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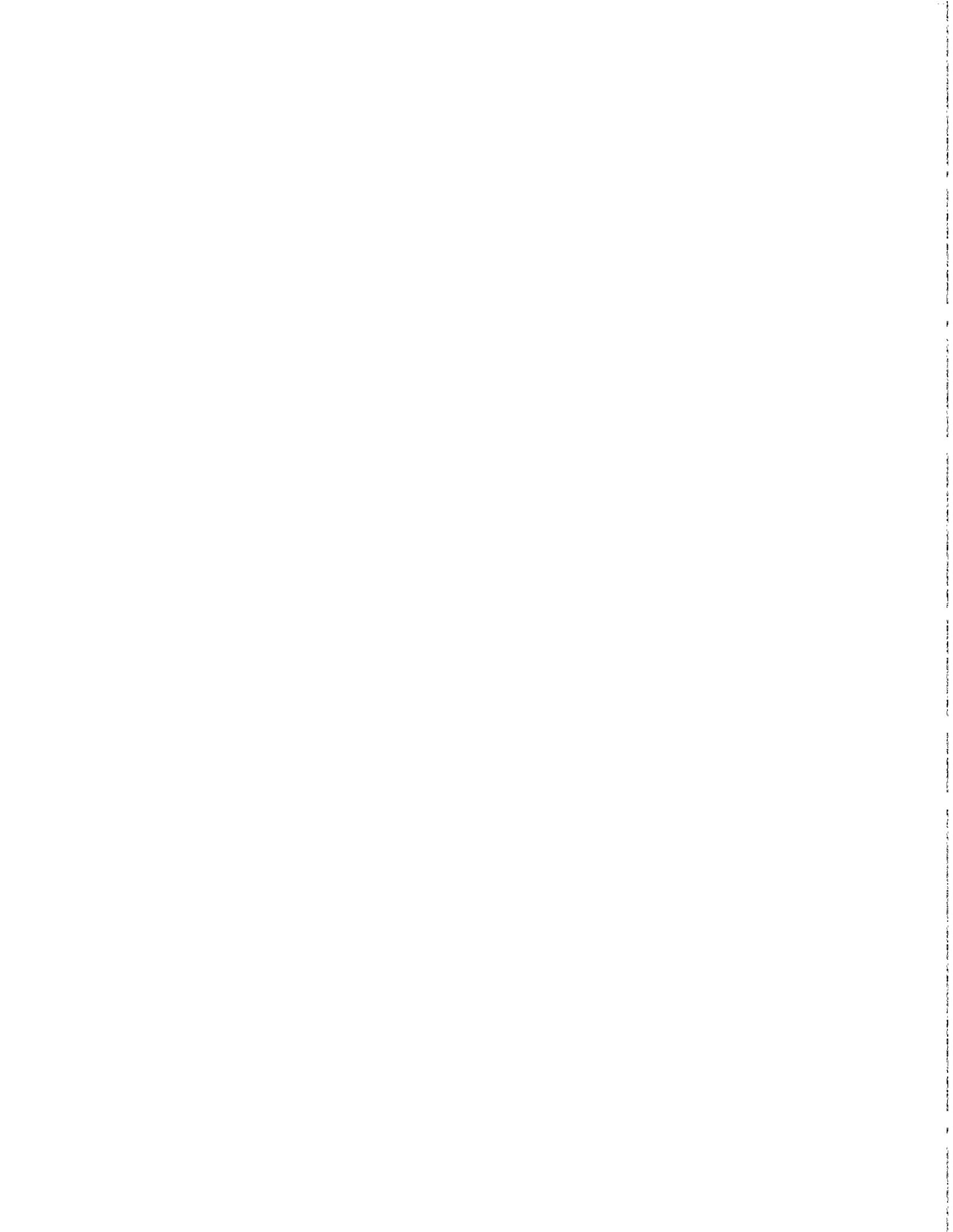
NUCLEAR MATERIALS

Removing Plutonium Residues From Rocky Flats Will Be Difficult and Costly



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**Resources, Community, and
Economic Development Division**

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September 4, 1992

The Honorable John Glenn
Chairman, Committee on
Governmental Affairs
United States Senate

The Honorable J. James Exon
The Honorable Timothy E. Wirth
United States Senate

The Honorable David E. Skaggs
The Honorable John M. Spratt, Jr.
House of Representatives

This report responds to your requests that we examine the backlog of plutonium residues at the Department of Energy's Rocky Flats Plant in Colorado. The report discusses (1) the quantity of lean plutonium residues (materials containing relatively low levels of plutonium) currently stored at the plant and (2) the agency's plans for removing the backlog.

Unless you publicly release its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies of the report to appropriate congressional committees, the Secretary of Energy, and other interested parties. We will also make copies available to others upon request.

This work was performed under the direction of Victor S. Rezendes, Director, Energy and Science Issues, who may be reached at (202) 275-1441. Major contributors to this report are listed in appendix I.

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

The Department of Energy's (DOE) Rocky Flats Plant, near Denver, Colorado, processed plutonium and used it in fabricating nuclear weapons components for nearly 40 years. These activities generated plutonium residues—materials that have been contaminated with varied amounts of recoverable plutonium. Because of past needs to produce a large number of components, processing problems, and the shutdown of the plant, large amounts of residues have accumulated at the plant. DOE does not intend to resume making weapons components from plutonium at Rocky Flats and now faces the task of removing the residues from the plant.

Five Members of Congress requested GAO to examine how DOE will undertake this task. Because of the requesters' desire for a publicly available report, GAO focused its review on lean residues (materials with relatively low amounts of plutonium) rather than on rich residues (materials with high amounts of plutonium), for which information is classified. As agreed with the requesters' offices, the report discusses (1) the quantity of lean plutonium residues stored at Rocky Flats and (2) DOE's plans to remove these residues from the plant.

Background

The Rocky Flats Plant is a government-owned facility operated by EG&G Rocky Flats, a subsidiary of EG&G, Inc., under a contract with DOE. The plant's primary function was to use plutonium, a man-made metallic element produced as a by-product of fission reactions, to fabricate "pits," the triggers for the nation's nuclear weapons. Plutonium is a long-lived radioactive material that is very toxic and must be handled with special equipment.

Plutonium not meeting weapons specifications and materials containing economically recoverable quantities of plutonium are defined by DOE as residues and have been retained for future processing. DOE has determined that these materials should be stored as residues when the cost of recovering the plutonium is less than the cost of obtaining new plutonium from reactors. Residue materials include ash, ceramic containers, and insulation—some of which are less than 1 percent plutonium—as well as liquids such as laboratory solutions and aqueous processing by-products.

All operations for processing plutonium and fabricating plutonium weapons components at Rocky Flats were shut down in 1989 for various reasons, including concerns about human health and safety. In January 1992 DOE announced that the principal function of the plant will shift from plutonium component production to site cleanup. Most of the buildings

that are housing plutonium operations, including buildings now storing residues, will not resume operations but will instead be decontaminated and decommissioned. Buildings whose use will resume will facilitate the plant's cleanup and provide a standby capability for weapons production.

Results in Brief

The plant's latest inventory records for lean residues show that 97,000 kilograms of solid residues and 14,000 liters of liquid residues—together containing about 2,900 kilograms of plutonium—are stored at the plant. In order to clean up Rocky Flats, DOE will have to remove these residues. However, removal of these residues will be difficult because they cannot be removed from the plant in their current form since they contain combustible materials or possess other characteristics that do not comply with shipping criteria for nuclear materials.

DOE has not determined how it will eliminate the residue backlog at Rocky Flats. Decisions on eliminating the backlog are expected to be made by DOE in mid-1993, after it completes an environmental impact analysis. The agency is currently evaluating three basic alternatives—processing the residues at Rocky Flats to separate out the plutonium, shipping them to other facilities for processing, or disposing of them as wastes. Furthermore, DOE is addressing important issues regarding an overall strategy for managing the agency's plutonium inventory, the cost of the alternatives, and the availability of waste disposal facilities. How these issues are resolved could greatly affect these decisions and the cost of implementing them.

Principal Findings

Residue Backlog Must Be Removed to Close the Plant

As of November 1991 Rocky Flats' inventory records for lean residues showed that the 97,000 kilograms of solid residues—such as ash, insulation, combustible materials, and chloride salts—stored at the plant hold about 2,800 kilograms of plutonium. These residues are stored in over 6,600 drums and other containers. The approximately 14,000 liters of liquid residues, stored in bottles and tanks, contain about 91 kilograms of plutonium.

DOE's decisions to not restart Rocky Flats' plutonium processing and fabricating operations and to decontaminate and decommission most

buildings housing these operations require that these plutonium residues be removed from the plant. None of the residues, however, can be removed from Rocky Flats in their current form. For example, residues that are liquids, contain any liquid or combustible materials, or generate gas violate the Nuclear Regulatory Commission's or the Department of Transportation's requirements for shipping nuclear materials. Also, many residues are large and bulky and cannot fit into containers that have been approved for transporting these materials.

DOE's Plans for Eliminating the Backlog Are Still Evolving

DOE faces difficult choices in eliminating the backlog of plutonium residues at Rocky Flats. The agency has been studying various options—processing the residues to separate the plutonium, preparing the residues for shipment to other DOE facilities, and/or disposing of the residues as wastes—in preparing an environmental impact statement for the task of removing the residues from the plant. However, because Rocky Flats' processing capabilities are limited, some additional capabilities will be needed under any alternative. For example, under the first option Rocky Flats would need the capability to extract plutonium from chloride salts using hydrochloric acid as a solvent, and under the second and third options, the plant would need the capability to reduce the volume of combustibles so that they could be repackaged for shipment. The costs to acquire these capabilities and eliminate the backlog could be substantial. DOE's preliminary data show that the costs to eliminate the backlog range from \$667 million to \$1.5 billion, depending upon the alternative chosen.

A final decision on eliminating the backlog of plutonium residues is not expected until 1993, after DOE completes the environmental impact statement and the Secretary of Energy issues a record of decision. DOE is also addressing several key issues that must be resolved before making its final determination about the plutonium residues at Rocky Flats. The agency is developing a long-term strategy for managing its entire inventory of plutonium—a strategy that determines how much plutonium is needed for the future, how this material will be used, and where and how it will be stored. The agency also is preparing more precise cost estimates that include the cost of long-term storage of plutonium and that adequately forecast waste disposal costs. Finally, DOE is assessing concerns related to the availability of waste disposal facilities—no facility for disposing of these materials is currently operating—and the criteria for shipping wastes to such disposal facilities. DOE is currently attempting to address these issues in its ongoing planning efforts.

Recommendations

Because DOE's plans for removing plutonium residues from Rocky Flats are evolving, GAO is not making any recommendations in this report.

Agency Comments

GAO discussed the report's contents with DOE officials in the agency's headquarters Office of Weapons and Materials Planning and Rocky Flats Office, as well as EG&G officials responsible for removing plutonium residues from the plant. These officials generally agreed with the information discussed in this report, and we incorporated their comments as appropriate. However, as requested, GAO did not obtain written comments from DOE on a draft of this report.

Contents

Executive Summary		2
Chapter 1		8
Introduction		8
	Operations at Rocky Flats Generated Plutonium Residues and Wastes	8
	Operations Involving Plutonium Have Been Shut Down	9
	Objectives, Scope, and Methodology	10
Chapter 2		12
Large Residue Backlog at Rocky Flats Will Be Difficult to Remove		12
	Large Quantities of Residues Are Stored at the Plant	12
	Residues Do Not Meet Shipping and Disposal Requirements	13
Chapter 3		18
DOE's Plans for Removing Residues From Rocky Flats Are Uncertain		18
	DOE Is Evaluating Three Alternatives for Removing Residues From the Plant	18
	Preliminary Residue Removal Plan Focuses on Processing to Remove Backlog	22
	DOE Is Addressing Key Issues Before Finalizing Elimination Plans	23
	Conclusions	26
Appendix		28
	Appendix I: Major Contributors to This Report	28
Tables		
	Table 2.1: Rocky Flats' Solid Lean Residues by Weight, Number of Containers, and Plutonium Content	13
	Table 2.2: Residues' Characteristics That Prevent Their Shipment From Rocky Flats	15
	Table 3.1: Rocky Flats' Estimates of Costs for Processing Residues to Recover Plutonium	19
	Table 3.2: Rocky Flats' Estimates of Costs for Processing Residues for Shipment and Later Recovery of the Plutonium	20
	Table 3.3: Rocky Flats' Estimates of Costs for Disposing of Residues as Wastes	22

Contents

Abbreviations

DOE	Department of Energy
EIS	environmental impact statement
EPA	Environmental Protection Agency
GAO	General Accounting Office
RCRA	Resource Conservation and Recovery Act
REM	roentgen equivalent man
WIPP	Waste Isolation Pilot Plant

Introduction

The Department of Energy (DOE) is responsible for developing all nuclear materials and weapons for the nation's defense programs. Among its missions are producing the special nuclear material necessary for nuclear weapons as well as researching, designing, fabricating, and dismantling these weapons. These activities are performed at various facilities located throughout the country.

One key facility in DOE's nuclear weapons complex is the Rocky Flats Plant near Denver, Colorado. Rocky Flats is owned by DOE and is now operated by EG&G Rocky Flats, a subsidiary of EG&G, Inc. EG&G took over the plant's operation on January 1, 1990, from the Rockwell International Corporation, North American Space Operations Group. Located on a 6,550-acre site, Rocky Flats began operations in 1953. Most portions of the plant were shut down in 1989 for various reasons, including concerns about human health and safety. Prior to the shutdown, Rocky Flats was responsible for fabricating weapons components. To fulfill this responsibility, the plant conducted a number of operations, including processing plutonium¹ to weapons specifications and fabricating plutonium into components for nuclear weapons. The finished products—known as “pits”—are the triggers for nuclear weapons and were shipped to the Pantex Plant in Amarillo, Texas, for final assembly in the weapons.

Operations at Rocky Flats Generated Plutonium Residues and Wastes

Rocky Flats' production of nuclear weapons components generated various materials that contain plutonium. These materials include scrap metal, plutonium oxides, ash, leaded gloves, filters, and insulation. Because of the high cost to produce plutonium from nuclear reactors, materials containing recoverable amounts of plutonium were retained at the plant as residues. Materials such as plutonium oxides and plutonium metal that had high concentrations of plutonium were considered “rich residues” and were retained for plutonium recovery. Other materials that had low concentrations of plutonium, such as ash, leaded gloves, and filters were considered to be “lean residues,” but they still were retained at the plant if the plutonium was economically recoverable.

To determine if contaminated material contained economically recoverable plutonium, DOE used a formula that compared the cost of recovering the plutonium with the cost of producing new plutonium and determined the concentration of plutonium needed in materials in order to make recovering it economical. All materials containing plutonium in

¹Plutonium is a long-lived, man-made fissile material that is produced as a by-product of nuclear reactions. When converted to a metal form, plutonium is particularly useful in nuclear weapons. Plutonium is also toxic if inhaled, ingested, or absorbed through an open wound.

concentrations greater than the discard limit were retained as residues for processing. Materials below the concentration deemed economically recoverable were generally designated as transuranic wastes.²

The processing of residues at Rocky Flats to recover plutonium did not keep pace with the generation of residues after the early 1980s. Large quantities of plutonium residues ended up in storage because the plant's processing capability and capacity declined as facilities aged. In the early 1980s, DOE built a new facility for processing residues to replace facilities built in the 1950s; however, this facility has never operated as planned because of design, materials, and mechanical problems. DOE has not been successful in its subsequent attempts to acquire funding to repair the facility. Consequently, in fulfilling requirements for fabricating weapons components, the plant processed the residues that only contained high percentages of plutonium. Residues with lower percentages of plutonium were stored.

Operations Involving Plutonium Have Been Shut Down

At this time, Rocky Flats is not producing plutonium weapons components or processing plutonium residues. Plutonium operations at the plant were suspended in late 1989 for a semiannual inventory of special nuclear materials. After the shutdown for inventory, DOE and EG&G Rocky Flats decided to keep the plant's plutonium operations closed in order to address key concerns about safety and management. DOE and the contractor believe, among other things, that certain managerial practices, systems, operations, and training programs either were not in place or had not benefited from lessons learned in the commercial nuclear industry and that a culture emphasizing safety did not exist at the plant.

DOE had been attempting to resolve these concerns at Rocky Flats and restart all operations related to processing plutonium and fabricating it into weapons components. However, in January 1992, the President announced the cancellation of all further production of warheads for the Trident II missile, thereby eliminating the sole remaining plutonium production requirement at Rocky Flats. Consequently, the Secretary of Energy decided to begin phasing out nuclear production work at the plant and begin cleaning it up. The Secretary announced that only three buildings that house plutonium operations—buildings 559, 707, and 371—will be reopened at the plant to facilitate the cleanup and to provide

²Transuranic wastes are materials contaminated with man-made elements, such as plutonium, that are heavier than uranium.

a standby capability for weapons production. The other such buildings will be decontaminated and decommissioned.

Because of this redirection for Rocky Flats, plutonium residues need to be removed. According to DOE's April 1991 "Plutonium Strategy Options Paper," the backlog of residues must be eliminated before the plant can be fully decontaminated. The residues are currently stored in buildings that housed plutonium operations, including buildings 771, 776, 777, and 779. DOE plans to transfer these buildings to a decontamination phase late in fiscal year 1992. Until the residues are removed, the decontamination of those buildings cannot be accomplished.

Objectives, Scope, and Methodology

Several Members of Congress—the Chairman, Senate Committee on Governmental Affairs, Senators J. James Exon and Timothy E. Wirth, and Representatives David E. Skaggs and John M. Spratt, Jr.—requested that we examine various issues regarding the residues at Rocky Flats. Specifically, we were asked to (1) determine the quantity of plutonium residues currently stored at Rocky Flats and (2) evaluate DOE's plans for eliminating and/or removing these residues from the plant. We were also requested to provide an unclassified report if possible. Because information on the quantities of plutonium in rich residues is classified, we focused our work on the lean residues so that we could keep the report unclassified.

Our review was conducted primarily at the Rocky Flats Plant near Denver, Colorado. To determine the quantity of lean residues currently stored at the plant, we reviewed EG&G's inventory data from the Rocky Flats Safeguards Accountability Network, the plant's computerized inventory system for nuclear materials. To determine the reliability of the data, we obtained DOE's internal reviews of the contractor's inventory procedures. We interviewed officials from DOE and representatives of EG&G who are responsible for monitoring and managing the residue inventory at Rocky Flats. Physical inspection to verify the inventory data, however, was not possible because the plant's present operating restrictions preclude opening drums for inspection.

To obtain data on DOE's plans for removing the residues from Rocky Flats, we reviewed available documents and interviewed DOE personnel at Rocky Flats and DOE headquarters. We reviewed files being used to prepare an environmental impact statement (EIS) for the task of eliminating the backlog of residues at the plant. In addition, we obtained and reviewed

DOE's report, prepared for the state of Colorado, for handling mixed residues, which are plutonium residues that also contain other hazardous materials. We discussed with cognizant DOE officials the methodology used in developing these documents.

To provide some assessment of the data and the plans being developed, we reviewed files pertaining to the types and quantities of residues that could be removed from Rocky Flats without being processed. We interviewed EG&G transportation personnel to determine what criteria regulate the shipping of residues to other locations for plutonium recovery and reviewed the applicable shipping criteria. We reviewed files describing the characteristics of the plutonium residues at the plant and compared those with the appropriate criteria.

To obtain data to determine whether the residues could be shipped as wastes, we interviewed DOE and EG&G personnel responsible for waste operations to identify appropriate shipping and storage criteria. We reviewed available criteria for shipping wastes in DOE's TRUPACT II waste container—the only container available for shipping transuranic wastes—and we reviewed criteria for storing wastes in DOE's Waste Isolation Pilot Project (WIPP) in New Mexico. We compared the characteristics of the residues at Rocky Flats to those defined by criteria.

We interviewed DOE and EG&G personnel to determine the processing capability that existed at the time the plant was shut down. We reviewed documents and held discussions pertaining to operations and operational problems in buildings housing plutonium operations.

We sought the views of DOE officials in its headquarters Office of Weapons and Materials Planning and its Rocky Flats Office, as well as EG&G officials responsible for removing plutonium residues from the plant. These officials generally agreed with the information discussed in this report, and we incorporated their comments as appropriate. However, as requested, we did not obtain written agency comments from DOE on a draft of this report. Our work was performed from March 1991 through May 1992 in accordance with generally accepted government auditing standards.

Large Residue Backlog at Rocky Flats Will Be Difficult to Remove

Rocky Flats' records show that about 97,000 kilograms of various types of solid lean residues containing about 2,800 kilograms of plutonium are stored at the plant. Also stored at Rocky Flats are over 14,000 liters of liquid lean residues containing approximately 91 kilograms of plutonium. No longer needed at the plant, the residues must be removed to decontaminate and decommission the buildings. However, none of the lean residues can be shipped to other DOE locations for plutonium recovery, storage, or disposal as wastes because the residues are ignitable contain liquids, or produce excessive heat and consequently do not comply with existing transportation and storage regulations. Furthermore many of the residues cannot be transported because they will not fit into approved shipping containers.

Large Quantities of Residues Are Stored at the Plant

Plutonium-contaminated materials have been retained by Rocky Flats as residues because of the need for plutonium in the weapons program. In the 1980s, the rate at which weapons were produced required that the maximum amount of plutonium be produced and recovered; consequently, DOE's policy has been to retain all scrap materials with economically recoverable plutonium. In accordance with this policy, such materials were stored for eventual use in weapons. Some of these residues have been stored since the early 1980s.

The rich residues stored at Rocky Flats, which include such materials as plutonium oxides and site returns,¹ contain concentrations of plutonium as high as 99 percent. The lean residues at the plant, which include such materials as ash, chloride salts, ceramic materials, and insulation, contain low concentrations of plutonium—less than 1 percent in some cases. The liquid residues, which include laboratory solutions as well as solutions from chemical processes conducted to extract plutonium, contain various concentrations of plutonium.

Rocky Flats' inventory records show that substantial quantities of plutonium residues are stored at the plant. Specific information on the amount and plutonium content of the rich residues is classified. These residues contain most of the plutonium in the inventory but take up comparatively little of the total volume. Lean residues are the bulk of the inventory. The solid lean residues weigh about 97,000 kilograms (approximately 213,000 pounds) and contain about 2,800 kilograms (approximately 6,100 pounds) of plutonium. Table 2.1 describes Rocky Flats' inventory of solid lean residues.

¹Site returns are plutonium components obtained from retired weapons.

**Chapter 2
Large Residue Backlog at Rocky Flats Will
Be Difficult to Remove**

Table 2.1: Rocky Flats' Solid Lean Residues by Weight, Number of Containers, and Plutonium Content

Residue	Weight (kgs)	Number of containers		Plutonium content	
		55- gallon drums	Smaller containers	Amount (kgs)	Percent
Ash	10,342	803	21	710	6.9
Ceramics/slags	12,728	346	366	308	2.4
Chloride salts	13,695	648	2,603	998	7.3
Combustibles	16,534	740	24	119	0.7
Dissolution heels ^a	10,011	404	4	283	2.8
Glass/rings	1,275	45	1	9	0.7
Graphite/ firebrick	22,475	473	86	228	1.0
Insulation	2,698	236	6	97	3.6
Leaded gloves	502	8	0	2	0.4
Metal	6,320	128	63	32	0.5
Other	223	20	3	1	0.5
Total	96,803	3,851	3,177	2,787	2.9

^aDissolution heels are insoluble materials remaining after the chemical processing of residues.

In addition to having the solid materials, Rocky Flats also has a significant amount of liquid residues. About 14,000 liters of liquids containing 91 kilograms of plutonium (approximately 200 pounds) are stored in 16 tanks and in over 400 4-liter plastic bottles. Some bottles are stored in gloveboxes and others are stored in 55-gallon drums. These liquids contain plutonium nitrate and plutonium chloride, which are by-products of various aqueous processing operations.

Residues Do Not Meet Shipping and Disposal Requirements

Because of the President's recent decision that eliminated the remaining warhead production requirements for Rocky Flats and the Secretary's plans to decontaminate and decommission the plant, there is no longer any need to retain these residues at the plant. Moreover, according to Rocky Flats officials, the backlog of residues must be removed before the plant can be fully decontaminated. The residues are currently stored in buildings used for plutonium processing that are to enter the decontamination phase beginning late in fiscal year 1992.

Existing transportation regulations, however, do not permit the residues to be removed from the plant in their present forms. Rocky Flats' evaluation of how to eliminate the backlog of residues is not yet completed, but

available information indicates that removing the backlog cannot be accomplished unless the residues are altered.

Residues Cannot Be Shipped for Plutonium Recovery

Other DOE facilities potentially are capable of storing the residues and processing them to obtain plutonium. The Savannah River Plant, in South Carolina, and the Los Alamos National Laboratory, in New Mexico, processed certain residues from Rocky Flats in the past to help the plant obtain plutonium to meet its weapons production requirements. Between 1980 and 1990, about 14,000 kilograms of residues—of which less than one-third were lean residues—were shipped from Rocky Flats to these facilities for plutonium recovery.

However, the lean residues at Rocky Flats have characteristics that prohibit their shipment to other facilities without processing to alter the residues' forms or chemical characteristics to meet regulations. The Department of Transportation's and the Nuclear Regulatory Commission's regulations contained in 10 C.F.R. 71 and 49 C.F.R. 173.400 govern the preparation, packaging, and shipping of nuclear materials to ensure they do not possess certain characteristics that make them unsafe or that could make a release of radioactivity more likely. The regulations provide that shipments of nuclear materials cannot

- be in liquid form or contain excessive moisture,
- be in a form that is pyrophoric (capable of igniting spontaneously) or have pyrophoric properties, or
- generate more than 10 watts of thermal energy per container.²

Certain rich residues such as site returns and impure plutonium meet current shipping requirements. None of the lean residues, however, can be transported because they violate one or more of the prohibitions on shipping. Table 2.2 lists the residues and their characteristics that preclude shipping them in their present form.

²Thermal energy, or decay heat, is the result of the radioactivity in a container. This heat will cause the decomposition of certain materials, such as plastic, which may produce gas and generate pressure within the container.

**Chapter 2
Large Residue Backlog at Rocky Flats Will
Be Difficult to Remove**

Table 2.2: Residues' Characteristics That Prevent Their Shipment From Rocky Flats

Residue	Characteristics that prevent shipment
Ash	Generates excessive thermal energy
Ceramics/slugs	Are pyrophoric
Chloride salts	Are pyrophoric, contain excessive moisture, generate excessive thermal energy
Combustibles	Are pyrophoric, contain excessive moisture, generate excessive thermal energy
Dissolution heels	Are pyrophoric, contain excessive moisture, generate excessive thermal energy
Glass/rings	Are pyrophoric, contain excessive moisture, generate excessive thermal energy
Graphite/firebrick	Are pyrophoric, generate excessive thermal energy
Insulation	Is pyrophoric, generates excessive thermal energy
Leaded gloves	Contain excessive moisture, generate excessive thermal energy
Metal	Is pyrophoric, contains excessive moisture
Other	Is pyrophoric

Additionally, residues must fit into containers approved for shipping nuclear materials. Residues must be shipped in containers approved for use in DOE's Safe Secure Trailers, which are specially built tractor-trailers for transporting weapons and special nuclear materials. The only container approved for shipping residues, however, has a useful capacity of about 2 liters, which restricts what can be placed in it. Bulky and oversized materials such as leaded gloves, insulation, and certain combustibles would not fit into this container without first being cut or shredded.

Acquiring new containers with greater capacity and/or new methods of shipment is possible but would be very time-consuming because the development, testing, and approval of new containers can take years, according to the EG&G official in charge of nuclear materials transportation. A 1990 study performed at Rocky Flats by personnel from Los Alamos National Laboratory raised the possibility of using other existing containers, such as those used for shipping fuel rods from nuclear power plants, but cautioned that this method also would be subject to a lengthy approval process.

According to an EG&G transportation official, the requirements for shipping nuclear materials have become more restrictive in recent years, and much of the material that has been shipped in the past would now need

additional processing before shipping would be permitted. Over half of the plutonium previously shipped was in an oxide form that cannot be shipped today unless it were put through a high-temperature process that would remove all ignitable materials. The official also said that processing to render residues shippable can require extensive efforts. For example, past shipments of approximately 600 kilograms of ash required almost 2 years of processing at Rocky Flats to meet shipping criteria.

Residues Cannot Be Shipped for Disposal

DOE can designate the residues as wastes for disposal if it decides it does not want to retain the plutonium. However, the criteria that will control any shipment to and disposal of waste at WIPP, currently the only transuranic waste disposal site under development, restrict allowable quantities of plutonium to levels much lower than those that exist in the residues. As a result, none of the lean residues currently meets the applicable requirements.

In order for the residues to be shipped to WIPP as wastes, they must meet the requirements both for transporting the material in DOE's transuranic waste shipping container, TRUPACT II, and for accepting the waste by WIPP. These requirements set significant restrictions on the waste material that can be shipped in order to reduce the likelihood of leakage, explosion, or radiation exposure. Specifically, the transportation and waste acceptance requirements place the following restrictions on shipping the residues for disposal.

- Powders, ashes, and similar particulate waste materials must be immobilized with cement, glass, or similar materials.
- Pyrophoric materials must be rendered safe by mixing them with chemically stable materials or processing them.
- Wastes must not be in liquid form or contain liquids, explosives, or compressed gases.
- The radionuclide content (the amount of plutonium and other radioactive elements) must be no greater than 200 grams in a 55-gallon drum for acceptance by WIPP; however, the radionuclide content is further limited by the TRUPACT II shipping criteria, which allows only about 23 grams of plutonium per drum.³

³The TRUPACT II criteria for shipping wastes permit 325 grams of plutonium per container. Since each TRUPACT II container holds 14 drums, this effectively limits each drum to approximately 23 grams of plutonium, significantly less than the criteria for acceptance at WIPP.

Chapter 2
Large Residue Backlog at Rocky Flats Will
Be Difficult to Remove

- The surface radiation on containers must not exceed 0.2 rem per hour.⁴

On the basis of analyses conducted in February 1992, Rocky Flats personnel concluded that none of the plutonium residues meets the criteria for shipping wastes in TRUPACT II containers or for accepting them at WIPP. For example, one type of graphite residue would exceed the shipping criteria limits on plutonium content by almost 40 times. Although certain other residues have a lower radionuclide content, all residues contain too much plutonium and other nuclear materials to meet the shipping criteria. Furthermore, certain residues, such as ash and combustibles, contain particulate and/or pyrophoric materials that would prevent the residues' acceptance at WIPP.

Rocky Flats personnel explained that for the residues to comply with all of the criteria would require that the residues be processed, repackaged, or both. Personnel estimated that complying with the applicable criteria would create approximately 72,000 additional drums of wastes that would have to be disposed of—about 10 times the number of drums and containers currently containing residues.

⁴A rem (roentgen equivalent man) is a unit of ionizing radiation that is estimated to have the same biological effect on body tissues as one roentgen of X-rays.

DOE's Plans for Removing Residues From Rocky Flats Are Uncertain

DOE's plans to resolve the residue backlog situation are still evolving. The agency is currently developing an environmental impact statement on the elimination of the residues and is assessing the resources that would be needed to eliminate the residues under three alternatives: (1) processing them at Rocky Flats to recover the plutonium; (2) shipping the residues to other DOE facilities; and (3) disposing of them as wastes. Owing in part to Rocky Flats' limited capability to process and/or prepare the residues to meet current restrictions on shipping the materials, substantial capital, operating, and wastes costs will likely be incurred under any alternative.

A final decision on eliminating the backlog of plutonium residues at the plant is not expected until 1993, after DOE completes the EIS for the residue elimination effort. A preliminary plan, prepared in February 1992, focuses on processing the residues to recover the plutonium to facilitate their removal. Before it can make a final decision, however, key issues regarding (1) the long-term need and uses for the plutonium, (2) the cost of each alternative, and (3) the shipping and disposal of wastes at WIPP, must be resolved. DOE is undertaking efforts to address these issues as part of its assessments on eliminating the residue backlog.

DOE Is Evaluating Three Alternatives for Removing Residues From the Plant

In compliance with the National Environmental Policy Act's requirements, DOE is developing an EIS that assesses the effects of removing residues from Rocky Flats. The preparation of the EIS is focusing on methods that could be used to eliminate the residue backlog under the three alternatives:

- processing the residues at Rocky Flats to recover the plutonium;
- processing and/or preparing the residues at Rocky Flats so they can be shipped to other DOE facilities, which would then either store them or recover the plutonium; or
- preparing the residues to ship them to waste repositories.

DOE is evaluating these alternatives on the basis of numerous factors, such as feasibility, reliability, cost, and the volume of wastes that would have to be disposed of. At the time of our review, only preliminary data were available on the estimated capital, operating, and wastes costs that would result from activities needed to eliminate the solid residues. The data show that all of the alternatives will require the installation of additional capabilities, such as nitric acid processes and volume reduction facilities, at Rocky Flats because the existing ones are not adequate.

Processing Residues to Recover Plutonium

The first alternative involves processing the backlog of residues to extract plutonium and produce a transportable plutonium oxide, which would then be shipped to other DOE locations for storage and possible later use. By-products from processing, which would contain little plutonium, would be sent to appropriate DOE waste facilities. According to a DOE official, this alternative resembles Rocky Flats' past plutonium processing activities since plutonium would be separated from other materials and recovered as a plutonium oxide. However, the final purification steps to produce a plutonium metal suitable for use in weapons are not needed and therefore would not be conducted.

According to Rocky Flats' data, this alternative would result in the lowest amount of waste that would need to be disposed of. Estimates developed for this alternative show that approximately 15,700 drums of transuranic wastes and 13,000 drums of low-level wastes¹ would be generated. Furthermore, this alternative would enable DOE to store the plutonium so it could be inspected and used if needed.

Data developed at Rocky Flats show that none of the buildings can process all of the residues to recover the plutonium unless the buildings are significantly modified and renovated. Even building 371, which DOE has proposed to use because it is more nearly in compliance with applicable design criteria than other buildings at the plant, would require new processing capabilities. Needed capabilities would include nitric acid processes to handle residues such as ash, firebrick, graphite, and filters; hydrochloric acid processes to dissolve plutonium contained in chloride salts; and volume reduction processes, such as incineration, to prepare paper, plastic, and other combustible residues for plutonium recovery.

Under this alternative, costs would be incurred to obtain the needed capabilities, operate facilities to recover the plutonium, and prepare and ship wastes for disposal. According to Rocky Flats' preliminary estimates, these costs could total about \$667 million, as shown in table 3.1.

Table 3.1: Rocky Flats' Estimates of Costs for Processing Residues to Recover Plutonium

Dollars in millions				
Alternative	Capital costs	Operating costs	Costs for disposal	Total costs
Processing for plutonium recovery	\$139	\$275	\$253	\$667

¹Wastes containing less than 100 nanocuries per gram of radioactive material are classified as low-level wastes.

**Chapter 3
DOE's Plans for Removing Residues From
Rocky Flats Are Uncertain**

Costs for packaging and shipping recovered plutonium and wastes to other facilities are included in the estimates. In addition, costs for disposal include a pro rata share of the projected development and operating costs at WIPP. According to Rocky Flats officials, although the plant will not have to pay for disposing of transuranic wastes at WIPP, a portion of the WIPP costs—based on the number of drums to be disposed of—were included in order to better estimate the total cost to the federal government of each alternative. However, certain other costs are not included in the estimates. During our review, DOE had not estimated the long-term costs for storing and safeguarding the plutonium at other DOE locations.

**Processing Residues for
Shipment and Later
Recovery of the Plutonium**

The second alternative involves processing or treating residues to a form that could be shipped to other DOE locations for either storage or plutonium recovery. This alternative would require fewer modifications to Rocky Flats facilities than the first alternative. However, since the plutonium would not be extracted at Rocky Flats, additional expenditures would be incurred at the receiving location for processing and storage. Furthermore, because the residues would undergo some processing at Rocky Flats to meet applicable shipping criteria, as well as processing at other DOE facilities, considerably more wastes would be generated than under the first alternative. Rocky Flats estimated that approximately 21,000 drums of transuranic wastes and 16,000 drums of low-level wastes would be created at Rocky Flats and the receiving facilities.

Although the processing activities at Rocky Flats under this alternative may not be as extensive as those under the first alternative, some upgrades to the plant's capabilities would still be needed. For example, Rocky Flats would need to reduce the size of certain residues so they fit into approved containers and prepare chloride-contaminated residues such as salts for shipment.

According to Rocky Flats' preliminary estimates, the costs to process residues for shipment to other DOE facilities total approximately \$1 billion, as shown in table 3.2.

**Table 3.2: Rocky Flats' Estimates of
Costs for Processing Residues for
Shipment and Later Recovery of the
Plutonium**

..... Dollars in millions				
Alternative	Capital costs	Operating costs	Costs for disposal	Total costs
Shipping residues for plutonium recovery elsewhere	\$87	\$511	\$423	\$1,021

Costs would be incurred primarily for operations necessary to process and prepare the residues at Rocky Flats so that they could be shipped for (1) operations at the receiving locations to either store the residues or recover the plutonium and (2) the disposal of wastes generated from activities at all locations. Estimated costs for operations and waste disposal at facilities other than Rocky Flats were based on similar operations planned for Rocky Flats in the first alternative. Information on additional costs that would be incurred to acquire any needed capabilities at the receiving location and to store and safeguard the recovered plutonium was not available and therefore not included in the estimates.

Preparing Residues for Disposal

To dispose of residues as wastes would require that they be prepared for shipment to a waste repository in accordance with applicable criteria and that they be shipped in approved containers. This alternative would remove all plutonium-contaminated materials from Rocky Flats but would not separate the plutonium from the other materials. The activities conducted at Rocky Flats would be limited primarily to altering the residues to shippable waste forms and repackaging them for shipment.

Unlike the other alternatives under which plutonium would be recovered and only the waste by-products disposed of, this alternative would ship the 2,800 kilograms of plutonium as well as the other materials for burial. Far more drums of wastes would be generated under this alternative than under the other alternatives. DOE's data show that if all residues were prepared for shipment as wastes in accordance with current shipping and storage regulations, an estimated 74,000 drums of transuranic wastes and 2,700 drums of low-level wastes would have to be disposed of.

As with the two previous alternatives, Rocky Flats would need additional capabilities. To prepare the residues for shipment as wastes, the plant would need facilities for packaging chloride residues, encasing small-particle residues in cement, miscellaneous treating and handling of other residues, and preparing and assembling the drums for shipment. All of the resulting products would also have to comply with applicable criteria for shipping and disposing of wastes.

According to Rocky Flats' preliminary estimates, it may cost \$1.5 billion to dispose of the residues as wastes, as shown in table 3.3.

Table 3.3: Rocky Flats' Estimates of Costs for Disposing of Residues as Wastes

Dollars in millions

Alternative	Capital costs	Operating costs	Costs for disposal	Total costs
Disposing of residues as wastes	\$91	\$236	\$1,185	\$1,512

The majority of costs shown are for waste disposal in WIPP. According to Rocky Flats officials, the costs of wastes disposal in WIPP were calculated using \$14,000 per drum, an amount based on data obtained from DOE headquarters.

Preliminary Residue Removal Plan Focuses on Processing to Remove Backlog

Although DOE is still determining the methods it will use to eliminate the residues, it has developed a baseline plan for reducing most of the residue backlog. In response to a compliance order issued by the Colorado Department of Health, DOE submitted a report to the state on February 28, 1992, describing a baseline plan to remove mixed residues from Rocky Flats.² The report states that DOE will have to perform a combination of functions to remove mixed residues—which comprise about 89 percent of the lean residues currently stored at the plant—including processing the residues to extract the plutonium and repackaging materials to meet applicable shipping criteria.

According to the report, the bulk of the residues will be processed to separate out the plutonium in order to eliminate the backlog. About 68 percent of the mixed residues will be processed to separate the plutonium from the bulk material. Another 26 percent, primarily chloride salts, will be treated to remove the RCRA-regulated materials and then will be processed to separate the plutonium from the other materials. Additionally, liquid residues constituting 2 percent of the mixed residues may also be processed to extract the plutonium, depending on its concentration. Only 4 percent of the total inventory of mixed residues could be shipped directly as wastes after being repackaged.

DOE further states that the removal of the residues will be a lengthy process. The compliance order requires that the mixed residue reduction report describe a program to reduce the inventory of all mixed residues by January 1999, unless it is not feasible to do so. According to DOE's plan, however, it will not be able to meet the January 1999 deadline for residue

²Mixed residues are plutonium residues that contain hazardous materials regulated by the Resource Conservation and Recovery Act (RCRA). The Colorado Department of Health is authorized by the U.S. Environmental Protection Agency (EPA) to enforce requirements stipulated in RCRA that pertain to mixed residues.

removal. DOE estimates, on the basis of this initial plan, that the residues would not be removed until at least 2009 because of the time required to obtain the necessary funding and facilities to process the residues.

According to Rocky Flats officials, this baseline plan will be compared with the results of the alternatives being evaluated for the EIS before any decisions on removing mixed residues are made. Moreover, the report itself recognizes that changes to the plan may be necessary. In this regard, the report states that as DOE reacts to the President's January 1992 decision to cease nuclear weapons production, fundamental changes to the plan may result. The report further states that the ongoing EIS analyses for removing all of the residues will better define the feasibility of alternatives.

DOE Is Addressing Key Issues Before Finalizing Elimination Plans

DOE's plans for eliminating the backlog of plutonium residues at Rocky Flats will not be finalized until the completion of the EIS process in 1993. As part of that effort, DOE is addressing key issues associated with the long-range management of plutonium, costs for the alternatives, and the shipping and disposal of wastes at WIPP, as part of its process to identify the most appropriate alternative for removing the residues from Rocky Flats.

DOE Is Developing a Long-Term Plutonium Management Strategy

In its evaluation of alternatives for eliminating Rocky Flats' residues, DOE will be deciding whether to retain the plutonium for future needs or to dispose of it. This decision is significant because DOE does not intend to produce any weapons-grade plutonium from reactors in the future, as stated in its January 1991 Nuclear Weapons Complex Reconfiguration Study. DOE stated that the plutonium from retired weapons will be sufficient to meet expected needs for weapons. Consequently, the plutonium contained in the residues is in excess of currently identified requirements.

Because it no longer will produce plutonium, DOE has stated that it needs a long-term strategy for managing all the plutonium it has in its inventory. In this regard, DOE's February 1992 report to Colorado states that a logical plan for removing residues from Rocky Flats must be predicated on, among other things, a strategy for managing the plutonium inventory. However, DOE does not currently have such a strategy. Consequently, Rocky Flats officials are having to develop plans for eliminating the backlog without knowing how much plutonium DOE intends to retain for

long-term needs, what other uses there may be for the material, and in what form plutonium should be stored. It is important that the strategy developed before an alternative is selected because the alternative DOE selects will have an affect on the total plutonium inventory.

DOE is developing a plutonium management strategy that will provide guidance on the need for, and uses of, plutonium into the next century. DOE's Weapons and Materials Planning Office has established a task force to review and analyze existing plutonium inventories as well as additional plutonium becoming available from the weapons stockpile. According to that office's deputy director, the task force was established to quantify projected requirements for plutonium through 2010, develop options for setting aside strategic quantities of plutonium, and assess the capabilities that DOE needs for plutonium operations and residue disposition. The task force's final report to DOE management on a long-term strategy was expected in late spring 1992 but has been delayed. The report is not expected until the end of fiscal year 1992.

DOE Is Preparing More Comprehensive Cost Estimates

An important factor in DOE's selection of an alternative to eliminate the residue backlog will be costs. As discussed earlier, DOE's estimates ranging from \$667 million to \$1.5 billion are preliminary and do not include all potential costs. For example, DOE has yet to identify where the plutonium will be stored and to estimate the costs that would be associated with storing and safeguarding the plutonium. Also, as DOE indicated in its report on mixed residues to the state of Colorado, it may have to incur costs—currently not incorporated in the estimate—to reactivate certain operations in building 771 to remove liquid residues presently stored in the building.

In addition to areas in which costs may be underestimated, the costs for waste disposal may be overstated. Rocky Flats calculated preliminary estimates for wastes disposal using a disposal cost of \$14,000 per drum. However, when officials from DOE's Office of Waste Management compiled cost data at our request to reflect their best estimate of WIPP's costs, they calculated those costs to be about \$7,000 per drum. Consequently, the cost of waste disposal of each alternative, as well as the total costs, may be substantially less. For example, at this lower disposal cost rate, the total cost of waste disposal under the first alternative would be reduced by about \$110 million—reducing the estimate for this option to \$557 million—while under the third alternative waste disposal costs would be

reduced by \$518 million—reducing this option to a total of about \$1 billion.

Rocky Flats officials stated that they are revising the estimates so that all appropriate costs for each alternative are included. They said that these efforts include estimating the costs at other facilities to handle and process residues and the costs for long-term storage of plutonium. The officials are also refining the estimates for disposal in WIPP. They said that their initial waste disposal estimate was based on informal guidance received from DOE headquarters on the amortized costs for constructing and operating WIPP. However, they will now use the cost data developed by the Office of Waste Management to recalculate the costs of each alternative.

Assessing Issues Related to WIPP

Removing residues from Rocky Flats in any manner will produce substantial wastes to be disposed of in accordance with applicable criteria. As discussed above, plans for disposing of wastes are being made with the expectation that WIPP will be available. However, questions exist about the availability of WIPP, the criteria for accepting wastes there, and the appropriateness of waste shipping criteria.

In the February 1992 report, in which DOE presented to Colorado a plan to completely remove mixed residues from Rocky Flats by 2009, the agency assumed that WIPP will be available to receive wastes from the plant beginning in December 1998. DOE's plans for WIPP call for various tests to be conducted over approximately 5 years before a final decision is made concerning the operational status of the facility. However, planned tests have been postponed because of a January 1992 U.S. District Court order, which revoked DOE's approval to proceed with the tests. The order required DOE to cease all activities relating to the testing phase because the transport and disposal of radioactive materials were prohibited under the terms of the 1983 land withdrawal for the WIPP site.³ It is unclear at this time when the testing phase will resume.

Furthermore, the criteria that have been issued for WIPP's acceptance of wastes may change before Rocky Flats begins eliminating its residue

³In 1982, the site was withdrawn from federal lands by the Secretary of Interior, pursuant to his authority under the Federal Land Policy and Management Act (43 U.S.C. 1701), for WIPP research and development, pending a legislative review. In 1983, DOE obtained a new withdrawal of the site to begin the construction phase (Public Land Order 6403) of WIPP. According to the court's interpretation of the land order, this withdrawal prohibited the transportation, storage, or burial of any radioactive waste. Consequently, the court ruled that the Secretary of Interior's January 1991 approval to proceed with the testing phase (Public Land Order 6826) was therefore not valid.

backlog. Currently, DOE's estimates of the costs of waste disposal are based on the existing criteria. According to the DOE official in charge of removing the residues from Rocky Flats, the criteria for accepting wastes at WIPP could change on the basis of the outcome of the testing to be done at the facility. Should the testing disclose problems that require changes to the existing criteria, the residues would have to be reanalyzed and additional processing steps may be required to meet the new criteria. This may increase costs for processing and/or disposing of waste and may also increase the time necessary to complete residue removal.

DOE is also reassessing the current criteria for transporting wastes to WIPP. As noted in the February 1992 report, the existing criteria for shipping materials to WIPP are very conservative and more restrictive than the WIPP acceptance criteria. In particular, the shipping criteria limit the amount of plutonium in a drum to about 15 percent of the amount allowable under the WIPP criteria. DOE informed the state of Colorado that it would review the criteria, particularly the restrictions on the quantities that can be loaded into each drum. If the limits are raised to those permissible under WIPP criteria, the number of drums and shipments to WIPP, and their associated costs, could be reduced. A Rocky Flats official said that this and other WIPP issues are being addressed as part of the planning and development of the EIS.

Conclusions

DOE's plans for eliminating the backlog are still evolving, and a final decision is not expected until 1993. On the basis of DOE's preliminary plans and cost estimates, however, it appears that any alternative DOE selects to remove the residues—processing the residues at Rocky Flats to recover the plutonium, shipping them to other DOE facilities for storage or processing, or disposing of the materials as wastes—will likely require the processing of residues in some manner and at considerable costs for upgrading facilities. Moreover, considerable time will be necessary to complete the actions required.

Due to the preliminary nature of the data currently available, it is not clear which alternative, or combination of alternatives, will be or should be pursued by DOE to resolve the residue backlog. It is clear, however, that there are outstanding issues that could greatly affect DOE's decision on how to eliminate the residue backlog. Foremost, in our view, is the need to develop a strategy for managing the plutonium inventory. The decision on how best to address the backlog will have an affect on the total inventory; consequently, the decision needs to be anchored to a long-term strategy

Chapter 3
DOE's Plans for Removing Residues From
Rocky Flats Are Uncertain

that specifies (1) the long-term defense needs for plutonium; (2) the amount of plutonium needed, if any, for a strategic reserve; and (3) the locations and methods for storing plutonium for future uses. Without such a strategy, DOE could find itself with more plutonium than it can manage or less than it needs for defense purposes.

DOE is undertaking efforts to address the need for a plutonium strategy, as well as other concerns, such as accurate cost estimates for the various alternatives and the availability of facilities for disposal of wastes. Because DOE is undertaking such efforts, we are not making any recommendations at this time in this report.

Major Contributors to This Report

Resources,
Community, and
Economic
Development
Division, Washington,
D.C.

James E. Wells, Jr., Associate Director
William F. Fenzel, Assistant Director
John R. Schulze, Assignment Manager

Denver Regional
Office

Paul S. Begnaud, Evaluator-in-Charge
David E. Flores, Senior Evaluator
Mary A. Crenshaw, Staff Evaluator
Cynthia C. Schilling, Reports Analyst

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