Figure 3-2. Waste contained in a waste insert being transferred from a shipping cask to a removable crib in Trench 55 in 1973 (photograph number 73-2345).

3.1.3.1 Subsurface Disposal Area Operations from 1985 to Present. Current disposal operations within the SDA comprise subsurface burial of LLW from the Idaho Cleanup Project, the INL Site, and NRF. Disposal of waste from off-INL Site generators was discontinued in the early 1990s. Use of trenches was discontinued in 1982, and use of SVRs was discontinued in 1993 (Seitz, Keck, and McCarthy 2001). Waste emplaced in the SDA is classified as either remote- or contact-handled LLW, depending on whether radiation levels at 1 m (3.3 ft) from the package surface are greater than or less than 500 mR/hour, respectively (DOE-ID 2005a). In general, remote-handled LLW is entombed in concrete vaults in the southwestern corner of Pit 20, and contact-handled LLW is stacked in an open pit (see Figure 3-1). Large or bulky LLW, with exposure rates greater than 500 mR/hour, is buried in specially isolated areas within the open pit.

Waste buried in the SDA must meet INL Waste Acceptance Criteria (DOE-ID 2005a). However, exceptions can be obtained from the DOE Idaho Operations Office (DOE-ID) by completing a special performance assessment to demonstrate that performance objectives and performance measures in DOE M 435.1-1 are met. Waste Area Group 7 staff and management review each exception before requests are submitted to DOE-ID. Several exceptions have been allowed in the last few years. These exceptions have occurred in cases where special packaging and disposal measures were taken to mitigate

the potential hazard associated with a specific waste. Waste disposal operations in the SDA are planned to extend until Fiscal Year (FY) 2009, but that date could change (DOE 2002).

3.1.3.1.1 Pit Disposals—Pits 17 through 20 constitute a 2.26-ha (5.6-acre) excavated area currently used for disposal of LLW. Pits 17 through 20 were blasted into basalt to a depth of approximately 10 m (33 ft), and the exposed basalt was covered with 0.6 m (2 ft) of soil and a thin layer of gravel (McCarthy et al. 2000). A contoured earthen berm surrounds Pits 17 through 20.

Waste is stacked within pits using forklifts and cranes. Stack height is limited by the self-supporting strength of containers and by administrative controls. Maximum stack height is limited to 7.3 m (24 ft). A variety of containers is used for disposal of contact-handled LLW, including cargo containers, wooden boxes, steel containers in several sizes, and soft-sided containers. As areas of the pits become full, waste is covered with at least 1.2 m (4 ft) of fine-grained soil from INL Site sources. The soil cover is spread and compacted with dozers and sloped for drainage. Seitz, Keck, and McCarthy (2001) provide additional information relating to interim closure of LLW disposal operations ongoing in Pits 17 through 20.

3.1.3.1.2 Concrete Vaults—Concrete vaults in the southwestern corner of Pit 20 contain remote-handled LLW. Concrete vaults provide shielded disposal for remote-handled LLW from NRF and the Reactor Technology Complex (RTC) (formerly the Test Reactor Area) and conserve space within the LLW Disposal Facility (commonly referred to as the LLW Pit). Vaults are constructed of precast, reinforced concrete sections resting on an integral base plate and are configured in honeycomb arrays. Each array is surrounded by soil for additional shielding and seismic stability. Void spaces between vaults in each array are filled with sand. Once full, each vault is covered with a 1.2-m (4-ft) -thick reinforced concrete plug. Two hundred concrete vaults have been constructed in Pit 20, and more than one-third of them are full.

3.1.3.1.3 Soil Vault Rows—Disposal in soil vaults was discontinued in 1993 (Seitz, Keck, and McCarthy 2001).

3.1.3.2 Transuranic Storage Area from 1985 to Present. The TSA consists of storage buildings, the Intermediate-Level Transuranic Storage Facility, the Stored Waste Examination Pilot Plant, the TSA Retrieval Enclosure, the Advanced Mixed Waste Treatment Project, and support facilities as described in the RWMC Safety Analysis Report (INEEL 2000) (see Figure 3-1). The primary purpose of current TSA operations is to provide environmentally safe and compliant management of contact-handled and remote-handled TRU waste stored at RWMC. Receipt of contact-handled TRU waste generated outside the INL Site ceased in 1989 when the last Rocky Flats Plant waste was received. One additional TRU shipment was received from Argonne National Laboratory in Chicago in 1995 for waste generated in support of INL Site activities, with State of Idaho approval. More than 100,000 containers of TRU waste were stored at the TSA. Approximately 90% of the containers are 55-gal steel drums. The remaining 10% include 1.2 × 1.5 × 1.8-m (4 × 5 × 6-ft) steel bins, 83- and 30-gal steel drums, plywood boxes, fiber-reinforced boxes, modular steel boxes, and some oversized containers (INEL 1995a). The TSA successfully met the requirement to prepare and ship 3,100 m^3 of stored TRU waste from RWMC to WIPP in accordance with the 1995 Settlement Agreement (DOE 1995). Preparation includes waste examination, segregation, certification, and interim storage and retrieval activities.

3.1.3.2.1 Transuranic Storage Area Storage Pads 1, 2, and R—TSA Pads 1, 2, and R were developed to provide retrievable interim storage for contact-handled TRU waste. This method of soil-covered waste storage was discontinued, and TSA Pads 1, R, and most of 2 were closed in 1982. One end of Pad R was used to receive and stage waste for transfer into an air-support weather shield or RCRA-compliant storage module. Air-Support Weather Shield-2 (i.e., WMF-711) was installed in 1973

over Cell 3 at the northern end of Pad 2. The air-support weather collapsed from high winds in 1986. The air-support weather shield was reinforced with a steel frame and remained in service until 1999, when it was dismantled. This building supported storage operations until 1997, when all accessible waste was moved into RCRA-compliant storage buildings. Activities at the closed pads are limited to monitoring and maintenance until soil-covered waste is removed.

3.1.3.2.2 Transuranic Storage Area Retrieval Enclosure—The TSA Retrieval Enclosure (i.e., WMF-636), constructed from 1994 to 1996, is a metal building that extends over areas of TSA Pads 1 and R. An adjacent annex extends over Cells 1, 1A, and 2 of TSA Pad 2. The enclosure provides a work area that allows year-round retrieval of contact-handled TRU waste presently stored on these three pad areas. In 2001, responsibility for the building was transferred to the Advanced Mixed Waste Treatment Project, and preparations are underway to retrieve the soil-covered stored waste.

3.1.3.2.3 Waste Storage and Examination Facilities—The EPA issued a Notice of Noncompliance to DOE in 1990 for deficiencies in configuration of stored waste at the TSA (EPA 1990). Subsequently, seven RCRA-approved Type 2 storage modules, designated WMF-628 to -634, were constructed for interim storage between 1994 and 1995.

Drum venting and testing are conducted in WMF-635, a RCRA-approved Type 1 modular building. The building encloses the existing drum venting facility (i.e., WMF-615) (see Figure 3-1). Building WMF-635 supports drum venting operations, gas generation testing, and preparation and loading of certified TRU waste for shipment to WIPP. One portion of WMF-635 is heated and insulated to thaw waste before examination at the Stored Waste Examination Pilot Plant. Another area in WMF-635 is maintained above freezing to provide a sheltered area for drum aspiration after venting. Building WMF-635 also has office space and a lunchroom.

The Stored Waste Examination Pilot Plant (i.e., WMF-610) was erected on Pad 3 in 1984 and began operations in 1985 to nondestructively examine TRU waste to ensure compliance with WIPP waste acceptance criteria. The facility contains real-time radiography and radioassay capabilities to support TRU waste certification. Certification authority for the Stored Waste Examination Pilot Plant was received in August 1985, and that project is characterizing waste for shipment to WIPP.

Various other facilities include those used for maintenance, storage for propane gas, and a sanitary waste system. The TRUPACT (i.e., transuranic package containers) Loading Station (i.e., WMF-618) is used for nuclear waste shipping.

3.1.3.2.4 Intermediate-Level Transuranic Storage Facility—The Intermediate-Level Transuranic Storage Facility currently stores remote-handled TRU waste (i.e., measuring greater than 200 mR/hour at the container surface). The facility contains 256 vaults measuring 41, 61, 76, and 122 cm (16, 24, 30, and 48 in.) in diameter. These vaults are embedded in a compacted earthen berm and store TRU waste having exposure rates between 0.2 and 4,500 R/hour at the surface of the waste containers. In addition, the facility also contains 16 vaults permitted under RCRA to store mixed TRU waste received from RTC. In 1995, RTC discontinued receiving remote-handled TRU waste generated off the INL Site.

In November 1997, mixed remote-handled TRU waste was retrieved from vaults, put into shielded overpacks, and placed in permitted storage in WMF-628 as contact-handled TRU waste. This change was made to reduce inspection costs. In October 2000, the State of Idaho requested that the permitted vaults be closed because no requirement had been identified to store mixed, remote-handled TRU waste (Jason Associates 2001). The vaults were closed in 2001 and accepted by the State of Idaho.

Remote-handled TRU waste is being retrieved from storage at the Intermediate Level Transuranic Storage Facility for disposal at WIPP. Retrieval is complete for all but two waste forms: Hot Fuel Examination Facility waste and Dry Rod Consolidation Technology waste. Facilities at Idaho Nuclear Technology Engineering Center (INTEC) (i.e., CPP-659) have been modified to support initial characterization. Ten drums of remote-handled TRU waste have been characterized by visual examination and dose measurement to demonstrate implementation of radiological characterization requirements to EPA. Remaining characterization (e.g., radiography and headspace-gas sampling) and transportation capabilities at CPP-659 are being developed and implemented.

3.1.3.2.5 Advanced Mixed Waste Treatment Project—In December 1996, DOE awarded British Nuclear Fuels, Limited (and its partners) a privatized, fixed-price contract to design, construct, and operate the Advanced Mixed Waste Treatment Project to treat mixed waste, TRU waste, and alpha-emitting LLW as required by Paragraph E.2 of the 1995 Settlement Agreement (DOE 1995) between the DOE, the U.S. Navy, and the State of Idaho. The Settlement Agreement requires that 65,000 m^3 of TRU waste be shipped out of Idaho for final disposition at WIPP by December 31, 2018. The 65,000 m^3 of TRU waste, most of which originated at Rocky Flats Plant, is in abovegrade storage at the TSA. Phase I of the Advanced Mixed Waste Treatment Project consisted of successfully completing all required preliminary permits and approvals by July 2000. Phase II of the Advanced Mixed Waste Treatment Project began in August 2000, and construction was completed in 2002. In 2001, one storage module and the TSA Retrieval Enclosure were transferred to the Advanced Mixed Waste Treatment Project. In 2005, Bechtel BWXT Idaho, LLC, was awarded the contract to manage the Advanced Mixed Waste Treatment Project, including responsibility to ship 6,000 m^3 of waste to WIPP by the end of 2005 in accordance with the Settlement Agreement.

3.1.3.3 Administration and Operations Area Activities from 1985 to Present. The administration and operations area includes administrative offices, security and gatehouse operations, radiological control support, maintenance buildings, equipment storage, and miscellaneous support facilities. The RWMC Safety Analysis Report (INEEL 2000) and the Collocated Facilities Analysis (Sebo and Whitaker 2005) describe each facility.

3.1.4 Summary of Waste Shipped from Rocky Flats Plant

In the ongoing validation of disposal records for the SDA, Edward Vejvoda, a retired Rocky Flats Plant employee, was contracted to compile information for Operable Unit 7-13/14. A synopsis of the sizable amount of information he compiled follows. Tables and data in this section are extracted directly from Vejvoda (2005).

Rocky Flats Plant shipped solid radioactive waste, including highly enriched uranium (Oralloy), depleted uranium, and process waste contaminated with weapons-grade plutonium and toxic chemicals, to the SDA. Shipping began in April 1954 and continued into late 1989. Waste from Rocky Flats Plant was buried in the SDA in a series of pits and trenches until 1970, when a U.S. Atomic Energy Commission policy was implemented requiring segregation and retrievable storage of all solid TRU waste. After 1970, TRU waste received from Rocky Flats Plant was placed in aboveground, earthen-covered retrievable storage.

An important distinction is that a large portion of waste previously designated TRU is not TRU by the current definition. Originally, TRU waste was defined as all waste contaminated with TRU radionuclides in concentrations greater than 10 nCi/g (AEC 1973). However, in 1982, the definition of TRU waste was revised based on a concentration of 100 nCi/g (DOE O 5820.1). Currently, TRU waste is defined as waste material containing any alpha-emitting radionuclide with an atomic number

greater than 92, a half-life longer than 20 years, and a concentration greater than 100 nCi/g, as defined in DOE M 435.1-1.

Also of importance, Rocky Flats Plant implemented programs and systems that ensured container integrity and compliance with loading requirements. These programs and systems progressed from very little control over the quality of waste shipped in the 1950s to a fully instituted quality program in the 1970s. These efforts included (1) eliminating free liquid and providing for absorption of any liquid that might develop during transport to the INL Site; (2) continued improvements and upgrades in waste packaging through drum and crate liners, closure mechanisms, and segregation of contents; and (3) upgrading shipping methods, packaging procedures, and shipping containers to meet new regulations. Improvements also included standardization of waste containers, packaging material, and procedures; descriptive labeling; and a more precise description of waste categories.

3.1.4.1 Waste Sources. Rocky Flats Plant processed and handled radioactive material, including weapons-grade plutonium, highly enriched uranium, and depleted uranium. Table 3-2 lists production facilities comprising the four plants, individual buildings within each plant, their operations, and types of material processed.

Table 3-2. Rocky Flats Plant production plants, operations, and types of material processed from 1953 to 1970.

Plant and Purpose	Types of Material Processed	Buildings	Operations
Plant A—Manufactured nuclear weapon components of nonspecial nuclear material	Depleted uranium, depleted uranium alloys, aluminum, beryllium, stainless steel, copper, and other metal in minor amounts	441	Analytical laboratory (441)
		444, 447	Foundry, machining, heat treating, and inspection (444 and 447)
		883A	Rolling and forming (883A)
Plant B—Manufactured nuclear weapon components of highly enriched uranium (Oralloy)	Highly enriched uranium	881	Foundry, machining, inspection, chemical recovery, and metal recycle Analytical laboratory (881)
		883	Rolling and forming (883B)
Plant C—Manufactured nuclear weapon components of plutonium	Weapons-grade plutonium	771, 776, 559	Foundry (771 and 776) Machining (771 and 776) Chemical recovery and metal recycle (771) Analytical laboratory (771 and 559) Pyrochemistry (776)
		774	Liquid waste treatment (774)
		777	Inspection and assembly (777)
		779	Research and development (779)
Plant D—Pit (plutonium trigger) assembly and certification	Plutonium, highly enriched uranium, depleted uranium, and other types of nonradioactive material (e.g., beryllium, stainless steel, and aluminum)	991	Assembly, inspection, certification, packaging, and shipping assemblies

Additionally, Rocky Flats Plant accepted waste from offsite sources from 1957 to 1971 and shipped it to the INL Site. Solid waste received at Rocky Flats Plant for transfer was not treated or repacked, but only shipped to the INL Site. However, beryllium- and uranium-contaminated liquid waste generated by the Coors Porcelain Company, for example, was put in solar evaporation ponds and shipped to the INL Site as solids recovered from the ponds. Vejvoda (2005) includes a summary table of waste containers received and the corresponding shippers.

3.1.4.2 Changes in Process and Plant Operations. The waste categories shipped to the INL Site changed over time because of changes in mission, processes, and plants. The majority of waste generated by plant operations and activities can be categorized as (1) housekeeping waste, (2) maintenance waste, (3) process waste, and (4) changes in mission. These categories are described in more detail in the following subsections.

3.1.4.2.1 Housekeeping Waste—Housekeeping waste results from operating a facility that houses and handles radioactive material. Examples of housekeeping waste are surgical, cotton, and glove box gloves; paper; plastic bags; rags; contaminated clothing; wood; tape; and other types of combustible material. Over the years, housekeeping waste remained fairly constant, but quantities varied with production and research and development levels. The only notable example is polyethylene-based plastics increased and polyvinyl chloride plastics decreased.

3.1.4.2.2 Maintenance Waste—Maintenance waste was generated by repair and replace activities, such as removing obsolete equipment, installing new equipment, upgrading safety systems, removing area equipment, and performing required preventive maintenance. These maintenance activities remained fairly constant over the active life of the plant.

3.1.4.2.3 Process Waste—Process waste was generated by five general operations: (1) foundry and fabrication, (2) component assembly and return disassembly, (3) production support activities (e.g., research and development analytical and metallurgical laboratories and inspection), (4) chemical recovery and metal recycle, and (5) waste treatment. Process waste also includes mission-related waste, such as that produced by the 1969 fire.

3.1.4.2.4 Changes in Mission—The original mission of Rocky Flats Plant included manufacturing components of depleted uranium, highly enriched uranium (Oralloy), and plutonium, coupled with assembling plutonium trigger components. In 1962, the Oralloy mission was terminated, and the plutonium mission was expanded. Cleaning out the Oralloy plant (Building 881) was completed in early 1965. Significant quantities of Oralloy waste were generated from 1962 to 1965; Oralloy waste was minimized after 1965.

Building 444 was originally assigned the mission of fabricating components of depleted uranium. In the late 1950s, fabricating beryllium components was introduced and slowly replaced fabricating uranium components. Depleted uranium waste was slowly reduced during the 1960s, and only minor quantities were generated during the 1970s and 1980s. In the 1960s, 1970s, and 1980s, uranium alloys (e.g., uranium-niobium and uranium-titanium) were introduced into Buildings 444 and 883 and became the major source of depleted uranium waste.

The demand for Am-241 by the Oak Ridge National Laboratory Isotope Pool initiated chemical recovery of Am-241 from returned plutonium components. The molten-salt-extraction process to remove Am-241 from returned plutonium components generated large amounts of mixed chloride-fluoride salt with gram quantities of Am-241 and plutonium. Rocky Flats Plant extracted Am-241 in small kilogram quantities until the early 1980s. The demand for Am-241 then dropped drastically, thereby terminating recovery processing. By DOE directive, Am-241 was sent to Series 741 and 742 sludge waste streams. In

the late 1980s, however, americium and plutonium in salts used in the molten-salt-extraction process were removed by an aluminum-alloy process and shipped to the Savannah River Site. Consequently, in the early and mid-1980s, a higher level of Am-241 was present in aqueous-based sludge from Building 774.

3.1.4.3 Assay Processes. Originally, Rocky Flats Plant waste policy was to declare loss of special nuclear material as a normal operating loss. The waste generator was responsible for assigning a special nuclear material value to waste generated. For liquid waste, a chemical or radiometric assay for special nuclear material was performed; for solid waste, the estimating procedure used was based mainly on a by-difference approach combined with operating experience. These assay methods proved to be inadequate because the material unaccounted for grew to an unacceptable level (Zodtner and Rogers 1964).

3.1.4.3.1 Liquid Waste Assay—Radiometric and chemical titration methods were used to determine plutonium and americium in liquid waste solutions. The radiometric method often required large dilutions of the original solution; this added to the inaccuracy of the assay. Waste solutions originating from Building 771, where the majority of plutonium-contaminated aqueous waste was generated, were collected in criticality safe tanks awaiting transfer to Building 774. Tanks were assayed for plutonium and Am-241 content. If below plutonium discard limits,[a] the solutions were transferred to Building 774 for disposal treatment. The sampling program was improved by requiring duplicate sampling that agreed statistically before the waste was transferred to Building 774. Improved analytical methods also were developed.

3.1.4.3.2 Solid Waste Assay—During the 1950s and early 1960s, chemical assay and radiometric analysis were two analytical methods used to identify special nuclear material. X-ray fluorescence methods also were developed for plutonium analyses in the early 1960s but were used mainly on production samples (Vejvoda 2005). New systems were installed to assay small containers, drums, crates, and high-efficiency particulate air (HEPA) filters. By the late 1970s and early 1980s, sophisticated counting systems had been developed that provided (1) helix scanning, (2) segmented gamma scanning, (3) low-resolution gamma assaying, (4) alpha-neutron corrections, (5) background corrections, (6) matrix density adjustments, and (7) computerization of radiometric calculations. These systems were operating to assay all item description codes; however, these advanced systems were not available for assaying the majority of pre-1970 waste sent to the INL Site.

3.1.4.3.3 Assaying Plutonium Waste Discards—Advancements and improvements in second-generation nondestructive assay drum-counting systems prompted a review of data for drums shipped to the INL Site under the old system. Consequently, counting data (covering February 1968 to June 1971) were reviewed for 24,000 drums assayed with the 1964 drum-counting system. A report addressing unaccounted for material states that total plutonium weight was understated by about 17.6 kg (38.8 lb) for 15,795 drums at the INL Site. Based on new correction factors, operating experience, and recounts of drums with similar item description codes in the Rocky Flats Plant backlog drum field, plutonium was estimated for suspect drums at the INL Site. These plutonium estimates are summarized in Table 3-3 for individual item description codes. Two INL suspect drums were assayed at the INL Site, and Table 3-4 compares these assays.

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a. Economic discard limits were determined by comparing the cost of recovering and processing plutonium, for example, to a pure metal state with the value of producing new reactor weapons-grade plutonium metal. The break-even point was the economic discard limit for a given residue. Ordinarily, these limits were expressed in (1) grams of plutonium per gram of residue for solids and (2) grams of plutonium per liter of solution for liquid. Any residue item above the discard limit required processing, and any residue item below the discard limit was considered waste (Vejvoda 2005).

Table 3-3. Suspect drums shipped to the Idaho National Laboratory Site.

Number of Drums	Item Description Code	Description	Original Rocky Flats Plant Plutonium Weight (g)	Estimated Plutonium Weight (g)
1	300	Graphite molds	0	7
1	320	Heavy nonspecial-source metal (e.g., tantalum, tungsten, and platinum)	5	9
8	330	Dry combustibles (e.g., paper and rags)	25	2,754
1	336	Wet combustibles (e.g., paper and rags)	0	27
3	338	Filter media	49	92
1	372	Grit	45	65
2	440	Glass (except raschig rings)	1	18
3	441	Unleached raschig rings	21	1,486
33	480	Light nonspecial-source metal (e.g., aluminum, copper, and beryllium)	268	1,208
53	All	Totals	414	5,666
		Difference	**5,666 - 414 = 5,252**	

Table 3-4. Comparison of two suspect drums.

Drum Number	Item Description Code	National Reactor Testing Station Plutonium Weight (g)	Original Rocky Flats Plant Plutonium Weight (g)	Estimated Rocky Flats Plant Plutonium Weight (g)
57493	330	500	0	476
59682	480	300	0	319

Plutonium discards-to-waste (i.e., normal operating losses) were tabulated for Calendar Year 1967; the total plutonium discard assumed to have been shipped to the INL Site for Calendar Year 1967 was 70,382 g (155.2 lb).

3.1.4.4 Typical Isotopic Levels. The four most prevalent types of radiological elements shipped to the INL Site were (1) weapons-grade plutonium, (2) highly enriched uranium, (3) depleted uranium, and (4) Am-241. The isotopic content of weapons-grade plutonium varied slightly from year to year because the mixture of returned plutonium and new plutonium from the Hanford and Savannah River Site reactors was not constant. Table 3-5 shows variations in the plutonium isotopic concentrations from 1959 to 1976. Improved mass spectrometry instrumentation provided lower detection limits for Pu-238 and Pu-242; specifically, these instruments provided values below 0.05 wt% rather than just a minimum of 0.05 wt%. This provided a more definitive evaluation of the isotopic content in the waste. Table 3-6 provides typical isotopic profiles for depleted uranium, highly enriched uranium, and weapons-grade plutonium.

Table 3-5. Rocky Flats Plant plutonium isotopic levels in waste by average weight percent.

Calendar Year	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242
1959 to 1960	<0.0500	93.714	5.593	0.5932	<0.0500
1961 to 1962	<0.0500	93.817	5.486	0.5979	<0.0500
1963 to 1964	<0.0500	94.398	4.854	0.6482	<0.0500
1965 to 1966	<0.0500	93.586	5.823	0.5610	<0.0500
1967 to 1968	<0.0500	93.451	5.953	0.5670	<0.0500
1969	<0.0500	93.538	5.953	0.4790	<0.0500
1970	<0.0500	93.450	5.965	0.4850	<0.0500
1971	<0.0500	93.533	5.929	0.4380	<0.0500
1972	<0.0500	93.513	5.939	0.4480	<0.0500
1973	<0.0500	93.596	5.918	0.4300	<0.0500
1974 (first half)	<0.0500	93.571	5.900[a]	0.4855	<0.0500
1974 (second half)	0.0104	93.656	5.893	0.4620	0.0317
1975	0.0102	93.707	5.861	0.3940	0.0266
1976	0.0102	93.827	5.814	0.3510	0.0219

a. Vejvoda (2005) contains a typographical error; this value is shown erroneously as 59.000.

Table 3-6. Typical isotopic concentrations in waste.

Material	Isotope	Weight Percent
Depleted uranium	U-235	0.30
	U-238	99.70
Highly enriched uranium (Oralloy)	U-234	1.02
	U-235	93.17
	U-236	0.44
	U-238	5.37
Weapons-grade plutonium	Pu-238	0.01
	Pu-239	93.63
	Pu-240	5.97
	Pu-241	0.37
	Pu-242	0.02

3.1.4.5 Limits on Discards and Contents of Shipping Containers

3.1.4.5.1 Economic Discard Limits—Introduction of economic discard limits probably began in the 1966-to-1967 timeframe. Vejvoda (2005) defines line-generated waste coupled with an economic-discard-limit range this way: "Line-generated wastes are graphite molds, filters, sludge, insulation, glass, washables, combustibles, metal, and miscellaneous residues with plutonium discard limits ranging from 7×10^{-3} g/g to 3.0×10^{-4} g/g." Vejvoda also indicates that economic discard limits were in place in 1968. Table 3-7 shows discard limits for 1969.

Table 3-7. Economic discard limits for Fiscal Year 1969.

Category	Discard Limit (g plutonium/g total)
Sweepings	0.007
Sludge	0.007
Magnesium oxide sand	0.007
Ion-exchange resin	0.007
Incinerator ash	0.007
Sweepings heels	0.007
Ash heels	0.007
Glass and ceramics	0.0005
Scarfed molds	0.00035
Graphite flow residue	0.002
Chemical Warfare Services filter (2 × 2 × 1 ft)	24.0 g/filter
Dry box filters (8 × 8 × 4 in.)	3.0 g/filter
Washables	0.0006
Combustibles	0.0007
Miscellaneous scrap metal	0.0003

3.1.4.5.2 Container Content Limits for Transportation—In the 1950s and early 1960s, a crate limit for fissile material of 15 g/ft^3 was generally accepted. The exact date when this criticality limit was reduced to 5 g/ft^3 is unavailable. The earliest documentation for 5 g/ft^3 is dated March 13, 1969 (Vejvoda 2005). Table 3-8 provides plutonium averages for drums shipped in 1966 and 1967 in reply to a request for approval to ship waste in 55-gal steel drums.

Table 3-8. Average plutonium values for drums shipped in 1966 and 1967.

Category	Drum Contents	Average Plutonium Content (g/drum)
Category A	Non-line-generated waste for 1,582 drums	0.024
Category B	Line-generated waste for 944 drums	30.8
Category C	Building 774 output, Series 741 first-stage sludge for 398 drums	5.6
742	Second-stage sludge	<1
743	Grease sludge	1
744	Neutralized hydrochloric acid and other liquid	<1
745	Dried salt	<1

3.1.4.6 Types of Waste: Mission-Related. The majority of waste produced by Rocky Flats Plant was generated by mission-related work. These types of waste are described in the following subsections.

3.1.4.6.1 Sludge—Liquid waste typically was mixed with an absorbent. Most of the resulting sludge shipped to the INL Site was generated by the Liquid Waste Treatment Facility (Building 774). Equipment cleanouts in other buildings also occasionally produced sludge-based material because sludge formed wherever liquids were used in operations and facility systems. Descriptions of the four general kinds of sludge comprising waste sent to the INL Site (Vejvoda 2005) follow:

- **Organic-based—**Most of the organic liquid waste was contaminated with depleted uranium, highly enriched uranium, or plutonium. Organic sludge typically contained machining coolant, cutting oils, vacuum pump oils, degreasing solvents, hydraulic fluids, and lubricating greases and oils. The radioactive contamination in this sludge was particulate matter, and in general, contamination was low. This sludge was shipped to the INL Site, buried at Rocky Flats Plant, or stored. Of the variety of chlorinated hydrocarbon solvents used, the most significant was carbon tetrachloride. Vejvoda (2005) includes two sources that record Rocky Flats Plant use of carbon tetrachloride for 1 year as 60,566.6 L (16,000 gal) and 52,995.8 L (14,000 gal), indicating high carbon tetrachloride use per year. About 50 to 70% of this carbon tetrachloride ended up in Series 743 sludge. As an example of the volume, Table 3-9 shows the rate of accumulation of liquid waste for a 3-month period in 1962.

Table 3-9. Organic waste accumulated over a 3-month period.

Waste	Source (building no.)	Rate of Accumulation[a] (gal/month)
Machine coolant[b] (Shell Vitrea-carbon tetrachloride)	776	4,500
Distillation-still bottom	444	200
Distillation-still bottom (chlorinated)	444	50
Machine coolant	881	500
Chlorinated solvents	881	50
Cold oils	Miscellaneous	1,000
Trichloroethylene	777	90
Trichloroethylene	991	180
Miscellaneous organics	777, 771, 444	70

a. Rates for May, June, and July 1962.
b. Shell Vitrea was replaced around 1970 to 1972 by Texaco Regal Oil.

- **Acidic-based—**Acidic-based sludge was formed in process equipment, such as dissolvers, evaporators, pumps, and tanks. This sludge was characterized by its acidity and plutonium content as follows: (1) high nitric acid with high plutonium content, (2) high nitric acid with low plutonium content, (3) low nitric acid with low plutonium content, (4) low hydrochloric acid with presence of low plutonium content and chloride salts. Based on the plutonium concentration, this sludge was either sent to plutonium recovery or transferred to Building 774. If sent to Building 774, the sludge became Series 741 and 742 sludge and was shipped to the INL Site.

- **Caustic-based—**Caustic-based sludge was characterized as either (1) high caustic (i.e., sodium hydroxide/potassium hydroxide) with low plutonium or (2) low caustic (i.e., sodium hydroxide/potassium hydroxide) with low plutonium. The sludge was dissolved by adding water or low nitric acid, filtered, and transferred to Building 774 for final treatment.
- **Organic aqueous-based—**Organic aqueous-based sludge formed mainly in the uranium-plutonium recovery process, which employed a tributyl phosphate-dodecane extractant. This sludge was handled by the Special Recovery Group to limit introducing organic material to the Building 774 aqueous stream and to control the quantity of aqueous solutions to Building 774.

3.1.4.6.2 Filters—Filter waste refers mainly to ventilation filters used to remove airborne contamination. In the 1950s and 1960s, these were basically Chemical Warfare Services filter designs used in ventilation systems and glove boxes. Beginning in the 1960s, these filters were assayed to determine whether they were above or below economic discard limits. If above discard limits, the filter medium was removed and processed to recover special nuclear material. Filters buried earlier than the 1960s may have contained concentrations of special nuclear material higher than the economic discard limits.

Before 1964, plutonium on HEPA filters was not measured and was not accounted for as a measured discard. In 1964, measuring plutonium on discarded HEPA filters began, and recovery procedures were developed for filters highly loaded with plutonium. Economic discard limits for HEPA filters were developed in the late 1960s. As indicated in Table 3-7, the economic discard limit for glove box filters was 3.0 g per filter, and the economic discard limit for larger plenum filters was 24 g per filter. Table 3-10 lists discard limits for filter media in 1992.

Table 3-10. Plutonium discard limits for filter media in 1992.

Filter Media	Discard Limits (g/g)
Item Description Code 33—HEPA filter	0.007380
Item Description Code 335—absolute dry box filter	0.006000
Interstate Commerce Commission—376 processed filter	0.007380

HEPA = high-efficiency particulate air

The waste identification system used from 1954 to 1970 did not record ventilation-filter-generation rates by building or function. The designation used was Type III Chemical Warfare Services filters. However, a summary report by the Waste Disposal Coordination Group at Rocky Flats Plant listed the number of filters shipped to the INL Site from 1954 to 1970 by year, as shown in Table 3-11. Table 3-11 information was obtained from monthly and annual reports of waste shipping history prepared by the Waste Disposal Coordination Group. Vejvoda (2005) includes a copy of a report listing a backlog of 463 Chemical Warfare Services filters as of June 1966.

Table 3-11. Summary of filters shipped to the Idaho National Laboratory Site.

Calendar Year	Number of Filters	Number of Cartons
1954	0	0
1955	1,205	0
1956	2	0
1957	1,251	101
1958	1,042	123
1959	1,679	0
1960	130	34
1961	1,592	0
1962	549	7
1963	535	0
1964	1,023	0
1965	762	0
1966	575	10
1967	990	948
1968	323	4,267
1969	209	249
1970	641	43
Total	**2,508**[a]	**5,782**[b]

a. Includes 24 × 24 × 14-in., 24 × 24 × 16-in., 24 × 24 × 18-in., 24 × 24 × 28-in., and 28 × 28 × 16-in. cartons of filters. A reasonable assumption for the 28 × 28 × 16-in. carton and the 28-in.-deep carton is to double the number of filters per carton.
b. Includes 5,496 cartons containing 55-gal drums.

3.1.4.6.3 Graphite—Scarfings from depleted uranium molds were calcined to convert uranium metal to an oxide form; the calcined material was packaged and placed in a drum for transport to the INL Site. Rocky Flats Plant did not have chemical recovery facilities for recycling depleted uranium. Converted uranium oxide was often identified as "RO" (roaster oxide) on the trailer and railcar load lists.

Graphite shipped to the INL Site had a variety of physical forms (e.g., whole molds, fines, pieces, chunks, and partial molds). Undoubtedly, a small amount of fines was present with any of the solid graphite mold configurations. The graphite stock used to fabricate the molds was a high-density, nuclear-grade extruded graphite. Zodtner and Rogers (1964) is the only formal documentation located that defines plutonium estimates in graphite molds. An informal reference for average plutonium content for line-generated waste was 30 g (1 oz). With installation of the first workable drum counter in 1964, internal reports indicate that plutonium results in graphite drums were low and required adjustment by a factor of 1.8 ± 0.18.

From 1957 to 1962, spent graphite molds were packaged in either a 5- or 8-mil polyethylene liner inside a 55-gal drum. The drum type was not standardized, and vendor drums often were used. Early graphite mold drums were usually considered full when their weight reached about 227 kg (500 lb). Later, a limit of 90.7 kg (200 lb) of graphite per drum was required. A certificate of approval issued in 1969 for fissile large-quantity shipping containers for railcars quotes a limit of 45.4 kg (100 lb) of graphite for 30-gal drums and 90.7 kg (200 lb) for 55-gal drums for nuclear criticality safety reasons.

In the late 1960s, graphite molds and graphite mold segments were scarfed or ground to remove surface plutonium. The resulting fine material removed from surfaces was placed in metal containers and bagged from the glove box line into 55-gal drums. The scarfed or ground segments were placed directly into 55-gal drums. This general drum packaging configuration remained reasonably constant until retrievable storage was required.

3.1.4.6.4 Roaster Oxide—Depleted uranium operations produced pyrophoric uranium fines, turnings, chips, chunks, and casting skull. Shipment to other sites was not feasible because of uranium pyrophoricity; therefore, a calcining system was constructed in 1956 to oxidize these pyrophoric materials to a uranium oxide form. After calcining, roaster oxide was placed in a 30-gal drum overpacked with a 55-gal drum. Vermiculite was added to fill void space between the two drums. The outer drum (55-gal) was wiped to remove any residual contamination and then labeled and prepared for shipment. Later, a plastic 55-gal-drum liner and a cardboard disc cover were used in the packaging configuration.

Table 3-12 summarizes the depleted uranium waste shipped to the INL Site from 1954 through 1970. Table content was generated from monthly and annual history reports by the Waste Disposal Coordination Group.

Table 3-12. Summary of depleted uranium waste shipments to the Idaho National Laboratory Site.

Calendar Year	Drums (55-gal)	Drums (40-gal)	Drums (30-gal)	Boxes[a]	Chemical Warfare Services Filters[b]	Tanks	Total Volume (ft^3)	Gross Weight (lb)	U-238[c] (kg)
1954	1,217[d]	—	—	—	—	—	—	—	738
1955	1,564	—	115	—	—	—	12,248	390,104	979
1956	1,795	—	—	—	—	2	12,347	315,727	1,174
1957	1,882	—	300	—	460	—	22,176	863,800	2,147
1958	818	37	220	—	327	—	8,055	283,938	4,209
1959	692	—	97	4	—	—	5,323	200,380	3,753
1960	839	—	28	17	—	—	6,866	230,913	4,123
1961	1,030	—	37	29	333	—	10,236	268,708	4,311
1962	839	—	4	24	—	—	6,775	208,882	4,674
1963	1,510	—	3	24	92	—	12,629	286,966	1,672
1964	2,058	—	—	42	93	—	19,381	386,931	1,339
1965	1,479	—	—	41	—	—	15,742	326,797	4,269
1966	1,488	—	—	31	—	—	14,509	420,113	53,452
1967	1,473	—	—	64	—	—	18,434	498,914	53,176
1968	1,491	—	—	44	—	—	16,216	390,470	33,373
1969	1,087	—	—	40	—	—	13,028	326,098	22,721
1970	567	—	—	63	—	—	11,252	172,383	7,084
Total	**21,829**	**37**	**804**	**423**	**1,305**	**2**	**205,217**	**5,571,124**	**203,194**

a. The standard size waste box was 4 × 4 × 7 ft. Some boxes of slightly different sizes were shipped.
b. Chemical Warfare Services filter was terminology used for what are now high-efficiency particulate air filters. In early years, most measured 2 × 2 × 1 ft and shipped in boxes. In later years, some were shipped in drums.
c. Data on total weight of shipped U-238 came from a separate summary report and were not related to individual containers.
d. The report for 1954 did not itemize drum size, volume, or weight.

3.1.4.6.5 Ion-Exchange Resins—Ion-exchange resins were used extensively from the late 1950s through 1989. Three major ion-exchange resins used for plutonium recovery were: (1) Dowex 1 × 4 (50-100) mesh, (2) Dowex II (20–50) mesh, and (3) Amberlite-938 (20–50) mesh (Becker et al. 1998). These three resins were used in a nitrate form. Dowex 50 × 8 cation resin was used in the americium separation process. The major resin used was Dowex 1 × 4 anion resin (nitrate form), and Dowex 50 × 8 cation resin was in second place. Amberlite IDA-938 was used in special recovery processing during the 1970s and 1980s. Spent-ion-exchange resins were water-washed to remove residual acids. Two disposal methods were used: (1) incineration and (2) mixing with cement for shipment to the INL Site. During the 1960s, spent-ion-exchange resins were mixed with cement in a 1:1 ratio. Later, the ratio was altered to 1.5 parts resin to 1 part cement.

3.1.4.6.6 Plutonium-Contaminated Oralloy Waste—Building 881 used a dilute nitric acid rinse followed by a water rinse to remove surface plutonium contamination of returned Oralloy plutonium trigger components. Plutonium-free, highly enriched uranium components were returned to the highly enriched uranium foundry. Evaporator concentrate was treated with ammonia gas to precipitate actinides. The leaching and rinsing process generated highly enriched uranium and plutonium-contaminated solid waste (e.g., rags, absorbent wipes, filters, and other solid waste), which were packaged and shipped to the INL Site.

Leaching of returned Oralloy was transferred to Building 771 in the 1970s. The highly enriched uranium-leach solution with plutonium contamination was processed to separate uranium and plutonium. The plutonium fraction was transferred to the War Reserve plutonium recovery stream. The uranium fraction was precipitated with ammonia gas and calcined to uranium oxide. If the plutonium was less than 500 ppm, this oxide was shipped to INTEC at the INL Site.

3.1.4.6.7 Decommissioning Building 881—Building 881 discontinued producing Oralloy (i.e., highly enriched uranium) components in the early 1960s. Decommissioning activities generated significant quantities of Oralloy waste, including capital equipment, which was shipped to the INL Site. Organic liquid waste was stored at Rocky Flats Plant on the 903 Pad and processed later by the Grease Plant, Building 774.

3.1.4.6.8 Oralloy-Contaminated Equipment—Building 889 was a decontamination facility for items contaminated with depleted uranium and highly enriched uranium that could be used elsewhere in the plant. However, a significant amount of Oralloy-contaminated capital equipment was identified as surplus and was crated and shipped to the INL Site. A property disposal record form was completed for capital items. In this case, D83 numbers are capital equipment numbers and not drum numbers.

3.1.4.6.9 Fire Waste—On May 9, 1969, a fire occured in the plutonium foundry, Building 776.[b] Fire cleanup generated a significant quantity of plutonium-contaminated waste. Special numbers (e.g., A00--) were assigned to fire-waste crates shipped to the INL Site. Vejvoda (2005) lists the waste, summarizes the procedure for determining the amount of plutonium on equipment and machine tools, and describes limitations associated with wooden waste shipping crates in railcars.

3.1.4.6.10 Mound Disposal—In April 1954, burial began for drums of depleted uranium, highly enriched uranium, and low-level, plutonium-contaminated waste in the Rocky Flats Plant Mound area. Burial of these waste types continued until September 1958, by which time, a total of 1,045 drums of oil and solid waste had been buried. The majority of radioactive contamination comprised depleted

b. For more information and more sources about the 1969 fire at the Rocky Flats Plant, see Abbott et al. (2005).

uranium with some highly enriched uranium and possible low-level plutonium. Retrievals from the Mound area and offsite disposal were accomplished by May 1970. Several trailer-load lists record shipments of these waste types to the INL Site.

3.1.4.6.11 Reactor-Grade Plutonium—Although Rocky Flats Plant did not process any irradiated reactor fuel material, in the late 1960s, Rocky Flats Plant fabricated fuel elements for the Zero Power Physics Reactor at the Materials and Fuels Complex (formerly Argonne National Laboratory-West). The fuel element alloy was composed primarily of depleted uranium and included plutonium, and molybdenum. The plutonium material had Pu-240 content in the 8-to-10% range. No packaged residue or waste was shipped to the INL Site. However, trace amounts of Zero Power Physics Reactor material probably were commingled in the organic liquid waste and the aqueous waste sent to Building 774.

3.1.4.6.12 Excess Chemical Compounds—Excess chemical compounds accumulated and required a disposal route. Excess noncontaminated, water-soluble chemical compounds were added to the solar evaporation ponds next to Building 774, provided the compounds were compatible with solar-pond constituents. These chemical compounds ended up in the Series 745 evaporator salts processed through Building 774 and sent to the INL Site. Chemical compounds not acceptable in the solar ponds were treated by the generator to fit a waste stream or sent to Building 774 for disposal. Building 774 accommodated these chemical compounds through the Series 744 sludge process or were fed into an acceptable waste treatment stream that produced Series 741, 742, and 743 sludge. The disposition route was governed mainly by the quantity received for disposal.

3.1.4.6.13 Polychlorinated Biphenyls—Polychlorinated biphenyls were used throughout Rocky Flats Plant in electrical transformers, capacitors, hydraulic presses, and vacuum diffusion pumps. From 1954 to 1970, polychlorinated biphenyls shipped to the INL Site probably came through combustible waste. Leaks from hydraulic and other equipment were absorbed using rags and absorbent wipes, which were sent to the INL Site if generated in depleted uranium, highly enriched uranium, and plutonium areas. Polychlorinated biphenyls[c] were phased out in the 1970s.

3.1.4.6.14 Complexing Agents—Small amounts of complexing agents were used by analytical laboratories, and much greater amounts were used in decontamination solutions. If neither the laboratories nor chemical recovery could dispose of complex aqueous waste, the complexing waste was bottled and sent to Building 774. These solutions were treated by cementation techniques for disposal at the INL Site. The contaminated decontamination solutions were collected and transferred to Building 774. These solutions were cemented for disposal at the INL Site. At the discretion of Building 774 operators, bottles of "hot" (i.e., radiologically contaminated) decontamination solutions would be included with Series 742 and 744 sludge.

3.1.4.6.15 Plutonium Disposal from 903 Pad—Generation of machine cutting oil and other organic solvents grew into a dilemma for storage and processing, forcing outside storage on 903 Pad. A treatment process was developed in 1966 that converted organics into grease, which was identified as Series 743 sludge. Processing the estimated 5,230 drums of Series 743 sludge began in January 1967. Table 3-13 summarizes disposal of plutonium-contaminated material from the 903 Pad storage area.

c. Oil contaminated with polychlorinated biphenyls could have been processed with other organic liquid waste and sent to the SDA as Series 743 sludge and oil waste (see Abbott et al. 2005).

Table 3-13. Disposal summary of plutonium-contaminated material from the Rocky Flats Plant 903 Pad storage area.

Description of Drums	Number of Drums
Total drums at start	5,230
Drums sent to Building 774 for processing	4,826
Drums containing plutonium contamination	3,572
Empty drums (includes original empty drums plus drums emptied after solution removal)	4,672[a]
Total drums processed in Building 774 with an average of 1.7 g of plutonium per drum	4,826

a. All 4,672 empty drums were assayed before being packaged and shipped to the Idaho National Laboratory Site.

3.1.4.6.16 Nitrate Salts— Treated solution high in chemical salts but meeting radioactive levels was stored in solar evaporation ponds next to Building 774, to which an evaporator system was added. Salts from the evaporator system were weighed and emptied into a wooden crate for shipment off the INL Site. Nitrate salts were designated as Series 745 sludge. Sources of these salts include the following:

- Cyanide salts used in heat-treating baths in Building 444. Disposal of these spent baths was a waste disposal problem. Cyanide heat-treating baths were eliminated in favor of carbonate-based baths.
- Spent salt baths consisted of a mixture of sodium, potassium, and lithium carbonate contaminated with uranium oxide. The original salts were a white crystalline powder, but spent salts were colored by the spent oxides and turned grayish or blackish. Spent salt baths with uranium oxide were packaged into drums and shipped to the INL Site as Type IV sludge.
- Pyrochemical processes in the 1960s introduced mixtures of chloride and fluoride salts. The process for removing Am-241 from returned plutonium components generated large amounts of waste. Additional pyrochemical development and pilot plant operations generated additional spent pyrochemical salts in the 1970s and 1980s.

3.1.4.6.17 Asbestos— Asbestos items were commonly used in the Building 444 uranium foundry. The asbestos items could have been discarded as Type I combustibles, Type V noncombustibles, or both, depending on the operator's discretion. Other sources of asbestos in all areas were HEPA filters, filter media, and furnace insulation. Asbestos items used in foundry operations and discarded as waste, when contaminated with depleted uranium, included aprons, fire blankets (1.2 × 2.4 m [4 × 8 ft]), gloves, jackets, hoods, shin guards, and tape.

3.1.4.7 Waste from Special-Order Work. In addition to plant mission assignments, the majority of special-order work was requested by three design agencies: (1) Los Alamos National Laboratory, (2) Lawrence Livermore National Laboratory, and (3) the two Sandia Laboratories. Waste from special-order work was not typical of mission-production waste and was of significantly less volume.

3.1.4.7.1 Radionuclide Tracers— A variety of radionuclides was used for nuclear device diagnostics by Lawrence Livermore and Los Alamos National Laboratories. Nuclear devices fabricated at Rocky Flats Plant for test shots at the Nevada Test Site often were traced with certain radionuclides. The most prevalent radionuclide used was Np-237, followed by U-233. Plutonium-238, Pu-242, Cm-244, and Am-241 were used occasionally but not to the extent of Np-237 and U-233. Radionuclide tracers were added to plutonium and Oralloy metal in minor quantities to form a tracer alloy. Tracer alloy preparation procedures generated scrap and residues that could not be processed by routine plutonium recovery and metal recycling processes. Consequently, plutonium tracer scrap and residues were processed by the research and development Special Recovery Group or were sent to the Savannah River Site.

3.1.4.7.2 Neptunium—Neptunium-237 in an oxide form was used by the Chemical Technology Research and Development Group. For the duration of the program, plutonium-neptunium oxide residues were shipped to the Savannah River Site for plutonium and neptunium recovery. Consequently, the Savannah River Site was a secondary source of neptunium. Yearly inventory of Np-237 at Rocky Flats Plant varied from 29 to 1,318 g (1 to 46.5 oz) from 1963 through 1988. Based on fiscal year inventories, Vejvoda (2005) concludes that a 5-to-10% loss to waste would not represent a significant quantity of neptunium sent to the INL Site.

The Nevada Test Site used Np-237 from one to four times per year, with two per year being the norm. Therefore, the quantity of neptunium shipped to the INL Site compared to plutonium waste can be considered insignificant. However, alpha decay of Am-241 to Np-237 also should be taken into account. The majority of neptunium sent to the INL Site was in Series 741, 742, and 743 sludge. Negligible amounts were sent through graphite and sand, slag, and crucible residue.

3.1.4.7.3 Uranium-233—The majority of U-233 work was associated with device-testing projects at the Nevada Test Site. Uranium-233 was received from Oak Ridge National Laboratory in oxide form in which U-233 and U-232 were present. The U-232 content varied from several hundred parts per million to less than 100 ppm. The decay scheme for U-232 produces daughter products with high gamma emissions. To interrupt the decay sequences, a thorium strike was performed to remove the Th-228 daughter.

Items that did not contain significant quantities of U-233 were declared waste and were shipped to the INL Site. All combustible waste was shipped. Other items that may have been shipped were glassware, small process-equipment items, filters, and other miscellaneous items. Leached reduction residues and graphite casting molds were shipped to the INL Site. Liquid waste was transferred to Building 774, the Liquid Waste Treatment Plant. Small amounts of U-233 were blended into Series 741 sludge. Higher levels of U-233 were processed as cemented liquids, if necessary.

Oak Ridge National Laboratory placed a limit of less than 30 ppm of plutonium in any residue returned there; however, slightly higher part-per-million levels were accepted if the returned material could be blended down. If the oxide was contaminated with unacceptable levels of plutonium, it was stored for future use. Other U-233 residues contaminated with plutonium were shipped to the INL Site.

The U-233 program was not a major effort at Rocky Flats Plant. The frequency and scope of the projects were less than one per year, with a duration of a month or two; however, discard limits were quite high for U-233 because reprocessing capability and capacity were limited.

3.1.4.7.4 Americium—Beta decay of Pu-241 to Am-241 provided a source for a single isotope of americium. The Pu-241 concentration in war reserve plutonium ranged from 0.3 to 0.6 wt%. With a half-life of 14 years for beta decay of Pu-241, returned plutonium triggers could have an Am-241 concentration from 500 to 1,500 ppm. Americium was recovered in Building 771, and liquid waste solutions were treated in Building 774. The majority of waste streams comprised liquid transferred to the Liquid Waste Treatment Plant, Building 774. Solid waste generated was spent anion and cation ion-exchange resins, filter pads, and general housekeeping combustibles. Some glassware and other similar noncombustible processing equipment were discarded as well. All discards were based on plutonium content regardless of their respective americium content.

3.1.4.7.5 Thorium and Curium-244—Thorium work was carried out mainly in Buildings 331 and 881 during the early 1960s. No records were searched to identify thorium work more precisely because the program was limited and had few progress reports available. A very limited amount of combustibles was generated and sent to the INL Site.

The Cm-244 program lasted about 6 months. Curium-244 was introduced into plutonium using the coreduction technique. The curium-plutonium short ingot was blended into a feed ingot to obtain the concentration of specified parts per million for the Cm-244. The curium-plutonium scrap and residues were stored pending shipment to the Savanna River Site. Line-generated combustibles and secondary residues were shipped to the INL Site, based on their plutonium content.

3.1.5 Subsurface Disposal Area Buried Waste Retrievals

Eight historical buried waste retrieval projects have been implemented in the SDA since 1969:

- **Pit 1—**In 1969, waste was retrieved from Pit 1 to locate experimental laboratory equipment that had been inadvertently buried in the SDA (Hiaring, Horton, and Schlafman 1992).
- **Pits 2, 5, 10, and 11—**In 1971, the Solid Radioactive Waste Retrieval Test, also known as the Allied Chemical Corporation ACI-120 Project, retrieved 16 drums from Pits 2, 5, 10, and 11 for examination in the Auxiliary Reactor Area I Hot Cell. One of three targeted drums was successfully retrieved (Thompson 1972).
- **Pits 11 and 12—**From 1974 to 1978, the Initial Drum Retrieval Project retrieved all drums from Pits 11 and 12 and transferred them either to the TSA or to Pad A (also known as the Transuranic Disposal Area) (Card and Wang 1976; McKinley and McKinney 1978a). A total of 20,262 drums and a volume of 4,397 m^3 were retrieved.
- **Pits 1 and 2, Trenches 1, 5, 7, 8, 9, and 10—**The Early Waste Retrieval Project (1976 to 1978) was initiated to investigate problems with large-scale removal of buried waste contaminated with TRU elements from the SDA landfill (Card 1977; McKinley and McKinney 1978b; Bishoff and Hudson 1979). A total of 457 drums and a volume of 170.4 m^3 were retrieved.
- **Pad A—**In 1978 and 1979, the Penetration and Inspection Project evaluated the condition of waste placed on Pad A (Bishoff 1979a, 1979b). Though no waste was retrieved, the physical condition of waste containers was evaluated.
- **Pad A—**Pad A was inspected again in 1989 during the Initial Penetration Project. A single drum of Rocky Flats Plant Series 745 evaporator salts was retrieved to support ex situ vitrification testing (INEL 1988; Halford et al. 1993).
- **Pit 9—**In 2004, the Operable Unit 7-10 Glovebox Excavator Method Project removed 454 drums of buried waste from Pit 9, meeting revised Phase II requirements of the Operable Unit 7-10 Record of Decision (ROD) (DOE-ID 1992).
- **Pit 4—**In 2005, the Accelerated Retrieval Project began Phase 1 of a non-time-critical removal action to reduce the source of TRU isotopes, volatile organic compounds (VOCs), and uranium in the SDA (DOE-ID 2004a). Between January 13, 2005, and April 30, 2005, 284 drums of targeted waste were retrieved, visually inspected, packaged, and assayed for safe storage.

Figure 3-3 shows the 11 locations from which waste has been retrieved in the SDA. The following subsections summarize each of the retrieval projects.

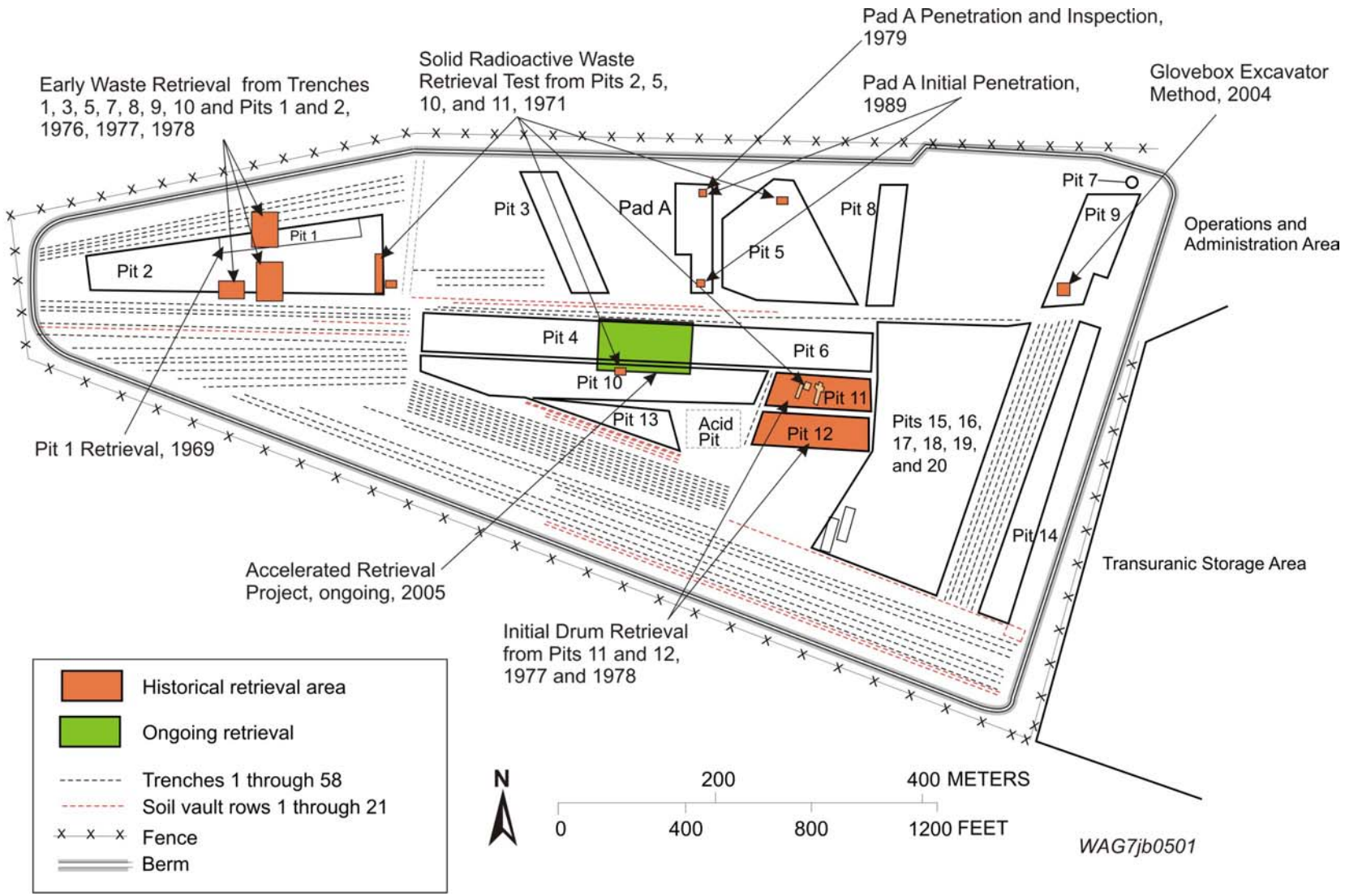

Figure 3-3. Historical and ongoing waste retrievals in the Subsurface Disposal Area.