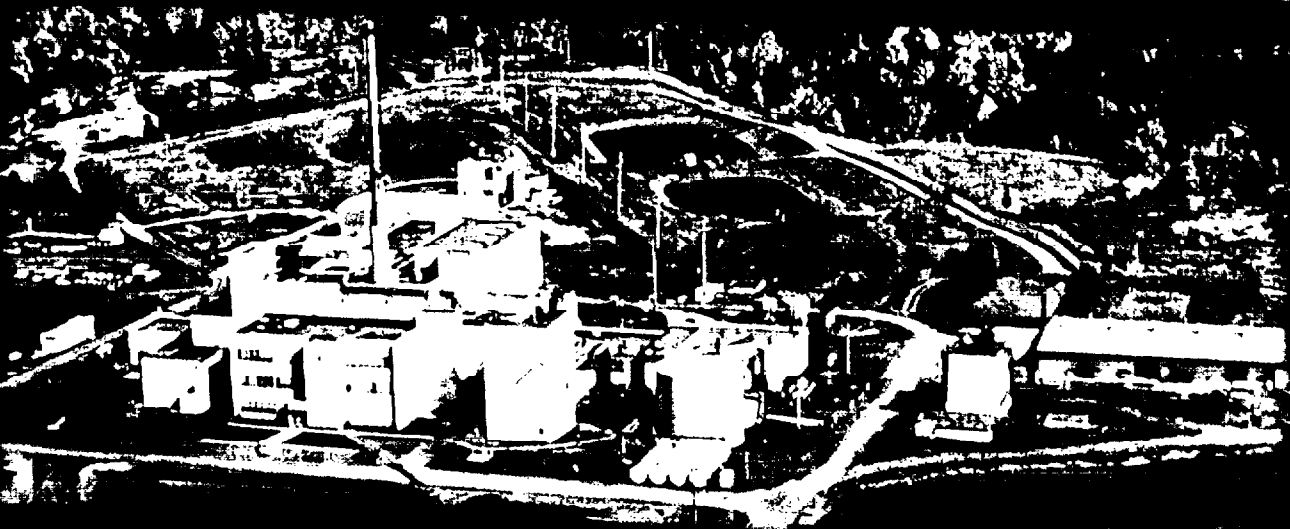


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Plutonium & Uranium Recovery from Spent Fuel Reprocessing by Nuclear Fuel Services at West Valley, New York from 1966 to 1972

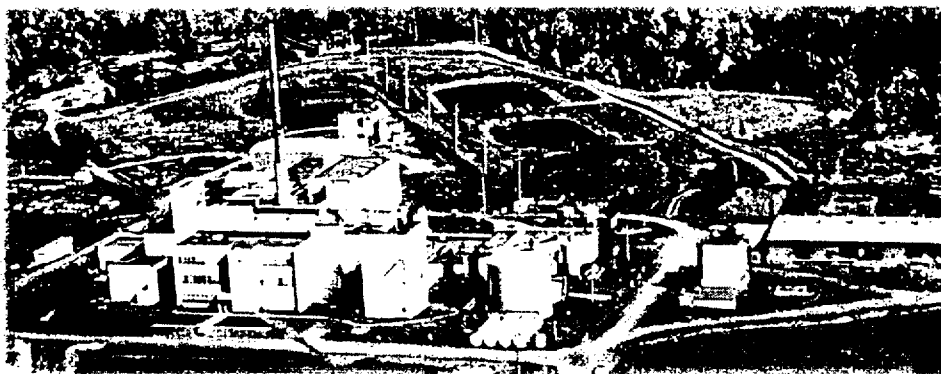


**Revised
November 1999**



**U.S. Department of Energy
Office of Defense Programs**

**Plutonium & Uranium Recovery
from Spent Fuel Reprocessing
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Executive Summary

This report provides a detailed accounting of the separated plutonium and uranium received by the U.S. Atomic Energy Commission (AEC), a predecessor to the Department of Energy (DOE), from Nuclear Fuel Services (NFS), which operated a commercial spent fuel reprocessing facility located near West Valley, New York, 35 miles south of Buffalo. The NFS facility was the first and only private plant in the U.S. to reprocess spent nuclear fuel. NFS began receiving spent nuclear fuel at West Valley in 1965, and operated the facility from 1966 to 1972 to chemically separate and recover plutonium and uranium from the fuel.

PLUTONIUM

In total, the plant recovered 1,926 kilograms (kg) of plutonium and shipped almost 80 percent (1,530 kg) of the material to the AEC. The remaining plutonium (396 kg) was either retained by the utility companies, sold to industry by the utilities, or purchased by NFS and later resold to industry for use in plutonium recycle operations.

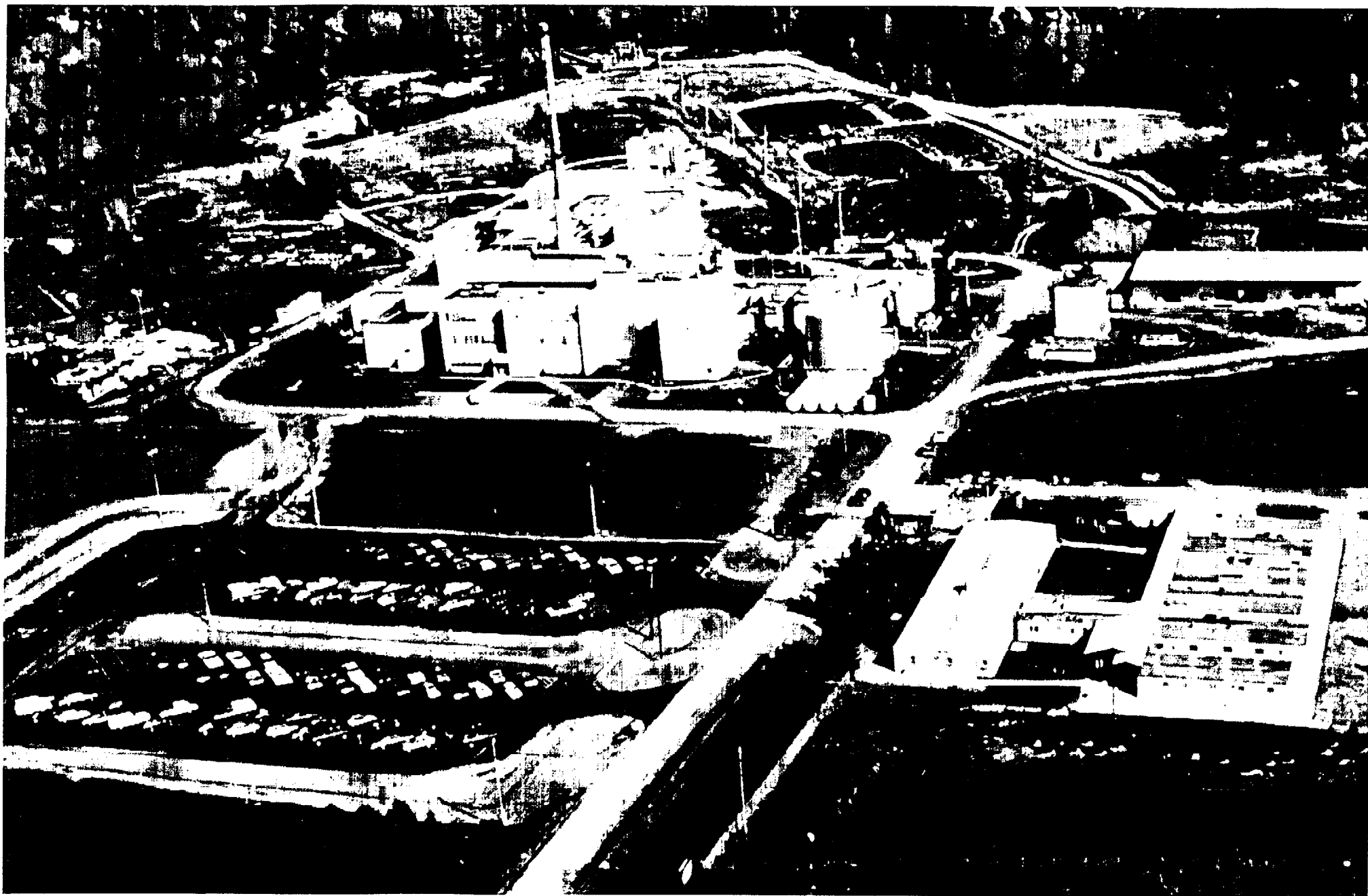
Of the 1,530 kg of separated plutonium received by the AEC from the NFS West Valley facility, 635 kg originated from fuel or reactors that were AEC-owned and 895 kg came from commercial power-reactor fuel. The AEC purchased the 895 kg of commercial power-reactor plutonium from the utility companies under a program named the Plutonium Credit Activity, which was established by the U.S. Congress in the Atomic Energy Act of 1954.

- Of the 635 kg of AEC-origin plutonium, most came from N-Reactor, a plutonium production reactor at the Hanford site near Richland, Washington. Specifically, 534 kg of plutonium came from N-Reactor, 95 kg from fuel from the Southwest Experimental Fast Oxide Reactor (SEFOR), and 6 kg from the Bonus Reactor, an AEC-owned demonstration reactor in Puerto Rico.
- Of the 895 kg of separated plutonium purchased by the AEC from the utility companies, 436 kg was from Yankee Atomic Electric Company (Yankee Rowe), 285 kg from Commonwealth Edison Company (Dresden-1), 63 kg from Consumers Power Company (Big Rock Point), 7 kg from Northern States Power Company (Pathfinder), and 104 kg from Consolidated Edison Company (Indian Point-1).

All of the AEC-owned and -purchased plutonium was shipped as plutonium nitrate solution from NFS to the Hanford Site. These shipments were made by commercial truck in accordance with applicable transportation regulations. Most of the plutonium received by the AEC from NFS was used in breeder reactor and zero-power reactor programs. To meet the isotopic and physical requirements for these programs, the NFS plutonium was blended with other plutonium and converted to either metal or oxide. The isotopic composition of the power reactor plutonium generally precluded its use in weapons production, even after blending, and there is no indication that blending occurred for that purpose.

URANIUM

The plant recovered 620 MTU and returned all of the uranium to the AEC. Of the total, 619.1 MTU was either slightly enriched or depleted. The slightly enriched and depleted uranium was returned to the Fernald Materials Production Center in Ohio. The remaining 0.9 MTU was highly enriched uranium and returned to the Oak Ridge Y-12 Plant in Tennessee. The assay of the highly enriched uranium was approximately 78% U-235 and 10% U-233.



Nuclear Fuels Services circa 1972

SECTION 1

INTRODUCTION

PURPOSE

The purpose of this report is to provide a detailed account of the separated plutonium and uranium received by the AEC from NFS, a commercial spent fuel reprocessing facility located near West Valley, New York, 35 miles south of Buffalo. This document is part of a larger effort to respond to the Secretary of Energy's June 27, 1994, announced goal to declassify and release detailed plutonium information (See the DOE report, Plutonium: The First 50 Years, February 1996). This report is the first comprehensive look at NFS West Valley reprocessing operations and is the result of an exhaustive search of open literature, historical memoranda, and nuclear materials accountability records.

BACKGROUND

In 1953, the U.S. announced the Atoms for Peace Program. This program signaled a shift in U.S. policy from closely guarding all information about nuclear science to encouraging peaceful uses of nuclear energy at home and abroad. The agreements implementing this program allowed a sharing of information about industrial applications of nuclear energy, including nuclear fuel reprocessing techniques, while discouraging nuclear weapons proliferation. This change in U.S. policy set the stage for the International Atomic Energy Agency (IAEA), and the Nonproliferation Treaty (NPT).

- The IAEA was established in the late 1950s to encourage the use of nuclear energy for peaceful purposes and to provide safeguards against proliferation; the safeguards were designed to detect, rather than to prevent, the diversion of nuclear materials.
- The NPT was ratified in 1968 and became effective in 1970, and in 1995 the NPT was extended indefinitely. Currently, more than 170 nations are adherents to this treaty. The NPT provides for the right of each participant to engage in peaceful nuclear activities, including spent fuel reprocessing. Nations not already in possession of nuclear weapons agreed not to develop them and to accept IAEA-directed safeguards for all peaceful nuclear activities under their control.

The objective of the Atoms for Peace Program was to promote the domestic and international exploration, development, and advancement of the technology necessary to build and operate reliable, economic nuclear power plants; to provide cooperative assistance in establishing a self-sufficient nuclear power industry; and to ensure the development and use of nuclear energy in electric power production and salt water desalination.

To insure a self-sufficient, domestic commercial nuclear power industry, the AEC encouraged the transfer of nuclear fuel reprocessing from the federal government to private industry. As a result of this policy, three commercial reprocessing facilities were built in the U.S.: General Electric's Midwest Fuel Recovery Plant at Morris, Illinois; Allied General Nuclear Services (AGNS) plant at Barnwell, South Carolina; Nuclear Fuel Service's facility located near West Valley, New York.

Optimism about the future growth of the nuclear industry led the State of New York to set aside 3345 acres near West Valley, New York, and to encourage nuclear industries to locate there. Although fuel reprocessing had been practiced in the U.S. since 1944, large-scale fuel reprocessing in the U.S. had been conducted only at DOE facilities in Idaho, South Carolina, and Washington State, until NFS began operations at West Valley, NY.

The NFS West Valley facility was the first and only private plant in the U.S. to reprocess spent nuclear fuel. The NFS facility was a PUREX (Plutonium Uranium Extraction) process plant with a design capacity of 300 tons of fuel per year. The PUREX process included storing spent fuel assemblies; chopping the assembly rods; dissolving the uranium, plutonium, and radioactive products in acid; separating and storing the radioactive wastes, and separating uranium nitrate from plutonium nitrate. Two other commercial reprocessing facilities were built in the United States, but never operated.

- The General Electric's Midwest Fuel Recovery Plant (also 300 tons per year) at Morris, Illinois, adjacent to the site of the Commonwealth Edison Company Dresden reactors, was completed at a cost of \$64 million but was declared inoperable in 1974.
- In 1970, Allied General Nuclear Services (AGNS) began construction of a 1500 tons per year reprocessing plant at Barnwell, South Carolina, adjacent to the DOE Savannah River Site. The Barnwell facility was due to begin operation in 1974, but following delays in construction and licensing, it still had not been completed or licensed when in 1977

President Carter decided to defer indefinitely all reprocessing of commercial irradiated fuel.

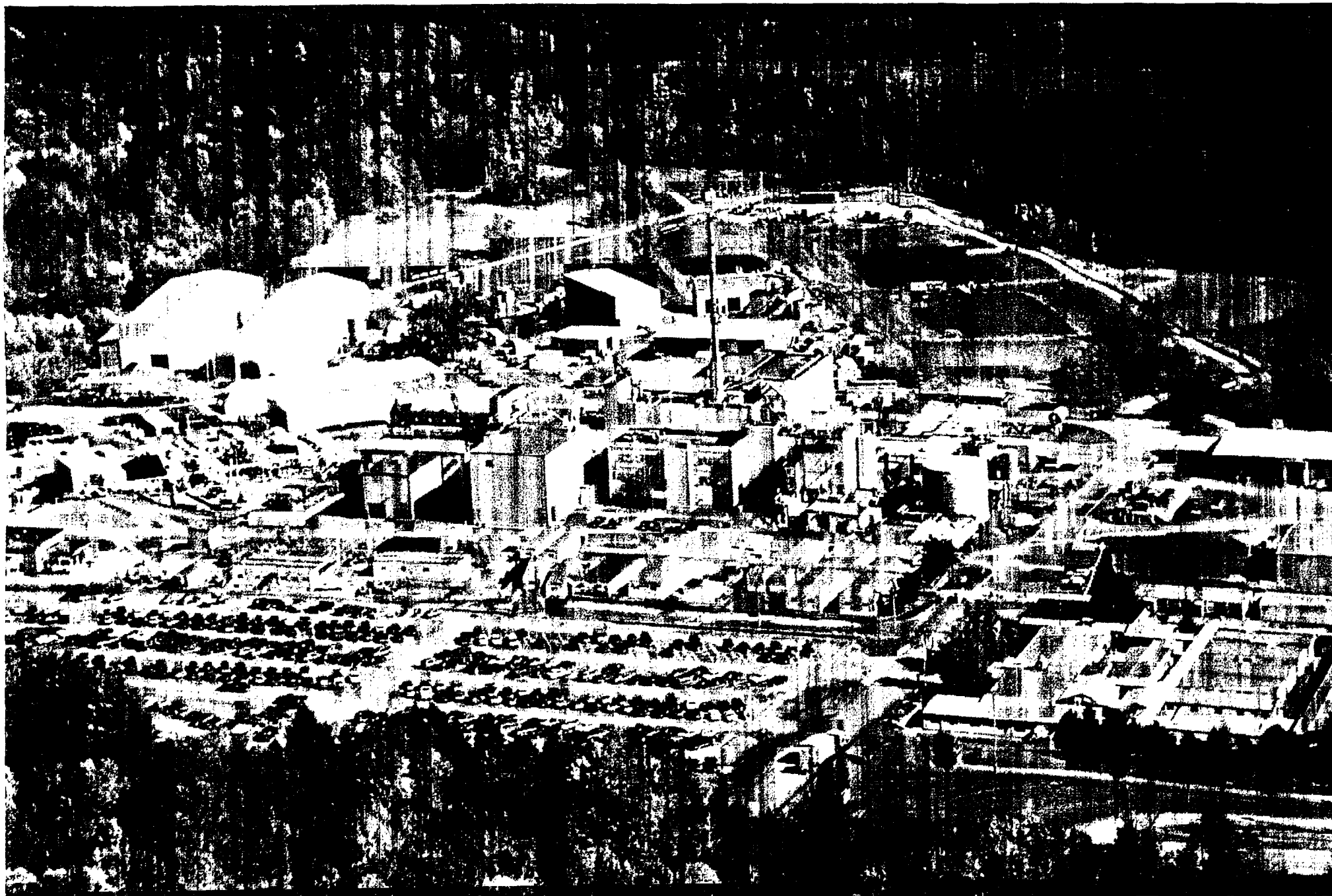
In the spring of 1963, the AEC issued the necessary permits to NFS, a subsidiary of the W.R. Grace Company (NFS was acquired by the Getty Oil Company in 1969), to begin construction of a fuel reprocessing facility. NFS was granted a license on May 27, 1965 to receive and store fuel at its reprocessing facility in West Valley. The first shipment of fuel, from the Yankee Rowe reactor in Massachusetts, was placed in the fuel storage pool at West Valley on June 5, 1965. Government and commercially-generated fuel continued to be received at NFS until 1973. There were a total of 756 truck and rail shipments.

The AEC encouraged NFS to focus on commercial fuel reprocessing; however, the AEC guaranteed a minimum quantity of government fuel to NFS in the absence of sufficient commercial supplies. Sufficient commercial supplies were not available because there were not many operating commercial reactors during the NFS reprocessing period of 1966 to 1972. As a result, approximately 60% of the facility's supply of fuel and 33% of the plutonium came from AEC reactors. Specifically, a majority of this came from N-Reactor.

In 1972, NFS (now owned by the Getty Oil Company) halted all reprocessing operations in order to increase reprocessing capacity, and to alter the facility to meet new regulatory requirements. However, subsequent difficulties were encountered in retrofitting the facility to meet these requirements and, after four years of fruitless negotiations with federal and state regulatory authorities, NFS announced its intention to cease reprocessing operations and transfer the management and long-term storage of approximately 600,000 gallons of high-level radioactive liquids and sludges at the West Valley Site to the site's landlord, the New York State Energy Research and Development Authority. This transfer was in accordance with contractual obligations.

By 1980, the West Valley Demonstration Project Act (WVDPA) (Public Law 96-368) directed the DOE to solidify the high-level radioactive waste at West Valley to borosilicate glass, suitable for permanent storage in an approved federal repository. The WVDPA also directed the Department to decontaminate and decommission the tanks and facilities used at West Valley, and dispose of the low-level and transuranic wastes.

The West Valley Nuclear Services Company, a wholly-owned subsidiary of Westinghouse Electric Corporation, was selected in 1981 as the prime contractor for the WVDPA. West Valley Nuclear Services Company has operated the West Valley site for the U.S. Department of Energy since 1982.



West Valley Demonstration Project circa 1993

SECTION 2

NFS WEST VALLEY REPROCESSING CAMPAIGNS

There were a total of 27 processing campaigns performed at West Valley, however, only the first 26 campaigns reprocessed intact reactor fuel. The last campaign involved processing liquid residues received from Nuclear Fuels Services Facility in Erwin, Tennessee, generated during the fabrication of fuel for the SEFOR reactor. Table 1 and 2 provide a summary of the NFS fuel reprocessing campaigns including the amount of plutonium and uranium recovered. The material reprocessed by NFS, summarized by source in Table 3, was both government and commercially-generated. In both tables the quantities of "Plutonium Received" were based on shipper's data, i.e., theoretical calculations of plutonium produced in the reactors.

The "Recovered Plutonium" is the actual amount of plutonium recovered by NFS. The difference between the often imprecise theoretical calculations of plutonium produced in reactors versus the measurement of the amount actually recovered is called an inventory difference. When the recovered amount is larger than the received amount, the shipper may have underestimated the amount of plutonium produced in the reactor.

Other factors that contribute to the difference between received and recovered plutonium include the measurement uncertainty, process holdup, and normal operating losses/measured discards. Normal operating losses/measured discards occur when known quantities of plutonium are intentionally removed from the inventory because they are technically or economically unrecoverable and are disposed of by approved methods. Two examples of normal operating losses are liquid discards to waste storage tanks, and solid waste packaged in drums and crates awaiting shipment to waste disposal facilities generically referred to as "burial sites." Examples of plutonium-bearing items sent to burial sites include discarded piping, spent ion exchange equipment, and contaminated laundry and shoe covers.

The AEC-owned plutonium came from the following:

- The Hanford N-Reactor, a production reactor formerly called the New Production Reactor, is located near Richland, Washington, about 150 miles southeast of Seattle. This reactor is owned and was operated by the AEC. N-Reactor was designed as a dual-purpose reactor for the production of plutonium and the production of by-product steam for electricity generation. It was a graphite-moderated, pressurized light water-cooled reactor. N-Reactor operated from 1963 to 1987.

- The Bonus Reactor, a demonstration boiling water reactor, was located at Ricon, about 75 miles west of San Juan, Puerto Rico. This reactor featured high-temperature, superheated steam and was owned by the AEC but operated by the Puerto Rico Water Resources Authority. The Bonus reactor began operation in 1964 and was permanently shut down in 1968.
- The remainder of the material came from the Nuclear Fuels Services facility in Erwin, Tennessee, and was in the form of liquid residues generated during the fabrication of reactor fuel for the Southwest Experimental Fast Oxide Reactor (SEFOR), an experimental reactor, located near Strickler, Arkansas. SEFOR was built by the Southwest Atomic Energy Associates^a for testing liquid metal fast breeder reactor fuel. SEFOR began operations in 1969 and was permanently shut down in 1972.

The remaining fuel came from seven commercial nuclear power reactors that were owned and operated by commercial utility companies.

- The Big Rock Point Nuclear Power Plant. This boiling water reactor, owned and operated by Consumers Power Company, is located on Lake Michigan near Charlevoix, Michigan, about 200 miles northwest of Detroit. Big Rock Point has operated since 1963.
- CVTR, Carolinas-Virginia Tube Reactor. This pressurized heavy water tube reactor, owned and operated by Carolinas-Virginia Nuclear Power Associates was located in Parr, South Carolina, about 25 miles northwest of Columbia. This reactor began operation in 1964 and was permanently shut down in 1967.
- Dresden Nuclear Power Station, Unit #1. This boiling water reactor, owned and operated by Commonwealth Edison Company, was located near Morris, Illinois, about 50 miles southwest of Chicago. Dresden-1 commenced operation in 1960 and was permanently shut down in 1978.

^a The Southwest Atomic Energy Associates consisted of seventeen U.S. investor-owned utilities, the Federal Republic of Germany, the General Electric Company, and Euratom. Euratom, the European Atomic Energy Community, is an organization that promotes the growth of nuclear power production in Europe. Its members are Belgium, France, West Germany, Italy, Luxembourg, and The Netherlands.

- Humboldt Bay Nuclear Plant. This boiling water reactor, owned and operated by the Pacific Gas and Electric Company, was located on Humboldt Bay near Eureka, California, about 200 miles north of San Francisco. This plant commenced operation in 1963 and was permanently shut down in 1976.
- Indian Point Nuclear Power Station, Unit #1. This pressurized water reactor, owned and operated by the Consolidated Edison Company, was located on the Hudson River at Buchanan, New York, about 35 miles north of New York City. Indian Point began operation in 1962 and was permanently shut down in 1974.
- Pathfinder Nuclear Power Plant. This experimental, boiling water reactor, owned and operated by the Northern States Power Company, was located on the Big Sioux River, near Sioux Falls, South Dakota. Pathfinder began operations in 1964 and was permanently shut down in 1967.
- Yankee Atomic Electric Power Station. This pressurized water reactor, owned and operated by the Yankee Atomic Electric Company, was located near Rowe, Massachusetts, about 45 miles east of Albany, New York. This reactor began operation in 1960 and was permanently shut down in 1992.

Table 1. Fuel Reprocessed and Plutonium Recovered at NFS West Valley

| Lot No | Fuel Source | Reactor Name | Process Date | Received ^b | | Recovered ^c kg Pu |
|--------------|--|--------------------------------|-----------------|-----------------------|--------------------|---------------------------------|
| | | | | MTU ^d | kg Pu | |
| 2 | Atomic Energy Commission | N-Reactor | 4-22-66 | 19.7 | 1.7 | 1.2 |
| 1 | | | 5-20-66 | 28.8 | 2.3 | 2.5 |
| 3 | | | 7-15-66 | 46.7 | 50.9 | 50.2 |
| 4 | Commonwealth Edison | Dresden-1 | 11-12-66 | 50.0 | 191.0 | 182.2 |
| 5 | Yankee Atomic Electric | Yankee Rowe | 6-7-67 | 49.8 | 285.1 ^e | 278.6 |
| 6 | Atomic Energy Commission | N-Reactor | 9-2-67 | 26.6 | 52.6 | 50.4 |
| 7 | | | 12-2-67 | 26.1 | 47.4 | 46.9 |
| 8 | | | 1-6-68 | 42.4 | 75.4 | 77.0 |
| 9 | | | 5-5-68 | 38.8 | 79.1 | 78.0 |
| 10 | | | 6-29-68 | 55.3 | 115.7 | 114.4 |
| 11 | Consolidated Edison ^f | Indian Point-1 | 11-15-68 | 1.1 | - | - |
| 12 | Atomic Energy Commission | N-Reactor | 2-13-69 | 48.9 | 102.5 | 90.2 |
| 13 | Yankee Atomic Electric | Yankee Rowe | 5-14-69 | 19.6 | 176.0 | 171.6 |
| 14 | Atomic Energy Commission ^g | N-Reactor | 8-16-69 | 30.3 | - | - |
| 15 | Commonwealth Edison | Dresden-1 | 10-1-69 | 21.5 | 104.6 | 102.3 |
| 16 | Consolidated Edison | Indian Point-1 | 11-23-69 | 15.6 | 107.6 | 104.2 |
| 17 | Yankee Atomic Electric | Yankee Rowe | 6-2-70 | 9.3 | 95.6 | 91.5 |
| 18 | Northern States Power | Pathfinder | 8-14-70 | 9.6 | 7.1 | 7.0 |
| 19 | Consumers Power | Big Rock Point | 11-26-70 | 18.4 | 72.8 | 72.7 |
| 20 | Consolidated Edison | Indian Point-1 | 1-11-71 | 7.6 | 68.1 | 63.0 |
| 21 | Atomic Energy Commission | N-Reactor | 2-25-71 | 15.8 | 25.4 | 22.8 |
| 22 | Puerto Rico Water Resources Authority | Bonus Superheater ^h | 4-15-71 | 1.7 | 0.9 | 6.5 |
| | | Bonus Boiler ⁱ | 4-18-71 | 2.4 | 4.0 | |
| 23 | Pacific Gas and Electric | Humbolt Bay | 5-20-71 | 20.8 | 87.2 | 86.0 |
| 24 | Yankee Atomic Electric | Yankee Rowe | 7-16-71 | 9.5 | 95.7 | 91.0 |
| 25 | Carolinas-Virginia Nuclear Power Associates | CVTR-PARR | 10-4-71 | 3.5 | 11.6 | 11.8 |
| 26 | Consumers Power | Big Rock Point | 11-30-71 | 5.8 | 27.9 | 28.4 |
| 27 | Nuclear Fuels Services, Erwin, Tennessee ^j | SEFOR | 12-12-71 | 0.1 | 95.5 | 95.2 |
| Total | | | | 625.7 | 1,983.7 | 1,925.6 |

Note: Footnotes for Table 1 can be found on the page 12.

Table 2. Fuel Reprocessed and Uranium Recovered at West Valley

| Lot No | Fuel Source | Reactor Name | Process Date | MTU | |
|--------------|---|--------------------------------------|--------------------|--------------|--------------|
| | | | | Received | Recovered |
| 2 | Atomic Energy Commission | N-Reactor | 4-22-66 | 19.7 | 19.3 |
| 1 | | | 5-20-66 | 28.8 | 28.7 |
| 3 | | | 7-15-66 | 46.7 | 46.3 |
| 4 | Commonwealth Edison | Dresden-1 | 11-12-66 | 50.0 | 49.6 |
| 5 | Yankee Atomic Electric | Yankee Rowe | 6-7-67 | 49.8 | 49.4 |
| 6 | Atomic Energy Commission | N-Reactor | 9-2-67 | 26.6 | 186.6 |
| 7 | | | 12-2-67 | 26.1 | |
| 8 | | | 1-6-68 | 42.4 | |
| 9 | | | 5-5-68 | 38.8 | |
| 10 | | | 6-29-68 | 55.3 | |
| 11 | Consolidated Edison | Indian Point-1 | 11-15-68 | 1.1 | 0.9 |
| 12 | Atomic Energy Commission | N-Reactor | 2-13-69 | 48.9 | 48.5 |
| 13 | Yankee Atomic Electric | Yankee Rowe | 5-14-69 | 19.6 | 19.6 |
| 14 | Atomic Energy Commission | N-Reactor | 8-16-69 | 30.3 | 30.0 |
| 15 | Commonwealth Edison | Dresden-1 | 10-1-69 | 21.5 | 21.7 |
| 16 | Consolidated Edison | Indian Point-1 | 11-23-69 | 15.6 | 15.4 |
| 17 | Yankee Atomic Electric | Yankee Rowe | 6-2-70 | 9.3 | 9.2 |
| 18 | Northern States Power | Pathfinder | 8-14-70 | 9.6 | 9.6 |
| 19 | Consumers Power | Big Rock Point | 11-26-70 | 18.4 | 18.3 |
| 20 | Consolidated Edison | Indian Point-1 | 1-11-71 | 7.6 | 7.5 |
| 21 | Atomic Energy Commission | N-Reactor | 2-25-71 | 15.8 | 19.7 |
| 22 | Puerto Rico Water Resources Authority | Bonus Superheater Bonus Boiler | 4-15-71 4-18-71 | 1.7 2.4 | |
| 23 | Pacific Gas and Electric | Humbolt Bay | 5-20-71 | 20.8 | 20.7 |
| 24 | Yankee Atomic Electric | Yankee Rowe | 7-16-71 | 9.5 | 9.5 |
| 25 | Carolinas-Virginia Nuclear Power Associates | CVTR-PARR | 10-4-71 | 3.5 | 3.3 |
| 26 | Consumers Power | Big Rock Point | 11-30-71 | 5.8 | 6.0 |
| 27 | Nuclear Fuels Services, Erwin, Tennessee | SEFOR | 12-12-71 | 0.1 | 0.1 |
| Total | | | | 625.7 | 619.9 |

Table 3. Summary of Fuel Reprocessed at NFS West Valley

| Fuel Source | Reactor Name | Received ^b | | Recovered ^c kg Pu |
|---|--------------------------------|-----------------------|----------------|---------------------------------|
| | | MTU ^d | kg Pu | |
| Atomic Energy Commission | N-Reactor | 379.4 | 553.0 | 533.5 |
| Carolinas-Virginia Nuclear Power Associates | CVTR-PARR | 3.5 | 11.6 | 11.8 |
| Commonwealth Edison | Dresden-1 | 71.5 | 295.6 | 284.5 |
| Consolidated Edison | Indian Point-1 | 24.3 | 175.7 | 167.2 |
| Consumers Power | Big Rock Point | 24.2 | 100.7 | 101.1 |
| Nuclear Fuels Services, Erwin, Tennessee ^j | SEFOR | 0.1 | 95.5 | 95.2 |
| Northern States Power | Pathfinder | 9.6 | 7.1 | 7.0 |
| Pacific Gas and Electric | Humbolt Bay | 20.8 | 87.2 | 86.0 |
| Puerto Rico Water Resources Authority | Bonus Superheater ^h | 1.7 | 0.9 | 6.5 |
| | Bonus Boiler ⁱ | 2.4 | 4.0 | |
| Yankee Atomic Electric | Yankee Rowe | 88.2 | 652.4 | 632.7 |
| Total | | 625.7 | 1,983.7 | 1,925.5 |

Table 1 and 3 Footnotes

^b The difference between the received and recovered amounts are due to measurement uncertainty of reactor calculations, process holdup, and normal operating losses/measured discards.

^c The 0.1 kg difference between Table 1 and Table 2 for N-Reactor plutonium is due to rounding.

^d Metric Tons Uranium

^e The Nuclear Fuel Services Inc., Safety Analysis Report – NFS' Reprocessing Plant, West Valley, New York, Docket No. 50-201, 1973, showed 185.1 kg – which was probably a typographical error.

^f The fuel in Lot 11 from Indian Point-1 consisted of highly enriched uranium and thorium but contained no plutonium.

^g The fuel in Lot 14 from N-Reactor was unirradiated and therefore contained no plutonium.

^h Bonus Superheater and Bonus Boiler were parts of an experimental reactor.

ⁱ *Ibid*

^j The material from Nuclear Fuels Services, Erwin, Tennessee was in the form of liquid residues generated during the fabrication of reactor fuel for the Southwest Experimental Fast Oxide Reactor (SEFOR).

SECTION 3

NFS WEST VALLEY PLUTONIUM SHIPMENTS TO THE AEC

In the 1950's, commercial utilities began returning fuel to the Atomic Energy Commission under a program called the Plutonium Credit Activity. This program, established by the U.S. Congress in the Atomic Energy Act of 1954, provided "credit" for plutonium produced in commercial nuclear reactors operating on fuel purchased or leased from the AEC. Although the uranium in the civilian power reactor industry in the 1950's and early 1960's was owned by the AEC and leased to the utility companies, the plutonium produced during operation of these reactors was owned by the utility companies.

The Plutonium Credit Activity program began in 1957 and ended in 1970. The U.S. Government paid the utilities approximately \$10.4 million for approximately 900 kg of plutonium. All of the plutonium purchased under this program was reprocessed at the NFS facility and shipped to the Hanford Site with the exception of 2.5 kg plutonium from the Vallecitos Boiling Water Reactor that was reprocessed at the Savannah River Site.

Both the AEC-owned plutonium and the plutonium purchased by the AEC under the Plutonium Credit Activity (1530 kg total) listed in Table 4, were shipped to the Hanford Site as plutonium nitrate solution. The liquid shipments were by commercial truck in accordance with applicable transportation regulations.

Of the 1530 kg of separated plutonium received by the Hanford Site from the NFS facility, 635 kg came from fuel or reactors that were AEC-owned, and the remaining 895 kg came from the commercial power-reactor fuel.

- Of the 635 kg of the AEC-origin plutonium, the majority came from N-Reactor, a plutonium production reactor at the Hanford Site near Richland, Washington. Specifically, 534 kg of plutonium came from N-Reactor, 95 kg from fuel from the Southwest Experimental Fast Oxide Reactor (SEFOR), and 6 kg from the Bonus Nuclear Electrical Station, an AEC-owned demonstration reactor.
- Of the 895 kg of separated plutonium purchased by the AEC from the utility companies, 436 kg was from Yankee Atomic Electric Company (Yankee Rowe), 285 kg from Commonwealth Edison Company (Dresden-1), 63 kg from Consumers Power Company

(Big Rock Point), 7 kg from Northern States Power Company (Pathfinder), and 104 kg from Consolidated Edison Company (Indian Point-1).

Most of the plutonium the AEC received from the NFS facility was used in the breeder reactor and the zero power reactor programs. To meet the isotopic and physical requirements for these programs, the NFS plutonium was blended with other plutonium and then converted to either a metal or an oxide. Even by blending, the isotopic mixture of the power reactor plutonium generally precluded its use in weapons production and there is no indication that blending for that purpose occurred.

Table 4. AEC Plutonium Receipts from the NFS West Valley Facility

| Plutonium Source | Reactor Name | Origin (kg Pu) | | | |
|--|-----------------------------------|----------------|--------------|----------------|----------|
| | | AEC | Commercial | Total | % Pu-240 |
| Atomic Energy Commission | N-Reactor | 533.5 | | 533.5 | 12.0 |
| Commonwealth Edison | Dresden-1 | | 284.5 | 284.5 | 23.0 |
| Consolidated Edison | Indian Point-1 | | 104.0 | 104.0 | 16.4 |
| Consumers Power | Big Rock Point | | 63.4 | 63.4 | 14.9 |
| Nuclear Fuels Services, Erwin, Tennessee | SEFOR | 95.2 | | 95.2 | 8.5 |
| Northern States Power | Pathfinder | | 7.0 | 7.0 | 7.9 |
| Puerto Rico Water Resources Authority | Bonus Superheater Bonus Boiler | 6.5 | | 6.5 | 9.2 |
| Yankee Atomic Electric | Yankee Rowe | | 435.7 | 435.7 | 14.6 |
| Total | | 635.2 | 894.6 | 1,529.8 | |

SECTION 4

NFS WEST VALLEY PLUTONIUM SHIPMENTS TO OTHERS

As shown in Table 5, not all of the NFS separated power-reactor plutonium was sold to the AEC. A total of 396 kg of separated power-reactor plutonium was either retained by the utility companies, sold by the utility company to industry, or purchased by NFS and later sold for use in plutonium recycle operations. Of that total, almost 60% was shipped from the NFS West Valley facility to foreign countries for use in research or as fuel for foreign breeder-reactor programs.

- A total of 221 kg plutonium was shipped to West Germany for use at the Karlsruhe Nuclear Research Center. Several reactors are located at the Center, and it is Germany's most important applied research installation engaged in breeder-reactor research. Work on fast breeders has been carried out at Karlsruhe since 1960, with Euratom support of the breeder work starting in 1963.
- A total of 10 kg plutonium was shipped to the United Kingdom's Atomic Energy Research Establishment at Harwell. The two experimental zero-power reactors at Harwell provided basic physics information on fast-reactor cores.
- Approximately 1 kg of plutonium was sent to the Santa Maria O'Galeria, Plutonium Research and Development Center in Casaccia, Italy.
- The remaining 164 kg of plutonium was sent from the NFS West Valley facility to domestic companies, i.e., Babcock and Wilcox Plutonium Laboratory in Leechburg, Pennsylvania, the Westinghouse Electric Plutonium Development Laboratory in Cheswick, Pennsylvania, and the Nuclear Fuels Services facility in Erwin, Tennessee, for use in research or the fabrication of reactor fuel.

Table 5. Summary of NFS West Valley Plutonium Shipments

| Plutonium Source | Reactor Name | To AEC | To Industry | Total |
|---|--------------------------------|----------------|--------------|----------------|
| Atomic Energy Commission | N-Reactor | 533.5 | | 533.5 |
| Carolinas-Virginia Nuclear Power Associates | CVTR-PARR | | 11.8 | 11.8 |
| Commonwealth Edison | Dresden-1 | 284.5 | | 284.5 |
| Consolidated Edison | Indian Point-1 | 104.0 | 63.2 | 167.2 |
| Consumers Power | Big Rock Point | 63.4 | 37.7 | 101.1 |
| Nuclear Fuels Services, Erwin, Tennessee | SEFOR | 95.2 | | 95.2 |
| Northern States Power | Pathfinder | 7.0 | | 7.0 |
| Pacific Gas and Electric | Humbolt Bay | | 86.0 | 86.0 |
| Puerto Rico Water Resources Authority | Bonus Superheater Bonus Boiler | 6.5 | | 6.5 |
| Yankee Atomic Electric | Yankee Rowe | 435.7 | 197.0 | 632.7 |
| Total | | 1,529.8 | 395.7 | 1,925.5 |