type
Scintillation Vials	183	55-gal drums
Various chemicals (mercury, acids, solvents, etc.) contaminated with radioactive materials	3 3 9 2 36.5 L	55-gal drums 30-gal drums 5-gal cans 1-gal cans Various containers
Octane with beta contamination	3	55-gal drums
Oils, cleaning materials, and equipment contaminated with PCBs and radioactive material	19 10 1 1	55-gal drums 30-gal drums 83-gal drum 24-ft^3 box
Lead contaminated with radioactive materials	11 2 3 -	55-gal drums 30-gal drums 5-gal cans 30-ft^3 in boxes
Thorium and uranium compounds in hazardous forms		146 lb

Ref.: Fentiman 1990
PCB - polychlorinated biphenyl

be inaccurate to assume that the containers are full. For example, a 55-gallon drum of scintillation vials contains a few plastic bags, each of which holds several small vials containing a few milliliters. The total amount of liquid in a 55-gallon drum may be as little as a few quarts.

Mound personnel are aware of the need to minimize the amount of mixed wastes generated and have responded by carefully segregating hazardous and radioactive materials when possible. One operation that requires the generation of mixed wastes is analysis of health physics and environmental samples. Scintillation fluids used in tritium analyses are generally classified as hazardous materials and, if the tritium concentration is greater than 50 μCi/L, the sample must also be classified as radioactive. In 1989, Mound generated 48 gallons of radioactive scintillation vials. Several small containers of oil and solvents contaminated with radioactive materials were also collected in 1989. Because of the nature of Mound's operations, a small amount of contaminated liquid is expected annually.

Because there is no mixed waste disposal site and none is likely to be opened in the near future, several DOE sites are developing facilities to treat their mixed wastes. Treatment generally means either destroying the hazardous components or converting them to a nonhazardous form so they may be disposed of as radioactive waste. Mound has a glass-producing furnace (called a glass melter) that can incinerate organic compounds while trapping radioactive ash in molten glass. After it is cooled, the glass can be buried as radioactive waste. Plans are in progress for a fully monitored trial burn in the glass melter (Cosmos 1989). This trial burn will be conducted in support of the RCRA Part B application.

6.4. GENERAL DEBRIS DISPOSAL

Some general debris disposal has occurred at Mound. The hillside disposal area (described below) was used as a general disposal area for construction contractors working at the plant. In the early 1970s, contractors were told to dump their debris there. Soils and spoils were dumped there until the new property was acquired in 1981. Thereafter, the spoils disposal area was used instead. General debris may have also been dumped in Area 7, as described earlier.

6.4.1. Hillside Disposal Area (Area J) (Historical)

The Area J, hillside disposal area is southwest of Building 38, at the base of the SM/PP Hill Area, in the east-central portion of Mound (Figure 6.1). The area began operations in the 1960s and remained in service until the early 1980s. It was used for the disposal of construction and building demolition and remodelling debris including pipe, plumbing fixtures, wood, wallboard, roofing materials, old laboratory furniture, ceiling tiles, and general debris. Chemical contaminants such as laboratory

reagents, asbestos, and other hazardous materials may also have been deposited there. Wastes were bulldozed over the hillside in a random and uncompacted fashion. The area encompasses four acres with a disposal volume that may exceed 100,000 yd^3. The area was observed to be graded and vegetated during the 1988 visual site inspection (EPA 1988). During the 1982 to 1985 Radiological Site Survey (DOE 1991c), the maximum plutonium-238 concentration measured was 71.30 pCi/g at a sample depth of 18 inches. The maximum thorium activity measured was 30.42 pCi/g at a sample depth of 162 inches (Stought et al. 1988).

Surface runoff and a liquid seep at the toe of the hillside disposal area drains into two ponds. The ponds are used to collect runoff and limit hillside discharges to the plant drainage ditch.

6.4.2. Sludge From the Old Sewage Disposal Plant

In the 1950s and 1960s, sludge from the old sewage disposal (SD) plant was excavated from the drying beds and used for fertilizer throughout the plant. The dried sludge was spread across all areas of the plant, which, at the time, did not include the new property currently comprising the southern half of the plant. During this time, the old SD plant was intermittently plagued by discharges from the plating shop that killed the bacteria in the treatment tanks (Thomas 1991). In December 1970, elevated alpha activity was observed at the influent tanks during routine monitoring. Subsequent search and sampling of the sanitary and process sewer lines indicated that seepage from the process lines had, in fact, affected the sanitary lines. To ensure the continued operation of the treatment plant, the contaminated sludge was pumped from the drying beds into a nearby trench for disposal. Other debris may have also been thrown into the trench for disposal (DOE 1992c).

The old SD plant is currently part of the Mound D&D Program and is now referred to as Area 4a (Figure 6.1) (DOE 1992c). Some potential exists for low levels of contamination, probably polonium-210, as well as metals from the plating shop, to have been spread over the vegetated areas of the plant during the 1950s and 1960s.

6.4.3. Trash Dumpsters

Trash dumpsters are located throughout Mound. The date of start-up of their use is unknown and they are still in operation. They are used for the collection of nonhazardous trash, but small quantities of laboratory chemicals may find their way into the trash (EPA 1988). Trash is transported off-plant for disposal. The dumpsters are metal, and many are 7 ft long, 4 ft wide, and 4 ft high with plastic or metal lids. Many are located on asphalt or concrete pads with runoff being discharged into the storm drains.

7. SUMMARY OF TABLES AND DATES OF OPERATIONS

This report provides summary descriptions of the key projects at Mound, focusing on waste generation, treatment, storage, and disposal. Table VII.1 summarizes the major programs conducted at Mound and their general life span. The ideal program cycle included research, pilot plant, production, and D&D phases. Not all of the programs followed this ideal cycle. The polonium-210 program entered Mound at the production phase and continued through to the D&D of the processing facilities. The thorium refinery program completed the research phase, but was cancelled before the production phase. Many programs, such as recovery of thorium-228, never really progressed beyond the research phase. The production phase of plutonium-238 was terminated in 1979 to advance to the D&D of the facilities, an activity that still continues.

The following pages provide lists of radioactive and chemical wastes generated, the past and present treatment and storage facilities, and the methods of waste disposal. Some waste treatment facilities or storage areas described in previous sections of this report were not identified in the RFA (EPA 1988) or the CEARP Installation Assessment (DOE 1986). Waste storage areas are summarized below and discussed in detail in Section 5. Past or historic activities and areas are discussed throughout the report.

7.1. LISTS OF WASTES GENERATED: CHEMICAL REAGENTS AND RADIONUCLIDES

Tables VII.2 and VII.3 present lists of chemical reagents and radionuclides used through the programmatic and support activities of the plant. These tables were compiled by review of the process descriptions. Because many of the process descriptions included historic activities, chemicals and metals may be listed that were not in the annual volume estimations provided in Section 6. No attempt has been made to correlate Table VII.1 with the volumetric data.

7.2. SUMMARY OF TREATMENT FACILITIES

Table VII.4 provides a summary list of the waste treatment facilities known to have been used over the history of the plant. The approximate dates of operation are included. This list includes historic waste incinerators not previously described. Area C, the historic location for burning of lithium powder, is included here simply because the burning is deemed a waste treatment rather than a disposal. The distinction seems arbitrary.

Table VII.1. Summary of Key Programs

Polonium-210 D&D	1949 - 1971 (peak 1954) 1974
Radium-226/Actinium-227 D&D	1949 - 1953 (peak 1953) 1955 to 1959
Biological studies Actinium-227 Polonium-210	 1952 - 1954 1949 - 1955
Purex pilot plant	1952 - 1953
Reactor waste research	1949 - 1953
Tritium	1955 - present
Thorium-232 refinery D&D	1955 1965 - present
Explosive detonators (plastics, ceramics and adhesives)	1956 - present
Neutron sources Polonium-210 Plutonium-239	 1949 - 1971 1956 - 1962
Plutonium-238 D&D	1960 - 1978 present
Reactor fuels	1953 - 1966
Rare isotopes Polonium-208, -209 Thorium-228, -229, -230 Uranium-233, -234 Thorium-230 (ionium) Protactinium-231	1956 - 1983 1956 - 1957 1957, 1972 - 1983
Stable isotopes	1957 - present

D&D - decontamination and decommissioning

Table VII.2. List of Chemicals

Acetic acid
Acetone
Acetonitrile
Acrylonitrile
Aluminum chloride
Ammonium bicarbonate
Ammonium chloride
Ammonium hydroxide
Ammonium iodide
Ammonium sulfate
Ammonium thiocyanate

Anco Algaecide No. 1
- 2-Benzyl-4-chlorophenol
- Sodium hydroxide

Ancocide 4020
- Aqueous glutaraldehyde

Ancool 3310
- Phosphonate
- Triazole
- Sodium molybdate
- Sodium hydroxide

Ancosperse 3830
- Polyalkylene glycol
- n-Alkyldimethylbenzl
- Ammonium chloride

Anion exchange resin (e.g. Dowex-50)
Arsenic
Asbestos fiber
Benzene
Benzidine
2-Benzyl-4-chlorophenol
Bismuth phosphate
Bis(tributylin) oxide
Blankrola
Boric acid
Brucine
2-Butanone
Calcium carbonate
Calcium hypochlorite
Calcium nitrate
Calcium chloride
Calcium phosphate
Carbon dioxide
Carbon disulfide
Carbon monoxide
Carbon tetrachloride
Caustic soda
Chlorine
Chlorobenzene
Chloroethene
Chromic acid
Citric acid
Copper cyanide
Copper sulfate
Cresols
Cyanide
Cyclohexane
Diacetone alcohol
Dially phthalate (DAP)
Dibutyl N, N diethyl
- Carbamoyl phosphonate
Dichlorodifluoromethane
Dichloromethane
Diethyl ether
Dimethylamine
Dimethylformamide
Dimethylsulfoxide
Epoxy resins
Ethyl acetate
Ethyl alcohol
Ethylene glycol
Ethylene glycol monobutyl ether
Ferric chloride
Ferrous hydroxide
Ferrous sulfide
Ferrous sulfomate
Ferric sulfate
Fluoboric acid
Fluorotrichloromethane
Formaldehyde
Formic acid
Freon-TF
Freon-TE
Glutaraldehyde
Hexane
Hexanitrostilbene
Herbicide
High explosives
- PETN
- PBX
- RDX
- HMX

Hydriodic acid
Hydrochloric acid
Hydrofluoric acid
Hydrogen peroxide
Hydrogen sulfide
Hydroxylamine nitrate
Iodomethane
Isobutyl alcohol
Isocyanate
Isopropal
Isopropanol
Kerosene
Lactic acid
Lead acetate
Lithium chloride
Lithium hydride
Maleic anhydride
Methanol

Table VII.2. (page 2 of 2)

2-Methyl-4-isothiazolin -3-one
Methyl alcohol
4'4'Methylene Bix(2-chloroanoline)
Methylene blue
Methylene chloride
Methyl ethyl ketone
Methyl isobutyl ketone
Microbicide 77
-5-Chloro-2 methyl-4 -isothiazoline-3-one
-2-Methyl-4-isothiazolin -3-one

Nalco 2532
-Ammonium chloride
-Potassium hydroxide
-Bis(tributyltin)oxide
-n-Alkylidimethylbenzyl

Nalco 2575
-Phosphonate
-Tolytriazole
-Polyacrylate
-Sodium chromate

Nalco 2590
-Calcium hypochlorite

n-Alkylidimethylbenzyl
1-Naphthlamine
2-Naphthylamine
Nickel acetate
Nickel chloride
Nickel sulfamate
Nickel sulfate
Nitrate
Nitric acid
Nitric oxide
Nitrous oxide
Nitrogen dioxide
Oakite
Organophosphate
Oxalic acid
PCB oils
p-Dioxane

Pentaether
Perchlorethylene
Perchlorate
Phenol
Phosphonate
Phosphoric acid
Polyacrylate
Polyalkylene glycol

Potassium bromide
Potassium carbonate
Potassium hydroxide
Potassium permanganate
Potassium pyrosulfite
Potassium sulfate
Propanol
Propylene glycol
Resorcinol
Silicon
Siltex
-Sodium polyacrylate

Sodium bisulfate
Sodium carbonate
Sodium chromate
Sodium cyanide
Sodium dichromate
Sodium hexametaphosphate
Sodium hydrogen sulfate
Sodium hydroxide
Sodium molybdate
Sodium nitrate
Sodium nitrite
Sodium polyacrylate
Sodium sulfite
Sodium tartrate
Sulfuric acid
Tetrachloroethane
Tetrahydrofuran
Thenoyltrifluoro acetone
Thermite
Toluene
Toluene diisocyanate
Tolytriazole
Triazole
Tribromomethane
Tributyl phosphate
1,1,1-Trichloroethane
Trichlorofluoromethane
Trichloroethane
Trichloroethene (trichloroethylene)
Trichloromethane
Xylene
Zinc chromate
Zirconium oxide

Resorcinol

Table VII.3. List of Radionuclides and Metals

Actinium-227

Americium-241

Cesium-137

Cobalt-60

Neptunium-237
Neptunium-239

Plutonium-238
Plutonium-239
Plutonium-240
Plutonium-241
Plutonium-242

Polonium-208
Polonium-209
Polonium-210

Protactinium-231

Radium-226
Radon-222[b]

Strontium-90

Thorium-228
Thorium-229
Thorium-230
Thorium-232

Tritium

Uranium-233
Uranium-234
Uranium-235
Uranium-238

Metals (includes unspecified radionuclides)

Aluminum
Antimony
Barium
Beryllium
Bismuth
Cadmium[a]
Chromium
Cobalt[a]
Copper
Curium
Gallium
Gold
Iron[a]
Lead
Lithium
Magnesium
Manganese
Mercury
Nickel[a]
Niobium
Selenium[a]
Silver[a]
Tellurium[a]
Tin[a]
Vanadium
Ruthenium
Zinc[a]
Zirconium

[a] These were identified as contaminants in either the bismuth or the aluminum cans that were irradiated to produce polonium. The specific radionuclides that may have been produced have not been thoroughly evaluated.
[b] Radon-222 is a daughter product of radium, actinium, and thorium.
HMX - octahydro-1,3,5,7-tetranitro-1,3,5,6-tetrazocine cyclo-tetramethylenetetranitramine
PBX - plastic bonded explosive
PCB - polychlorinated biphenyl
PETN - pentaerythritol tetranitrate (explosive)
RDX - hexahydro-1,3,5-trinitro-s-triazine cyclotetratmethylene-tetranitramine

Table VII.4. Waste Treatment Facilities

Facility	Dates of Operation
Alpha Wastewater Treatment System	
-WD Building (polonium)	1949 - 1970
-WD Building (plutonium)	1970 - present
-WDA Building (plutonium)	1967 - 1970
-SM Building (plutonium)	1961 - 1967
Alpha Waste Solidification Facilities	early 1960s - 1982
- HH Building (polonium)	1949 - ca. 1961
- T Building (polonium)	ca. 1961 - 1972
- SM Building (plutonium)	1961 - 1967
- WD Building (plutonium)	1967 - 1974
- WS Building (plutonium)	1974 - 1982
Beta Wastewater Solidification Facility	1973 - present
Tritium Effluent Removal System	1965 - present
Beta Waste Solidification Facility	1974 - present
Cyclone Incinerator	1975 - 1981
Glass Melter Furnace	1981 - present
Off-Gas Treatment System	1981 - present
Waste Evaporation Treatment System	
-Purex pilot plant	1952 - 1953
-Radium/actinium	1952 - 1954
Area H Trash Burner	1950s - 1988
Area H Thermal Treatment Unit	1968 - present
Retort	1984 - present
Biodegradation Unit	1975 - present
Building 1 Leach Pit	early 1960s - 1985
Building 27 Leach Pit	early 1960s - 1985
Building 1 Sump	early 1960s - 1985
Building 27 Sump	early 1960s - 1985
Historic Landfill (Area B)	1949 - 1971
Building 51, Waste Incinerator	1971 - 1974
Area C, Lithium Burn Area	mid-1950s
Area 13, Polonium-Contaminated Wood from Dayton Unit IV	1955
Solid Radioactive Waste Compactors	1974 - 1987

7.3. SUMMARY OF STORAGE AREAS

Table VII.5 provides a summary of the waste storage areas known to have been used over the history of the plant. There are four historical warehouses included on the list that were not previously described. At least one of the warehouses (#10) and perhaps a second (#14) were too contaminated to be sold for salvage when they were demolished and were burned in place. They are not listed in the treatment areas, although burning was a common waste treatment. Two additional solvent storage sheds are listed that were not included in the RFA (EPA 1988). These are located at Buildings 29 and 49.

7.4. SUMMARY OF ON-PLANT DISPOSAL AREAS

Table VII.6 provides a list of the on-plant areas known to have been used for waste disposal. The research for this report did not identify any on-plant disposal sites that were not already known (DOE 1992g).

Table VII.5. Waste Storage Areas

Area	Dates of Operation
WD Building Drum Staging Area	1981 - 1990
Radioactive/Mixed Storage Area (Building 23)	1966 - present
Building 31, Contaminated Material Storage Building	1966 - present
Area 9, Thorium Drums	1956 - 1966
Building 21, Thorium Sludge Storage Facility	1964 - 1974
Evaporator Storage Area	1955 - 1960
Area 3, Thorium Drums	1955 - 1964?
Area 1, Thorium Drums	1964 - 1966?
Plutonium Drums	1967
Contaminated Soil Box Area	1974
Old Warehouses	
9 (thorium)	1955
10 (polonium)	1949 - 1956
13 (radium/actinium)	1952 - 1953
14 (plutonium)	1964? - 1966
15 and 15A	1948 - 1964
Old Quonset hut	
Thorium	1955 - 1956
Purex waste	1952
Polonium	1949 - 1954
Area 21, Old Bunker	1947 - 1955
Test Firing Residual Area	1956 - present
Explosive Waste Storage Bunker	1970 - present
Pyrotechnic Waste Shed	1975 - present
Building 27 Drum Storage Area	1985 - present
Hazardous Waste Storage Area	1986 - present
Scintillation Vial Storage Area	Present
Building DS Solvent Storage Shed	Present
Building B Solvent Storage Shed	Present
SW Building Drum Staging Area	Present
Building 49 Solvent Storage Shed	1985 - 1990
Old Firing Range Drum Storage Site	1970 - 1974
Area B Drum Storage Area	1974 - 1975
Chemical Waste Storage Area	1975 - 1982
Past Hazardous Waste Storage Area	1982 - 1985
Waste Oil Drum Field Area	1986
Building E Solvent Storage Shed	Unknown - 1988
Building 29 Solvent Storage Shed	1972 - 1989
Asphalt-Lined Pond	1979 - present
Overflow Pond	1977 - present
Drilling Mud Drum Storage Areas	1987 - 1989

Table VII.6. Waste Disposal Units

Unit	Dates of Operation
Area 2, thorium- and polonium-contaminated wastes	Late-1950s - 1960s
Area 7, thorium, polonium, and actinium wastes	Mid-1950s - mid-1970s
Area 8, thorium-contaminated soils from Areas 1 and 9	1965
Area 10, debris from Dayton Units	1950
Area 12, thorium-contaminated soil from Area 1	1965
Area 15, entombed old SW cave	1955
Area 16, SM Building sanitary sewage septic tank and leach basin	1960 - 1964
Area D, acid leach field	1967 - 1987
Area 22, orphan soil from other areas	1985
Spoils Disposal Area	1985 - present
Excavated Materials Disposal	Mid-1980s
Pyrotechnic Waste Disposal Area	1975 - 1985
Historic Landfill (Area B)	1949 - 1975
Area 18, Site Sanitary Landfill	1976
Area F, chromium trench	1963
Hillside Disposal Area (Area J)	1970s - early 1980s
Trash dumpsters	Present

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A

Appendices

Part 2 of 2

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B

Cardinal®

APPENDIX B

NUCLIDE DATA INVENTORY REPORTS

POLLUTANT INVENTORY REPORT

November 8, 1973

Mr. R. L. Wainwright, Area Manager
U. S. Atomic Energy Commission
P. O. Box 66
Miamisburg, Ohio 45342

Dear Mr. Wainwright:

Nuclide Inventory Data

The enclosed information is submitted in response to your letter, this subject, dated October 18, 1973. The enclosures consist of:

Off-site Nuclide Inventory Data
On-site Nuclide Inventory Data
Nuclide Inventory Data - Discussion

If you have any questions, please advise.

Very truly yours,

Donald R. Storey
Director, Administration

Hebb:bjs
Enclosures (3)

cc: R. L. Wainwright (2)

bc: P. C. Adams w/enc.
W. T. Cave w/enc.
R. K. Flitcraft w/enc.
J. L. Hebb w/enc.
H. E. Meyer w/enc.
W. H. Westendorf w/enc.
R. A. Wolfe w/enc.

November 7, 1973

OFF-SITE NUCLIDE INVENTORY DATA
(Data Presented in Curies)

RADIONUCLIDE	ATMOSPHERE		SURFACE STREAMS		GROUND WATER		SOIL		DITCHES	
	D	R	D	R	D	R	D	R	D	R
^{227}Ac	5.3×10^{-6}	5.06×10^{-6}	NS	NS	NS	NS	NS	NS	NS	NS
Gross β^-	NS	NS	9.19	U	NS	NS	NS	NS	NS	NS
$^{238,239}Pu$	0.36	0.33	0.46	0.45	--	ND	--	0.53	--	0.013
^{210}Po	0.49	0.15×10^{-3}	4.27	4.16×10^{-3}	--	NB	--	NB	--	NB
^{226}Ra, ^{227}Ac, ^{228}Th + drs.	0.16	U	U	---	U	--	U	--	U	--
^{232}Th + drs.	NS	---	NS	---	NS	--	U	--	U	--
^{3}H	2.85×10^{6}	1.98×10^{6}	3.33×10^{3}	2.81×10^{3}	--	S	NS	NS	NS	NS

NOTE: See Nuclide Inventory Data - Discussion

D - Deposited over the years of operation
R - Remaining as of this date. Corrected for decay
NS - Not Sampled
U - Unknown
ND - Non-detectable
S - Special. See discussion section
NB - Natural Background

November 7, 1973

ON-SITE NUCLIDE INVENTORY DATA
(Data Presented in Curies)

RADIONUCLIDE	BURIAL GROUNDS		SOIL		DITCHES		GROUND WATER	
	D	R	D	R	D	R	D	R
^{227}Ac	NS	NS	NS	NS	NS	NS	NS	NS
Gross β^-	NS	NS	NS	NS	NS	NS	NS	NS
$^{238,239}Pu$	7	0.58	--	0.18	--	0.012	--	ND
^{210}Po	U	--	--	NB	--	NB	--	NB
^{226}Ra, ^{227}Ac, ^{228}Th + drs.	U	--	U	--	U	--	U	--
^{232}Th + drs.	U	--	U	--	U	--	NS	--
^{3}H	NS	NS	NS	NS	NS	NS	--	S

NOTE: See Nuclide Inventory Data - Discussion

D - Deposited over the years of operation
R - Remaining as of this date. Corrected for decay
NS - Not Sampled
U - Unknown
ND - Non-detectable
S - Special. See discussion section
NB - Natural Background

November 7, 1973

NUCLIDE INVENTORY DATA - DISCUSSION

1. ^{227}Ac

Emission to the atmosphere resulted from a small scale R&D program conducted in the SW-140 Cave. There were no liquid discharges to surface streams from the cave operation, so no monitoring of surface streams, ground water or ditches was required and is indicated by NS. Soil sampling was not conducted since the emission to the atmosphere was minimal. Also, there was no burial on-site of ^{227}Ac from this program.

Estimated accuracy of data:

a. Atmosphere = ± 100%

Basis: Counting error due to count rate being near counter background; normal fluctuations in stack air flow; possibility of non-representative sampling; filter paper self-absorption.

Note: See discussion on accuracy of data at the end of this section.

2. Gross β^-

Under the heading of Surface Streams, Gross β^- does not include tritium beta. Monitoring consisted of determining the total hard beta emitted by the many inpurities in the irradiated raw material for the polonium-210 program. Since there were a large number of beta emitters in the process liquid waste stream, and therefore numerous simultaneous rates of decay, no single decay value or estimate of the curie quantity remaining at the end of CY-1972 can be given.

The liquid effluent discharge was controlled on the basis of attributing the total beta count to the most restrictive (healthwise) isotope in the effluent and controlling the average beta concentration to less than the RCG for that isotope.

Estimated accuracy of data:

a. Surface Streams = ± 100%

Basis: Counting error (for proportional counting); non-representative sampling; analytical.

3. $^{238,239}Pu$

Generally, analyses have been for total plutonium so both 238 and 239 isotopes are indicated. The 239 isotope represents only a few hundredths per cent of the total plutonium in terms of curie quantity. Plutonium-238 is the predominant isotope; therefore, the half-life of this isotope was used in decaying to the quantity remaining.

Soil core sampling for plutonium inventory on-site and off-site has been performed out to a concentration of $3 \times 10^{-3} \mu Ci/m^2$ (maximum distance of 2.5 miles) in all directions from Mound Laboratory. Based on data obtained out to $3 \times 10^{-3} \mu Ci/m^2$ we estimate that the inventoried area accounts for most of the off-site deposition. However, additional core samples out to background levels will be required to complete and refine the estimate for total inventory.

Soil data is given as the quantity remaining since the data is recent. The quantity deposited over the years of operation is unknown, could only be estimated and would therefore not be meaningful. There is relatively good correllation between the quantity emitted to the atmopshere (and subsequently falling out to the ground) and the quantity detected in soil.

The seven (7) curies listed under the heading of Burial Grounds resulted from a radioactive waste line break in 1969. The spill area soil was removed to a large extent and shipped to off-site burial. An estimated 0.58 curies remains since complete removal would have been extensive and costly. Decay was calculated for the quantity remaining. This burial constitutes only part of the Burial inventory. Concerning Burial Grounds, Soil and Ditches, see discussion at the end of this section.

Estimated accuracy of data:

a. Atmosphere = ± 50%

Basis: Counting error; fluctuations in stack air flow; non-representative sampling; filter paper self-absorption.

b. Surface Streams = ± 50%

Basis: Counting error; non-representative sampling; residue self-absorption.

c. Soil = ± 50%

Basis: Counting error; non-representative sampling; analytical error.

d. Ditches = ± 200%

Basis: Counting error; non-representative sampling; analytical. Data obtained is <u>only</u> <u>preliminary</u> from 2" deep core samples.

e. Burial Ground = ± 100%

Basis: Counting error; non-representative sampling; analytical.

4. ^{210}Po

Concerning Burial Grounds, see discussion at the end of this section.

Estimated accuracy of data:

a. Atmosphere = ± 50%

Basis: Counting error; non-representative sampling; fluctuations in stack air flow; filter paper self-absorption.

b. Surface Streams = ± 50%

Basis: Counting error; non-representative sampling; residue self-absorption.

5. ^{226}Ra, ^{227}Ac, ^{228}Th and drs

R and D program conducted in early 1950's to recover ^{227}Ac from irradiated ^{226}Ra. The three parent isotopes and their daughters were therefore involved. This presented many complications in the monitoring program. Air sample counting was based on gross alpha emission; therefore, specific isotopes were not identified. Since there were many isotopes involved and numerous rates of decay, an acceptable quantity remaining at the end of CY-1972 cannot be assigned.

No data are given for Surface Streams since gross alpha monitoring was performed for effluent control only and not for nuclide inventory.

Sampling Ground Water, Soil, Ditches and Burial Grounds for inventory also was not performed. Concerning these subjects see discussion at the end of this section.

Estimated accuracy of data:

a. Atmosphere = ± 200%

Basis: Non-representative sampling; correction factors applied to gross alpha count to arrive at parent isotopes quantity; counting error.

6. ^{232}Th and drs

This material has been in storage at Mound Laboratory since its receipt in 1954. Some on-site contamination resulted from leaky storage drums and redrumming operations.

Concerning Soil and Burial Grounds, see discussion at the end of this section.

7. ^{3}H

Under Ground Water, we do not know the volume of the ground

water aquifer, the extent of contamination throughout the acquifer, or the rate of transport through the aquifer sampled. We can give only the concentration of tritium detected at sampling points. We have no reliable or acceptable way to estimate the gross quantity of tritium deposited or remaining in the ground water.

Concentration in Ground Water (in 1972):

a. Off-site - 0.03 μCi/ml
@ 800 ft. west of Mound Laboratory

- 0.01 μCi/ml
@ 3000 ft. west of Mound Laboratory

b. On-site - 0.08 μCi/ml

Estimated accuracy of data:

a. Atmosphere = $^{+10}_{-25}$%

Basis: Non-representative sampling; hand calculation and reduction of Kanne' ionization chamber strip chart data; influence of radon and thoron on ionization chamber response.

b. Surface Streams = ± 20%

Basis: Non-representative sampling; counting error; analytical.

c. Ground Water = ± 5%

Basis: Counting error; analytical.

Burial Grounds, Soil and Ditches

The tables of data indicate for several of the isotopes that the quantity deposited in Burial Grounds, Soil and Ditches is unknown. In the "Mound Laboratory Radioactive Waste Management Site Plant" dated June 15, 1973, we informed the AEC that there are some 15 land areas on-site containing

radioactive contamination. These areas have been identified on a Mound Laboratory Site Plan. Monitoring was performed to identify the areas; however, a comprehensive soil core sampling program has not been conducted to date to determine the quantity of radioactive material in each site.

In a letter dated October 23, 1973, to the AEC on the subject "Decontamination and Decommissioning of A.E.C. Facilities" the cost of performing deep core sampling and analysis of the contaminated areas is presented. The referenced letter comprehensively reviews the subject of specified contaminated facilities and land areas and presents the associated annual cost of surveillance and maintenance.

The data requested for the present "Nuclide Inventory Data" report cannot be furnished until a comprehensive program of deep core sampling is completed.

Accuracy of Data

Comprehensive historical data for statistical analysis of error in data was not available. Therefore, the error estimation was based on the errors known to be associated with the techniques and instruments used in earlier operations. It should be noted that the error estimates used are based on earlier techniques and instrumentation and not those employed at present.

U. S. Atomic Energy Commission
Albuquerque Operations Office
Area Office DAO
AEC Contractor MRC

Inventory of Pollutants
Released to the Environment

Facility Mound Laborato
Location Miamisburg, Oh
Date Prepared March 7, 1974
Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Perio
B Building	Hydrogen Chloride	Airborne	$1.0 \times 10^3 \mu g/m^3$	None Available	Not Applicable	5.0 Kg
"	Oxides of Nitrogen	"	$1.2 \times 10^3 \mu g/m^3$	"	"	5.0 Kg
"	Organics: Ether (Di-ethyl)	"	$1.6 \times 10^3 \mu g/m^3$	"	"	4.0 Kg
"	Cobehn (96% $CHCl_3$)	"	$1.6 \times 10^3 \mu g/m^3$	"	"	42.0 Kg
"	Chloroform	"	$1.0 \times 10^3 \mu g/m^3$	"	"	25.0 Kg
"	Acetone	"	$4.3 \times 10^2 \mu g/m^3$	"	"	22.0 Kg
"	Isopropyl Alcohol	"	$1.8 \times 10^1 \mu g/m^3$	"	"	5.0 Kg
"	Ethyl Alcohol	"	$1.6 \times 10^3 \mu g/m^3$	"	"	1000.0 Kg
"	Trichloro-ethylene	"	$1.6 \times 10^2 \mu g/m^3$	"	"	110.0 Kg
"	Freon TE	"	$6.0 \times 10^2 \mu g/m^3$	"	"	15.0 Kg
"	Freon TF	"	$1.7 \times 10^2 \mu g/m^3$	"	"	16.0 Kg
"	Toluene	"	$1.4 \times 10^1 \mu g/m^3$	"	"	1.1 Kg
"	Total Organics From Above Listing		7.5 Lb/day	40 Lb/day OEPA*	18.8%	2728.2 Lb

*Ohio Environmental Protection Agency

U. S. Atomic Energy Commission
Albuquerque Operations Office
Area Office DAO
AEC Contractor MRC

Inventory of Pollutants
Released to the Environment

Facility Mound Laboratory
Location Miamisburg, Ohi
Date Prepared March 7, 1974
Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Airborne or Waterborne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Perio
Burning Area*	Particulates	Airborne	0.3 lbs/hr (136 g/hr)	Not Applicable	Not Applicable	1.36 Kg
"	Carbon Monoxide	"	$3.0 \times 10^{-1} \mu g/m^3$	"	"	8.0 Kg
"	Nitric Oxide	"	$7.5 \times 10^{-1} \mu g/m^3$	"	"	20.0 Kg
"	Nitrous Oxide	"	$1.5 \times 10^{-1} \mu g/m^3$	"	"	4.0 Kg
"	Nitrogen Dioxide	"	$2.0 \times 10^{-1} \mu g/m^3$	"	"	5.5 Kg

* Mound Laboratory has a permit from the Montgomery County Combined General Health District for the disposal of explosive wastes by open burning.

U. S. Atomic Energy Commission
Albuquerque Operations Office
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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released Durin Reporting Peri
DS Building	Hydrogen Chloride	Airborne	2.0×10^{-2} μg/m³	None Available	Not Applicable	0.5 Kg
"	Oxides of Nitrogen	"	3.0×10^{-2} μg/m³	"	"	1.1 Kg
"	Organics: Ethyl Alcohol	"	6.2×10^{1} μg/m³	"	"	1510.0 Kg
"	Acetone	"	2.6×10^{1} μg/m³	"	"	400.0 Kg
"	Stoddard Solvent (51% parafin) (39% naptha) (9% aromatics)	"	1.5×10^{0} μg/m³	"	"	4.0 Kg
"	Trichloro-ethylene	"	1.3×10^{1} μg/m³	"	"	225.0 Kg
"	Chloroform	"	1.3×10^{0} μg/m³	"	"	30.0 Kg
"	Methyl Alcohol	"	1.7×10^{-1} μg/m³	"	"	705.0 Kg
"	Cobehn (96% $CHCl_3$)	"	6.5×10^{0} μg/m³	"	"	125.0 Kg
"	Isopropyl Alcohol	"	2.2×10^{-1} μg/m³	"	"	3.5 Kg
"	Toluene	"	4.0×10^{-2} μg/m³	"	"	2.2 Kg
"	Total Organics From Above Listing	"	18.1 Lb/day	40 Lb/day OEPA*	45.3%	6625.4 Lb

* Ohio Environmental Protection Agency

U. S. Atomic Energy Commission
Albuquerque Operations Office
Area Office DAO
AEC Contractor MRC

Inventory of Pollutants
Released to the Environment

Facility Mound Laboratory
Location Miamisburg, Ohio
Date Prepared March 7, 1974
Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Airborne or Waterborne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Period
E Building	Hydrogen Fluoride	Airborne	3.4×10^1 $\mu g/m^3$	None Available	Not Applicable	0.6 Kg
"	Oxides of Nitrogen	"	6.6×10^1 $\mu g/m^3$	"	"	1.2 Kg
"	Hydrogen Chloride	"	6.6×10^1 $\mu g/m^3$	"	"	0.9 Kg
"	Ammonia	"	1.3×10^4 $\mu g/m^3$	"	"	2.0 Kg
"	Oxides of Sulfur	"	.0012 ppm	2000 ppm OEPA*	.0001%	0.05 Kg
"	Phosphates	"	1.6×10^1 $\mu g/m^3$	None Available	Not Applicable	0.05 Kg
"	Cyanides	"	7.8×10^1 $\mu g/m^3$	"	"	0.05 Kg
"	Organics:					
"	Hydrocarbon smoke	"	1.9×10^1 $\mu g/m^3$	"	"	0.25 Kg
"	Hydrocarbon fumes	"	3.5×10^2 $\mu g/m^3$	"	"	2.0 Kg
"	Toluene	"	7.5×10^0 $\mu g/m^3$	"	"	1.1 Kg
"	Trichloroethylene	"	9.3×10^2 $\mu g/m^3$	"	"	1.0 Kg
"	Freon TF	"	1.7×10^2 $\mu g/m^3$	"	"	17.0 Kg
"	Ethyl Alcohol	"	8.1×10^0 $\mu g/m^3$	"	"	8.0 Kg
"	Acetone	"	2.7×10^2 $\mu g/m^3$	"	"	1.0 Kg
"	Total Organics From Above Listing	"	.18 Lb/day	40 Lb/day OEPA*	.45%	66.9 Lb

* Ohio Environmental Protection Agency

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Inventory of Pollutants
Released to the Environment

Facility Mound Labor
Location Miamisburg,
Date Prepared March 7, 19
Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Airborne or Waterborne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quant: of Pollutant Released Dur Reporting Pe
HH Building	Carbon Monoxide	Airborne	*1.25×10^3 g/m³	None Available	Not Applicable	990 Kg
"	Carbon Disulfide	"	5.7×10^1 μg/m³	"	"	7.97 Kg
"	Organics:					
	Acetone	"	3.56×10^1 μg/m³	"	"	4.98 Kg
"	Methanol	"	3.65×10^1 μg/m³	"	"	5.1 Kg
"	Trichloroethylene	"	6.65×10^1 μg/m³	"	"	9.3 Kg
"	Chloroform	"	5.0×10^1 μg/m³	"	"	6.99 Kg
"	Benzene	"	3.97×10^1 μg/m³	"	"	5.55 Kg
"	Total Organics From Above Listing	"	.19 Lb/day	40 Lb/day OEPA**	.48%	70.38 Lb

* Released continuously at a very low flow from building through small vent pipe.
** Ohio Environmental Protection Agency

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Facility Mound Laborat
Location Miamisburg, Ol
Date Prepared March 7, 1974
Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released Durin Reporting Peri
I Building	Organics: Ethyl Alcohol	Airborne	5.3×10^1 $\mu g/m^3$	None Available	Not Applicable	5.4 Kg
"	Total Organics From Above Listing	"	.03 Lb/day	40 Lb/day OEPA*	.08%	11.9 Lb

* Ohio Environmental Protection Agency

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Facility Mound Laborato
Location Miamisburg, Oh
Date Prepared March 7, 1974
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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Airborne or Waterborne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released Durin Reporting Peri
M Building	Chromates	Airborne	6.43×10^3 $\mu g/m^3$	None Available	Not Applicable	.454 Kg
"	Oxides of Sulfur	"	.028 ppm	2000 ppm OEPA*	.0014%	8.4 Kg
"	Organics: Trichloroethylene	"	1.55×10^4 $\mu g/m^3$	None Available	Not Applicable	1329.0 Kg
"	Acetone	"	2.08×10^4 $\mu g/m^3$	"	"	179.2 Kg
"	Total Organics From Above Listing	"	9.1 Lb/day	40 Lbs/day OEPA*	22.8%	3325.6 Lb

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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released Durin Reporting Peri
Paint Shop	Organics:					
"	Lacquer (alcohol)	Airborne	1.0×10^3 $\mu g/m^3$	None Available	Not Applicable	8.7 Kg
"	Thinner (kerosene)	"	1.0×10^3 $\mu g/m^3$	"	"	8.7 Kg
"	Total Organics From Above Listing	"	.11 Lbs/day	40 Lbs/day OEPA*	.28%	38.4 Lbs

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Inventory of Pollutants
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Facility Mound Laborator
Location Miamisburg, Ohi
Date Prepared March 7, 1974
Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Airborne or Waterborne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Perio
Powerhouse	Aldehydes	Airborne	.46 mg/m³	None Available	Not Applicable	49.1 Kg
"	Benzo(a) pyrene	"	8.49 μg/m³	"	"	.9 Kg
"	Carbon monoxide	"	.03 mg/m³	"	"	3.3 Kg
"	Hydrocarbons	"	2.47 mg/m³	"	"	261.8 Kg
"	Oxides of Sulfur	"	.001 lbs/ Million BTU Input	1.6 lbs/Million BTU Input OEPA*	.69%	151.2 Kg
"	Oxides of Nitrogen	"	.49 g/m³	None Available	Not Applicable	52027.3 Kg
"	Particulates	"	.02 lbs/ Million BTU Input	.25 lbs/Million BTU Input OEPA*	8.0%	2655.5 Kg

Quantities obtained from P.H.S. Publication #999-AP-29

* Ohio Environmental Protection Agency.

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Inventory of Pollutants
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Facility Mound Laboratory
Location Miamisburg, Ohio
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Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Period
PP Building	Hydrogen Chloride	Airborne	$.30 \times 10^{0} \mu g/m^3$	None Available	Not Applicable	.25 Kg

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R Building	Nitrogen Dioxide	Airborne	1.32×10^{0} $\mu g/m^3$	None Available	Not Applicable	2.99 Kg
"	Sulfur Trioxide	"	.00001 ppm	2000 ppm OEPA*	.000001%	.085Kg
"	Hydrogen Chloride	"	1.9×10^{-1} $\mu g/m^3$	None Available	Not Applicable	.368Kg
"	Chlorine	"	9.0×10^{-1} $\mu g/m^3$	"	"	2.04 Kg
"	Organics:					
	Acetone	"	3.3×10^{-1} $\mu g/m^3$	"	"	.75 Kg
	Dioctylphthalate (DOP)	"	4.9×10^{-1} $\mu g/m^3$	"	"	.95 Kg
"	Petroleum Ether	"	1.4×10^{-1} $\mu g/m^3$	"	"	.31 Kg
"	Total Organics From Above Listing	"	.012 Lb/day	40 Lb/day OEPA*	.03%	4.4 Lb

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Date Prepared March 7, 1974
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SW Building	Nitrogen Dioxide	Airborne	$8.7 \times 10^{-1} \mu g/m^3$	None Available	Not Applicable	0.17 Kg
"	Sulfur Trioxide	"	.0013 ppm	2000 ppm OEPA*	.00007%	.86 Kg
"	Hydrogen Chloride	"	$1.1 \times 10^{0} \mu g/m^3$	None Available	Not Applicable	.21 Kg
"	Hydrogen Fluoride	"	$5.7 \times 10^{-1} \mu g/m^3$	"	"	.11 Kg
"	Organics:					
	Ethanol	"	$1.84 \times 10^{1} \mu g/m^3$	"	"	51.0 Kg
	Methanol	"	$1.7 \times 10^{-1} \mu g/m^3$	"	"	.38 Kg
"	Acetone	"	$4.4 \times 10^{0} \mu g/m^3$	"	"	10.85 Kg
"	Trichloroethylene	"	$2.42 \times 10^{1} \mu g/m^3$	"	"	12.62 Kg
"	Xylene	"	$1.8 \times 10^{-1} \mu g/m^3$	"	"	.41 Kg
"	Toluene	"	$3.21 \times 10^{1} \mu g/m^3$	"	"	6.56 Kg
"	Total Organics From Above Listing	"	.49 Lb/day	40 Lb/day OEPA*	1.23%	180.4 Lb

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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Perio
T Building	Hydrogen Chloride	Airborne	$.89 \times 10^{0}$ μg/m³	None Available	Not Applicable	.12 Kg

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Test Fire Building	Nitric Oxide	Airborne	$7.5 \times 10^{-1} \mu g/m^3$	None Available	Not Applicable	0.45 Kg

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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Peric
WD Building	Hydrogen Chloride	Airborne	$8.76 \times 10^1 \mu g/m^3$	None Available	Not Applicable	.12 Kg

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Reporting Period CY 1973

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Building 1	Graphite	Airborne	1.34×10^1 $\mu g/m^3$	None Available	Not Applicable	0.25 Kg
"	Organics:					
"	Acetone	"	1.34×10^1 $\mu g/m^3$	"	"	37.0 Kg
"	Cyclonite & Cyclotol (oxides of nitrogen)	"	1.34×10^1 $\mu g/m^3$	"	"	.25 Kg
"	Total Organics From Above Listing	"	.22 Lb/day	40 Lb/day OEPA*	.55%	82.1 Lb

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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Perio
Building 28	Asbestos	Airborne	1.0×10^{-1} μg/m³	None Available	Not Applicable	1.0 Kg
"	Organics:					
"	Chloroform	"	2.0×10^{0} μg/m³	"	"	5.0 Kg
"	Acetone	"	1.4×10^{1} μg/m³	"	"	22.0 Kg
"	Trichloro-ethylene	"	2.0×10^{0} μg/m³	"	"	5.0 Kg
"	Diallylph-thalate	"	1.4×10^{-1} μg/m³	"	"	1.0 Kg
"	Total Organics From Above Listing	"	.20 Lb/day	40 Lb/day OEPA*	.5%	72.8 Lb

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Building 29	Boron	Airborne	$6.3 \times 10^3 \mu g/m^3$	None Available	Not Applicable	0.23 Kg
"	Asbestos	"	$3.2 \times 10^0 \mu g/m^3$	"	"	.9 Kg
"	Organics:					
"	Acetone	"	$7.2 \times 10^2 \mu g/m^3$	"	"	210.0 Kg
"	Diallylphthalate	"	$3.2 \times 10^0 \mu g/m^3$	"	"	4.53 Kg
"	Total Organics From Above Listing	"	1.3 Lb/day	40 Lb/day OEPA*	3.2%	473.0 Lbs

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Location Miamisburg, Ohio
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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Period
Building 34 (Fire Training Facility)	Particulates	Airborne	.77 g/hr	Not Applicable**	Not Applicable	1.6 Kg
"	Aldehydes	"	.1 g/hr	"	"	.3 Kg
"	Benzo(a)pyrene	"	.006 g/hr	"	"	.012 g
"	Hydrocarbons	"	.1 g/hr	"	"	.3 Kg
"	Oxides of Nitrogen	"	4.7 g/hr	"	"	9.8 Kg
"	Oxides of Sulfur	"	.1 g/hr	"	"	.2 Kg
"	Carbon Monoxide	"	.1 g/hr	"	"	.3 Kg

Concentrations and quantities from PHS Publication 999-AP-29

** Mound Laboratory has a permit from Montgomery County Combined General Health District for open burning in fire fighting exercises.

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Reporting Period CY 1973

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Perio
Building 42	Organics: Freon TF (fluorinated & chlorinated hydrocarbons)	Airborne	$1.34 \times 10^3 \mu g/m^3$	None Available	Not Applicable	60.0 Kg
"	Total Organics From Above Listing	"	.36 Lb/day	40 Lb/day OEPA*	.9%	132.3 Lb

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Building 46	Organics:					
"	Acetone	Airborne	$3.06 \times 10^3 \mu g/m^3$	None Available	Not Applicable	9.0 Kg
"	Isopropanol	"	$3.03 \times 10^3 \mu g/m^3$	"	"	8.9 Kg
"	Total Organics From Above Listing	"	.11 Lb/day	40 Lb/day OEPA*	.28%	39.5 Lb

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Building 48	Organics:					
"	Sulfurized Mineral Oil & Chlorinated Wax	Airborne	4.94×10^{1} $\mu g/m^3$	None Available	Not Applicable	3.675 Kg
"	Acetone	"	1.51×10^{1} $\mu g/m^3$	"	"	1.125 Kg
"	Alcohol	"	3.02×10^{1} $\mu g/m^3$	"	"	2.250 Kg
"	Stoddard Solvent (51.4% parafin) (39% Naptha) (9% Aromatics)	"	6.85×10^{1} $\mu g/m^3$	"	"	5.1 Kg
"	Total Organics From Above Listing	"	.07 Lb/day	40 Lb/day OEPA*	.18%	26.8 Lb

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Building 49	Organics:					
"	Cobehn (96% $CHCl_3$)	Airborne	1.9×10^3 $\mu g/m^3$	None Available	Not Applicable	120 Kg
"	Ethyl Alcohol	"	7.0×10^3 $\mu g/m^3$	"	"	1048 Kg
"	Acetone	"	2.5×10^2 $\mu g/m^3$	"	"	30 Kg
"	Total Organics From Above Listing	"	7.2 Lb/day	40 Lb/day OEPA*	18%	2641.6 Lb

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Building 51 (Incinerator)	Particulate	Airborne	2.32 lb/100 lb Input	.1 lb/100 lb Input OEPA*	2320.0%	19254.1 Lb

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SD, WD & WDA	Barium	Waterborne	.120 mg/1	None Available	Not Applicable	122.7 Kg
"	Bismuth	"	.031 mg/1	"	"	32.9 Kg
"	Boron	"	.146 mg/1	"	"	155.6 Kg
"	Cadmium	"	.005 mg/1	"	"	5.5 Kg
"	Chromium	"	.014 mg/1	"	"	14.8 Kg
"	Cobalt	"	.028 mg/1	"	"	29.7 Kg
"	Copper	"	.103 mg/1	"	"	109.8 Kg
"	Iron	"	.430 mg/1	"	"	459.9 Kg
"	Lead	"	.021 mg/1	"	"	22.6 Kg
"	Manganese	"	.034 mg/1	"	"	36.0 Kg
"	Mercury	"	< .00075 mg/1	"	"	< .8 Kg
"	Nickel	"	.023 mg/1	"	"	24.2 Kg
"	Selenium	"	.0017 mg/1	"	"	1.8 Kg
"	Silver	"	.006 mg/1	"	"	6.4 Kg
"	Zinc	"	.101 mg/1	"	"	107.7 Kg

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SD, WD & WDA	Dissolved Oxygen	Waterborne	8.2 mg/1	None Available	Not Applicable	Not Applicable
"	pH	"	7.6	"	"	"
"	Suspended Solids	"	15.7 mg/1	"	"	1.68×10^4 Kg
"	Biological Oxygen Demand	"	7.5 mg/1	"	"	7.99×10^3 Kg
"	NH_3	"	.3 mg/1	"	"	3.19×10^2 Kg
"	Oil & Grease*	"	2.8 mg/1	"	"	2.96×10^3 Kg
"	Chlorides	"	925.3 mg/1	"	"	9.87×10^5 Kg
"	Fluorides	"	.14 mg/1	"	"	1.48×10^2 Kg
"	Nitrates	"	1.7 mg/1	"	"	1.82×10^3 Kg
"	Phosphates	"	1.7 mg/1	"	"	1.86×10^3 Kg
"	Sulfates	"	103.0 mg/1	"	"	1.10×10^5 Kg
"	Dissolved Solids	"	1683.0 mg/1	"	"	1.79×10^6 Kg

* Emulsifiable Oil and Grease

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SD, WD & WDA	Conductivity	Waterborne	1801 Mho	None Available	Not Applicable	Not Applicable
"	Turbidity	"	<25 JTU	"	"	"
"	Total Hardness	"	620.0 mg/1	"	"	6.61×10^6 Kg
"	Calcium	"	155.0 mg/1	"	"	1.66×10^6 Kg
"	Magnesium	"	50.6 mg/1	"	"	5.39×10^4 Kg
"	Total Coliform	"	503/100 cc	"	"	Not applicable
"	Fecal Coliform	"	25/100 cc	"	"	"

bc: P. C. Adams
J. E. Bradley
W. T. Cave
C. H. Davenport
R. K. Flitcraft
L. V. Jones
F. D. Lonadier
J. R. McClain
H. J. Monnin
~~E. A. Rembold~~
W. H. Westendorf
E. Wheeler - St. Louis
R. A. Wolfe

March 19, 1974

Mr. R. L. Wainwright, Area Manager
U. S. Atomic Energy Commission
P. O. Box 66
Miamisburg, Ohio 45342

Dear Mr. Wainwright:

1973 Pollutant Inventory Report

We are submitting the Pollutant Inventory Report for CY-1973 as required by ALO. The inventory indicates that all emission sources were within applicable emission standards, with the exception of the General Waste Incinerator. The Laboratory has undertaken a Reclamation and Recycling Program to dispose of wastes generated on-site. As a result, operation of the General Waste Incinerator has ceased as of February 15, 1974.

If you have any questions, please advise.

Very truly yours,

DRS DEK

Donald R. Storey
Director, Administration

Hebb:lr
Enclosure

cc: R. L. Wainwright (2)

U. S. Energy Research and Development Administration
Albuquerque Operations Office
Area Office Dayton Area Office
ERDA Contractor MRC

Inventory of Pollutants
Released to the Environment

Facility Mound Laborato:
Location Miamisburg, Oh:
Date Prepared March 19, 1975
Reporting Period CY 1974

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released Durin; Reporting Peri
Building 34 (Fire Training Facility)	Particulates	Airborne	0.3 g/hr	Not Applicable**	Not Applicable	0.7 Kg
	Aldehydes	"	0.01 g/hr	"	"	0.02 Kg
	Benzo (a) Pyrene	"	0.001 mg/hr	"	"	0.003 g
	Hydrocarbons	"	0.1 g/hr	"	"	0.2 Kg
	Oxides of Nitrogen	"	0.001 g/hr	"	"	0.002 Kg
	Oxides of Sulfur	"	0.002 g/hr	"	"	0.004 Kg

** Mound Laboratory has a permit from Montgomery County Combined General Health District for open burning in fire fighting exercises.

3.500 mg

3.52 lb	1.5 lb	.7 kg	795/lb
.66	.036	.02	.8g/lb
.012g	3.500 mg	.003g	.0001
.66	~~28~~ .4	~~.2~~ .2	8
21.56	0.005	.002	.08
.44	.008	.004	.2g/lb
.66			

2 lb / month

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B Building	Hydrogen Chloride	Airborne	$1.0 \times 10^2 \mu g/m^3$	None Available	Not Applicable	5.0 Kg
"	Oxides of Nitrogen	"	$1.2 \times 10^2 \mu g/m^3$	"	"	5.0 Kg
	ORGANICS					
"	Ether (diethyl)	"	$1.6 \times 10^2 \mu g/m^3$	"	"	4.0 Kg
"	Cobehn (96% $CHCl_3$)	"	$1.6 \times 10^2 \mu g/m^3$	"	"	42.0 Kg
"	Chloroform	"	$1.0 \times 10^2 \mu g/m^3$	"	"	25.0 Kg
"	Acetone	"	$4.3 \times 10^2 \mu g/m^3$	"	"	22.0 Kg
"	Isopropyl Alcohol	"	$1.8 \times 10^1 \mu g/m^3$	"	"	5.0 Kg
"	Ethyl Alcohol	"	$1.6 \times 10^2 \mu g/m^3$	"	"	100.0 Kg
"	Trichloroethylene	"	$1.6 \times 10^2 \mu g/m^3$	"	"	110.0 Kg
"	Freon TE	"	$6.0 \times 10^2 \mu g/m^3$	"	"	15.0 Kg
"	Freon TF	"	$1.7 \times 10^2 \mu g/m^3$	"	"	16.0 Kg
"	Toluene	"	$1.4 \times 10^1 \mu g/m^3$	"	"	1.1 Kg
"	Total organics	"	7.5 lb/day	40 lb/day OEPA*	18.8%	2728.2 Lb

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Date Prepared March 19, 197
Reporting Period CY 1974

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Burning Area *	Particulates	Airborne	0.3 lb/hr (136 g/hr)	Not Applicable	Not Applicable	1.36 Kg
"	Carbon Monoxide	"	$3.0 \times 10^{-1} \mu g/m^3$	"	"	8.0 Kg
"	Nitric Oxide	"	$7.5 \times 10^{-1} \mu g/m^3$	"	"	20.0 Kg
"	Nitrous Oxide	"	$1.5 \times 10^{-1} \mu g/m^3$	"	"	4.0 Kg
"	Nitrogen dioxide	"	$2.0 \times 10^{-1} \mu g/m^3$	"	"	5.5 Kg

* Mound Laboratory has a permit from the Montgomery County Combined General Health District for the disposal of explosive wastes by open burning.

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Facility Mound Laborato
Location Miamisburg, Oh
Date Prepared March 19, 1975
Reporting Period CY - 1974

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Air-borne or Water-borne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released Durin Reporting Peri
DS Building	Hydrogen Chloride	Airborne	2.0×10^{-2} µg/m^3	None Available	Not Applicable	0.5 Kg
"	Oxides of Nitrogen	"	3.0×10^{-2} µg/m^3	"	"	1.1 Kg
	ORGANICS:					
"	Ethyl Alcohol	"	6.2×10^{-1} µg/m^3	"	"	15.0 Kg
"	Acetone	"	2.6×10^{1} µg/m^3	"	"	400.0 Kg
"	Stoddard Solvent (51% parafin) (39% naptha) (9% promatics)	"	1.5×10^{0} µg/m^3	"	"	4.0 Kg
"	Trichloroethylene	"	3.25×10^{0} µg/m^3	"	"	50.0 Kg
"	Chloroform	"	1.30×10^{0} µg/m^3	"	"	30.0 Kg
"	Methyl Alcohol	"	1.70×10^{-1} µg/m^3	"	"	705.0 Kg
"	Cobehn (96% $ChCl_3$)	"	6.5×10^{0} µg/m^3	"	"	125.0 Kg
"	Isopropyl Alcohol	"	2.2×10^{-1} µg/m^3	"	"	3.5 Kg
"	Toluene	"	4.0×10^{-2} µg/m^3	"	"	2.2 Kg
"	Total Organics from above listing	"	8.04 lb/day	40 lb/day OEPA*	20.1%	2936.3 lb

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E Building	Hydrogen Fluoride	Airborne	$3.4 \times 10^1 \mu g/m^3$	None Available	Not Applicable	0.6 Kg
"	Oxides of Nitrogen	"	$5.0 \times 10^3 \mu g/m^3$	"	"	348.0 Kg
"	Hydrogen Chloride	"	$5.6 \times 10^1 \mu g/m^3$	"	"	0.9 Kg
"	Ammonia	"	$1.3 \times 10^4 \mu g/m^3$	"	"	2.0 Kg
"	Oxides of Sulfur	"	0.0012 ppm	2000 ppm OEPA*	.0001%	0.05 Kg
"	Phosphates	"	$1.6 \times 10^1 \mu g/m^3$	None Avaliable	Not Applicable	0.05 Kg
"	Cyanides	"	$7.8 \times 10^1 \mu g/m^3$	"	"	0.05 Kg
	ORGANICS:					
"	Hydrocarbon Smoke	"	$1.9 \times 10^1 \mu g/m^3$	"	"	0.25 Kg
"	Hydrocarbon Fumes	"	$3.5 \times 10^2 \mu g/m^3$	"	"	2.0 Kg
"	Toluene	"	$7.5 \times 10^0 \mu g/m^3$	"	"	1.1 Kg
"	Trichloroethylene	"	$9.3 \times 10^2 \mu g/m^3$	"	"	1.0 Kg
"	Treon TF	"	$1.7 \times 10^2 \mu g/m^3$	"	"	17.0 Kg
"	Ethyl Alcohol	"	$8.1 \times 10^0 \mu g/m^3$	"	"	8.0 Kg
"	Acetone	"	$2.7 \times 10^2 \mu g/m^3$	"	"	1.0 Kg
"	Total organics from above listing	"	.18 lb/day	40 lb/day OEPA*	.45%	66.9 lb

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HH Building	Carbon Disulfide	Airborne	45.5 $\mu g/m^3$	None Available	Not Applicable	7.97 Kg
	ORGANICS:					
"	Acetone	"	$2.8 \times 10^1 \mu g/m^3$	"	"	4.98 Kg
"	Methanol	"	$2.9 \times 10^1 \mu g/m^3$	"	"	5.10 Kg
"	Trichloroethylene	"	$5.3 \times 10^1 \mu g/m^3$	"	"	9.30 Kg
"	Chloroform	"	$3.99 \times 10^1 \mu g/m^3$	"	"	6.99 Kg
"	Benzene	"	$3.16 \times 10^1 \mu g/m^3$	"	"	5.55 Kg
	Total organics from above listing	"	.19 lb/day	40 lb/day OEPA*	.48%	70.22 lb

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I Building	ORGANICS:					
"	Ethyl Alcohol	Airborne	$5.3 \times 10^1 \mu g/m^3$	None Available	Not Applicable	5.4 Kg
	Total organics from above listing	"	.03 lb/day	40 lb/day OEPA*	.08%	11.9 lb

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M Building	Chromates	Airborne	$6.43 \times 10^2 \mu g/m^3$	None Available	Not Applicable	0.454 Kg
"	Oxides of Sulfur	"	.028 ppm	2000 ppm OEPA*	.0014%	8.4 Kg
	ORGANICS:					
"	Acetone	"	$2.08 \times 10^4 \mu g/m^3$	None Available	Not Applicable	179.2Kg
"	Trichloroethylene	"	$1.55 \times 10^4 \mu g/m^3$	"	"	1329.0 Kg
	Total organics from above listing	"	9.1 lb/day	40 lb/day OEPA*	22.8%	3325.6 lb

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	ORGANICS:					
Paint Shop	Lacquer (Alcohol)	Airborne	$1.0 \times 10^3 \mu g/m^3$	Non Available	Not Applicable	8.7 Kg
"	Thinner (Kerosene)	"	$1.0 \times 10^3 \mu g/m^3$	"	'	8.7 Kg
	Total Organics from above listing	"	.11 lb/day	40 lb/day OEPA*	.28%	38.4 lb

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Powerhouse	Aldehydes	Airborne	2.19 mg/m³	None Available	Not Applicable	238.4 Kg
"	Benzo (a) Pyrene	"	.35 mg/m³	"	"	2.3 Kg
"	Carbon Monoxide	"	1.31 mg/m³	"	"	8.5 Kg
"	Hydrocarbons	"	102.96 mg/m³	"	"	670.2 Kg
"	Oxides of sulfur	"	.002 lbs/ million BTU input	1.6 lbs/million BTU input OEPA*	.13%	295.5 Kg
"	Oxides of Nitrogen	"	.44 g/m³	"	"	43963.1 Kg
"	Particulates	"	.023 lbs/ million BTU input	.25 lbs/million BTU input OEPA*	9.2%	3366.5 Kg

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R Building	Nitrogen Dioxide	Airborne	$4.67 \times 10^1 \mu g/m^3$	None Available	Not Applicable	72.77 Kg
"	Sulfur Trioxid	"	.0014 ppm	2000 ppm OEPA*	.00007%	7.90 Kg
"	Chlorine	"	$2.14 \times 10^1 \mu g/m^3$	None Available	Not Applicable	36.08 Kg
"	Hydrogen Chloride	"	$0.30 \times 10^1 \mu g/m^3$	"	"	0.50 Kg
	ORGANICS					
"	Acetone	"	$.47 \times 10^0 \mu g/m^3$			0.79 Kg
"	Diocylphthalate (DOP)	"	$5.02 \times 10^{-5} \mu g/m^3$	"	"	0.075 Grams
"	Petroleum Ether	"	$.20 \times 10^0 \mu g/m^3$	"	"	0.33 Kg
"	Total Organics From Above Listing	"	.007 lb/day	40 lb/day OEPA*	.02%	2.6 lb

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SW Building	Nitrogen Dioxide	Airborne	$9.1 \times 10^{-1} \mu g/m^3$	None Available	Not Applicable	0.17 Kg
"	Sulfur Trioxide	"	.0013 ppm	2000 ppm OEPA*	.00007%	.86 Kg
"	Hydrogen Chloride	"	$5.5 \times 10^{-1} \mu g/m^3$	None Available	Not Applicable	0.11 Kg
"	Hydrogen Fluoride	"	$3.0 \times 10^{-1} \mu g/m^3$	"	"	0.06 Kg
	ORGANICS:					
"	Ethanol	"	$4.53 \times 10^{1} \mu g/m^3$	"	"	99.00 Kg
"	Methanol	"	$2.4 \times 10^{-1} \mu g/m^3$	"	"	0.40 Kg
"	Acetone	"	$8.0 \times 10^{0} \mu g/m^3$	"	"	15.05 Kg
"	Trichloroethylene	"	$1.86 \times 10^{1} \mu g/m^3$	"	"	40.73 Kg
"	Carbon Tetrachloride	"	$7.88 \times 10^{2} \mu g/m^3$	"	"	151.20 Kg
"	Benzene	"	$5.92 \times 10^{0} \mu g/m^3$	"	"	9.96 Kg
"	Toluene	"	$5.00 \times 10^{1} \mu g/m^3$	"	"	9.84 Kg
"	Xylene	"	$2.60 \times 10^{-1} \mu g/m^3$	"	"	4.40 Kg
"	Cyclolexane	"	$2.4 \times 10^{0} \mu g/m^3$	"	"	0.74 Kg
"	Freon 12 (CCL_2F_2)	"	$4.35 \times 10^{0} \mu g/m^3$	"	"	0.86 Kg
"	Touluene Diisocyanates	"	$5.0 \times 10^{-1} \mu g/m^3$	"	"	0.09 Kg
"	Total Organics from above Listing	"	2.0 lb/day	40 lb/day OEPA*	50%	730.99 Lb

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Test Fire Building	Nitric Oxide	Airborne	$7.5 \times 10^{-1} \mu g/m^3$	None Available	Not Applicable	0.45 Kg

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Building 1	Graphite	Airborne	$1.34 \times 10^1 \mu g/m^3$	None Available	Not Applicable	0.25 Kg
	ORGANICS:					
"	Acetone	"	$1.34 \times 10^1 \mu g/m^3$	"	"	37.0 Kg
"	Cyclonite & Cyclotol (oxides of nitrogen)	"	$1.34 \times 10^1 \mu g/m^3$	"	"	.25 Kg
	Total Organics From Above Listing	"	.22 lb/day	40 lb/day OEPA*	.55%	82.1 Lb.

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Building 28	Asbestos	Airborne	$1.0 \times 10^{-1} \mu g/m^3$	None Available	Not Applicable	1.0 Kg
	ORGANICS					
"	Chloroform	"	$2.0 \times 10^{0} \mu g/m^3$	"	"	5.0 Kg
"	Acetone	"	$1.4 \times 10^{1} \mu g/m^3$	"	"	22.0 Kg
"	Trichloroethylene	"	$2.0 \times 10^{0} \mu g/m^3$	"	"	5.0 Kg
"	Diallylphthalate	"	$1.4 \times 10^{-1} \mu g/m^3$	"	"	1.0 Kg
	Total Organics From Above Listing	"	.20 lb/day	40 lb/day OEPA *	.5%	72.8 Kg

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Building 29	Boron	Airborne	$6.3 \times 10^3 \mu g/m^3$	None Availalbe	Not Applicable	0.23 Kg
"	Asbestos	"	$3.2 \times 10^0 \mu g/m^3$	"	"	0.90 Kg
	ORGANICS:					
"	Acetone	"	$7.2 \times 10^2 \mu g/m^3$	"	"	210.0 Kg
"	Diallylphthalate	"	$3.2 \times 10^0 \mu g/m^3$	"	"	4.53 Kg
"	Total organics from above listing	"	1.3 lb/day	40 lb/day OEPA*	3.2%	473.0 Lb.

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Building 34 (Fire Training Facility)	Particulates	Airborne	0.3 g/hr	Not Applicable**	Not Applicable	0.7 Kg
	Aldehydes	"	0.01 g/hr	"	"	0.02 Kg
	Benzo (a) Pyrene	"	0.001 mg/hr	"	"	0.003 g
	Hydrocarbons	"	0.1 g/hr	"	"	0.2 Kg
	Oxides of Nitrogen	"	0.001 g/hr	"	"	0.002 Kg
	Oxides of Sulfur	"	0.002 g/hr	"	"	0.004 Kg

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Building 46	ORGANICS:					
"	Acetone	Airborne	$3.06 \times 10^2 \mu g/m^3$	None Available	Not Applicable	9.00Kg
"	Isopropanol	"	$3.03 \times 10^2 \mu g/m^3$	"	"	8.90 Kg
"	Trichloroethylene	"	$3.80 \times 10^1 \mu g/m^3$	"	"	1.12 Kg
"	Total Organics From Above Listing	"	.11 lb/day	40 lb/day OEPA*	.28%	41.8 Lb.

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Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Airborne or Waterborne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Period
Building 48	ORGANICS:					
"	Sulfurized Mineral Oil and Chlorinated Wax	Airborne	$4.94 \times 10^1 \mu g/m^3$	None Available	Not Applicable	3.675 Kg
"	Acetone	"	$1.51 \times 10^1 \mu g/m^3$	"	"	1.125 Kg
"	Alcohol	"	$3.02 \times 10^1 \mu g/m^3$	"	"	2.250 Kg
"	Stoddard Solvent (51.4% paraffin) (39% Naptha) (9% Aromatics)	"	$6.85 \times 10^1 \mu g/m^3$	"	"	5.100 Kg
	Total Organics From Above Listing	"	.07 lb/day	40 lb/day OEPA*	.18%	26.8 Lb.

* Ohio Environmental Protection Agency

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Building 49	ORGANICS:					
"	Cobehn (96% CHCl)	Airborne	$1.9 \times 10^3 \mu g/m^3$	None Available	Not Applicable	120.0 Kg
"	Ethyl Alcohol	"	$7.0 \times 10^2 \mu g/m^3$	"	"	100.0 Kg
"	Acetone	"	$2.5 \times 10^2 \mu g/m^3$	"	'	30.0 Kg
"	Total Organics From Above Listing	"	1.5 Lb/day	40 Lb/day OEPA*	3.75%	550.0 Lb

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SD, WD, & WDA	Barium	Waterborne	.007 mg/l	None Available	Not Applicable	8.9 Kg
"	Bismuth	"	.024 mg/l	"	"	29.8 Kg
"	Boron	"	.091 mg/l	"	"	112.0 Kg
"	Cadmium	"	.002 mg/l	"	"	2.7 Kg
"	Chromium	"	.007 mg/l	"	"	9.1 Kg
"	Cobalt	"	.022 mg/l	"	"	26.6 Kg
"	Copper	"	.085 mg/l	"	"	105.4 Kg
"	Iron	"	.395 mg/l	"	"	487.2 Kg
"	Lead	"	.006 mg/l	"	"	7.4 Kg
"	Manganese	"	.022 mg/l	"	"	27.3 Kg
"	Mercury	"	.0008 mg/l	"	"	1.0 Kg
"	Molydenum	"	.012 mg/l	"	"	14.6 Kg
"	Nickel	"	.012 mg/l	"	"	14.4 Kg
"	Silver	"	.002 mg/l	"	"	2.2 Kg
"	Zinc	"	.112 mg/l	"	"	138.8 Kg
"	Dissolved Oxygen	"	7.2 mg/l	"	"	Not Applicable
"	pH	"	8.0	"	"	"
"	Suspended Solids	"	20.3 mg/l	"	"	2.51×10^4 Kg
"	NH_3	"	1.1 mg/l	"	"	1.25×10^3 Kg
"	Oil & Grease	"	1.5 mg/l	"	"	1.88×10^3 Kg
"	Chlorides	"	826.0 mg/l	"	"	1.02×10^6 Kg
"	Nitrates	"	4.2 mg/l	"	"	5.22×10^3 Kg
"	Phosphates	"	4.9 mg/l	"	"	6.10×10^3 Kg

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SD, WD, & WDA	Sulfates	Waterborne	102.0 mg/l	None Applicable	Not Applicable	1.26×10^5 Kg
"	Dissolved Solids	"	1090.0 mg/l	"	"	1.34×10^6 Kg
"	Fluorides	"	.2 mg/l	"	"	2.47×10^2 Kg
"	Conductivity	"	1169 Mho	"	"	Not Applicable
"	Total Hardness	"	442.0 mg/l	"	"	5.46×10^5 Kg

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B Building	Hydrogen Chloride	Airborne	1.0×10^2 μg/m³	None Available	Not Applicable	5.0 Kg
"	Oxides of Nitrogen	"	1.2×10^8 μg/m³	"	"	5.0 Kg
"	Organics:					
"	Ether (Diethyl)	"	1.6×10^2 μg/m³	"	"	4.0 Kg
"	Cobehn (96% $CHCl_3$)	"	1.6×10^2 μg/m³	"	"	42.0 Kg
"	Chloroform	"	1.0×10^3 μg/m³	"	"	25.0 Kg
"	Acetone	"	4.3×10^2 μg/m³	"	"	22.0 Kg
"	Isopropyl Alcohol	"	1.8×10^1 μg/m³	"	"	5.0 Kg
"	Ethyl Alcohol	"	1.6×10^3 μg/m³	"	"	1000.0 Kg
"	Trichloroethylene	"	1.6×10^2 μg/m³	"	"	110.0 Kg
"	Freon TE	"	6.0×10^2 μg/m³	"	"	15.0 Kg
"	Freon TF	"	1.7×10^2 μg/m³	"	"	16.0 Kg
"	Toluene	"	1.4×10^1 μg/m³	"	"	1.1 Kg
	Total Organics From Above Listing		13.4 Lb/day	40 Lb/day OEPA*	33.5%	4917.4 Lb

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Burning Area*	Particulates	Airborne	0.3 lbs/hr (136 g/hr)	Not Applicable	Not Applicable	1.360 Kg
"	Carbon Monoxide	"	3.0×10^{-1} μg/m³	"	"	8.0 Kg
"	Nitric Oxide	"	7.5×10^{-1} μg/m³	"	"	20.0 Kg
"	Nitrous Oxide	"	1.5×10^{-1} μg/m³	"	"	4.0 Kg
"	Nitrogen Dioxide	"	2.0×10^{-1} μg/m³	"	"	5.5 Kg

* Mound Laboratory has a permit from the Montgomery County Combined Health District for the disposal of explosive wastes by open burning.

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DS Building	Hydrogen Chloride	Airborne	2.0×10^{-2} µg/m³	None Available	Not Applicable	0.5 Kg
"	Oxides of Nitrogen	"	3.0×10^{-2} µg/m³	"	"	1.1 Kg
	Organics:					
"	Ethyl Alcohol	"	6.2×10^{1} µg/m³	"	"	1510.0 Kg
"	Acetone	"	2.6×10^{1} µg/m³	"	"	400.0 Kg
"	Stoddard Solvent (51% parafin) (39% naptha) (9% aromatics)	"	1.5×10^{0} µg/m³	"	"	4.0 Kg
"	Trichloro-ethylene	"	1.3×10^{1} µg/m³	"	"	225.0 Kg
"	Chloroform	"	1.3×10^{0} µg/m³	"	"	30.0 Kg
"	Methyl Alcohol	"	1.7×10^{-1} µg/m³	"	"	705.0 Kg
"	Cobehn (96% $CHCl_3$)	"	6.5×10^{0} µg/m³	"	"	125.0 Kg
"	Isopropyl Alcohol	"	2.2×10^{1} µg/m³	"	"	3.5 Kg
"	Toluene	"	4.0×10^{-2} µg/m³	"	"	2.2 Kg
	Total Organics From Above Listing	"	18.1 lb/day	40 lb/day OEPA*	45.3%	6625.4 lb.

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E Building	Hydrogen Fluoride	Airborne	3.4×10^1 μg/m³	None Available	Not Applicable	.6 Kg
"	Oxides of Nitrogen	"	3.0×10^4 μg/m³	"	"	527.0 Kg
"	Hydrogen Chloride	"	5.4×10^3 μg/m³	"	"	95.0 Kg
"	Ammonia	"	8.6×10^2 μg/m³	"	"	15.1 Kg
"	Hydrogen Iodide	"	1.2×10^1 μg/m³	"	"	.5 Kg
"	Oxides of Sulfur	"	.0012 ppm	2000 ppm OEPA*	.0001%	.05Kg
"	Phosphates	"	1.6×10^1 μg/m³	None Available	Not Applicable	.05Kg
"	Cyanides	"	7.8×10^1 μg/m³	"	"	.05Kg
"	Organics: Hydrocarbon smoke	"	1.9×10^1 μg/m³	"	"	.25Kg
"	Hydrocarbon fumes	"	3.5×10^2 μg/m³	"	"	2.0 Kg
"	Toluene	"	7.5×10^0 μg/m³	"	"	1.1 Kg
"	Trichloro-ethylene	"	9.3×10^2 μg/m³	"	"	1.0 Kg
"	Freon TF	"	1.7×10^2 μg/m³	"	"	17.0 Kg
"	Ethyl Alcohol	"	8.1×10^0 μg/m³	"	"	8.0 Kg
"	Acetone	"	2.7×10^2 μg/m³	"	"	1.0 Kg
"	Total Organic From Above listing	"	.17 lb/day	40 lb/day OEPA*	.43%	62.6 lb

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HH Building	Carbon Monoxide	Airborne	1.25×10^3 g/m^3 *	None Available	Not Applicable	909.0 Kg
	Organics:					
"	Acetone	"	10.6 μg/m^3	"	"	1.0 Kg
"	Methanol	"	10.6 μg/m^3	"	"	1.0 Kg
"	Trichloro-ethylene	"	19.6 μg/m^3	"	"	1.85 Kg
"	Chloroform	"	14.8 μg/m^3	"	"	1.40 Kg
"	Total Organics From Above Listing	"	.03 lb/day	40 lb/day OEPA**	.08%	11.58 lb

* Released continuously at a very low flow from building through small vent pipe.

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I Building	Organics: Ethyl Alcohol	Airborne	$5.3 \times 10^1 \mu g/m^3$	None Available	Not Applicable	5.4 Kg
	Total Organics From Above Listing	"	.03 lb/day	40 lb/day OEPA*	.08%	11.9 lb

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Test Fire Building	Nitric Oxide	Airborne	7.5×10^{-1} μg/m³	None Available	Not Applicable	0.450 Kg

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M Building	Chromates	Airborne	643 $\mu g/m^3$	None Available	Not Applicable	454 g
"	Oxides of Sulfur	"	92 $\mu g/m^3$	"	"	8.4 Kg
"	Organics:					
"	Trichlorethylene	"	15.5 mg/m^3	"	"	1,329.0 Kg
"	Acetone	"	20.8 mg/m^3	"	"	179.2 Kg
"	Total Organics From Above Listing	"	9.1 lbs/day	40 lbs/day OEPA*	22.8%	3,345.1 lb

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Paint Shop	Organics: Lacquer (Alcohol)	Airborne	1,000μg/m³	None Available	Not Applicable	8.7 Kg
"	Thinner (Kerosene)	"	1,000μg/m³	"	"	8.7 Kg
"	Enamel (Kerosene)	"	1,000μg/m³	"	"	8.7 Kg
"	Total Organics From Above Listing	"	.16 lbs/day	40 lbs/day OEPA*	.4%	57.6 lbs

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Powerhouse	Aldehydes	Airborne	1.47 mg/m^3	None Available	Not Applicable	262.7 Kg
"	Benzo(a) pyrene	"	.01μg/m^3	"	"	2.4 g
"	Carbon Monoxide	"	.05mg/m^3	"	"	8.6 Kg
"	Hydrocarbons	"	3.85 mg/m^3	"	"	689.9 Kg
"	Oxides of Sulfur	"	.002 lbs/ Million BTU Input	1.6 lbs/Million BTU Input OEPA*	.13%	687.0 lbs
"	Oxides of Nitrogen	"	.29 g/m^3	None Available	Not Applicable	52,080.5 Kg
"	Particulates	"	.01 lbs/Million BTU Input	.25 lbs/Million BTU Input OEPA*	4.0%	3,806.4 lbs

Quantities obtained from P.H.S. Publication # 999-AP-29

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R Building	Nitrogen Dioxide	Airborne	11.9 $\mu g/m^3$	None Available	Not Applicable	27.64 Kg
"	Sulfur Trioxide	"	.00011 ppm	2000 ppm OEPA*	.00001%	.85 Kg
"	Hydrogen Chloride	"	40.3 $\mu g/m^3$	None Available	Not Applicable	93.61 Kg
"	Chlorine	"	8.7 $\mu g/m^3$	"	"	20.40 Kg
	Organics:					
"	Acetone	"	.3 $\mu g/m^3$	"	"	.75 Kg
"	Petroleum ether	"	.1 $\mu g/m^3$	"	"	.31 Kg
"	Total Organics From Above Listing	"	.006 lb/day	40 lb/day OEPA*	.02%	2.3 lb

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Security Incinerator *	Particulates	Airborne	1.1 lb/100 lbs Input	.2 lbs/100 lbs Input OEPA**	550%	1125 lb.
"	Aldehydes	"	.83 lb/hr	None Available	Not Applicable	1725 lb.
"	Benzo (a) Pyrene	"	2.4 mg/hr	"	"	5 g
"	Carbon Monoxide	"	2.6 lb/hr	"	"	5500 lb.
"	Hydrocarbons	"	.84 lb/hr	"	"	1750 lb.
"	Oxides of Nitrogen	"	.04 lb/hr	"	"	80 lb.

Concentrations and Quantities were estimated by emission factors from PHS Publication 999-AP-29.

*Replaced with disintegrater (Hammermill) beginning CY 73.

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SW Building	Nitrogen Dioxide	Airborne	14.8 $\mu g/m^3$	None Available	Not Applicable	3.18 Kg
"	Sulfur Trioxide	"	.0024 ppm	2000 ppm OEPA*	.0001%	1.73 Kg
"	Hydrogen Chloride	"	9.4 $\mu g/m^3$	None Available	Not Applicable	2.02 Kg
"	Hydrogen Fluoride	"	2.68 $\mu g/m^3$	"	"	.58 Kg
"	Organics: Ethanol	"	34.0 $\mu g/m^3$	"	"	96.37 Kg
"	Methanol	"	.17 $\mu g/m^3$	"	"	.38 Kg
"	Acetone	"	4.3 $\mu g/m^3$	"	"	11.60 Kg
"	Trichloroethylene	"	46.0 $\mu g/m^3$	"	"	22.40 Kg
"	Xylene	"	.18 $\mu g/m^3$	"	"	.41 Kg
"	Toluene	"	36.0 $\mu g/m^3$	"	"	6.56 Kg
	Total Organics From Above Listing	"	.83 lb/day	40 lb/day OEPA*	2.08%	303.7 lb.

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T Building	Nitrogen Dioxide	Airborne	20 $\mu g/m^3$*	None Available	Not Applicable	2.70 Kg

*These releases occurred from January through June, 1972

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Building 1	Graphite	Airborne	$1.34 \times 10^1 \mu g/m^3$	None Available	Not Applicable	37.0 Kg
	Organics:					
	Acetone	"	$1.34 \times 10^1 \mu g/m^3$	"	"	.25 Kg
	Cyclonite & Cyclotol (Oxides of Nitrogen)	"	$1.34 \times 10^1 \mu g/m^3$	"	"	.25 Kg
	Total Organics From Above Listing	"	.22 lb/day	40 lb/day OEPA*	.55%	82.1 lb.

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Building 28	Asbestos	Airborne	$1.0 \times 10^{-1} \mu g/m^3$	None Available	Not Applicable	1.0 Kg
	Organics:					
"	Chloroform	"	$2.0 \times 10^{0} \mu g/m^3$	"	"	5.0 Kg
"	Acetone	"	$1.4 \times 10^{1} \mu g/m^3$	"	"	22.0 Kg
"	Trichloro-ehtylene	"	$2.0 \times 10^{0} \mu g/m^3$	"	"	5.0 Kg
"	Diallylphthalate	"	$1.4 \times 10^{-1} \mu g/m^3$	"	"	1.0 Kg
"	Total Organics From Above Listing	"	.20 lb/day	40 lb/day OEPA*	.5%	72.8 lb.

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Building 29	Boron	Airborne	$6.3 \times 10^3 \mu g/m^3$	None Available	Not Applicable	.23 Kg
"	Asbestos	"	$3.2 \times 10^0 \mu g/m^3$	"	"	.9 Kg
	Organics:					
"	Acetone	"	$7.2 \times 10^2 \mu g/m^3$	"	"	210.0 Kg
	Diallylphthalate	"	$3.2 \times 10^0 \mu g/m^3$	"	"	4.53 Kg
	Total Organics From Above Listing	"	1.3 lb/day	40 lb/day OEPA*	3.2%	473.0 lb.

*Ohio Environmental Protection Agency

U. S. Atomic Energy Commission
Albuquerque Operations Office
Area Office DAO
AEC Contractor MRC

Inventory of Pollutants
Released to the Environment

Facility Mound Laboratory
Location Miamisburg, Ohio
Date Prepared
Reporting Period CY 1972

Source of Pollutant - Building Name or Number	Nature of Pollutant	Method of Release (Airborne or Waterborne	Concentration of Pollutant in Air or Liquid Stream - Average	Most Restrictive Quality Standard and Authority Setting Standard	Percentage of Standard	Total Quantity of Pollutant Released During Reporting Period
Building 34* (Fire Training Facility)	Particulates	Airborne	20.7 g/hr	Not Applicable**	Not Applicable	43.1 Kg
"	Aldehydes	"	1.8 g/hr	"	"	3.7 Kg
"	Benzo(a)pyrene	"	.2 mg/hr	"	"	.5 g
"	Hydrocarbons	"	123.5 g/hr	"	"	257.0 Kg
"	Oxides of Nitrogen	"	.2 mg/hr	"	"	.5 Kg
"	Oxides of Sulfur	"	.5 g/hr	"	"	1.1 Kg
"	Ammonia	"	2.2 g/hr	"	"	4.5 Kg
"	Organic Acids	"	.7 g/hr	"	"	1.4 Kg

Concentrations and quantities from PHS Publication 999-AP-29

* In operation approximately two hours per month

** Mound Laboratory has a permit from Montgomery County Combined Health District for open burning in fire fighting exercises.

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Building 40	Ammonia	Airborne	Trace	None Available	Not Applicable	Trace

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Building 42	Organics: Freon TF (Fluorinated and Chlorinated Hydrocarbons	Airborne	$1.34 \times 10^3 \mu g/m^3$	None Available	Not Applicable	60.0 Kg
	Total Organics From Above Listing	"	.36 lb/day	40 lb/day OEPA*	.9%	132.3 lb.

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Building 46	Organics:					
	Acetone	Airborne	610μg/m³	None Available	Not Applicable	9.0 Kg
"	Isopropanol	"	605μg/m³	"	"	8.9 Kg
	Total Organics From Above Listing	"	.11 lb/day	40 lb/day OEPA*	.28%	39.5 lb.

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Building 48	Organics:					
	Sulfurized Mineral Oil and Chlorinated wax	Airborne	$4.94 \times 10^1 \mu g/m^3$	None Available	Not Applicable	3.675 Kg
"	Acetone	"	$1.51 \times 10^1 \mu g/m^3$	"	"	1.125 Kg
"	Alcohol	"	$3.02 \times 10^1 \mu g/m^3$	"	"	2.250 Kg
"	Stoddards Solvent: (51.4% Paraffin) (39% Naptha) (9% Aromatics)	"	$6.85 \times 10^1 \mu g/m^3$	"	"	5.1 Kg
	Total Organics From Above Listing	"	.07 lb/day	40 lb/day OEPA*	.18%	26.8 lb.

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Building 49	Organics:					
"	Cobehn (96% $CHCl_3$)	Airborne	1.9×10^3 μg/m³	None Available	Not Applicable	120 Kg
"	Ethyl Alcohol	"	7.0×10^3 μg/m³	"	"	1,048 Kg
"	Acetone	"	2.5×10^2 μg/m³	"	"	30 Kg
	Total Organics From Above Listing	"	7.2 lb/day	40 lb/day OEPA*	18%	2,641.6 lb.

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Building 51 (Incinerator)	Particulate	Airborne	.03 lb/100 lb input	.1 lb/100 lb input OEPA*	30%	216 lb.
"	Aldehydes	"	8.01 mg/m³	None Available	Not Applicable	49.0 Kg
"	Benzo(a)pyrene	"	.03 mg/m³	"	"	180.0 g
"	Carbon Monoxide	"	12.81 mg/m³	"	"	49.0 Kg
"	Hydrocarbons	"	8.01 mg/m³	"	"	49.0 Kg
"	Oxides of Sulfur	"	48.05 mg/m³	"	"	293.9 Kg
"	Oxides of Nitrogen	"	52.86 mg/m³	"	"	326.6 Kg

Quantities obtained from PHS Publications 999-AP-29

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SD, WD and WDA	Barium	Waterborne	.139 mg/1	None Available	Not Applicable	174.5 Kg
"	Boron	"	.200 mg/1	"	"	251.4 Kg
"	Cadmium	"	.005 mg/1	"	"	6.8 Kg
"	Chromium	"	.010 mg/1	"	"	12.6 Kg
"	Cobalt	"	.019 mg/1	"	"	24.4 Kg
"	Copper	"	.072 mg/1	"	"	90.3 Kg
"	Iron	"	.401 mg/1	"	"	504.4 Kg
"	Lead	"	.040 mg/1	"	"	50.3 Kg
"	Manganese	"	.038 mg/1	"	"	48.1 Kg
"	Mercury	"	.001 mg/1	"	"	1.3 Kg
"	Nickel	"	.025 mg/1	"	"	31.1 Kg
"	Silver	"	.017 mg/1	"	"	21.5 Kg
"	Zinc	"	.079 mg/1	"	"	99.9 Kg

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SD, WD and WDA	Dissolved Oxygen	Waterborne	9.45 mg/1	None Available	Not Applicable	Not Applicable
"	pH	"	8.05	"	"	"
"	Suspended Solids	"	17.76 mg/1	"	"	2.23×10^4 Kg
"	Biological Oxygen Demand	"	4.53 mg/1	"	"	5.69×10^3 Kg
"	NH_3	"	.51 mg/1	"	"	6.44×10^2 Kg
"	Oil and Grease	"	1.66 mg/1	"	"	2.09×10^3 Kg
"	Chlorides	"	965.65 mg/1	"	"	1.21×10^6 Kg
"	Fluorides	"	.19 mg/1	"	"	2.33×10^2 Kg
"	Nitrates	"	3.62 mg/1	"	"	4.55×10^3 Kg
"	Phosphates	"	1.82 mg/1	"	"	2.29×10^3 Kg
"	Sulphates	"	108.23 mg/1	"	"	1.36×10^5 Kg
"	Dissolved Solids	"	2084.13 mg/1	"	"	2.62×10^6 Kg
"	Conductivity	"	3039 Mho	"	"	Not Applicable
"	Turbidity	"	<25 JTU	"	"	"
"	Total Hardness	"	593.31 mg/1	"	"	"
"	Calcium	"	148.40 mg/1	"	"	7.46×10^5 Kg
"	Magnesium	"	44.04 mg/1	"	"	1.87×10^5 Kg
						5.54×10^4 Kg

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SD, WD and WDA	Total Coliform Fecal Coliform	Waterborne "	2900/100cc 22/100cc	None Available "	Not Applicable "	Not Applicable "

C

Cardinal®

APPENDIX C

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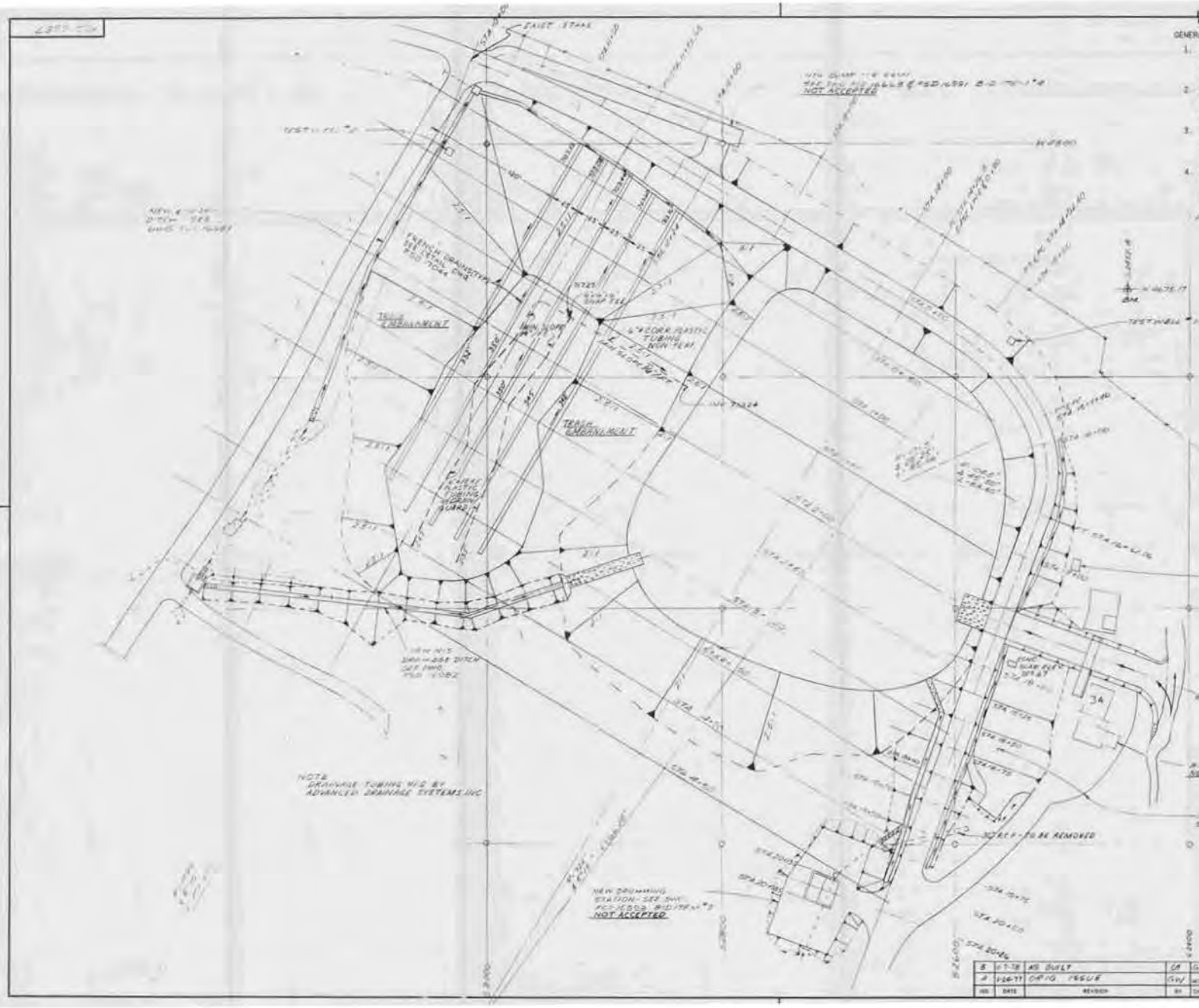


GENERAL NOTES:

1. MATERIAL LISTS PREPARED BY [illegible] ARE TO BE USED AS A GUIDE TO INDICATE THE MAGNITUDE OF THE PROJECT. THE [illegible] SHOULD PREPARE MATERIAL LISTS OR OTHERWISE VERIFY THE MATERIAL REQUIREMENTS FOR THE PROJECT.
2. BURIED WASTE MATERIAL AT THE SITE WILL REQUIRE SPECIAL CARE DURING EXCAVATION & RECONPACTION. SEE SHEET FSD16694 FOR BURIED MATERIAL LOCATIONS & SHEETS FSD16666-68 & FSD16677-79 FOR LANDFILL DISPOSAL REQUIREMENT.
3. AFTER EXCAVATING THE POND BOTTOM TO ELEV. 706' ALL SEAMS, LENSES & ZONES OF GRANULAR SOIL SHALL BE REMOVED TO A DEPTH OF 3 FT. AND REPLACED WITH SUITABLE MATERIAL AS DIRECTED BY THE CONTRACTING OFFICER. THE BASE SHALL THEN BE PROOF-ROLLED & COMPACTED TO A MAX. DRY DENSITY OF AT LEAST 100%.
4. PRIOR TO THE CONSTRUCTION OF EMBANKMENTS THE ORIGINAL GROUND SHALL BE CLEARED OF ALL BRUSH AND LOOSE SOIL. THE REMAINING GROUND SHALL THEN BE KNEADED WITH A HEAVY SHEEPSFOOT ROLLER TO INSURE PROPER BONDING OF THE FILL WITH THE ORIGINAL SOIL EXCEPT WHERE BENCHING IS REQUIRED.

PLANT GRID

N — 25°30'48.53" PLANT — TRUE

5. EARTHEN TRASH EMBANKMENT SHALL BE CONSTRUCTED IN LIFTS NOT TO EXCEED 6 IN. IN HEIGHT. EACH LIFT SHALL BE COMPACTED TO 90-95% OF MAXIMUM DRY DENSITY WITH MOISTURE CONTENT BETWEEN -2 AND +5% FROM OPTIMUM. FOR COMPACTION OF TRASH WITHIN EMBANKMENT, SEE SPECS.
6. LOCATIONS OF EXISTING PIPING, DRAINS, WATER LINES, ELECTRICAL CONDUITS, SEWERS AND OTHER STRUCTURES ARE BASED ON THE MOST RECENT INFORMATION AVAILABLE. ALL APPURTENANCES NOT SHOWN OR NOT IN THE LOCATION INDICATED SHOULD BE CALLED TO THE ATTENTION OF THE CONTRACTING OFFICER AND APPROVAL OBTAINED BEFORE PROCEEDING WITH THE WORK.
7. BACKFILLING AND COMPACTION OF ALL PIPING & STRUCTURES SHALL BE PERFORMED UNDER THE SUPERVISION OF THE CONTRACTING OFFICER.
8. ELEVATIONS SHOWN ON ROAD SECTIONS REFER TO FINISHED GRADE OF PAVEMENT.
9. ALL DISTURBED SOIL TO BE SEEDED UNLESS OTHERWISE NOTED. SEE SPEC'S.
10. SELLER SHALL FURNISH REQUIRED INDEPENDENT SOILS ENGINEERING AND LABORATORY ASSISTANCE TO INSPECT EXCAVATION, PLACEMENT, AND COMPACTION OF EMBANKMENTS. SELECTION OF THESE SERVICES TO BE SUBJECT TO APPROVAL OF CONTRACTING OFFICER; SOILS ENGINEER SHALL REPORT TO AND BE RESPONSIVE TO CONTRACTING OFFICER. THESE SERVICES ARE REQUIRED TO MAINTAIN CRITICAL COMPACTION DENSITIES, TO DISTINGUISH BETWEEN ACCEPTABLE AND UNACCEPTABLE EMBANKMENT MATERIALS AND TO PROVIDE PROPER ENCAPSULATION OF WASTE MATERIALS.
11. SEE SPECIFICATIONS FOR ROADWAY CONSTRUCTION AND COMPACTION REQUIREMENTS

REV	DATE	REVISION	BY	CHKD	APPD	AP
3	1-7-78	AS BUILT	CA	GB	[illegible]	
2	12-6-77	OPTIO. TRENCH	GW	WW	WK	

CODE IDENT. NO. 14065

DWG. CLASSIFICATION

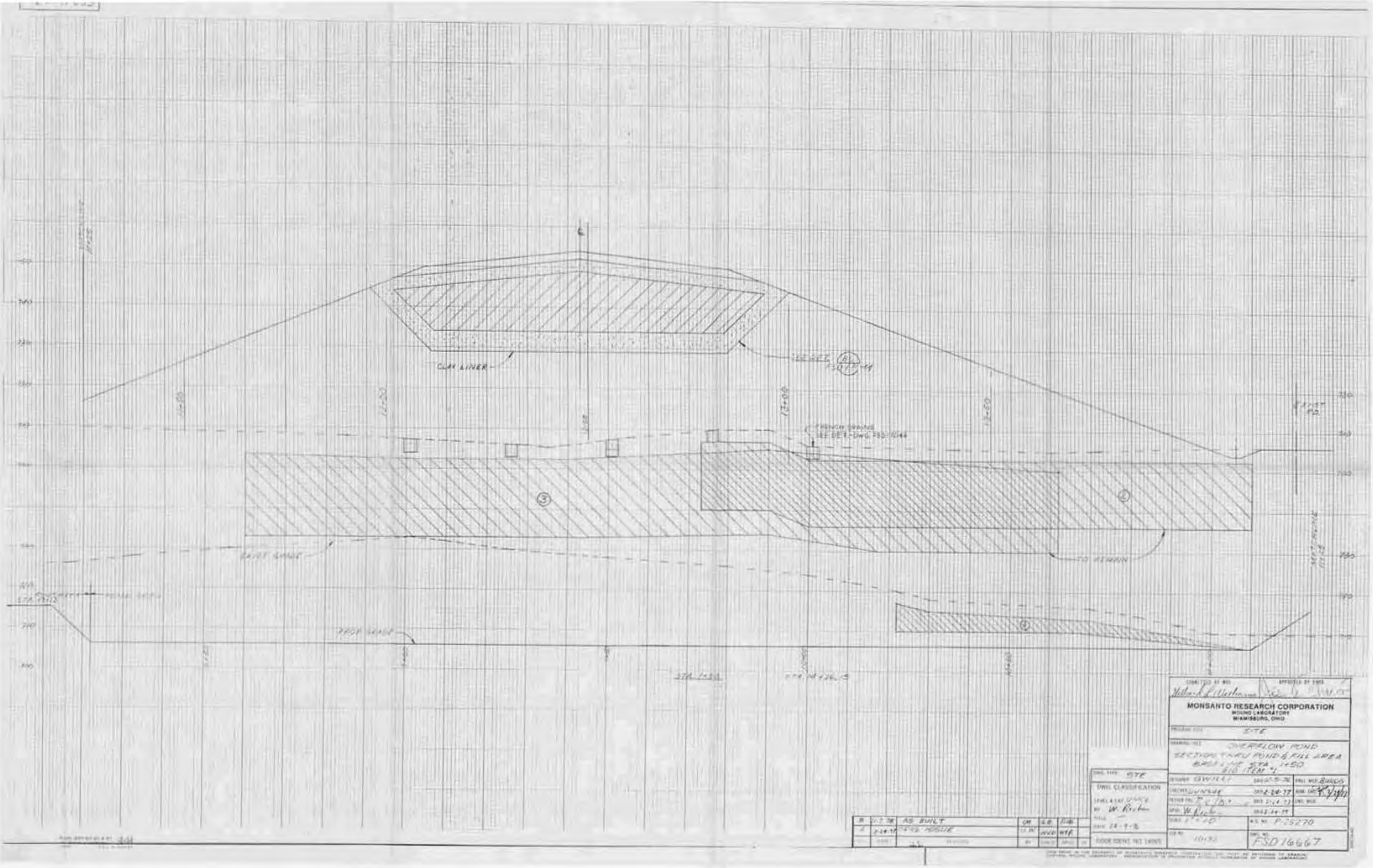
DWG. TYPE: SITE

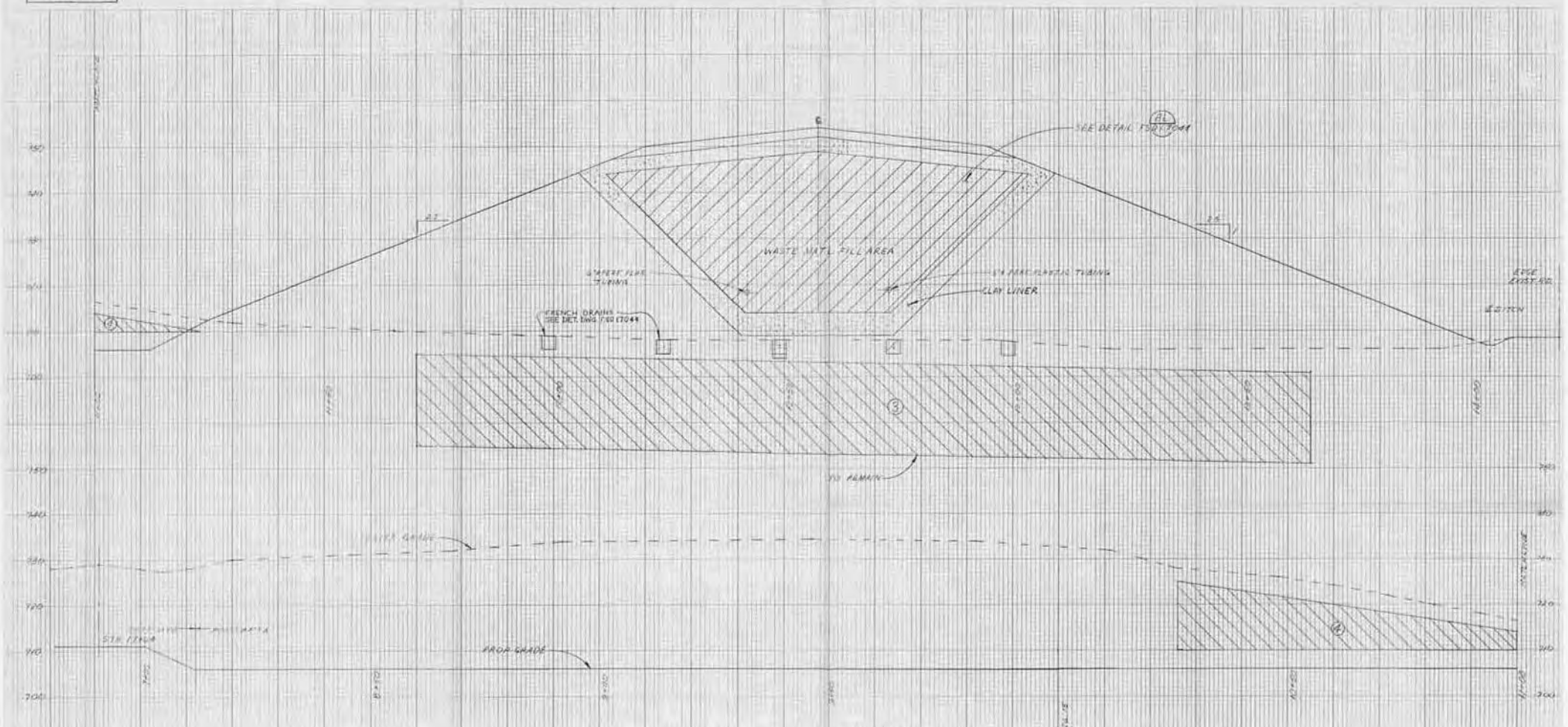
MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

PROGRAM TITLE: SITE

DRAWING TITLE: OVERFLOW POND EARTHWORK PLAN BID ITEM #1

DESIGNED: [illegible] DATE: 10-19-76
CHECKED: [illegible] DATE: 12-6-77
DATE: 1-4-78
PROJ. NO. 25270
CODE NO. 10114
DWG. NO. FSD16657


CLAY LINER
FRENCH DRAINS
SEE DET - DWG. FSD 16644
EXIST. GRADE
TO REMAIN
PROP. GRADE
STA. 14+26.15
MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO
SITE
OVERFLOW POND
SECTION THRU POND & FILL AREA
BASELINE STA. 14+50
BID ITEM #1
AS BUILT
DWG. CLASSIFICATION
P-25270
FSD 16667



B	11-7-78	AS BUILT	DM	GB	OB
A	2-24-77	ORIG. ISSUE	GHV	HAS	WER

CODE IDENT. NO. 14095

DWG. TYPE: STE

DWG. CLASSIFICATION

LEVEL & CAT. UNCLA.
BY W. Rieber
DATE 12-9-76

COMPILED BY MRC: Wilbur L. Williams
APPROVED BY TSR: M. W. Chenoweth

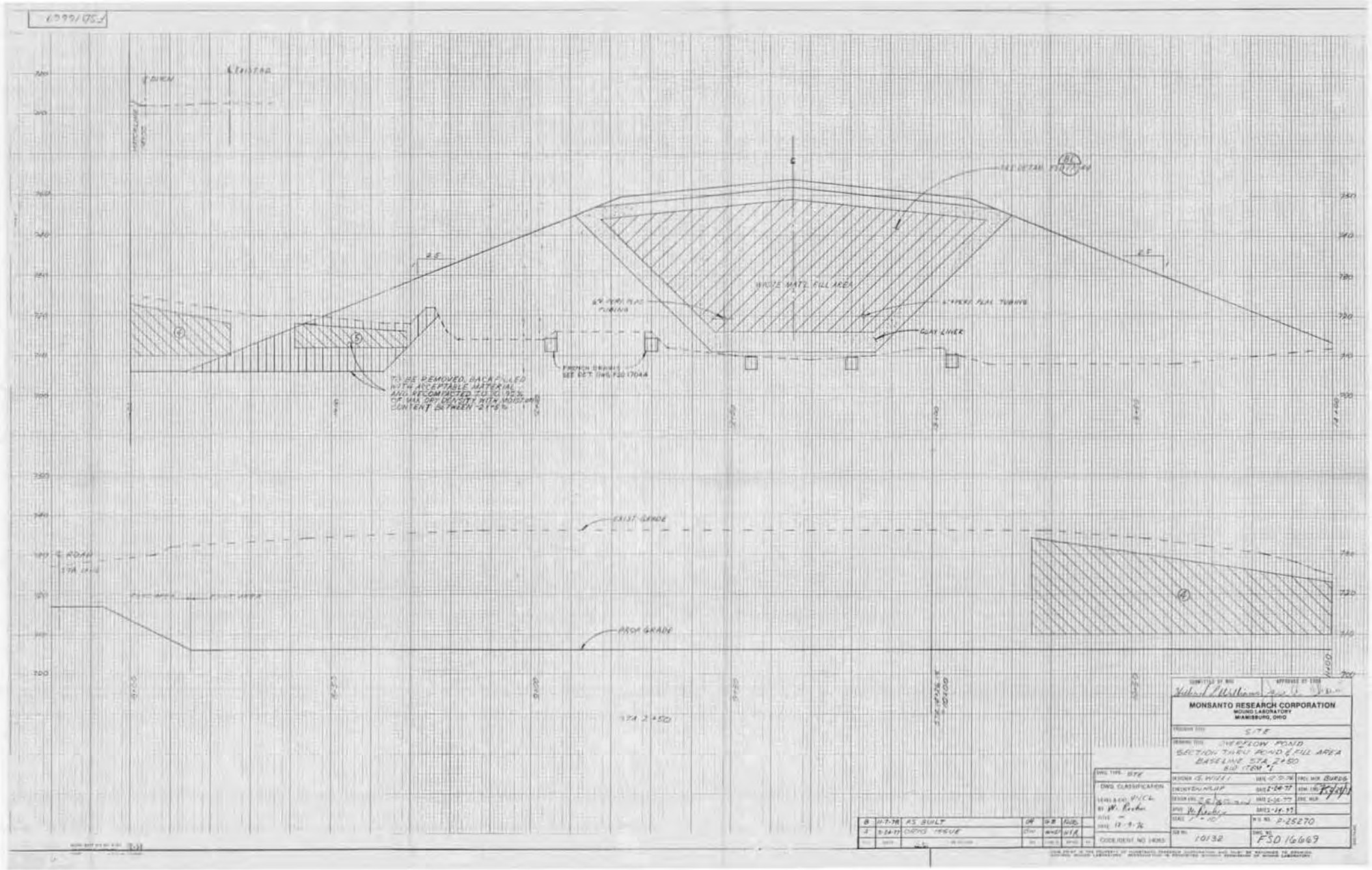
MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

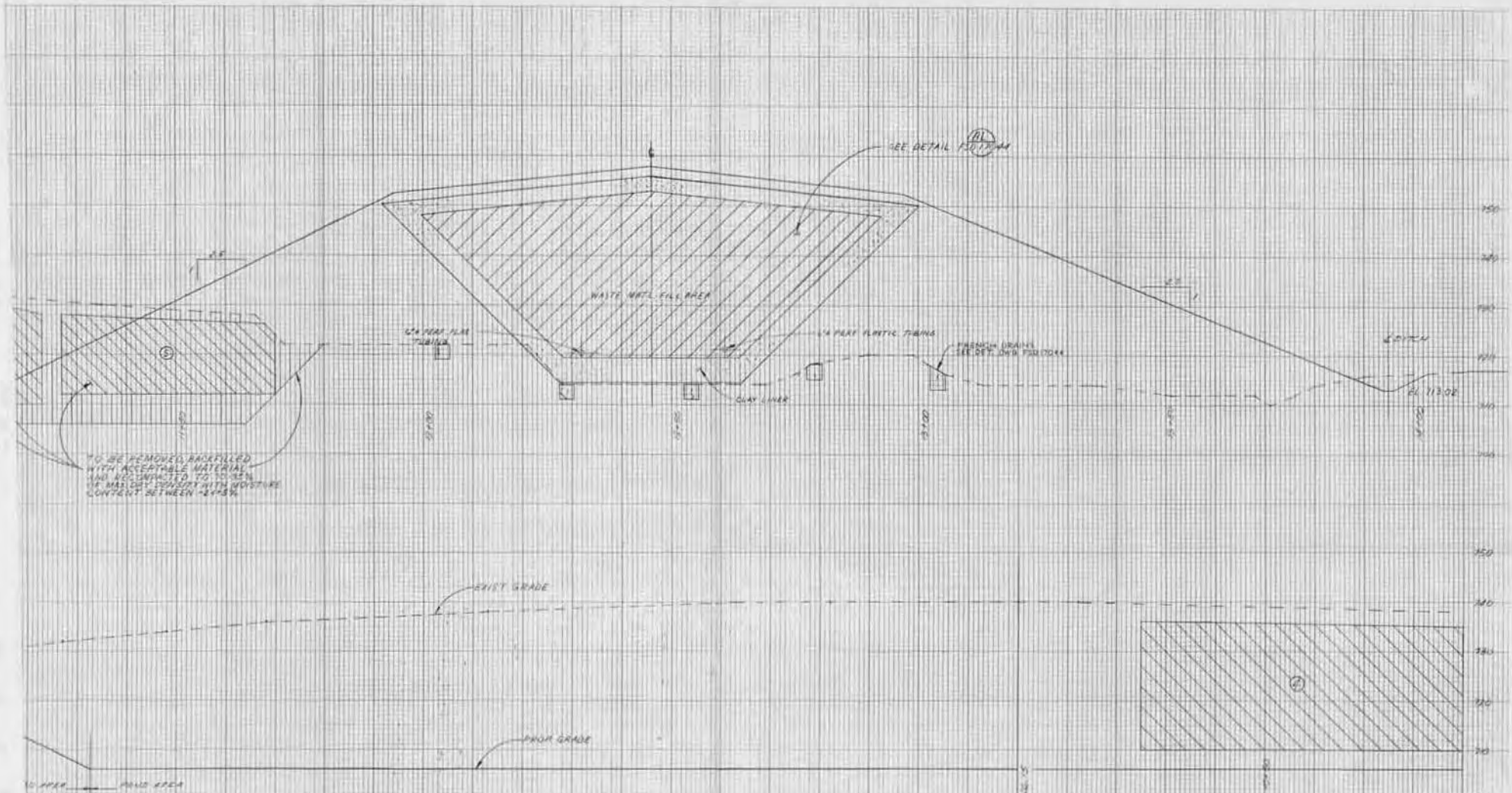
PROJECT NO.: STE

DRAWING TITLE: OVERFLOW POND
SECTION, SLUDGE POND & FILL AREA
BUILDING STA. 2+00
BID ITEM 4, 2

DESIGNER: W. Rieber	DATE: 5-3-76	PROJ. MGR.: Chenoweth	
CHECKED: Chenoweth	DATE: 2-24-77	SUPR. ENG.:	
REVIEW ENG.:	DATE: 2-24-77	ENG. MGR.:	
APPD.: W. Rieber	DATE: 2-24-77		
SCALE: 1" = 10'		W.O. NO.: P-23270	
FILE NO.: 10192		DWG. NO.: FSD16668	

THIS DRAWING IS THE PROPERTY OF MONSANTO RESEARCH CORPORATION AND MUST BE RETURNED ON DEMAND. CONTENTS, MOUND LABORATORY, REPRODUCTION IN PROHIBITED WITHOUT PERMISSION OF MOUND LABORATORY


DIKE
C
2.5
2.5
WASTE MATL FILL AREA
CLAY LINER
TO BE REMOVED, BACKFILLED WITH ACCEPTABLE MATERIAL AND RECOMPACTED TO 95% OF MAX DRY DENSITY WITH MOISTURE CONTENT BETWEEN -2+5%
FRENCH DRAINS SEE DET DWG F20170AA
EXIST GRADE
ROAD
PROP GRADE
STA 2+50
MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO
SITE
OVERFLOW POND
SECTION THRU POND & FILL AREA
BASELINE STA. 2+50
BID ITEM 1
DWG. TYPE SITE
DWG. CLASSIFICATION
DESIGNED G. WILLS
CHECKED N.L.P.
DRAWN W. Rocker
SCALE 1" = 10'
SIZE 10132
CODE/IDENT NO 14063
DWG. NO. FSD 16669
B 11-7-78 AS BUILT
A 5-24-77 CHG'D ISSUE



B	11-7-78	AS BUILT	JR	GB	GB
A	2-6-77	OPTG. ISSUE	GW	WVD	WR

DWG. TYPE: STE

DWG. CLASSIFICATION

CODE IDENT NO. 24065

MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

PROGRAM TITLE: SITE

DRAWING TITLE: OVERFLOW POND SECTION THRU POND & FILL AREA BASELINE STA. 3+00 BID ITEM

DESIGNED: G. WILEY

CHECKED

DRAWN: R. B.

APVD: W. Rieder

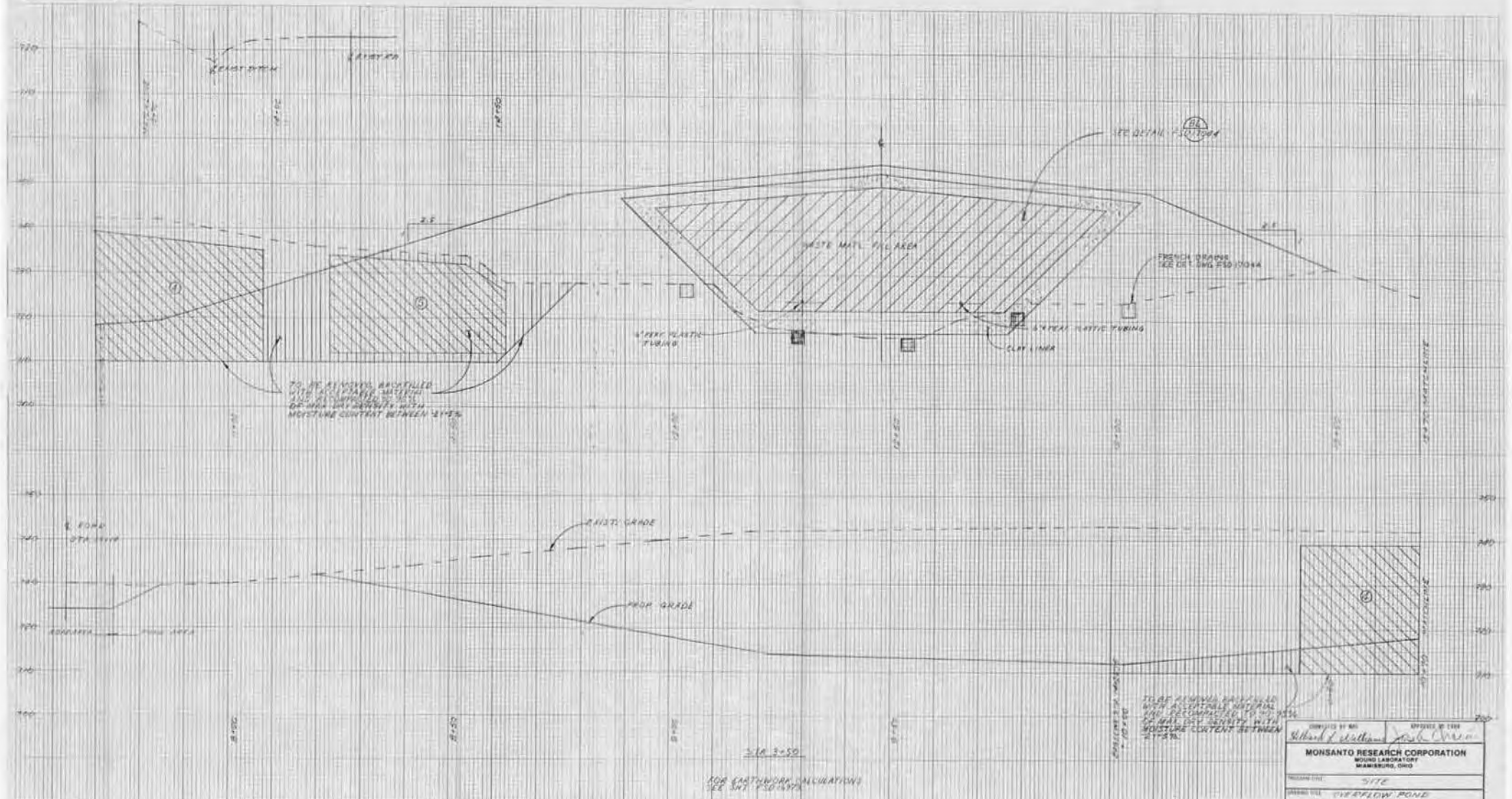
SCALE: 1" = 10'

JOB NO. 10132

DWG. NO. FSD16977

A.O. NO. P-25270

FSD 16978



B	11-7-78	AS BUILT	CH	GE	GAB
A	2-16-77	OPTIO ISSUE	GW	WD	WER

DWG TITLE SITE

DWG CLASSIFICATION

CODE IDENT NO. 14933

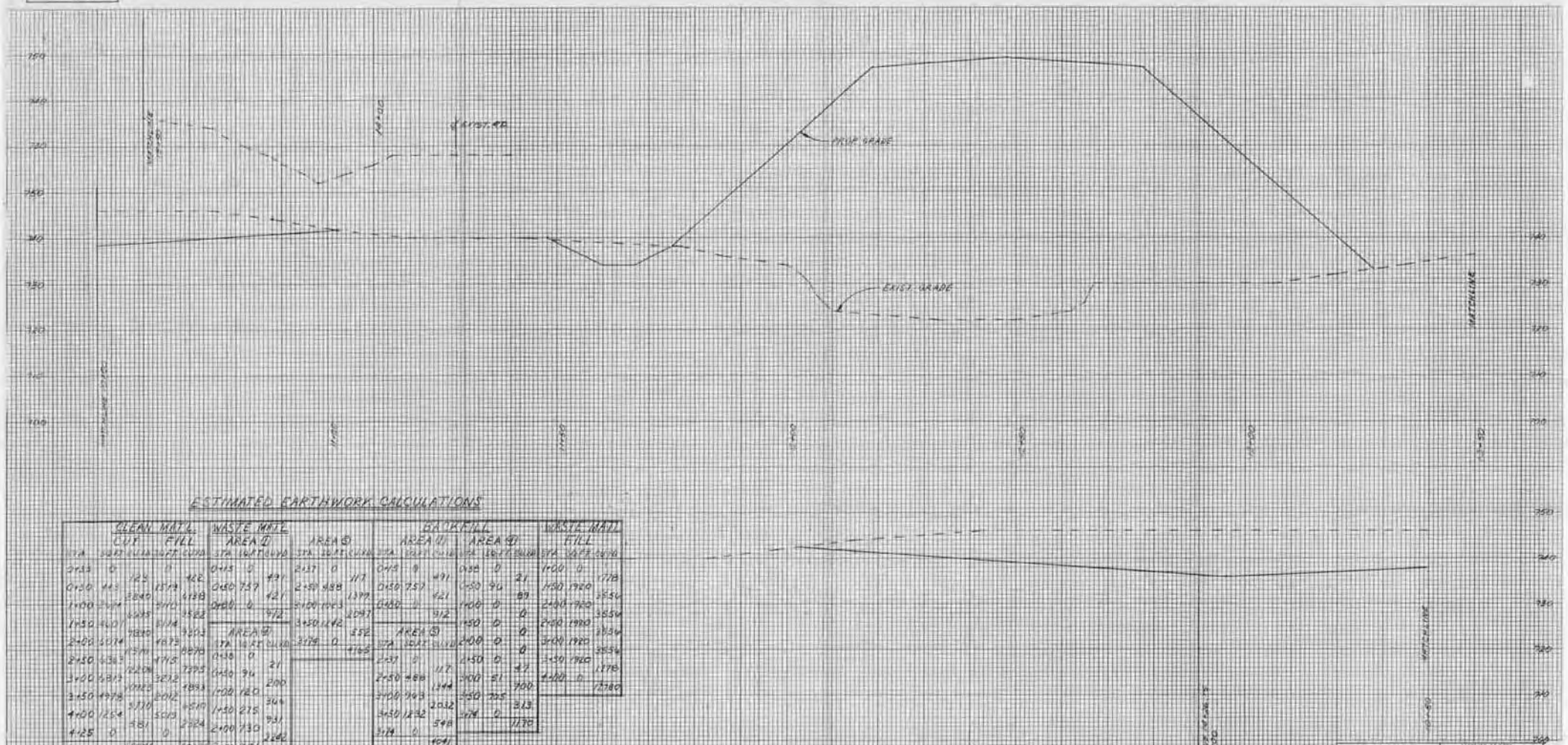
MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

PROGRAM TITLE SITE

DRAWING TITLE OVERFLOW POND
SECTION THRU POND & FILL AREA
BASELINE STA. 3+50
BID ITEM 4

DESIGNED S. WILLI DATE 2-25-76 CHKD. NO. BARDG
DRAWN J. WARNER DATE 2-26-77 REV. DATE 11-7-78
DESIGN ENG. DATE 2-28-77 ENG. MGR.
APPD. DATE 2-24-77
SCALE 1" = 10' MAX. NO. P-25270
JOB NO. 10132 DWG. NO. FSD 16978

FSD 16979



ESTIMATED EARTHWORK CALCULATIONS

CLEAN MATL. CUT

STA	SQ FT	CU YD
0+35	0	
0+50	145	125
1+00	2614	3840
1+50	4407	6345
2+00	5074	9114
2+50	4363	9220
3+00	4813	9176
3+50	4978	10125
4+00	1254	6110
4+25	0	3481
		67194

CLEAN MATL. FILL

STA	SQ FT	CU YD
0+35	0	
0+50	1122	422
1+00	2110	4188
1+50	2114	5582
2+00	4875	9203
2+50	4715	9070
3+00	3212	7295
3+50	2012	4893
4+00	5103	9510
4+25	0	2524
		62186

WASTE MATL. AREA ①

STA	SQ FT	CU YD
0+35	0	
0+50	757	491
0+60	0	421
		912

WASTE MATL. AREA ②

STA	SQ FT	CU YD
0+35	0	
0+50	94	21
1+00	120	200
1+40	275	349
2+00	730	931
		2262

WASTE MATL. AREA ③

STA	SQ FT	CU YD
2+37	0	
2+50	438	117
3+00	1063	1379
3+50	1242	2097
3+74	0	552
		4165

WASTE MATL. AREA ④

STA	SQ FT	CU YD
2+37	0	
2+50	438	117
3+00	943	1344
3+50	1232	2032
3+74	0	548
		4041

BACKFILL AREA ①

STA	SQ FT	CU YD
0+35	0	
0+50	757	491
0+60	0	421
		912

BACKFILL AREA ②

STA	SQ FT	CU YD
0+35	0	
0+50	94	21
1+00	0	89
1+50	0	0
2+00	0	0
2+50	0	0
3+00	81	27
3+50	205	300
3+74	0	313
		1750

WASTE MATL. FILL

STA	SQ FT	CU YD
1+00	0	
1+50	1920	178
2+00	1920	3554
2+50	1920	3554
3+00	1920	3554
3+50	1920	3554
4+00	0	1778
		17780

SUMMARY - BID ITEM "1" - EARTHWORK

CLEAN MATL. CUT - 66,544 C.Y. CLEAN MATL. FILL - 53,385 C.Y.
WASTE MATL. CUT - 16,987 C.Y. WASTE MATL. FILL - 12,780 C.Y.
ROADWAY EXCESS - 2,831 *
N.S. DITCH EXCESS - 282 **
86,814 C.Y.
LESS BACKFILL - 2,123
TOTAL FILL - 73,165 C.Y.
86,690 C.Y.

* CARRIED OVER FROM SHT. FSD 16662
** CARRIED OVER FROM SHT. FSD 16983

REV.	DATE	REVISION	BY	CHK'D	APPD.	M
A	2-24-77	ORIG. ISSUE	GWJ	HWD	WSR	

SUBMITTED BY MRC: Willard L. Williams
APPROVED BY ERDA: G. Dwyer

MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

PROGRAM TITLE: SITE

DRAWING TITLE: OVERFLOW POND
SECTION THRU POND & FILL AREA
BASELINE STA. 4+00
BID ITEM "1"

DWG. TYPE: SITE	DESIGNER: G. WILLIS	DATE: 12-9-76
DWG. CLASSIFICATION	CHECKER: [illegible]	DATE: 2-24-77
LEVEL & CAT: UNCL.	DESIGN ENG: E. S. Jackson	DATE: 2-24-77
APV'D: W. Reichen	APV'D: W. Reichen	DATE: 2-25-77
TITLE: —	SCALE: 1" = 10'	W.O. NO.: P 25270
DATE: 12-9-76	JOB NO.: 10132	DWG. NO.: FSD 16979
CODE IDENT. NO.: 14065		

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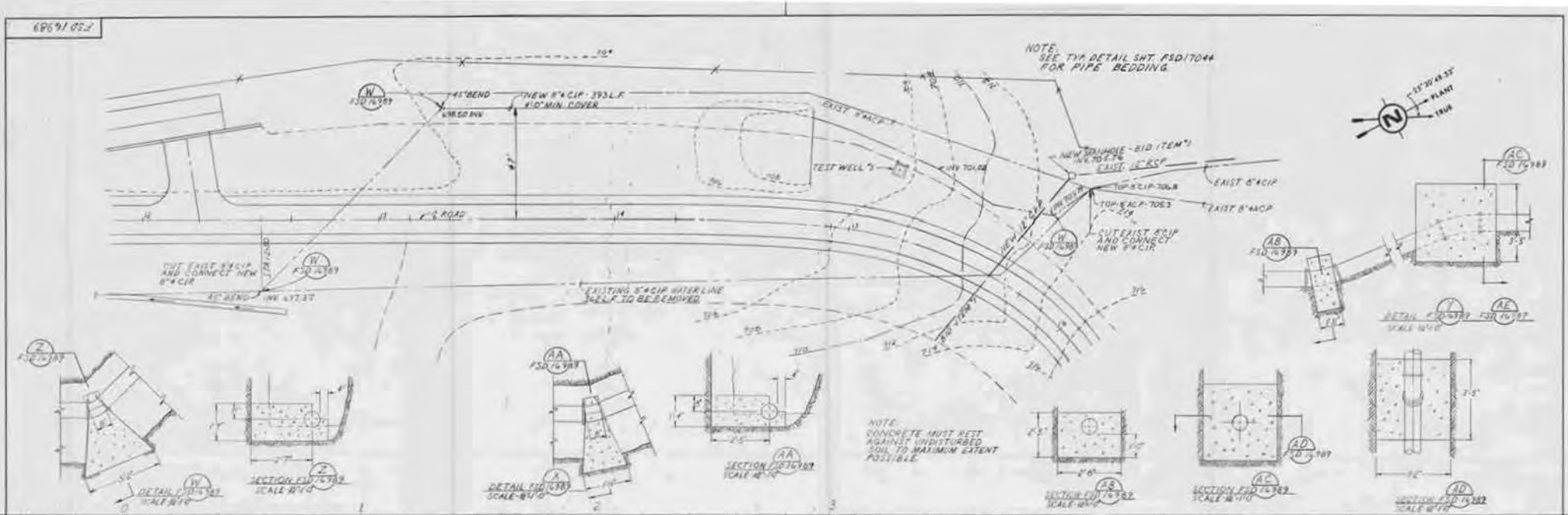
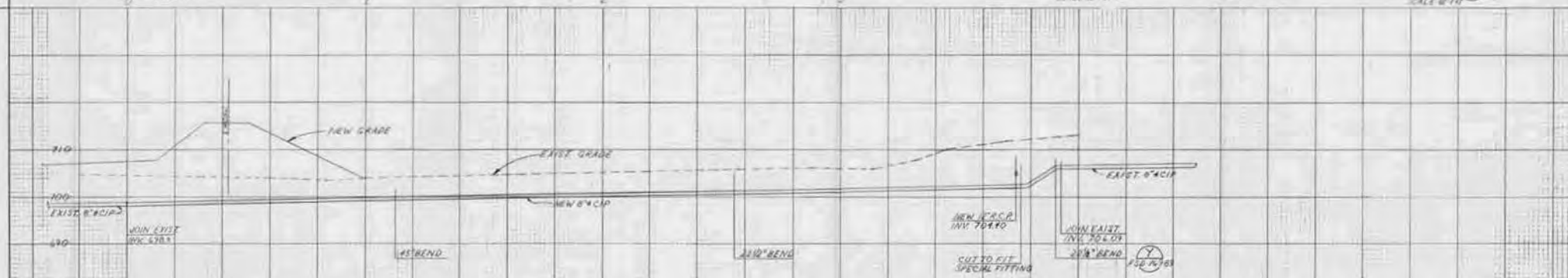
FSD 16989





B	11-9-76	AS BUILT	CM	WB	GAB
A	2-24-77	ORIG. ISSUE	CM	WHD	WER
NO.	DATE	REVISIONS	BY	CHKD	APVD

CODE OR NO. 1 AREAS

DWG. TYPE: STE

DWG. CLASSIFICATION

LEVEL & CAT. UNCL

BY W. Rocker

DATE 12-9-76

SUBMITTED BY MSC: Willard L. Williams

APPROVED BY EPA: Paul E. Bryant

MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

PROJECT TITLE: SITE

DRAWING TITLE: OVERFLOW POND
RELOCATION 8" CIP WATER LINE
CONSTRUCTION PLAN & PROFILE
BID ITEM #2

DESIGNED: C. MARSHALL DATE: 11-9-76 PROJ. MGR.: GUARDIA

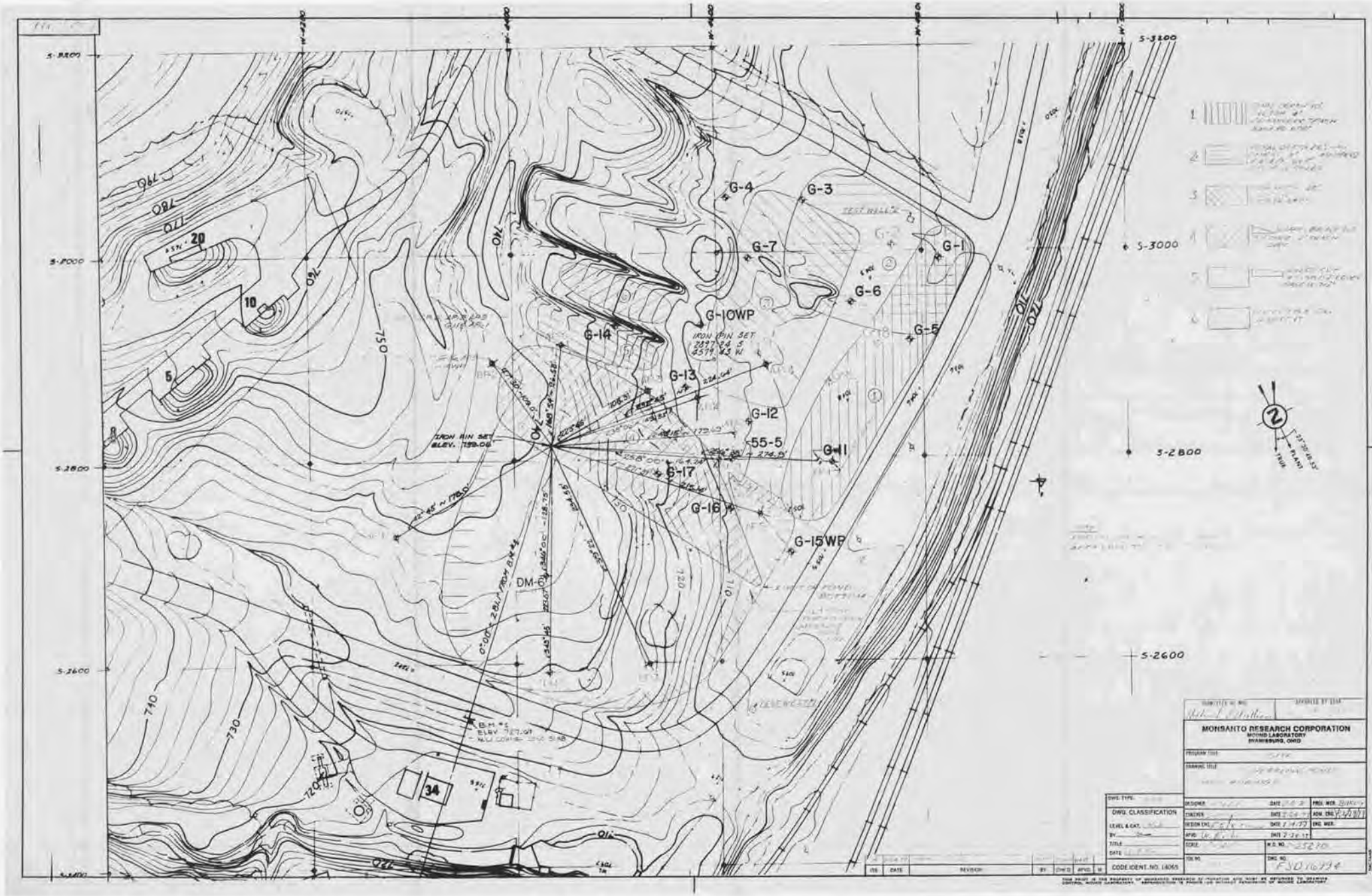
DRAWN: DWARD P. DATE: 2-24-77 ADM. ENG.: [illegible]

DESIGN ENG.: R. E. [illegible] DATE: 2-24-77 ENG. MGR.: [illegible]

REVIEW: W. Rocker DATE: 2-24-77

SCALE: 1"=20' A.E. NO.: P-25270

JOB NO.: 10132 DWG. NO.: FSD 16989


MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO
G-1
G-3
G-4
G-5
G-6
G-7
G-10WP
G-11
G-12
G-13
G-14
G-15WP
G-16
G-17
55-5
DM-6
IRON PIN SET
ELEV. 759.06
B.M. #5
ELEV. 727.07
S-3200
S-3000
S-2800
S-2600
S-2400
DWG. CLASSIFICATION
CODE IDENT. NO. 14065

SK-C-2281

REMARKS

			CLEANED UP
1	Th^{228}	STORAGE AREA CONTAMINATED AROUND BLDG DUMPING THORIUM INTO BLDG	
2	Po^{210}	CONTAMINATED SAND FROM SAND BLASTING WD SAND FILTERS + Thorium Drums.	1965
3	Th^{228}	STORAGE AND REDRUMMING AREA	1965 SUMMER
4	Po^{210}	WD INFLUENT TANKS RAN OVER SD DRYING PITS ALSO CONTAMINATED	
4A	Po^{210}	SD DRYING PITS CONTAMINATED WHEN "HOT" & COLD LINES BROKE AREA 5	1965
5	Po^{210}	LINE CARRYING CONTAMINATED WASTE TO WD & COLD LINE TO SD BROKE	1963

REMARKS

6	Po^{210}	CONTAMINATED SAND BURIED WERE FROM WD SAND BLASTING OPERATION
7	Th^{228}	BURYING AREA FOR A NUMBER OF ISOTOPES MOSTLY Th^{228} DIRT FROM AREA 3 OR AREA 1 ALSO OLD THORIUM DRUMS Po^{210} E-31 SYSTEM FROM T-BLDG Ra^{226} Ac^{227} THIS IS BURIED IN AN OLD SEPTIC TANK FROM Th^{228} PROJECT ENDED 1954 WASHER FROM LAUNDRY REDRUMMING 1952 THORIUM
8	Th^{228}	BURYING AREA FOR CONTAMINATED DIRT FROM AREA 9 & 1
9	Th^{228}	STORAGE & REDRUMMING AREA THORIUM
10	Po^{210}	CONCRETE FROM UNIT 4 DUMPED THERE 1950

CLEANED UP 1965 BURIED 1964

REMARKS

11 & 11A		CONTAMINATED FROM SM OPERATION
12	Th^{228}	BURYING AREA FOR CONTAMINATED DIRT FROM AREA 1
13	Po^{210}	CONTAMINATED WOOD FROM UNIT 4 CAUGHT FIRE

CLEANED UP

15 Ra^{226} Th^{228} Ac^{227} SW-219 STEEL TRACKS AND CRANE PLUS SHIELDING PANELS ARE BURIED UNDER CONCRETE - CAVE OPERATION

REMARKS

14 SW LINE TO WD - REPAIRED AT FENCE SOUTH OF SD DRY BEDS FLOW DOWN HILLSIDE COVERED WITH CLEAN DIRT

TRUE NORTH — PLANT NORTH

MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

SITE PLAN

HOT WASTE BURIAL AREA

DRAWN M.N.	DATE 2-15-72	APPROVALS	
CHECKED G.A.B. / T.C.J.	DATE 2-15-72		
APPROVED	DATE		
JOB NO. P163			
SCALE 1" = 200'			

DWG. NO. SK-C-2281

CLASSIFICATION

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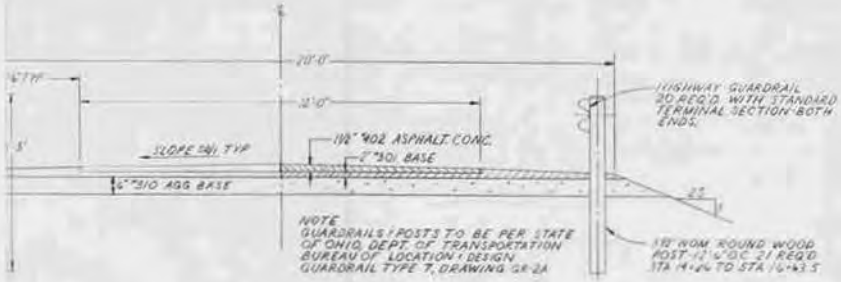
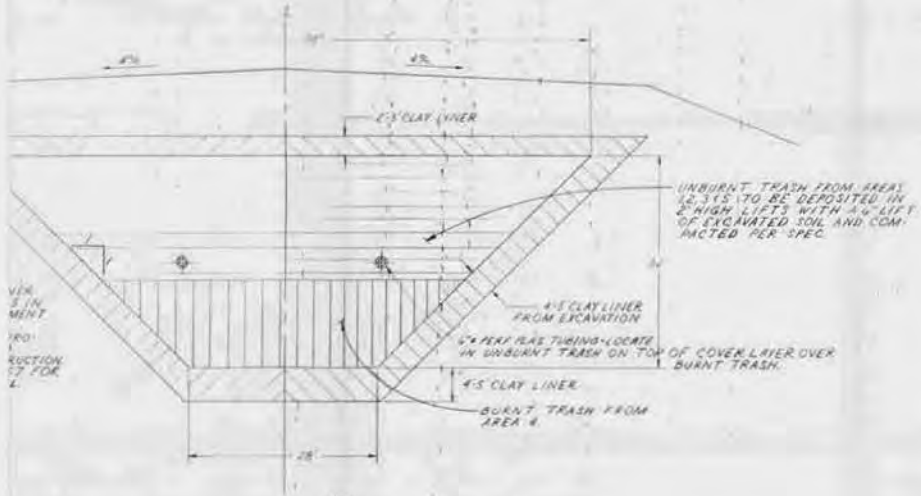
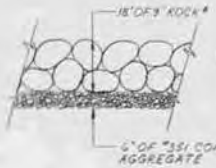


TYP. RDWY SECTION FSD 16482 (BA)
SCALE 1/8"=1'-0"



SECTION FSD 16482 (BL)
SCALE 1"=10'

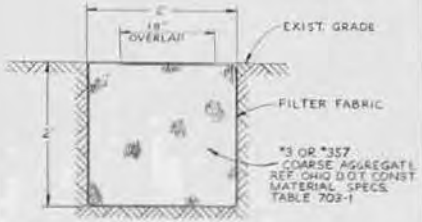
MATERIAL DISPOSAL DETAIL



* NOTE
ROCK SIZE INDICATES THE SQUARE OPENING ON WHICH 85% OF THE MAT'L BY WEIGHT WILL BE RETAINED.

DETAIL (BD)
SCALE-1/8"=1'-0"

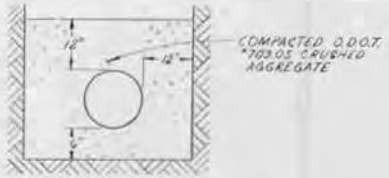
ROCK CHANNEL PROTECTION (R.C.P.) TYPE-B



TYPICAL SECTION-FRENCH DRAIN
NO SCALE

NOTE: DRAINS TO BE CONSTRUCTED IN EXIST. SOIL AND SLOPED TO DRAIN INTO NEW DITCH (SEE PLAN).

EXCAVATION & BEDDING DETAIL FOR PRESSURE PIPE
NO SCALE



EXCAVATION & BEDDING DETAIL FOR DRAINAGE PIPE
NO SCALE

NOTE TO BE USED ALSO FOR PERF. TUBING IN THE TRASH AREA, BUT NOT FOR NON-PERF. TUBING WHICH PENETRATES THE CLAY LINER. BACKFILL WITH CLAY.

A	12-29-77	ORIG. ISSUE	CM	WHP	W.A.R.
ISS	DATE	REVISION	BY	CHKD	APPD

MONSANTO RESEARCH CORPORATION
MOUND LABORATORY
MIAMISBURG, OHIO

PROGRAM TITLE: SITE
DRAWING TITLE: OVERFLOW POND TYPICAL DETAILS BID ITEM #1

DWG. TYPE: SITE
DWG. CLASSIFICATION
LEVEL & CAT. UNCL.
BY: W. Fisher
TITLE: —
DATE: 12-31-76
CODE IDENT. NO. 14065

DESIGNER: C. MARSHALL DATE 12-3-76 PROJ. MGR. GURDG
CHECKER DATE 12-26-77 ADM. ENG.
DESIGN ENG. DATE 12-28-77 ENG. MGR.
APPD. DATE 12-27-77
SCALE: NOTED
M.S. NO. P-25270
JOB NO. 10182
DWG. NO. FSD 17044

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A-17002 [redacted]

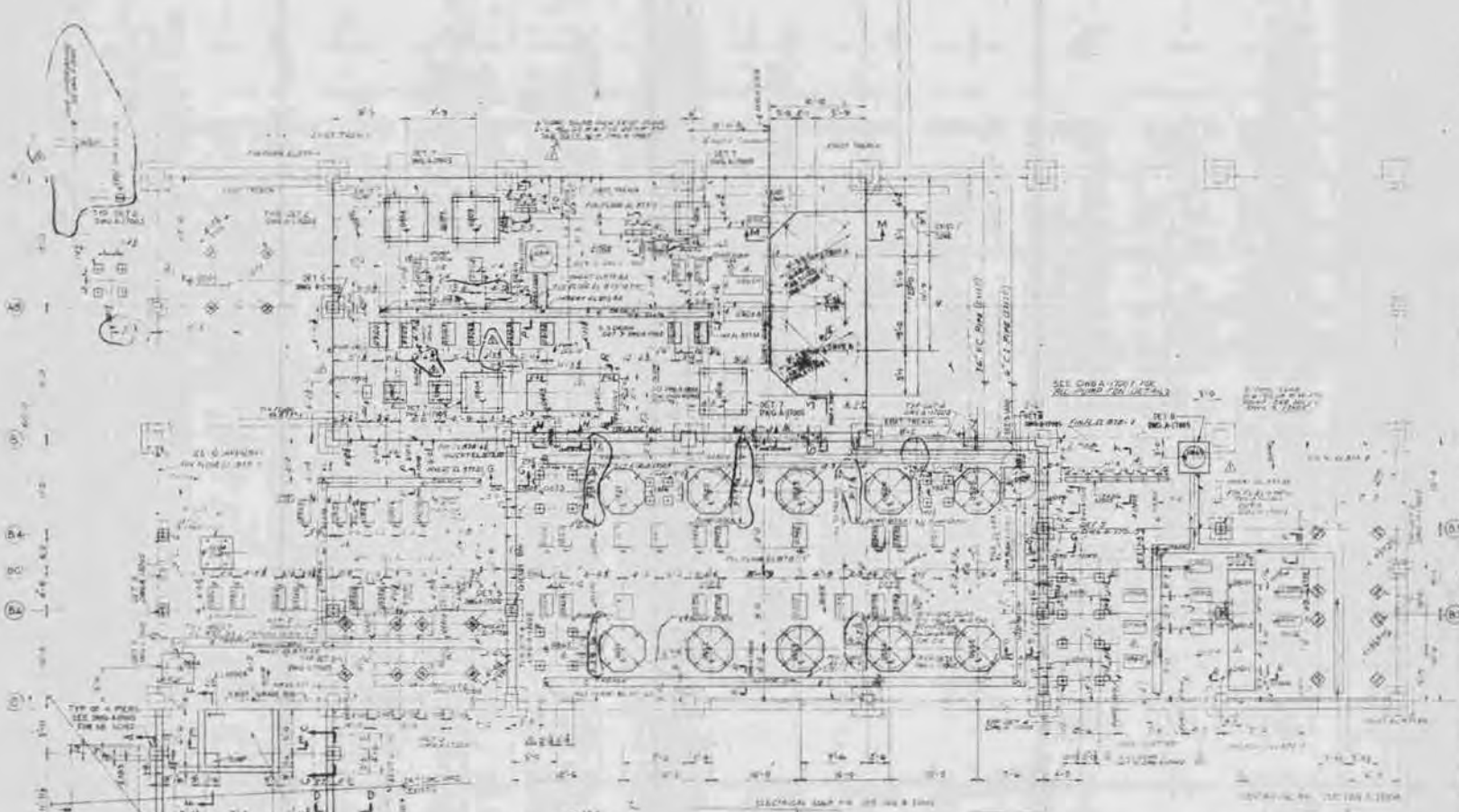
GENERAL NOTES

CONCRETE

1. ALL REINFORCED CONCRETE WORK AND MATERIAL SHALL BE IN ACCORDANCE WITH CATALYTIC CONSTRUCTION CO. MASTER SPEC. FOR REINFORCED CONCRETE WORK SP-17001-01 AND SPEC FOR REINFORCED CONCRETE WORK SPEC-17002-01.
2. CONCRETE TO DEVELOP 3000 P.S.I. AT 28 DAYS WITH 1-1/2" MAX. SIZE AGGREGATE, EXCEPT FOR FLOOR SLABS WHICH MAY USE AGGREGATE SIZE OF 3/4" AND EXCEPT IF OTHERWISE NOTED ON DWGS.
3. ALL EDGES AND EXPOSED CORNERS OF CONCRETE TO HAVE A 1" CHAMFER, EXTENDING 1 FOOT BELOW GRADE.
4. ALL BARS TO HAVE A MINIMUM COVER OF 3" UNLESS OTHERWISE NOTED.
5. UNDERGROUND PIPING AND CONDUIT REQUIRING ROUGHTOUTS TO BE PLACED BEFORE CONCRETE IS POURED.
6. REINFORCING RODS TO BE BENT AROUND PIPE OPENINGS AND ANCHOR BOLTS WHERE THERE IS INTERFERENCE.

REFERENCE DRAWINGS

A-17003	CONCRETE — FOUNDATION DETAILS SH 1
A-17004	STRUCTURAL STEEL — PLATFORM PLANS SH 1
A-17005	STRUCTURAL STEEL — PLATFORM PLANS SH 2
A-17006	ARCHITECTURAL — INTERIOR PARTITIONS
A-17007	PIPING PLAN SH 1 FEED PREP
A-17008	PIPING PLAN SH 1 SEPARATION & PURIF.
A-17010	PIPING PLAN SH 1 NEUTRALIZATION
A-17011	ITEM CR01 & CR02 FLOOR TANK
A-17012	ITEM CR03 CONC STORAGE TANK
A-17013	ITEM CR05 & CR06 G-R-I-D-CHER SURGE TANK
A-17021 (THRU)	ITEM CR21 THRU CR25 & CR31 THRU CR35 PULSE COLUMNS
A-17031	ITEM CR27 & CR37 RAFFINATE SURGE TANKS
A-17032	ITEM CR30 ALL ULTRATE SURGE TANK
A-17033	ITEM CR04 CARBONATE SURGE TANK
A-17034	ITEM CR08 & CR10 RAFFINATE NEUTRALIZER
A-17035	ITEM CR09 & CR11 CLARIFIERS
A-17036	ITEM CR14 & CR15 FILTERS
A-17037	ITEM CR16 CR17 FEED TANK
A-17038	ITEM CR18 CR19 ACID TANK
A-17039	ITEM CR20 FILTER ACID TANK
A-17040	ITEM CR26 & CR27 VACUUM TANK
A-17041	ITEM CR28 & CR29 ACID TANK
A-17042	ITEM CR36 METAL CLIPS
A-17043	CONC. PEDESTAL CUTAWAY SH 2
A-17044	CONCR STEEL PLATFORM PLAN & SECTIONS SH 1
A-17045	CONCR STEEL LINE HANDLING STRUCTURE
A-17046	CONCR STEEL PLAN & SECTIONS
A-17047	CONCR LEVELS PLAN SH 1
A-17048	CONCR LEVELS PLAN SH 2
A-17049	CONCR SECTIONS
A-17050	CONCR SECTIONS
A-17051	CONCR SECTIONS
A-17052	CONCR SECTIONS



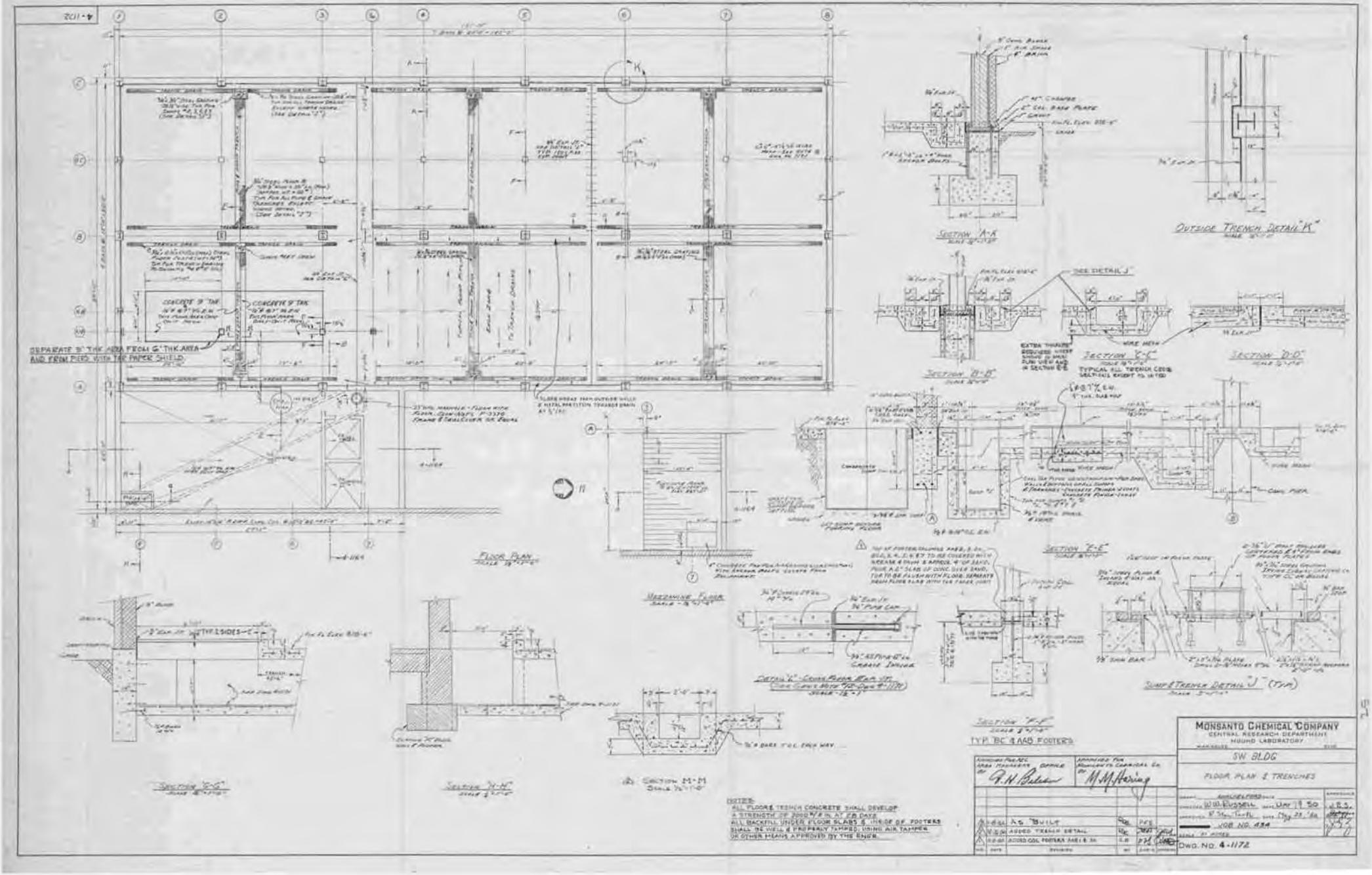
REVISION 5

REV.	DATE	DESCRIPTION	DR.	CHK.	APP.
5		[illegible]			
4		[illegible]			
3		[illegible]			
2		[illegible]			
1	4-13-61	ADD & RELOCATED PIPING, ADDED UPPER FLR. CONCRETE. ASBUILT REF. [illegible]			
0	3-6-61	CERTIFIED FOR CONSTRUCTION			
	1-27-61	FOR APPROVAL			

DRAWN BY	DATE	UNITED STATES ATOMIC ENERGY COMMISSION
DESIGNED BY	DATE	MOUND LABORATORY OPERATED BY MONSANTO CHEMICAL COMPANY MIAMISBURG, OHIO
APPROVED BY	DATE	CATALYTIC CONSTRUCTION COMPANY 1528 WALNUT ST. PHILA. PENNA. CONTRACT NO.AT(40-1)-1520

DRAWING TITLE: CONCRETE FLOOR & FOUNDATION PLAN

SCALE	SUBSTATION	JOB NUMBER	DRAWING NUMBER
1/4" = 1'-0" UNLESS NOTED	SW	4300	A-17002


SEPARATE 9" THK AREA FROM 6" THK AREA AND FROM PIERS WITH TAR PAPER SHIELD
FLOOR PLAN
MEZZANINE FLOOR
SECTION A-A
OUTSIDE TRENCH DETAIL "K"
SEE DETAIL J
SECTION B-B
SECTION C-C
TYPICAL ALL TRENCH COVER SECTIONS EXCEPT AS NOTED
SECTION D-D
SECTION E-E
SECTION F-F
TYP. BC & AAB FOOTERS
SECTION G-G
SECTION H-H
SECTION M-M
SUMP & TRENCH DETAIL "J" (TYP)
MONSANTO CHEMICAL COMPANY
CENTRAL RESEARCH DEPARTMENT
HOUND LABORATORY
SW BLDG
FLOOR PLAN & TRENCHES
JOB NO. 434
Dwg. No. 4-1172
NOTES:
ALL FLOORS TRENCH CONCRETE SHALL DEVELOP A STRENGTH OF 2000 #/□" IN 28 DAYS.
ALL BACKFILL UNDER FLOOR SLABS & INSIDE OF FOOTERS SHALL BE WELL & PROPERLY TAMPED, USING AIR TAMPER OR OTHER MEANS APPROVED BY THE ENGR.
AS BUILT
ADDED TRENCH DETAIL
ADDED COL FOOTERS AAB & BC

MONSANTO RESEARCH CORPORATION
SITE PLAN
HOT WASTE SEWER
INSERT - NO SCALE
INSERT - NO SCALE
INSERT - 1/4 SCALE
N