FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

HISTORICAL DOCUMENTATION OF THE FERNALD SITE AND ITS ROLE WITHIN THE U.S. DEPARTMENT OF ENERGY WEAPONS COMPLEX

JANUARY 1998

U.S. DEPARTMENT OF ENERGY
FERNALD AREA OFFICE

20900-RP-0001
REV. 0

Historical Documentation of the Fernald Site and Its Role within the U.S. Department of Energy Weapons Complex

January 1998

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ACRONYMS

ACHP	Advisory Council on Historic Preservation
AEC	Atomic Energy Commission
ARAR	Applicable or Relevant & Appropriate Requirement
ARC	Atlantic Richfield Corporation
AWWT	Advanced Waste Water Treatment Plant
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CRARE	Comprehensive Response Action Risk Evaluation
D&D	Decommissioning and Decontamination
DMA	Division of Military Application
DNT	Dinitrotoluene
DOE	Department Of Energy
EIS	Environmental Impact Statement
EM	Environmental Restoration and Waste Management
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
FEMP	Fernald Environmental Management Project
FERC	Federal Energy Regulatory Commission
FERMCO	Fernald Environmental Restoration Management Corporation
FFCA	Federal Facility Compliance Agreement
FMPC	Feed Materials Production Center
FR	Federal Register
HE	High Explosive
I & E	Inner and Outer Diameter
INEL	Idaho National Engineering Laboratory
IROD	Record of Decision for Interim Remedial Action
LANL	Los Alamos National Laboratory
MTU	Metric Tons of Uranium
NCP	National Contingency Plan
NEPA	National Environmental Policy Act

ACRONYMS
(Cont'd)

NHPA	National Historic Preservation Act
NLO	National Lead Company of Ohio
NPR	New Production Reactor
NRC	Nuclear Regulatory Commission
OHPO	Ohio Historic Preservation Office
OSDF	On-Site Disposal Facility
OU	Operable Unit
PEIS	Programmatic Environmental Impact Statement
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI/FS	Remedial Investigation/Feasibility Study
RMI	Reactive Metals, Inc.
ROD	Record Of Decision
SARA	Superfund Amendments and Reauthorization Act
SWCR	Site-Wide Characterization Report
TNT	Trinitrotoluene
TVA	Tennessee Valley Authority
UO_2	Uranium Dioxide
UO_3	Uranium Trioxide or Orange Oxide
UF_4	Uranium Tetrafluoride or Greensalt
UF_6	Uranium Hexafluoride
UNH	Uranyl Nitrate Hexahydrate
WEMCO	Westinghouse Environmental Management Company of Ohio

1.0 INTRODUCTION

The purpose of this report is to document the history of the Fernald site. The Fernald site played a critical role in the support of weapons production for the Nation's defense, and this role should be documented for the posterity of future generations. A second aspect of the history of the Fernald site is the change in site mission from feed materials production to environmental restoration.

The Fernald site is a contractor-operated federal facility where high purity uranium metals were produced for the Atomic Energy Commission (AEC) and, later, the United States Department of Energy (DOE) between 1951 and 1989. The Fernald site is located on 1,050 acres in a rural area of Hamilton and Butler counties approximately 18 miles northwest of Cincinnati, Ohio. The communities of Fernald, New Baltimore, Ross, New Haven, and Shandon are all located within a few miles of the Fernald site (Figure 1-1).

From the time operations began in 1951, the Fernald site has played an important role in the United State's nuclear weapons complex. This site, which was known as the Feed Materials Production Center (FMPC), was commissioned under the AEC as part of the emerging nuclear weapons production complex. The newly-formed DOE assumed responsibility for the FMPC in 1977.

The FMPC was operating by October 1951, just five months after ground was broken for the complex. The production area was limited to an approximate 136-acre tract near the center of the site. During the production years, the FMPC was tasked with producing high-purity uranium metal as feed materials for reactors and other AEC programs, and later the DOE weapons production process. By the time production ceased in 1989, the Fernald site had provided over 152,000 metric tons of uranium (MTU) to other AEC/DOE sites such as Hanford, Savannah River, and Rocky Flats. The final products were primarily uranium metal products machined to exacting specifications for use as fuel cores in production reactors. In addition, over 41,000 MTU of intermediate products, such as uranium trioxide (UO_3, or orange oxide) and uranium tetrafluoride (UF_4 or green salt) that was refined into metal were sent to several sites within the AEC/DOE complex.

Demand for the feed materials fluctuated greatly. After a rapid buildup in the 1950s and a peak demand in the early 1960s, production tapered off through the late 1960s and 1970s. Production picked up again in the 1980s, but by 1989, demand for feed materials from the FMPC was very low. This decrease in demand, coupled with an increase in environmental restoration efforts, led to the closure of the FMPC as a production facility in July, 1989. By 1991, FMPC management was transferred from DOE's Defense Programs Division to the Environmental Restoration and Waste Management Division (EM), and the site was officially renamed the Fernald Environmental Management Project (FEMP).

Today, the FEMP is undergoing comprehensive environmental remediation pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as well as waste management under the Resource Conservation and Recovery Act (RCRA). Throughout this report, the "Fernald site" will be used to identify the site, rather than the FMPC or FEMP, except within quotes or report titles. AEC and DOE will be used as appropriate.

The content of this report was agreed upon by the Ohio Historic Preservation Office (OHPO) and the Advisory Council on Historic Preservation (ACHP) in a Programmatic Agreement that was signed by all parties in January, 1996. The Programmatic Agreement was written pursuant to 36 Code of Federal Regulations (CFR) 800.13. The agreement establishes a procedure for compliance with Sections 106 and 110 of the National Historic Preservation Act (NHPA), with respect to documenting the history of the Fernald site. OHPO advised DOE in 1994 that the Fernald site was eligible for listing on the National Register of Historic Places. DOE agreed and proposed this report as part of the documentation of the history of the Fernald site, since preservation of the site is impossible due to the environmental remediation required under CERCLA.

The format of the report is as follows. The history of the AEC and DOE is summarized, with an emphasis on the site selection and rapid expansion of the nuclear weapons complex following the Manhattan Project. A summary is then provided of the major products that were manufactured within the AEC/DOE complex. The next section describes the role of the Fernald site within the AEC/DOE weapons production complex.

The Fernald site history is documented from construction through the shut down of production. A discussion on how the feed materials produced at the Fernald site were used within the overall weapons production process is then provided. In conclusion, the change in mission from production to remediation is discussed, as the Fernald site has undergone large-scale environmental restoration efforts.

This report is by no means an exhaustive account of the history of the Fernald site. It is only intended to summarize the history of the site as it fits in to the overall AEC/DOE complex. The reports referenced provide a much more detailed description of the Fernald site. It is the position of DOE that a wealth of information is already available with respect to the history of the Fernald site, and that this document should consolidate and summarize this information. All historical records kept for the Fernald site, including photographs and negatives, engineering and architectural drawings, reports, letters, memos, production records, etc., are catalogued and archived as directed by DOE Order 1324.5B. Historically relevant records will be sent to the National Archives.

2.0 HISTORY OF THE ATOMIC ENERGY COMMISSION AND DEPARTMENT OF ENERGY

Modern applications of nuclear energy originated in the late 1930s through experiments by German Scientists Otto Hahn and Fritz Strassman, who were the first to successfully split the uranium-235 atom into two parts using a bombardment of neutrons. In the same period of time, Austrian physicist Lise Meitner and British physicist Otto Frisch uncovered the process of nuclear fission, which opened the door for further research and discovery relating to the release of nuclear energy. In early 1939, the world became somewhat engrossed in the idea of nuclear energy as the results of early research were coming available to the public and many sorts of nuclear powered creations (e.g., power stations, bombs, submarines) were envisioned.

Numerous other key developments in nuclear energy research occurred in several countries in the late 1930s and early 1940s (*Goldschmidt, 1982*). It was discovered in the early 1940s that a new element, in addition to uranium-235, could be used to sustain a fission chain reaction. At the University of California-Berkeley in 1941, Chemist Glen Seaborg discovered that bombarding the uranium-238 isotope with neutrons would cause a series of disintegrations, leading to the development of the isotope plutonium-239. This element would also undergo fission after the absorption of neutrons and could be used as a bomb material. In December 1942, Enrico Fermi achieved the first controlled nuclear fission chain reaction at a University of Chicago laboratory. These key events had significant ramifications on the direction that the United States chose to pursue in terms of developing nuclear energy and establishing the U.S. atomic energy complex (*Goldschmidt, 1982*).

Other countries in the world were also researching the potential of nuclear energy at that time. The concern that Nazi Germany might develop nuclear weapons before the United States led to the decision to develop the nuclear bomb in the United States. In fact, the Germans had concluded that utilizing uranium-235 to make an explosive would be time consuming and difficult. Further, they were unaware of the existence of plutonium; therefore, the decision was made that development of a nuclear weapon within a few years was impossible and they abandoned the effort with no fears that the Allies were ahead of them in the race. Not until the Allied occupation of Germany in 1945 was the discovery made that Germany was not developing nuclear weapons *(Goldschmidt, 1982).*

In August 1942, a massive effort (code-named the "Manhattan Project") to develop the atomic bomb for possible use during World War II was initiated in the United States. The name "Manhattan Project" evolved from the U.S. Army Corps of Engineers practice of naming projects (or "districts") after the city housing the project headquarters. The Manhattan Project was directed by U.S. Army Engineer Major General Leslie Groves and included many prominent scientists such as Robert Oppenheimer, Harold Urey and Enrico Fermi. In 1942 and 1943, the Oak Ridge Facility (Site X for uranium-235 isolation), Hanford Site (Site W containing plutonium producing reactors) and Los Alamos National Laboratory (Site Y for assembly and testing of bombs) were established to support the Manhattan Project. More about the siting and construction of these sites is provided in Section 3. After many months of research and development, the first atomic bomb was tested at Alamogordo, New Mexico, on July 16, 1945. The blast resulted in a ball of light that could be seen for 60 miles. In August 1945, two atomic bombs (one made with uranium-235 and one made with plutonium) were used at Hiroshima and Nagasaki, Japan.

2.1 Atomic Energy Commission Formation

At the conclusion of the Manhattan Project and World War II, the United States government recognized the need to regulate the production and use of atomic power. The Atomic Energy Act of 1946 established the AEC, which was to be a civilian agency of the U.S. government administering atomic power use. The fundamental purpose of the Atomic Energy Act of 1946 was to put the power and possibilities of atomic energy under civilian control while leaving nuclear materials and facilities in government hands.

The major areas of AEC concentration were the production of fissionable material, biologic and health research, accident prevention, the production of electricity, nuclear aircraft research and data declassification. The weapons complex that is now under the control of DOE was developed as part of the programs focusing on the production of fissionable material.

The AEC was tasked with planning and developing a complex in the United States to produce atomic weapons in large volumes. The task would involve building off of the facilities that had already been constructed between 1942 and 1943 as part of the Manhattan Project. Later sections provide information on each site, including siting and operation and how they interacted with the Fernald site.

2.2 Switch to the Department of Energy

The Energy Reorganization Act of 1974 abolished the AEC and established two new federal agencies to administer and regulate nuclear energy activities. The Energy Research and Development Administration (ERDA) and the Nuclear Regulatory Commission (NRC).

The NRC was established as a regulating body for nuclear energy in the United States. The NRC was tasked with protecting public health and safety, preserving environmental quality, protecting nuclear materials from theft or diversion and nuclear facilities from sabotage, and assuring conformity with U.S. antitrust laws.

Specific functions of the NRC include developing standards and enforcement, conducting safety reviews, licensing actions, technical studies and safety research. A major responsibility of the NRC is regulating the use of nuclear energy to generate electricity in nuclear reactors. In addition, the NRC regulates a wide variety of radioactive material uses in industry, commerce, agriculture, medicine and education.

The ERDA was responsible for the U.S. nuclear weapons program, as well as the development of new energy sources. The Department of Energy Reorganization Act of 1977 abolished the ERDA and established the Department of Energy as an executive department of the U.S. government. The responsibilities of ERDA were absorbed by DOE, while the NRC remained essentially intact. The primary functions of the DOE were the marketing of federal power, promoting more efficient uses of energy, and the nuclear weapons program. The DOE was also required to work closely with other federal agencies such as the Environmental Protection Agency (EPA) and the NRC, which have authority over the establishment of air and water pollution standards and the safe design of nuclear power plants. The Federal Energy Regulatory Commission (FERC) is an independent regulatory agency within the DOE, which has the authority to establish and monitor rates charged for electricity and the transportation of oil and gas by pipeline.

2.3 Change in Mission to Environmental Restoration

The change of the Fernald site mission to environmental restoration is discussed in more detail in Section 5.0. This change was part of a larger process that was occurring across the country throughout the DOE weapons complex. As the Cold War concluded and the threat of nuclear conflict was reduced, the demand for nuclear weapons declined. The new mission facing DOE was limiting the proliferation of nuclear weapons into the hands of rogue states, the safe dismantlement of nuclear weapons and maintenance of the stockpile without nuclear testing. In addition to this, the production of nuclear weapons created an estimated $300 billion cleanup legacy which will result in the single largest environmental program in United States history *(DOE, 1994)*.

DOE also faced having to redirect the same national commitment that built the nuclear weapons arsenal toward addressing the environmental and safety risks that now exist at hundreds of contaminated sites. DOE has responsibility for 137 sites nationwide. Significant portions of the over 3300 square miles of lands managed by DOE contain contaminated soil, groundwater, and structures. The new mission of environmental restoration must be carried out while continuing to ensure the safety of workers and the public. In addition, the input of stakeholders such as members of the public around the site, states, and Native Americans must be factored into all decision making (*DOE, 1994*) connected to restoration activities.

3.0 ESTABLISHMENT OF THE WEAPONS COMPLEX

This section is a summary of information originally presented in a report entitled the "History of the Production Complex: The Methods of Site Selection." The report was prepared by Burgess, McCormick and Pingitore and was issued in September 1987 under a DOE contract. The report should be consulted for more detailed information on the siting of the facilities involved in the weapons complex.

3.1 Manhattan Project Sites

There were two phases in the establishment of the AEC/DOE weapons complex as it exists today. The initiation of the Manhattan Project in 1942 led to the construction of the first three sites in the weapons complex between 1942 and 1944. The expansion phase of the weapons complex occurred between 1947 and 1953. This section will first discuss the three main sites constructed to support the Manhattan Project. It is important to note that materials and processes from numerous locations around the country contributed to the Manhattan Project. However, this report will focus on the primary sites involved in weapons production. Subsequently, the sites constructed as part of the expansion phase will also be discussed grouped into three categories: the reactor sites, the gaseous diffusion plants, and the assembly plants.

In the interests of secrecy and of ensuring protection of the public in case of an accident, the Manhattan Project facilities were sited in remote, isolated areas. In fact, all AEC/DOE weapons complex facilities were sited in locations that were felt to be less vulnerable to Soviet attack, as discussed throughout this section. This strategy was a departure from previous government practices, but had the advantage of ensuring security and safety. This disadvantage was the lack of adequate skilled labor, housing, and personal services near the new facilities. As a result, whole cities had to develop around the Manhattan Project facilities; for example, the city of Oak Ridge, Tennessee, was established to support the Oak Ridge National Laboratory (as indicated by the school nickname the "U.C. Atoms"). There were numerous housing shortages during the early years of the plant's operation, which led to a change in philosophy when siting future facilities during the expansion phase of the weapons complex.

The United States discovered that nuclear weapons could be produced utilizing the fission of both uranium-235 and plutonium isotopes. Therefore, two of the plants constructed were dedicated to: 1) the separation of the uranium-235 isotope (Oak Ridge National Laboratory) and 2) the production of the plutonium isotope (the Hanford Site). The third and final facility established to support the Manhattan Project was Los Alamos National Laboratory, which was to function as an assembly and testing plant.

One of the primary considerations in siting the Oak Ridge facility was electricity. The gaseous diffusion process to separate the uranium-235 isotope consumes large amounts of electricity (a capacity of 150,000 kW was required for Oak Ridge by the end of 1943). The vast majority of natural uranium (over 99%) is made up of the uranium-238 isotope which is heavier than the fissile uranium-235 isotope. The required feed material for the gaseous diffusion process is uranium hexafluoride (UF_6) gas. The gas is cycled through thousands of barriers containing many millions of tiny holes which causes the lighter uranium-235 atoms to diffuse and be recovered at a slightly greater rate than the heavier molecules containing uranium-238. The final product is a weapons grade uranium containing 90% uranium-235. Initial surveys for the first gaseous diffusion plant were carried out by Union Carbide. The Knoxville, Tennessee area was identified as a prime location for the Oak Ridge facility largely due to recommendations made by the Tennessee Valley Authority (TVA). The area could supply adequate power, is situated between the Appalachian and Rocky Mountains and is more than 200 miles from the Mexican and Canadian borders. This geographical location would have made attack by Soviet carrier-based aircraft very difficult.

When siting the Oak Ridge facility in conjunction with the engineering firm of Stone and Webster, the Office of Scientific Research and Development was also considering requirements related to topography and water availability. The site had to be near a river that could provide hundreds of thousands of gallons of fresh water per minute. In addition, the reservation housing the facilities would need to be approximately 200 square miles, located in an area that would not be sloped so severely as to cause construction problems, and have ground that would be stable enough to support very heavy buildings. A three day survey of the Knoxville area identified only one site on the Clinch River satisfying the requirements. Shortly after General Leslie Groves was sworn in as the head of the Manhattan Project on September 23, 1943, his first official act was to select the Oak Ridge, Tennessee site for the Nations first gaseous diffusion plant.

At that time, the Oak Ridge site was also being considered for the location of the nation's "plutonium pile" (i.e., nuclear reactors that would produce plutonium). However, the company that General Groves selected to build and operate the Oak Ridge facility, Dupont, had serious reservations about locating the plutonium pile in that area. Their concern centered around their perception that a premature criticality of plutonium could devastate the reservation and send a cloud of lethal fallout over the city of Knoxville to the east. However, the decision to find a new location for the nation's plutonium pile was made more out of the concern that the construction of the plutonium reactors would drain the labor resources in the area, many of which were already engaged in constructing the gaseous diffusion plant, subsequently slowing the project. Therefore, the search for a new location for the plutonium reactors began.

Siting the facility to house the plutonium reactors was challenging due to isolation requirements. Reactor engineers with the Metallurgical Laboratory of Chicago developed the operational criteria for siting the facility. The recommendation was made to take enough land for six reactors although only two were currently planned (although, in the end, nine reactors would be put into operation at the Hanford Site). The reactors had to be sited between one and four miles from one another for safety considerations, depending on the type. In addition, to avoid endangering adjacent populations, there would have to be a 10-mile exclusion zone around the reactors which could contain no major roads or railroads. This would require an area of 700 square miles for the reservation. There were very few places in the country that had that much land available in conjunction with the requirements for water and electricity. A secondary criterion for siting the facility was that the isolation needed for the reservation should not be created by displacing large numbers of people.

Once the criteria for siting the facility had been established, General Groves chose to consult with the Army Corps of Engineers to find a site. The Army Corps of Engineers advised that the Pacific Northwest, specifically the Bonneville Power Authority in Washington, had enough unused electrical capacity that they would not have to install new generating equipment. The officers of the Manhattan Project already had a prime location in mind, the Hanford-White Bluffs area in Washington. However, they sent Manhattan Project Officers to investigate a number of other sites, including two sites near the Grand Coulee Dam in central Washington, one site near Mt. Shasta in Northern California and one site in the Deschutes River Valley system in northern Oregon. Problems relating to the proximity of the other candidate sites to the Pacific Ocean and fluctuating power supplies resulted in the selection of the Hanford Site.

A year passed after construction of the sites at Oak Ridge and Hanford began before a location for the third Manhattan Project Site was designated. In early 1942, work on various aspects of developing nuclear weapons were being carried out under nine separate contracts with universities around the country (e.g., University of Chicago, Massachusetts Institute of Technology, Rice University, Purdue). This approach was creating various problems related to the communication between scientists in different locations due to the tight security on telephone calls, teletypes, etc. It did not take long before those involved in the project realized that a secure, central location to carry out theoretical and experimental efforts and final assembly of the bombs was needed. Therefore, it was decided by the AEC that a new "National Laboratory" would be sited and constructed to carry out these functions.

The decision of who would be the director of the new laboratory was left to General Groves. General Groves was determined to select someone who had significant prestige to command the scientists who would work at the laboratory because the nature of the work to be carried out would require civilian leadership rather than military. More than anything, General Groves wanted a Nobel Prize winner to head up the laboratory. In late 1942, the decision was made that Robert Oppenheimer would be the director. Planning for the new laboratory was initiated out at the University of California - Berkeley by Oppenheimer and his associates.

In early 1942, General Groves, along with Oppenheimer, began searching the west for a new laboratory site. Initial ideas of siting the laboratory at Oak Ridge were dropped as Groves felt the project required a more remote site in a climate that would allow year-round construction. Another site near Los Angeles was also rejected on security grounds and a third site near Reno was rejected due to the amount of snow in the winter. The first site recommended by Groves was Jemez Springs in New Mexico, which met all of the criteria including the fact that it was surrounded by a ring of hills to secure the site in case of accidental explosions. Another interesting feature was that the site was divided in two by a line of hills so that if an accident did occur it would only involve the scientists and not their families. On November 16, 1942, Oppenheimer first saw the Jemez Springs site and after one look told General Groves that it would not do. Oppenheimer felt that the site needed a more expansive setting than Jemez Springs offered and consideration of that site was dropped.

The other site under consideration was a very small town in New Mexico called Los Alamos. Prior to World War II, Los Alamos was not an established town. Native Americans used the land to graze sheep and cattle and it was the site of the Los Alamos Boys' School Ranch. Groves and Oppenheimer visited the site a week after visiting Jemez Springs. The site was considered expansive enough for the facility with easily controllable access. It was adequately surrounded by hills and canyons and was expansive enough to be used for tests. On November 25, 1942, the acquisition of Los Alamos was approved and it was mutually agreed that the occupants of the Boys Ranch would have until February 8, 1943 to vacate the premises.

On April 15, 1942, a contract was signed between the University of California and the Manhattan District of the Corps of Engineers to operate Los Alamos National Laboratory (LANL). Interestingly enough, the signing of the contract occurred after the site, equipment and men for the project had already been selected, indicating it was likely an afterthought. The University of California continued operation of the laboratory until 1947, when the AEC assumed responsibility for the facility.

The mission of the laboratory was very broad and complex. Scientists at the laboratory were tasked with finding the best method for combining nuclear materials so that they would reach a critical mass (using both uranium-235 and plutonium). The primary method pursued was the firing of one fraction of nuclear material into another using a gun. In addition, a second method of implosion, thought to be more efficient than the gun, was also pursued. Other work would focus on the behavior of neutrons during fission. However, the overall objective of the work carried out at Los Alamos was the assembly of the bomb (or "gadget" as it was called at the laboratory to avoid construction workers and others from learning the nature of the work there). The first full scale test of an atomic bomb took place near Alamogordo, New Mexico, some 300 miles south of LANL in July 1945.

3.2 Reactor Complexes

At the end of World War II and the Manhattan Project, the priority for the nuclear weapons complex in the United States was to expand nuclear weapons production capability. The arms race with the Soviet Union and the Cold War had its beginnings in the years following World War II. The perception at that time was that the nuclear weapons arsenal had to be expanded so that the right mix of strategic locations supplied with nuclear weapons (e.g., missile sites, submarines, etc.) could be established and sustained.

The first task facing the newly formed AEC was to build additional plutonium reactors in an effort to duplicate the plutonium production activities at Hanford. In July 1947, the AEC authorized General Electric Corporation to construct two new plutonium reactors with the intent of locating them at the Hanford Site. In the fall of the same year, the U.S. Army released a study questioning the defensibility of the area. The Army concluded that the entire area was vulnerable to a Soviet long-range bomb attack. The idea of siting new plutonium reactors elsewhere in the country was considered in late 1947 and early 1948. However, on August 5, 1948 the AEC shelved the idea, due to the high cost and the potential disruption of splitting up the General Electric operating team that was currently operating the existing Hanford Reactors. In addition, it was believed that the existing inventory at Los Alamos, coupled with the idea that production of uranium-235 could be increased in the event production at Hanford was lost, would provide adequate fissile material to support the weapons program.

The next step in the expansion program was to site a "reactor proving ground" to house the AEC's experimental reactors that were proposed for increasing the production efficiency of fissile material. Three sites were identified on a "short-list" on October 18, 1948 by the AEC. The sites included: Fort Peck, Montana; Oahe, South Dakota; and Wilmington, North Carolina. The AEC worked with the Army Corps and the U.S. Geologic Survey to evaluate these sites. As it turned out, none of the sites were selected as the location for the reactor proving ground. The reason they were not selected was the potential for hydrologic contamination downstream from the reactors, an emerging concern among the AEC staff. Another site under consideration, upon elimination of the other three, was the Kingsley Dam site in Nebraska. It too was eliminated because it was located over a vast aquifer. By mid-October, the AEC staff was working with the Army Corps of Engineers, Air Force, and the Geologic Survey to try and identify another site. A large government reservation in the Pocatello Area on the Snake River in Idaho was considered because, at that time, it housed the Naval Proving Ground operated by Atlantic Richfield Corporation (ARCO).

The site was closely reviewed in early 1949 and transferred to the AEC formally on March 1, 1949. This site is the current location of DOE's Idaho National Engineering Laboratory (INEL) which has seen a number of experimental reactors built and tested on the site over the years.

Research in the late 1940s resulted in the discovery of a new type of fissile material, tritium. Tritium could produce a more powerful thermonuclear weapon based on the energy released as a result of the fusion of light elements such as hydrogen (thus the term "H-bomb") as opposed to the fission of the heavier uranium and plutonium elements. The concept of a thermonuclear weapon had its beginnings in theories that were developed prior to the Manhattan Project. New emphasis was placed on the establishment of tritium reactors after detonation of the first Soviet nuclear device in August 1949.

The decision was made in early 1950 to expand the weapons complex to include tritium reactors. The location of the reactors was to be separate from the Hanford site due to the perceived growing vulnerability of the Pacific Northwest to Soviet attack and the desire not to disrupt production at Hanford. In 1950, the AEC invited Dupont to site the facility and subsequently design, construct and operate the reactors. The criteria for the new facility site were a low population density somewhere within the southern United States, and not within 100 miles of the Atlantic and Gulf Coasts. It was estimated that the site would require between 100 - 150 thousand acres (roughly 350 square miles).

During the site investigation phase, the AEC instructed Dupont to plan for four reactors instead of two, doubling water requirements for the site from 200 cubic feet per second to 400 and dropping the number of sites under consideration from 17 to seven. Later the AEC raised the potential number of reactors to six, which increased water requirements further and increased the required acreage to approximately 160,000 acres. On November 10, 1950, Dupont recommended South Carolina Site No. 5, 22 miles southeast of Augusta, Georgia on the Savannah River. The AEC commissioners met on November 27, 1950, to approve the selection of the Savannah River Site.

In January of 1951, construction crews poured into the Aiken, South Carolina area and quickly overwhelmed the capacity of the area to support them. The problem was so significant that a congressional hearing was held in February to determine whether the AEC had taken appropriate steps to ensure that there was adequate housing in the area. No blame was placed on the AEC conduct as a result of the Savannah River siting.

By the time the first Savannah River reactor went into operation in 1953, it was clear that the AEC had over-built the entire weapons complex. Austerity programs were being put into effect throughout the government that would require the AEC to either close one of the plants or delay construction at the plants. Subsequently, the sixth reactor was never built at the Savannah River Site. In addition, the AEC decided to alternate closings of individual reactors between the Hanford and Savannah River Sites over the years to reduce the economic impact associated with the shutdown of the sites. The first reactor was shut down at each site in 1964 and by early 1971 all of the Hanford reactors were shut down except for the "N" Reactor.

3.3 Gaseous Diffusion Plants

In parallel with the decision to construct new reactors, the AEC was planning to construct new gaseous diffusion plants. The new plants would ensure that an adequate supply of uranium-235 could be maintained in the event that one of the sites was not able to produce. In addition, the new plants would provide a more secure supply of uranium-235 through dispersion of the processes. The Korean War, which began in 1950, just one year after the first Soviet detonation of a nuclear weapon, heightened U.S. anxiety that they may be losing the nuclear advantage. Subsequently, a baseline goal was established to have two new gaseous diffusion plants in operation by November 1953.

The same criteria considered for selection of the Savannah River Site were also applied to the first gaseous diffusion plants. The task focused on areas with adequate housing and services, with a skilled work force, with a steady supply of water (preferably with a low mineral content) and without extreme temperature swings. The search was narrowed to three sites: the Kentucky Ordinance Works in Paducah, KY; the Louisiana Ordinance Plant at Shreveport, LA; and the Longhorn Ordinance Works at Marshall, TX. None of the three sites offered as much toward meeting the objectives of siting the facility as the Paducah Site. Therefore, on October 18, 1950, only nine days after President Truman had approved the expansion of the gaseous diffusion facilities, the AEC approved the Paducah Site for the construction of the facility.

Shortly after the selection of the Paducah Site, several problems arose that may have been avoided had the selection proceeded at a more cautious pace. For example, both of the electric contractors under consideration by the AEC presented problems. The first contractor was planning to supply electricity over too great a distance from the plant, creating the potential for shutdowns and security problems. The second contractor (TVA) planned to add two new generating units at its New Johnsonville Steam Plant, the same plant supplying the Oak Ridge Site. This would defeat much of the purpose of duplicating the functions of the Oak Ridge Plant. The issue was resolved on May 4, 1951, when a new contract was signed with Electric Energy, Inc., who agreed to build a new plant seven miles from Paducah.

In October 1951, the AEC authorized the search for a third gaseous diffusion plant. The AEC again worked with Stone and Webster Engineering Corporation to identify a suitable site for the facility. A major factor during the survey of the site was the population base. The AEC preferred not to repeat previous experiences that led to the establishment of new "government towns." The search focused on the Ohio River Valley, which was considered an excellent location for the plants for a number of reasons; Ohio is a dependable source of water, has immediate access to electrical power, and the availability of labor and services. In March 1952, the firm recommended Cincinnati, Ohio as the best location for the third gaseous diffusion site. The siting of the plant proved to be very political and the Cincinnati location was later eliminated due to labor problems at the Fernald Site (which will be discussed in the next section and Section 4). The second choice, Louisville, Kentucky, was eliminated due to very strong local opposition. Ultimately, the site, near Portsmouth, Ohio, was selected in August of 1952. Portsmouth labor unions were anxious for jobs in their area and were receptive to the site being located there. The precise location of the site was a 6500 acre tract of land 22 miles from Portsmouth, Ohio, on the Scioto River. The ultimate size of the site was reduced to 3700 acres, most of which was acquired by June 1953. By December 1953, construction of the site was underway.

3.4 The Fabrication and Assembly Facilities

Throughout the wartime Manhattan Project, the fabrication of high explosive (HE) components was done in a small shop in Los Alamos. In October 1950 it was recommended by the AEC's Division of Military Application (DMA) that an additional fabrication facility be constructed to match the output of the new gaseous diffusion plants and reactors. The DMA further recommended that the AEC acquire the Pantex Ordinance Works near Amarillo, TX and convert it to AEC specifications. The site was remote enough that a great number of people would not be disturbed during explosives testing and it was close enough to Amarillo, Texas for commuting. The Army concluded that they could not completely transfer the Pantex Plant to the AEC due to the potential need to reactivate the plant during the Korean War. Therefore, it was agreed that the AEC's contractor (Proctor and Gamble) would operate the plant under contract to the Army.

The AEC envisioned a total of five assembly sites to meet the output of the reactor facilities and gaseous diffusion plants after 1955. The Fluor Corporation was contracted to site the third facility. Fluor narrowed the choices down to the Weldon Springs Ordinance Works in Missouri and Camp Ellis near Spoon River, Illinois. The sites were relatively equal in terms of the criteria being considered. However, Fluor preferred the Camp Ellis Site and the AEC eventually agreed to the site because the Army had informed the AEC that it might have to restart operations at the Weldon Springs Site in the event of national mobilization. However, before construction plans were finalized for the site, it was determined that no more than two assembly plants would be necessary, and the plans for the Spoon River Site and the remaining two sites were abandoned.

In early 1951, the AEC determined the need for an alternate fabrication facility to duplicate the processes carried out at Los Alamos. Dow Chemical, the chosen contractor, was instructed to find a location in proximity to Los Alamos that offered attractive environs in order to compensate for the hazardous work that would be carried out at the plant. Two sites were considered for the facility: one north of Denver, Colorado near the Rocky Mountain Arsenal, and the other northwest of Denver at the Rocky Flats Site. The site to the north was eliminated because it would have to share power lines with the arsenal and because loose soil existed at the site, which would generate large amounts of dust. The Rocky Flats site was constructed on 6600 acres of privately owned land 17 miles northwest of Denver.

The primary function of Rocky Flats during the cold war was manufacturing nuclear trigger devices, or "pits." A "pit" is a hollow sphere of plutonium used to trigger a fission reaction in a nuclear warhead. The triggers were produced from plutonium metal that was extracted from reactors in Hanford and Savannah River. Once constructed, the triggers were sent to the Pantex facility in Texas for final assembly. Rocky Flats was also responsible for recycling plutonium retrieved from retired nuclear warheads. In addition, a machine shop produced other weapons parts from stainless steel, beryllium, depleted uranium and other metals. Since the conclusion of the cold war, Rocky Flats is no longer in production and is focused on the cleanup of contaminated areas. Large quantities of waste exist at the site, along with the largest stockpile of weapons grade plutonium in the United States (over 14 tons).

The production of initiators for nuclear weapons occurred at two facilities leased in Dayton and Oakwood, Ohio. The facilities were hastily established in 1943 under the name "Dayton Project." The facilities furnished initiators for weapons produced for the Manhattan Project. In 1945, it was decided that a new site providing greater capacity for initiator production was needed. Some consideration was given to moving the production of initiators to Oak Ridge; however, the reluctance of the workforce to relocate played a major role in the decision to keep the site in Dayton. By July 1946, Monsanto, which operated the Dayton facility, had designed a new underground facility per AEC's request. A 170-acre site was then acquired about 15 miles southwest of Dayton near Miamisburg, Ohio. By January 1949, all weapons initiator work was transferred to the new facility in Miamisburg and the other two operations (Dayton and Oakwood) were shut down.

In late 1955, General Electric was chosen to manufacture a special initiator that was considered to be an extremely urgent need. None of the original criteria were considered critical to the siting of the new facility. The primary considerations were that the facility be near a good work force and be in the best climate possible to ensure as few production interruptions as possible. The Pinellas Plant was sited on the Pinellas Peninsula in Tampa Bay, Florida, in 1955.

The operation of the reactor and gaseous diffusion plants required a variety of uranium "feed materials" which comprised several different chemical and physical forms of uranium. Prior to 1953, feed materials were produced at three separate locations: Mallinckrodt Chemical Works in St. Louis produced ore into uranium dioxide ("brown oxide"); the Harshaw Chemical Works in Cleveland processed the brown oxide into uranium hexafluoride ("green salt"); and the Union Carbide and Chemical Electro-Metallurgical Division Works in Buffalo, New York refined green salt into uranium metal. In 1950, the AEC reviewed the idea of a single consolidated processing facility containing a chemical processing component and a uranium metal refinery to supply feed materials to the rest of the weapons complex. The AEC authorized the siting and construction of a production plant with the goal of having it operational by January 1, 1953.

The New York Operations office of the AEC assigned the job of siting the new plant to its engineering contractor Catalytic Construction Company. The requirements established for siting the facility included the following:

- A stream flow of 500 cubic feet per second and a fast current to disperse effluent,
- an area of approximately one square mile of flat land,
- 30,000 kilowatts of electrical power,
- rail and highway connections, and
- a sufficiently skilled work force.

The Army Corps of Engineers was consulted for possible locations in the Ohio River Valley and the southern states, and delivered an initial list of twenty sites. However, these sites were all considered unacceptable as they contained existing ordinance works that were likely to be reactivated during the Korean War.

A second approach to the siting of the facility with smaller water requirements and an increased emphasis on available housing brought 34 sites into consideration. The railroad added another eight. Catalytic Construction inspected all of the sites and eliminated all but four in the Ohio-Indiana area. Out of those four, the two sites that were deemed best were the site near Fernald, Ohio and Terre Haute, Indiana site. The Fernald site (Figure 3-1) was chosen due to projected lower labor costs and property values. Additional attractions included its proximity to Cincinnati, and the fact that it was near the AEC "foci" for other sites made it extremely desirable. Also, it was centrally located for incoming ore shipments from the ports of New York and New Orleans.

The Weldon Spring site, which produced uranium feed material similar to Fernald, was originally acquired by the Department of Army in April 1941. The site was originally operated as an Ordinance Works by Atlas Power Company to produce trinitrotoluene (TNT) and dinitrotoluene (DNT). The site, which occupied 17,000 acres, was operational from November 1941 to January 1944. The Army declared the site surplus in April 1946, and by 1949, 5,000 acres of the site had been transferred to the State of Missouri and became the Busch Memorial Wildlife Refuge and the University of Missouri for agricultural use. A portion of the remaining land became a U.S. Army Resource and National Guard Training Area, and about 220 acres were transferred to the AEC in May 1955 and became the Weldon Spring Uranium Feed Materials Plant.

Uranium and thorium ore concentrates were processed at the plant from June 1957 to December 1966. Mallinckrodt Chemical Works acted as the AEC operating contractor during the production years. During production, an average of 16,000 tons of uranium material were processed per year to make uranium trioxide, uranium tetrafluoride and uranium metal. In addition, a small amount of thorium was also processed at the plant. A 15-acre tract of the site was committed to waste disposal. The plant was shut down as part of the scaling back of the weapons complex and production of feed material was carried out only at the Fernald site. The Army re-acquired the chemical plant in 1967 and initiated decontamination and dismantling in January 1968 to prepare the plant for an anticipated conversion to an herbicide plant. However, this project was canceled in February 1969. In 1975, the AEC contracted National Lead Company of Ohio to perform environmental monitoring and maintenance of the waste disposal areas. The site was placed on the CERCLA National Priorities list in July 1987, and environmental restoration of the site is currently ongoing.

4.0 THE FERNALD SITE

The AEC established the Fernald site for processing uranium and its compounds from natural uranium ore concentrates and recycled recoverable residues for government needs. In 1951, National Lead Company of Ohio (now NLO Inc.) entered into a contract with the AEC as Operations and Management Contractor. This contractual relationship continued with AEC, and subsequently with the DOE, until January 1, 1986. Westinghouse Materials Company of Ohio, a wholly owned subsidiary of Westinghouse Electric Corporation, then assumed management responsibilities of the site operations and facilities for a minimum of five years. In 1991, Westinghouse renamed this subsidiary the Westinghouse Environmental Management Company of Ohio (WEMCO). A new contractor, Fernald Environmental Restoration Management Corporation (FERMCO), assumed management responsibilities for the environmental cleanup and restoration of the facility on December 1, 1992.

4.1 Construction

Once the location of the Fernald site was chosen, construction of the plants and support facilities was soon initiated. The George A. Fuller Company was awarded the construction contract and ground was broken in May 1951 (Figure 4-1). Several properties were acquired prior to construction activities. Some of the houses and buildings acquired were used as construction offices for the AEC, the George A. Fuller Construction Company, and the Catalytic Construction Company, who was contracted as the architect/engineer design firm for the Fernald site. Other houses were moved from the Fernald site boundaries as appropriate, or used by AEC (Figures 4-2, 4-3).

The presence of the Catalytic Construction Company was increased dramatically because of the need to construct the facilities while engineering work was still in progress. The AEC directed the George A. Fuller Company to proceed with construction upon receipt of drawings that had reached the 70% stage. This resulted in a substantial increase in the number of field inspectors needed at the Fernald site. Also, a stronger presence of design engineers was required in order to answer engineering questions in the field. The Catalytic Construction Company created a "job engineer" position that coordinated projects and acted as a clearinghouse for all data on specific jobs. This approach was successful in expediting the construction of the Fernald site in the fastest manner possible (Catalytic Construction Co., 1953).

Startup of Fernald site operations was conducted on a plant-by-plant basis. As construction of each production plant was completed, the processes were tested and the operation began. The Pilot Plant was the first of the production plants to be put into operation in October 1951, just five months after ground breaking at the Fernald site (Fig. 4-4). Operation at the Metals Fabrication Plant (Plant 6) began in the Summer of 1952. Plant 5, the Metals Production Plant, was operational in May 1953, while Plant 1, Plant 2/3, and Plant 4 began operating in the Fall of 1953. The last plants to begin operating at the Fernald site were Plants 7 and 9. Both were operational by Fall 1954 (DOE, 1985).

By the time construction was complete, the Production Area encompassed 136 acres, 19 of which were under roof. Four miles of railroad tracks were installed, and 24 acres of paved roads and storage areas were constructed. This is the equivalent of a 20-mile stretch of highway (Figure 4-5), (Catalytic Construction Co., 1953).

4.2 Production Process

The primary mission of the Fernald site was to produce uranium metal products as feed materials in the AEC/DOE weapons production program. The Fernald site was not a nuclear reactor, nor were explosive devices, nuclear weapons, or highly radioactive materials produced or handled at any time. The feed materials produced at the Fernald site included derbies, ingots, billets, and fuel cores. This was accomplished as described below. Figure 4-6 provides a schematic diagram of the Fernald site production process. For a more detailed description of the production processes of the buildings at the Fernald site, refer to the report titled "Historical Report of The Facilities and Structures at The Fernald Site."

The production process at Fernald began with the purification of uranium contained in materials recycled from production and/or received from other sites (Figure 4-7). Scrap metals generated on site or received from other sources were also refined for production.

In the early years of production, uranium ores were processed, including pitchblende ore from the Belgian Congo. This source contained radium and required a separate processing stream for purification. The incoming uranium sources were received, weighed, sampled, and stored at the Sampling Plant (Plant 1). The materials were dried, ground, and classified by type using crushers, mills, and samplers. The materials were then drummed and transported to Plant 2/3 for further processing (DOE, 1985).

Plant 2/3, the Ore Refinery, is where incoming materials from the Sampling Plant were converted to uranium trioxide (UO_3 or "orange oxide"). Initially, the materials from the Sampling plant were dissolved in nitric acid to produce a crude uranyl nitrate hexahydrate solution (UNH) for solvent extraction purification. Purified UNH was concentrated by evaporation and was thermally denitrated to UO_3. The orange oxide from Plant 2/3 was loaded into portable metal hoppers and transported to Plant 4, the Green Salt Plant.

Within Plant 4, orange oxide was converted to uranium tetrafluoride (UF_4), or green salt, for reduction to metal. As an intermediate step, UO_3 was converted to uranium dioxide (UO_2), or brown oxide, by reducing it with hydrogen. The brown oxide was then reacted with anhydrous hydrogen fluoride to produce UF_4. Green salt was also produced at the Fernald site from uranium hexafluoride (UF_6) received from other AEC/DOE sites. Once the UF_4 was produced, it was packaged in 10-gallon cans for reduction to uranium metal in the Metals Production Plant (Plant 5), (DOE, 1985).

To begin metal production, UF_4 was blended with magnesium granules and placed in a closed reduction pot. The reduction pot was heated in a furnace until the contents reacted to produce uranium metal shaped in forms called derbies, weighing up to 1,400 pounds. Some derbies were sent directly to other AEC/DOE sites; most, however, were cast into ingots at the Fernald site. Ingots were formed by melting derbies, along with metallic scrap and briquettes recycled from earlier production and fabrications, in a graphite crucible. When the molten metal reached the proper temperature, it was bottom poured into a graphite mold to form ingots (DOE, 1985).

In the Metals Fabrication Plant (Plant 6), and the Special Products Plant (Plant 9), uranium metal ingots were machined to exacting specifications as required by other AEC/DOE sites. Some ingots were shipped offsite for extrusion and returned to the Fernald site for heat treatment and final machining. The exact size and shape of the finished product depended on the needs of the other AEC/DOE sites (DOE, 1985). Several different types of finished products were produced at the Fernald site, as discussed below.

Small amounts of thorium were produced at Fernald on several occasions from 1954 through 1975. Thorium operations were performed in the Metals Fabrication Plant (Plant 6), the Recovery Plant (Plant 8), the Special Projects Plant (Plant 9), and the Pilot Plant (DOE, 1985). The Fernald site currently serves as the thorium repository for the DOE and maintains long-term storage facilities for a variety of thorium materials.

4.3 Products from the Fernald Site

Throughout the years, products from the Fernald site have been used at many different AEC/DOE facilities (Figure 4-7). Feed materials produced at the Fernald site were utilized by three major "customers" within the AEC/DOE weapons complex. From 1952 through 1976, depleted, normal, and enriched uranium cores and fuel elements were fabricated for both the Hanford and Savannah River sites. From 1976 until the halt of production in 1989, the main products were depleted uranium fuel elements for the Savannah River site, enriched extrusion ingots/billets for the Hanford site, and derbies for Oak Ridge and Rocky Flats, along with slab billets for Rocky Flats. Depending on the specifications, fuel cores were either solid or hollow, with a specified inner and outer diameter (I&E). Figure 4-8 shows examples of the types of fuel cores produced for the different AEC/DOE sites. The production of feed materials for each of these sites is detailed below.

4.3.1 Products for Hanford

The Fernald site produced fuel cores for reactors at the Hanford site. As discussed previously, the Hanford site reactors were tasked with producing plutonium for use in the fabrication of weapons. Each reactor at the Hanford site required a different size fuel core. Solid fuel cores were used at the Hanford site from 1953 to 1957, when I&E type cores were used instead. Production of I&E type cores continued, with minor changes in dimensions, until the last K-Reactor was closed in 1971. Approximately 50% of the cores produced for the Hanford site were composed of enriched uranium (DOE, 1985).

A different type of feed material was sent to the Hanford site in 1962. New Production Reactor (NPR) billets were produced until the late 1980s. Ingots cast at the Fernald site were shipped to Reactive Metals, Inc. (RMI) in Ashtabula, Ohio, where billets were produced. From RMI, the finished billets were sent directly to the Hanford site (DOE, 1985).

Shipments of fuel cores from the Fernald site peaked in 1960, when eight reactors were in operation at Hanford. As reactors at Hanford were shut down, shipments from Fernald decreased. By 1971, Fernald shipped roughly 6% of the amount of feed material produced in the early 1960s.

Shipments of finished fuel elements to the Hanford site were discontinued in 1972, except for the NPR billets fabricated and shipped directly to the Fernald site from RMI (DOE, 1985).

4.3.2 Products for Savannah River

Fuel cores for the Savannah River site consisted of the following. Solid type fuel cores, known as Mark I, were produced from 1953 to 1957. Fernald site shipments totaled 13,105 MTU. This stream was changed to an I&E type from 1957 to 1961, when the Mark VII program was initiated. After 4,605 MTU of Mark VII fuel cores were shipped to the Savannah River site, a tube-in-tube type fuel element program was initiated in 1961. This program took place from 1961 through 1968, in what was known as the Mark V program. The Mark V program resulted in a total of 11,510 MTU shipped to the Savannah River site. Yet again, the feed material requirements changed in 1968 when the Mark XXX target element replaced the Mark V tube-in-tube element. A total of 4,765 MTU of Mark XXX target elements were shipped from 1968 until 1972, when the Mark XXXI program was initiated. By the mid-1980s, over 15,000 MTU of Mark XXXI target elements were produced for the Savannah River site. Approximately 16% of the fuel cores produced for the Savannah River site were of the enriched uranium type (DOE, 1985).

4.3.3 Products for the Gaseous Diffusion Plants, Y-12, and Rocky Flats

Other sites within the AEC/DOE weapons complex received various intermediate products from the Fernald site, including UO_3, UF_4, and uranium metal derbies. The gaseous diffusion plant at Paducah, Kentucky received over 35,000 MTU of UO_3 from the Fernald site between 1971 and 1977. Over 5,500 MTU of derbies were shipped to the Y-12 Plant in Oak Ridge, Tennessee, starting in 1975 and continuing through the 1980s. Depleted uranium metal was sent to Rocky Flats beginning in 1975. By the mid-1980s, over 4,800 MTU of depleted metal was produced at the Fernald site for use at Rocky Flats (DOE, 1985).

4.3.4 Work-for-Others Products

The objective of the "Work-for-Others" program was to make use of the expertise of the Fernald site staff and operating personnel and the available production facilities. This was conducted in order to assist other DOE sites, governmental agencies, and private industry so that related uranium technology programs that were mutually beneficial could be extended to the sites concerned. The facilities of the Fernald site were used when justification was submitted that satisfied one or more of the following criteria: 1) the private sector could not do the work; 2) there were comparatively unreasonable costs within the private sector; or 3) there were excessive time requirements within the private sector. Justification for Work-for-Others projects were reviewed on a case-by-case basis (DOE, 1985).

Sites that have utilized the capabilities of the Fernald site through the Work-for-Others program include: the Y-12 Plant, Oak Ridge National Laboratory, Rocky Flats, Sandia Laboratories, Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Mound Laboratory, the Savannah River Site, and the Department of Defense. A variety of products were produced for these sites. Examples include armor-piercing depleted uranium missile components and uranium ballasts for Sandia National Laboratory (DOE, 1985).

Large quantities of liquid and solid wastes were generated by the various operations at the Fernald site. Wastes generated were often hazardous, radioactive, or both (termed "mixed" waste). Over the years, wastes were stored at various locations around the Fernald site. Drummed wastes continue to be stored throughout the production area. Other wastes are stored in various impoundments, including Solid Waste Landfill, the North and South Lime Sludge Ponds, the Inactive and Active Flyash Piles, and the South Field Disposal Area (Figure 4-9). Site operations and the associated storage and/or disposal of these and other wastes slowly led to the contamination of soil, groundwater, and structures at the Fernald site. This gradual degradation of the Fernald site and its natural resources was one factor in the eventual shutdown of production activities in 1989. The primary mission of the Fernald site changed from feed materials production to environmental restoration, as described in the next section.

5.0 ENVIRONMENTAL RESTORATION

On March 9, 1985, the U.S. Environmental Protection Agency (EPA) issued a Notice of Noncompliance to the DOE, identifying the EPA's major concerns over potential environmental impacts associated with the Fernald site's past and present operations. Between April 1985 and July 1986, conferences were held between DOE and EPA representatives to discuss the issues and to identify the steps the DOE proposed to achieve and maintain environmental compliance.

On July 18, 1986, a Federal Facility Compliance Agreement (FFCA) pertaining to environmental impacts associated with the FEMP site was signed by the DOE and the EPA. The FFCA was entered into pursuant to Executive Order 12088 (43 FR 47707) to ensure compliance with existing environmental statutes and implementing regulations such as the Clean Air Act, the Resource Conservation and Recovery Act (RCRA), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In particular, the FFCA was intended to ensure that environmental impacts associated with past and present activities at the FEMP site are thoroughly and adequately investigated so that appropriate remedial response actions can be formulated, assessed, and implemented. In response to the FFCA, a Remedial Investigation/Feasibility Study (RI/FS) was initiated pursuant to CERCLA, as amended by Superfund Amendments and Reauthorization Act (SARA).

A Work Plan for the site-wide RI/FS, based on the requirements of the FFCA, was originally submitted to the EPA in December 1986. After a series of technical discussions, the Work Plan was modified and resubmitted in March 1988. It received EPA approval in May 1988.

The Work Plan identified 27 units of the Fernald site to be investigated in the RI/FS. Several modifications to the list eventually increased this total to 39 units. During the course of the investigation, it became apparent for technical and program management purposes, that these 39 units needed to be categorized and grouped together. The concept of operable units was introduced into the program to allow the remedial action process to proceed to completion for the most well-defined or problematic units, while data collection and analysis continued for other operable units.

The 1986 FFCA was amended by a Consent Agreement under Sections 120 and 106(a) of CERCLA (Consent Agreement) in order to achieve consistency with the operable unit (OU) concept and the commitments of the RI/FS program without modifying the underlying objectives. The Consent Agreement was signed on April 9, 1990 and became effective on June 29, 1990.

The Consent Agreement was itself amended the next year to revise the schedules for completing the RI/FS for the five operable units. The site was divided into five operable units which are shown in Figure 5-1 and defined as follows:

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

Each of these operable units has completed a RI/FS process (e.g., five individual RI/FS documents). The Amended Consent Agreement, signed on September 20, 1991, and effective December 19, 1991, added a Comprehensive Site-Wide Operable Unit (OU) designed to evaluate the remedies selected for the five operable units on a site-wide basis.

5.1 The Fernald Site RI/FS Process

The RI/FS process was conducted in accordance with the basic methodology outlined in the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, the *National Contingency Plan* (NCP), and the requirements outlined in CERCLA as amended by Section 121 of SARA. The RI/FS guidance, the provisions of SARA Section 121, and the NCP were used as the basis for development of FEMP site RI/FS documents. The NCP states:

> *The appropriate extent of remedy shall be determined by the lead agency's (i.e., DOE's) selection of a cost-effective remedial alternative that effectively mitigates and minimizes threats to, and provides protection of public health and welfare and environment. Except as provided in 300.68(I)(5), this will require selection of a remedy that attains or exceeds applicable or relevant and appropriate Federal public*

health and environment requirements that have been identified for a specific area [40 CFR 300.68(l)(1)].

The Feasibility Study (FS) process emphasizes the development of remedial alternatives that meet the following conditions:

- Protect human health and the environment,
- provide permanent solutions and long-term effectiveness to contamination problems, and
- meet Applicable or Relevant and Appropriate Requirements (ARARs).

The purpose of the FS is to develop and evaluate a range of remedial alternatives that will protect the public and the environment from risks associated with the Fernald site. Additionally, the FS provides sufficient information on the alternatives developed to allow evaluation of residual risks for the entire site.

An evaluation of residual risks at the Fernald site is mandated by the Amended Consent Agreement which requires that each operable unit's FS include a Comprehensive Response Action Risk Evaluation (CRARE).

The purpose of the CRARE is to enable evaluation of cumulative risks for each operable unit's selected remedial action with regard to residual risks remaining after remediation at the Fernald site is complete. The CRARE for each OU must include consideration of the following:

- Anticipated use of the Fernald site property immediately after implementation of the response actions, and
- future use scenarios.

5.2 Feasibility Study Process

The following steps were taken in Fernald site FSs:

- Establish remedial action objectives (RAOs) .
- Identify ARARs.
- Develop preliminary remediation goals, which included a description of the risk assessment exposure scenarios and the chemicals of concern.

- Identify general response actions to meet RAOs, including no action.
- Identify remedial technologies and process options under each general response action with emphasis on permanent solutions.
- Screen remedial technologies and process options based on technical implementation.
- Evaluate remedial technologies based on effectiveness, implement ability and cost.
- Develop remedial alternatives based on remedial technologies and process options.
- Screen remedial alternatives according to effectiveness, ability to be implemented and cost.
- Perform a detailed evaluation of the remedial alternatives based on: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and performance; reduction of toxicity, mobility or volume; short-term effectiveness; ability to be implemented and cost.
- Perform a comparative evaluation between remedial alternatives.

State and community acceptance also are considered, but not until the RI/FS process reaches the Record of Decision (ROD) phase.

5.3 NEPA Compliance

An additional purpose of the FS is to provide National Environmental Policy Act (NEPA) analyses of environmental impacts of the proposed remedial actions.

The Remedial Investigation (RI) reports include discussions and data related to floodplains and wetlands, threatened and endangered species, population and land use, etc. The FS report includes sections which summarize the data provided in the RI. The site-wide database required for analyses of potential impacts of site-wide remedial activities is contained in the Site-Wide Characterization Report (SWCR) and incorporated into succeeding documents by reference.

This approach was in accordance with the DOE's intent to integrate the requirements of NEPA and CERCLA as set forth in DOE Order 5400.4. The specific NEPA/CERCLA integration approach for the FEMP site was published in the Notice of Intent (55 Federal Register 20183, May 15, 1990), which concluded that:

- Environmental Impact Statement (EIS) is the appropriate level of NEPA documentation for the lead OU.
- NEPA/CERCLA integration will also be provided in the remaining OU RI/FS documents. These documents will be "tiered to" (or reference) the lead RI/FS-EIS (OU 4) and will present impacts specific to the operable units. The EIS sections of each RI and FS report also will update site-wide and cumulative impacts, as necessary.

Then in June 1994, the DOE signed a revised NEPA Policy Statement which streamlined the existing process even more. Implications of this new policy were minimal relative to RI/FS documentation.

DOE prepared a Programmatic Environmental Impact Statement (PEIS) to assess broad issues and integrated approaches to the DOE's nationwide environmental restoration and waste management activities. The FEMP site will be considered within the PEIS, because the site requires environmental restoration that will involve disposing of large volumes of radioactive, hazardous, and mixed waste. Thus, the PEIS may have an impact on disposal alternatives and planning for potential interim storage of these wastes at the FEMP site.

5.4 RD/RA

The conclusion of the CERCLA RI/FS process and NEPA process for each OU at Fernald is the selection of a preferred alternative. In the case of the Fernald Site, since CERCLA is the primary driver for cleanup of the site, each of the integrated CERCLA/NEPA processes has resulted in the selection of the preferred alternative in the form of a remedy (or remedial action) for each portion of the site cleanup. Remedies have been selected through the issuance of a ROD for OUs 1, 2, 4, and 5 and an Interim ROD (IROD) has been issued for OU 3 (with issuance of the final ROD specified in 1996).

The remediation of the Fernald Site will involve the decommissioning and decontamination (D&D) of all contaminated structures on the site by approximately the year 2005. The

Advanced Wastewater Treatment Plant (AWWT) and other administrative buildings will be left in place for a period of time after that for limited activities. While the existing facilities are being taken down, several facilities necessary to support remediation of the site will be constructed. The On-Site Disposal Facility (OSDF) will be constructed in phases over the ten year period. Fernald site waste material that meets the waste acceptance criteria will remain on-site in the OSDF. Other facilities and structures will be constructed as well, including an upgraded rail yard to support the shipment of waste off-site and a vitrification plant for OU 4 Wastes.

The selected remedy for OU 1 (Waste Pits) is to remove all material from the waste pits, stabilize the material by drying and shipping it off-site for disposal. The remediation of OU 2 (Other Waste Units) will involve removing material from the units (e.g., inactive flyash piles, lime-sludge ponds), disposing of material that meets the on-site waste acceptance criteria in the OSDF, and shipping all other material off-site for disposal. The remediation of OUs 1 and 2 is scheduled for completion by approximately the year 2004. As stated above, the remediation of OU 3 will involve the D&D of all contaminated structures and buildings at the Fernald Site as stipulated in the IROD. The remaining OU 3 waste material will be recycled if possible; if the material is contaminated and meets criteria for disposal in the OSDF, it will be dispositioned there; otherwise, it will be shipped off-site for disposal. The remediation of the waste silos (OU 4) will involve the removal of all material from the silos, vitrification (i.e., glassification) of the material and disposal at an off-site disposal facility. Completion of OU 4 remediation is scheduled for approximately the year 2004. The remaining contaminated soil, water and vegetation will be addressed by OU 5. As waste units and structures are remediated in the other OUs, remediation of any underlying contaminated soil will follow. Again, material meeting the on-site waste acceptance criteria will be disposed of in the OSDF and all other material will be shipped off-site with completion scheduled to occur by approximately the year 2006.

Once site remediation is complete, the process of restoring the site will occur for whatever final land-use is deemed necessary by the numerous stakeholders at the site. A number of groups such as the Fernald Citizens Task Force, Fernald Natural Resource Trustees, Community Reuse Organization and the general public will "have a say" in what happens at the Fernald site. It is also important to note that remediation levels at the site will limit final land-use. For example, residential and agricultural uses will not be permitted at the site. However, other uses such as greenspace, wildlife management areas, and light industrial use will be possible and will be determined through extensive consultation between DOE and Stakeholders.

The Fernald site played an important role within the Nuclear Weapons Complex. From 1952 through 1989, the Fernald site met the challenge of producing high-purity uranium metal to exact specifications for use at other DOE sites. As the Cold War came to an end, Fernald was faced with an entirely different yet equally important mission. The Fernald site must now meet the challenge of environmental restoration, for the community and the environment.

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GLOSSARY

Billet - the form of uranium metal that results from cropping ingots and that is further machined within Plant 6, Plant 9, and/or off-site to produce a final product.

Blanking - the cutting of extruded uranium tubes into specific lengths for further machining.

Brown Oxide - uranium dioxide, UO_2, an intermediate product in the conversion of UO_3 to UF4 within Plant 4.

Calcination - the chemical process used within Plant 2/3 and Plant 8 where materials are roasted in order to change the chemical composition.

Comprehensive Environmental Response, Compensation, and Liability Act - the Federal law that governs the cleanup of hazards, toxic, and radioactive substances.

Core - a fuel core; the target material in DOE production reactors. This was the primary use of the uranium metal produced at the Fernald site.

Denitration - the chemical process used within Plant 2/3 where uranyl nitrate is calcined to produce UO_3.

Depleted Uranium - uranium that has been stripped of most of the Uranium-235 isotope.

Derby - the mass or uranium metal formed during the Plant 5 reduction process.

Digestion - the chemical process used within Plant 2/3 where impure uranyl nitrate is produced from mixing incoming uranium-bearing materials with nitric acid.

Enriched Uranium - uranium that has an increased percentage of U^{235}. At the Fernald site, enriched uranium usually consisted of approximately 1.25% U^{235}. In some cases, uranium was enriched to 10% U^{235}.

Enrichment - the process of separating different isotopes of elements, such as the separation of U^{235} from U^{238}.

Extrusion - the process by which billets are converted into tubes of various inner-diameter and outer-diameter dimensions.

Extraction - the chemical process used within Plant 2/3 where uranyl nitrate is purified.

Feed Material - Purified and formed uranium metal that is machined to exact specifications for use at the other DOE sites.

Fission - the splitting of the nucleus of a heavy atom like uranium or plutonium with a neutron which causes the release of more neutrons and large amounts of energy.

GLOSSARY
(Cont'd)

Thorium - a radioactive element that is a by-product of the decay or uranium.

Transite - a commercial brand name of asbestos-containing material historically used throughout the Fernald site as siding and roofing material for production facilities.

Uranium - a dense, sightly radioactive, naturally occurring metal that is the basic material for nuclear technology.

Uranium Trioxide - an intermediate product in the uranium metal production process, often referred to as "orange oxide" or UO_3.

Uranium-235 - an isotope of uranium that makes up less than 1% of naturally occurring uranium.

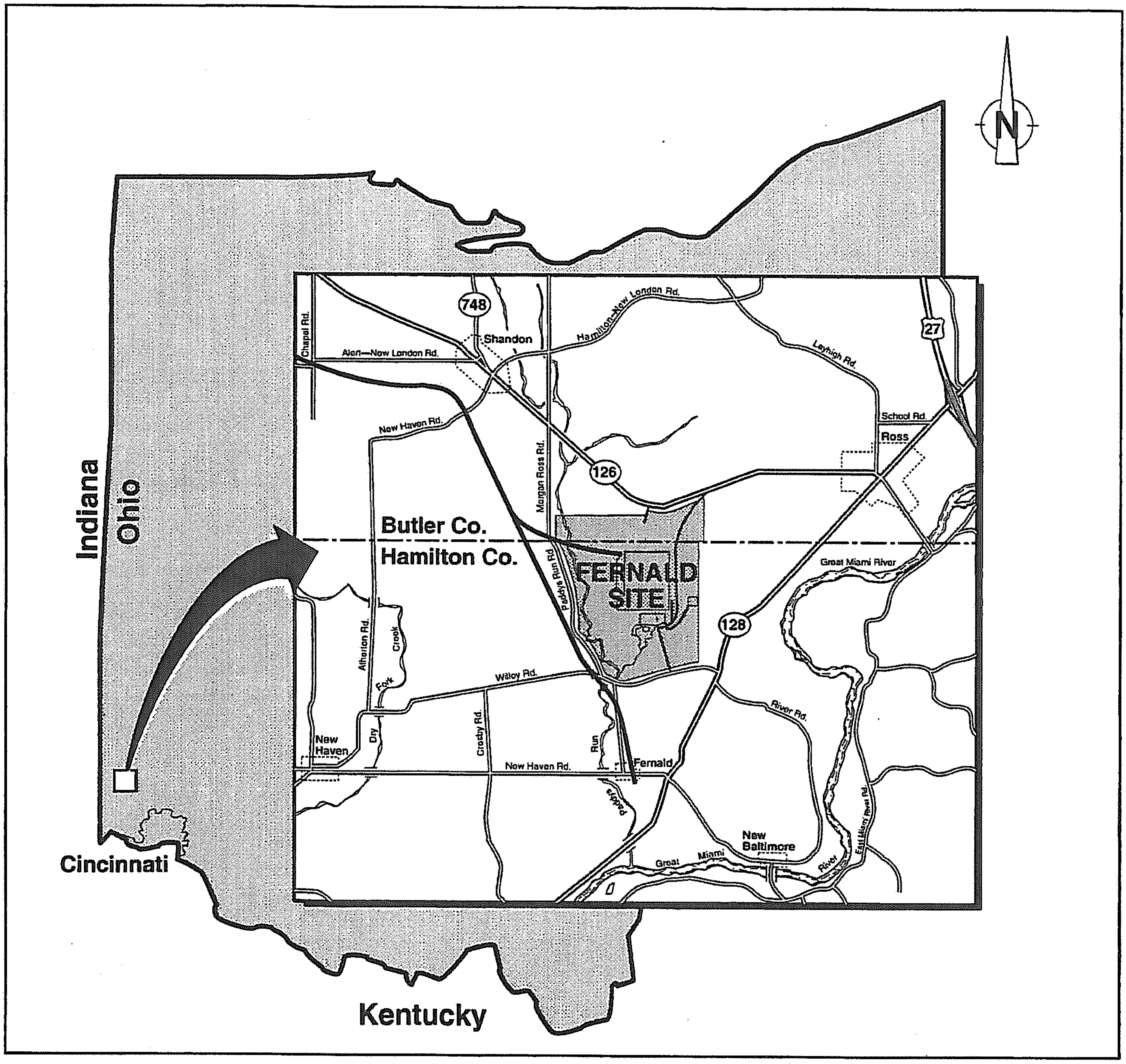
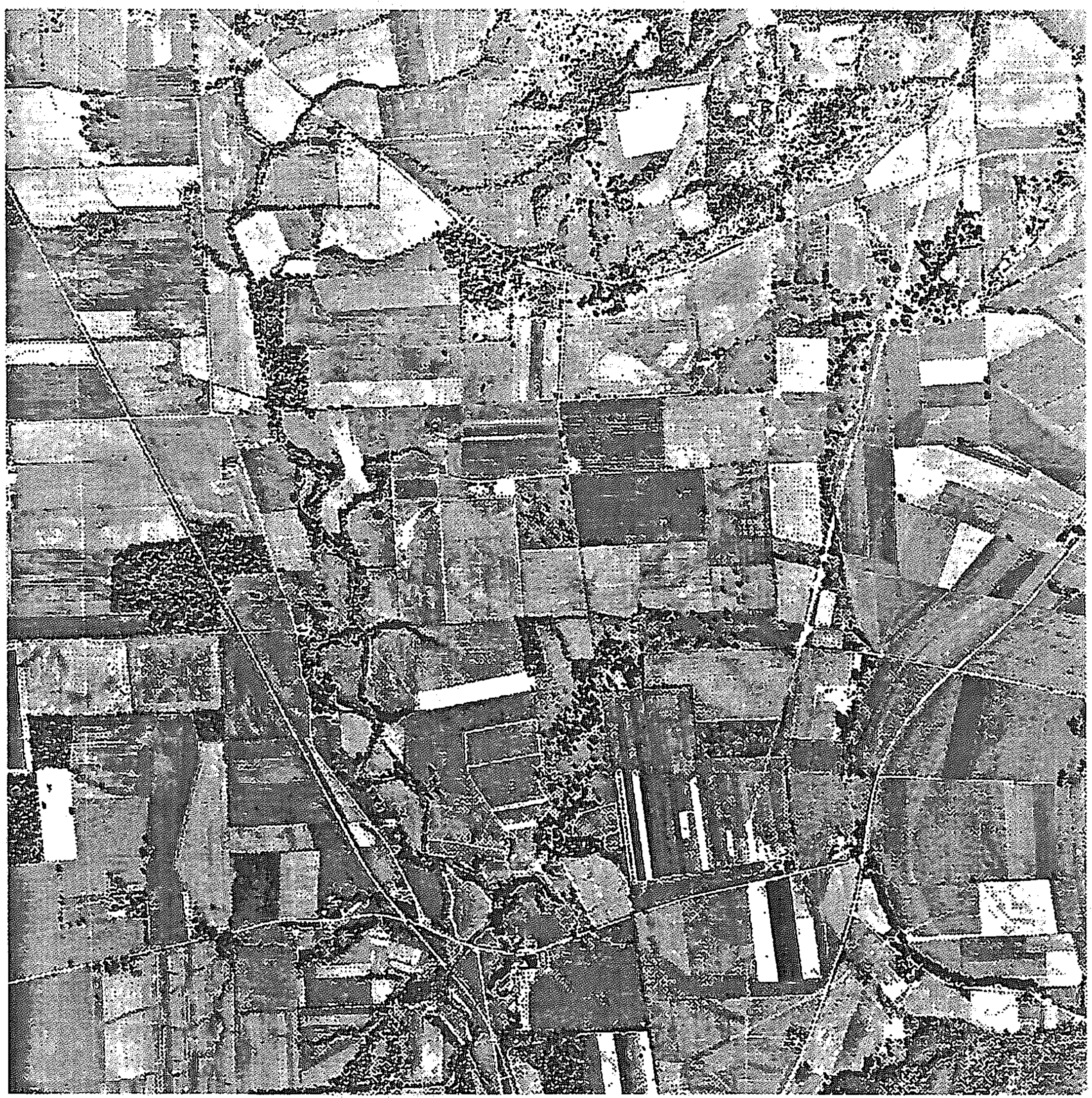


FIGURE 1-1
The Fernald Site Vicinity

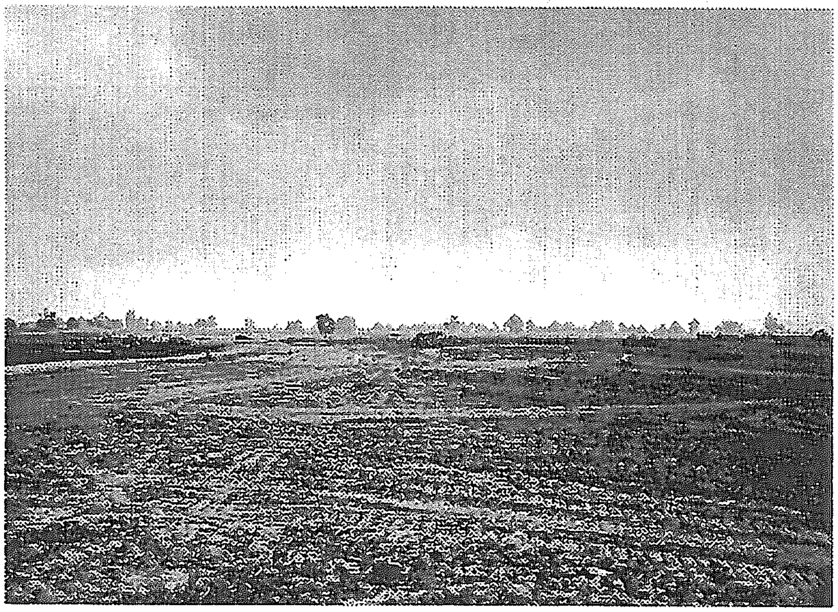
Graphics #5039A.1



5808-1

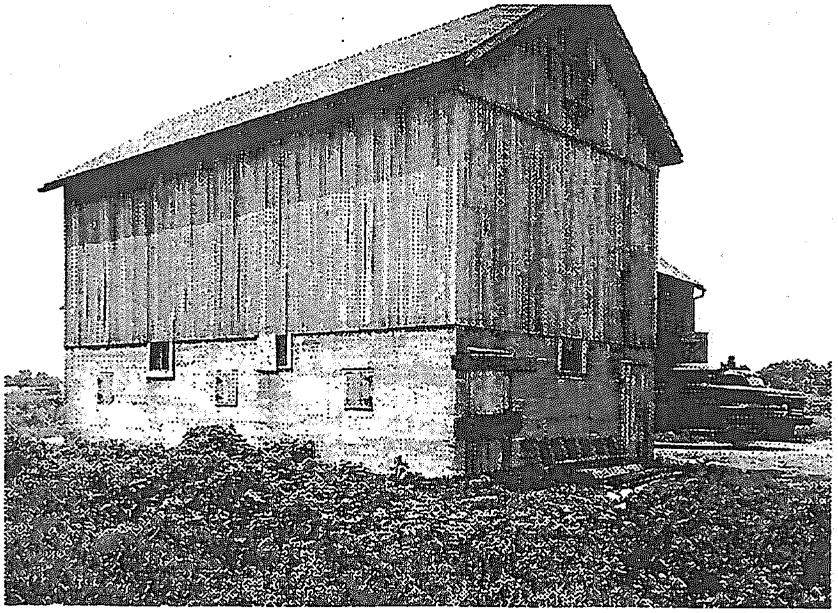
FIGURE 3-1
Aerial Photograph of the Fernald Site (ca. 1950)

Graphics #5039A.2



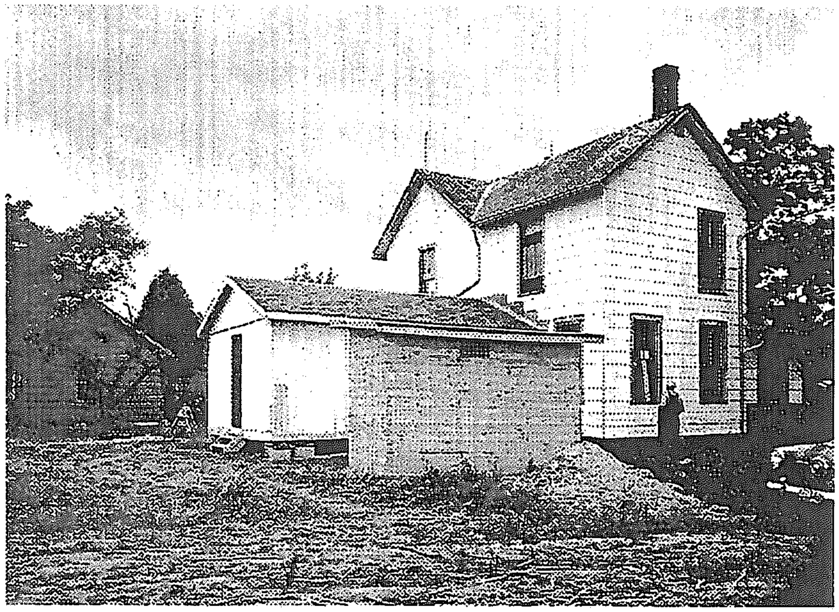
6335-8

FIGURE 4-1
Construction of the Fernald Site (ca. 1951)



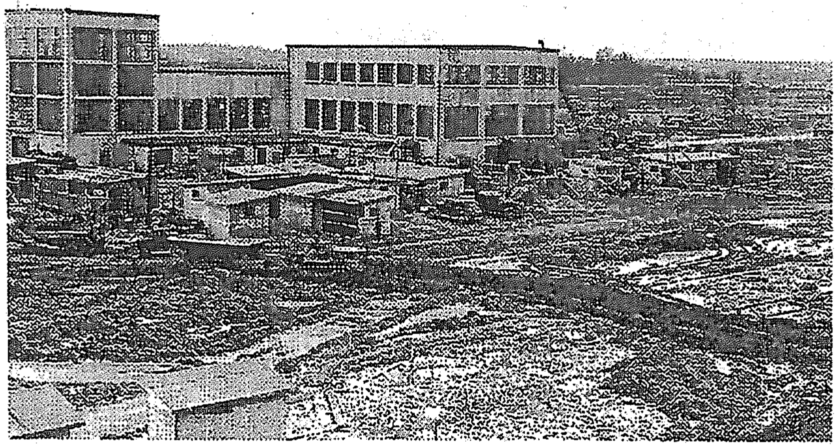
6335-12

FIGURE 4-2
Use of Existing Houses for Office Space (ca. 1951)



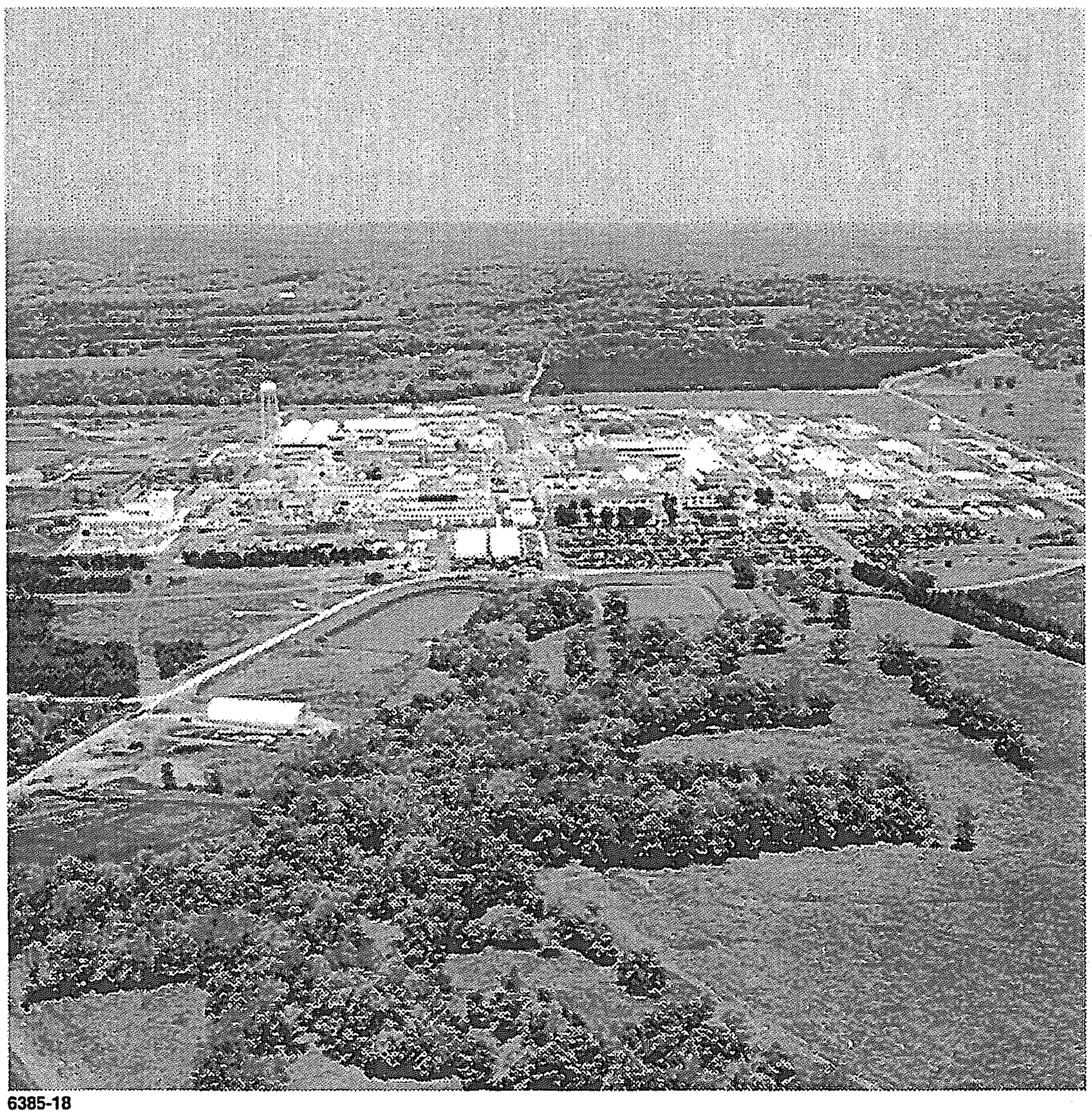
6335-18

FIGURE 4-3
Use of Existing Houses for Office Space



6335-231

FIGURE 4-4
Construction of Pilot Plant (ca. 1951)



6385-18

FIGURE 4-5
South View of the Fernald Site (1995)

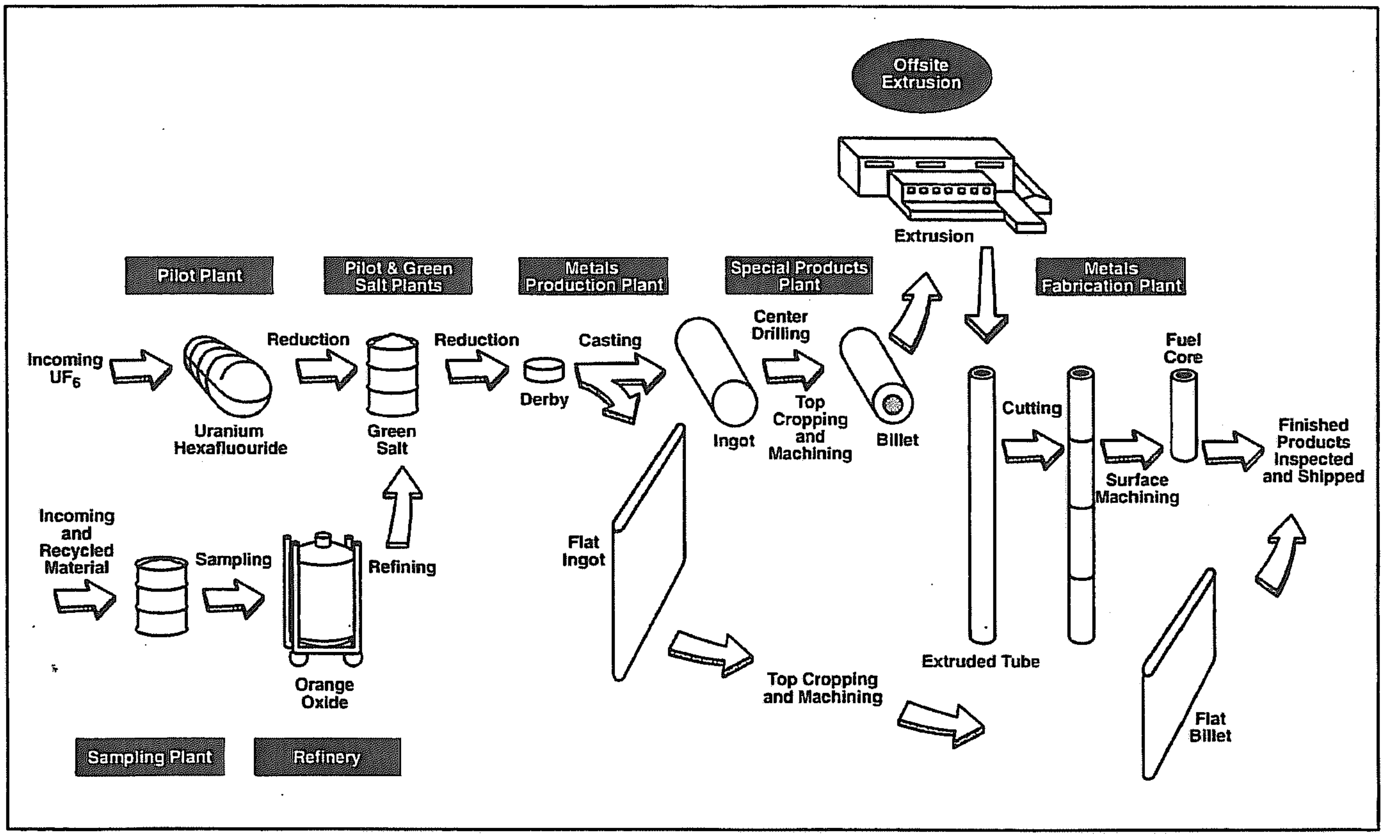


FIGURE 4-6
Schematic of the Production Process

Graphics #5039A.6

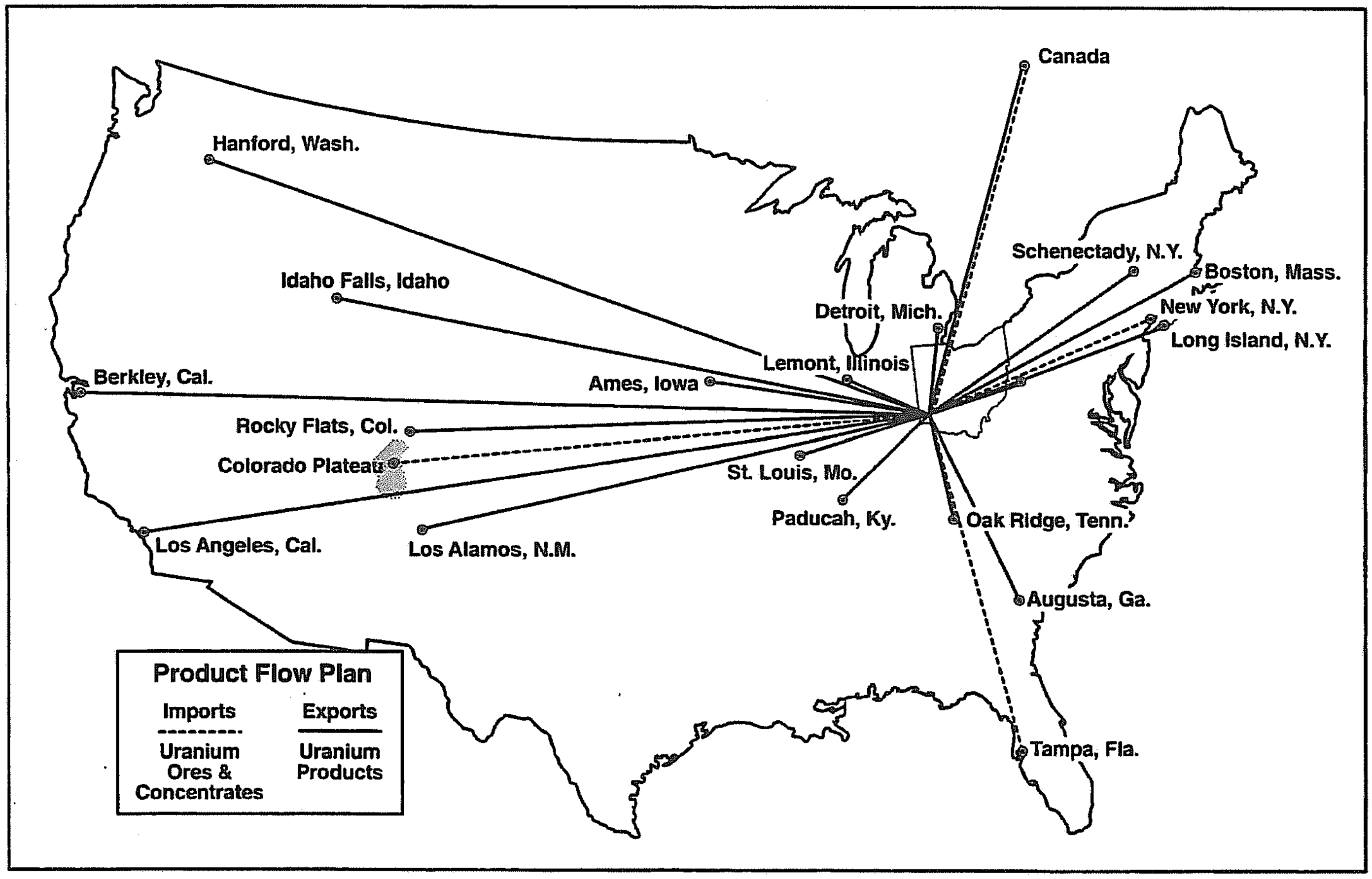
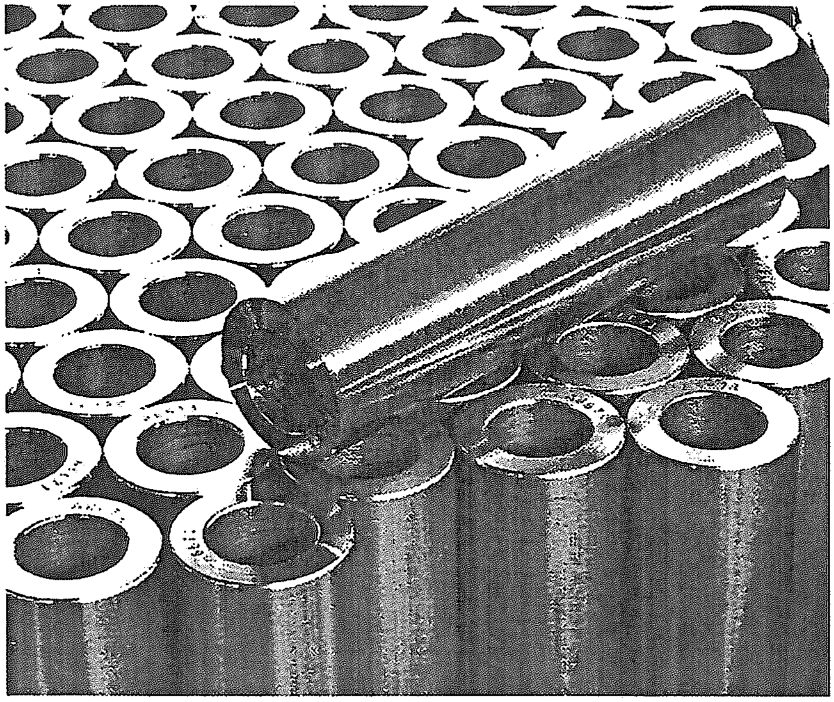


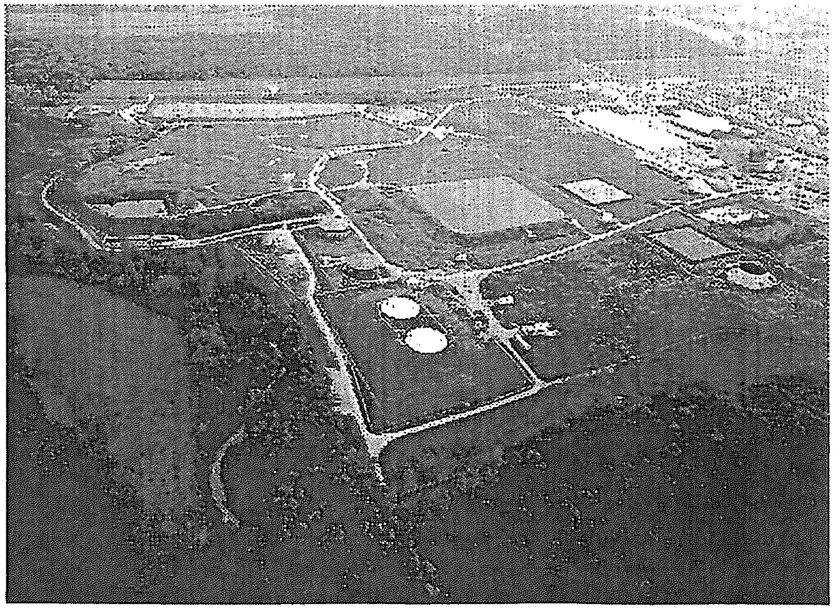
FIGURE 4-7
Shipment of Products from the Fernald Site

Graphics #5039A.7



6335-9

FIGURE 4-8
Products of the Fernald Site



6335-13

FIGURE 4-9
Aerial View of the Waste Storage Area

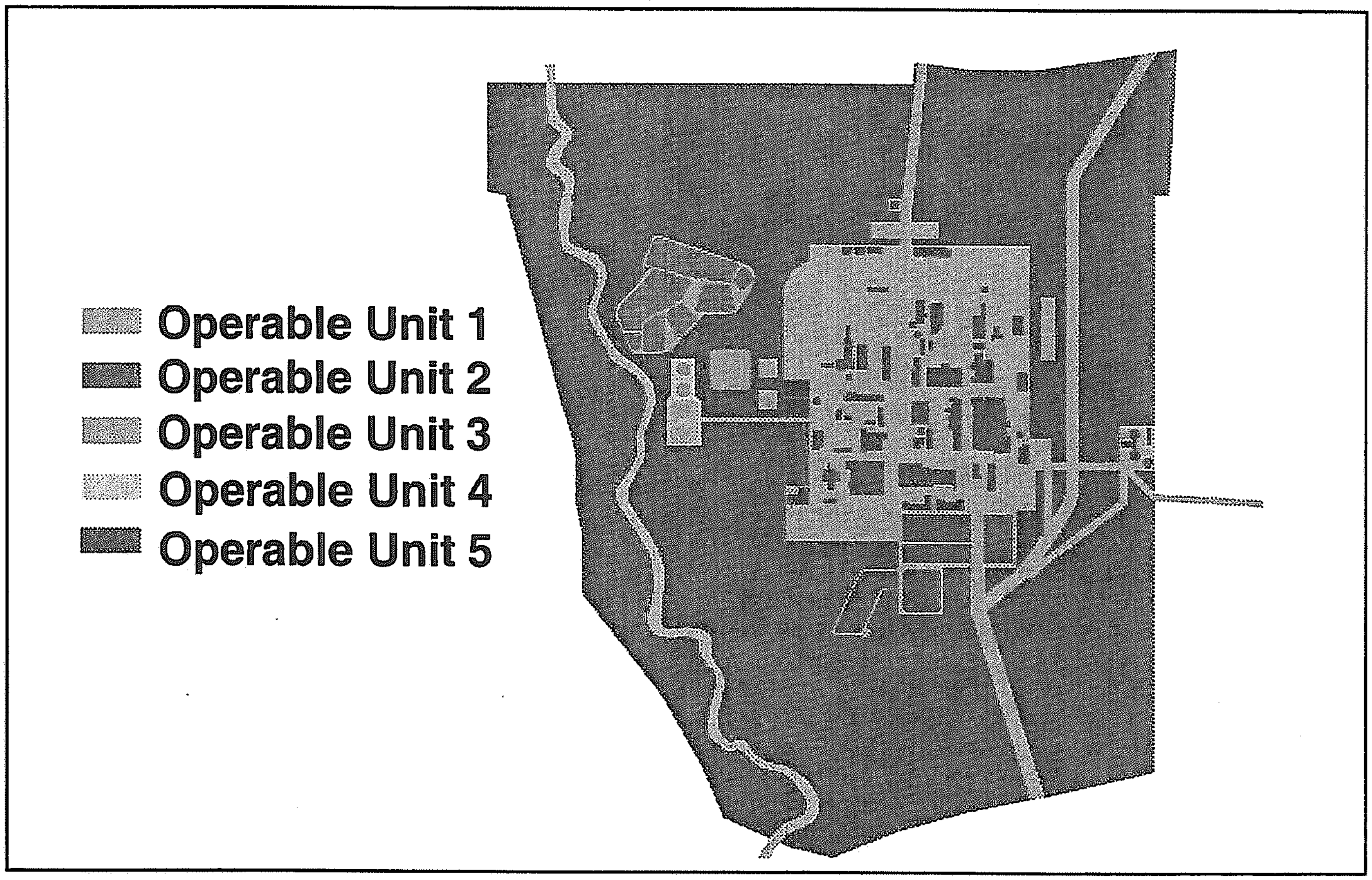


FIGURE 5-1
Operable Units at the Fernald Site

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