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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

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NUCLEAR REGULATION

NRC's Decommissioning Procedures and Criteria Need to Be Strengthened

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GAO

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Resources, Community, and
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The Honorable Mike Synar
Chairman, Environment, Energy,
and Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

On July 22, 1987, you asked us to determine the mechanisms that the Nuclear Regulatory Commission uses to ensure that fuel cycle facility operators and utilities with nuclear power plants appropriately provide for the decommissioning of these facilities. On the basis of subsequent discussions with your staff, we agreed to provide you with two reports—one on decommissioning cost estimates and another on the Commission's criteria and procedures for decommissioning fuel cycle facilities. In July 1988, we provided you with a report that discussed the adequacy of the Commission's decommissioning cost estimates and the methods that can be used to ensure that funds would be available. This report discusses other issues, such as the actions the Commission has taken or plans to take to ensure that fuel cycle facility licensees appropriately decommission their sites.

Unless you publicly announce 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 to appropriate congressional committees; the Chairman of the Commission; and the Director, Office of Management and Budget. We will also make copies available to others upon request.

This work was performed under the direction of Keith O. Fultz, Director, Energy Issues. Other major contributors are listed in appendix II.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Today, 112 nuclear power plants, 22 facilities that support these plants, 54 reactors used in research, and approximately 23,000 organizations hold licenses from either the Nuclear Regulatory Commission (NRC) or various states to use radioactive material. In addition, government agencies, such as the Department of Energy, have a multiplicity of facilities that use and dispose of such material. Eventually, most of these facilities will be decommissioned, which involves removing the radioactive material and terminating the license.

The Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked GAO to determine NRC's procedures to ensure that licensees appropriately decommission their facilities. On July 29, 1988, GAO provided the Chairman with a report that discussed the adequacy of NRC's decommissioning cost estimates. Since only limited decommissioning actions have occurred at nuclear power plants, this report primarily discusses the actions that NRC has taken to ensure that fuel cycle facility licensees appropriately decommission their sites.

Background

NRC regulates the private uses of nuclear material. NRC requires that at the end of their useful lives, owners of nuclear facilities have to remove the radioactive material from the site, including land, groundwater, buildings and contents, and equipment. This is called decontamination. To terminate their licenses, the owners must eventually decommission the site by reducing residual (any remaining) radioactivity to a level that allows the property to be used for unrestricted use (any purpose). Once decontaminated, NRC can also release part of a facility for unrestricted use without terminating the license.

NRC is not the only federal agency involved in the decommissioning process. Since 1970, the Environmental Protection Agency (EPA) has been responsible for developing residual radiation standards. EPA expects to complete this effort by 1992. In the interim, NRC uses guidelines developed in the early 1970s to ensure that residual contamination will not endanger public health and safety. (See ch. 1.)

Results in Brief

NRC needs to ensure that licensees appropriately decontaminate their facilities. Under current regulations, NRC cannot specifically require additional cleanup once it terminates a license. On the basis of a review of eight fuel cycle licensees, GAO found that NRC fully or partially released two sites for unrestricted use where contamination at 1 was up

to 4 times, and at the other, up to 320 times higher than NRC's guidelines allowed. The other six cases also indicated instances of poor regulatory oversight either because NRC did not require the licensees to fully document the decontamination activities conducted or the data that NRC did have were incomplete.

Also, for five licensees that buried waste, NRC does not know the types and amounts of radioactive waste that have been buried at four of the sites. Licensee records are either nonexistent or incomplete. Although NRC does not believe the buried waste has caused significant environmental damage, all five sites have groundwater contamination higher than federal drinking water standards allow. For at least four sites, some of the contamination appears to be caused by the buried waste and, at one site, the contamination was 400 times higher than the standards.

Further, no federal standards exist for acceptable levels of radiation that can remain after NRC terminates a license. As a result, licensees are using NRC guidance developed in the early 1970s to decommission their facilities.

Principal Findings

Licensees Do Not Adequately Decontaminate Their Facilities

In two of eight cases that GAO reviewed, NRC fully or partially released sites for unrestricted use where radioactive contamination was higher than its guidelines allowed. In one case, contamination in different parts of the facility ranged from about 3 to 320 times higher; in the other, contamination in some soil ranged from 2 to 4 times higher. For the other cases, GAO could not determine whether similar situations occurred because

- licensee information, such as surveys showing the cleanup activities conducted, was sometimes incomplete, ambiguous, or did not exist and
- NRC did not always have inspection or other information that confirmed or refuted the licensees' findings on the buildings, land, and equipment that had been decontaminated.

The concern over inadequate or incomplete NRC information is not new. Although GAO raised this concern to NRC in 1976 and 1982, problems still

exist today. Also, NRC's regulations do not specify how long either the agency or the licensees should retain information.

Further, where data existed, GAO found that some licensees had not initially decontaminated their facilities to meet NRC's guidelines. In one case, NRC had to go back and conduct at least four additional inspections prior to releasing two buildings from the license. The release was made only after the licensee conducted extensive decontamination activities that included removing interior walls, concrete floors, and part of a roof and building. Further, NRC requires licensees to decontaminate facilities below NRC's guidelines if cost-beneficial to do so. Eleven of 19 decommissioning plans did not show that the licensees would meet this requirement. (See ch. 2.)

Monitoring of Buried Waste Should Be Improved

For almost 25 years, NRC allowed licensees to bury radioactive waste onsite without prior NRC approval. NRC required the licensees to retain records on the amounts and substances buried rather than provide them to NRC. In five of the eight cases GAO reviewed, licensees buried waste onsite, but four licensees either did not keep disposal data or the data are incomplete. In one case, NRC terminated a license and 10 years later learned that radioactive material had been buried on the site. Also, NRC generally does not require licensees to monitor for groundwater or soil contamination from buried waste. All five licensees have found groundwater contaminated with radioactive substances. At four sites, some of the contamination appears to have resulted from the buried waste—the contamination at one site was 400 times higher than EPA's drinking water standards allow. At another site, the contamination was 730 times higher, but the source was not known. (See ch. 4.)

NRC Lacks Regulations to Require Cleanup After Terminating a License

If NRC terminates a license and subsequent events show that contamination is higher than NRC's guidelines allow, NRC staff believe they can require the former licensee to conduct additional cleanup activities to protect public health and safety. However, NRC's regulations do not address the actions that NRC can take. Since (1) NRC has found contamination in excess of its guidelines after terminating a license, (2) complete information does not exist for all licensed activities or buried waste, and (3) NRC's regulations do not contain a time requirement for document retention, NRC needs to ensure that an appropriate basis exists to support a license termination decision. According to NRC staff, they expect to propose regulations to implement their authority in this area but could not estimate when they would do so. (See ch. 4.)

Federal Residual Radiation Criteria Are Lacking

Since 1970, EPA has been responsible for developing residual radiation standards. EPA began to develop these standards in 1984 but, because of higher priority work, does not expect to finalize them until 1992. As a result, NRC uses guidelines it developed in the early 1970s to determine whether it can terminate a license. A professional group, the Health Physics Society Standards Committee, has also been developing residual radiation standards. For some radioactive material, the society proposed levels 3 to 50 times higher than NRC's guidelines and for other substances, 3 to 5 times lower. The society expects to complete the proposed standards by March 1991. (See ch. 3.)

Recommendations

To enhance NRC's regulatory oversight of decommissioning activities, GAO is making a number of recommendations. In part, GAO recommends that the Chairman, NRC,

- require licensees to specifically list in one document all land, buildings, and equipment involved with their licensed operations;
- ensure that the licensees decontaminate their facilities in accordance with NRC's guidelines before NRC fully or partially releases a site for unrestricted use;
- determine if NRC's residual radiation criteria should be revised on the basis of the standards proposed by the Health Physics Society Standards Committee;
- ensure that licensees appropriately monitor buried waste sites to determine the extent of environmental contamination; and
- ensure that NRC obtains and keeps decommissioning information for more than 10 years.

Agency Comments

GAO discussed the facts presented in this report with NRC. NRC generally agreed with the facts but offered some clarifications that were incorporated where appropriate. As requested, GAO did not ask NRC to review and comment officially on this report.

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Abbreviations

ANSI	American National Standards Institute
EPA	Environmental Protection Agency
CE	Combustion Engineering, Inc.
CFR	Code of Federal Regulations
DOE	Department of Energy
GAO	General Accounting Office
GE	General Electric Company
GUNC	Gulf United Nuclear Corporation
NFS	Nuclear Fuel Services, Inc.
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
TI	Texas Instruments, Inc.
UNC	United Nuclear Corporation

Introduction

The Atomic Energy Act of 1954, as amended, allowed and encouraged the development of peaceful uses of nuclear materials, including commercial nuclear power plants. Along with the development of nuclear power, a commercial infrastructure, including fuel cycle facilities, was developed to support the plants. Fuel cycle facilities include plants that convert uranium ore to a gas suitable for enrichment, fabricate the enriched uranium into fuel elements, and reprocess the spent or used reactor fuel to recover unused materials for refabrication into new fuel elements. As of April 1989, the Nuclear Regulatory Commission (NRC), the agency responsible for regulating private uses of nuclear materials, had licenses with 112 nuclear power plants; 22 facilities that support the industry; about 54 reactors used in research; and, along with states authorized by NRC to perform certain regulatory functions, approximately 23,000 organizations for industrial, medical, and educational purposes. Each of these activities will eventually have to be decommissioned; the manner and extent depend on the radiation hazards present.

Decommissioning Nuclear Facilities

At the end of their useful lives, the owners and/or operators of nuclear facilities, including the site, buildings and contents, and equipment, have to decontaminate the facilities by removing the radioactive material they contain. To terminate their NRC license, the owners must decommission the facilities by removing them safely from service and reducing the residual (remaining) radioactivity to a level that allows the property to be used for unrestricted use (any purpose). Once decontaminated, NRC can release part of a facility for unrestricted use without terminating the license.

Further, owners of commercial nuclear power plants do not have to take all decontamination actions immediately. NRC's regulations allow the owners to partially decontaminate the facilities and protect access to them. However, most of these facilities will probably be decommissioned within 60 years of the end of their useful lives. During that time, radioactive material with a short half-life[1] will decay to levels that will reduce worker exposures and the volume of waste generated.

Because of their size and the large inventory of radioactive materials, commercial nuclear power plants will pose unique decommissioning problems. However, no utility has decommissioned a large plant (about 1,000 megawatts), and NRC does not expect a utility to do so until after the year 2000. Because no facility exists to permanently dispose of the

[1] Time required for radioactive material to decay or decrease by 50 percent.

high-level waste produced by commercial nuclear power plants, utilities plan to partially decontaminate them and put them into "safe storage" until a high-level waste repository is available. As of January 1989, seven small nuclear plants had started decommissioning.[2] NRC has approved decommissioning plans for four of the plants. In addition, about 60 demonstration, military, and research reactors have been or are being decommissioned, including the Department of Energy's (DOE) 22-megawatt Elk River reactor. DOE is also decommissioning its 72-megawatt reactor at Shippingport, Pennsylvania, and expects to complete these activities in 1990. Further, 14 of the 22 currently licensed fuel cycle facilities have completed, or are in the process of, decontaminating all or a portion of their sites. Table 1.1 shows these facilities and the status of their decommissioning activities.

Table 1.1: Status of Fuel Cycle Facility Decommissioning Efforts as of October 31, 1988

Type/licensee/location	Type of material primarily processed	Status
Uranium conversion plants:		
Allied-Signal, Metropolis, Ill.	Conversion of uranium oxides to uranium hexafluoride	Operating.
Sequoyah Fuels, Gore, Okla.	Conversion of uranium oxides to uranium hexafluoride	Operating.
Uranium fuel fabrication plants:		
Babcock and Wilcox, Lynchburg, Va.	High- and low-enriched uranium	Both a high- and a low-enriched plant are operating.
Babcock and Wilcox, Apollo, Pa.	High- and low-enriched uranium	Some high- and low-enriched areas have been decontaminated. Decontamination of site ongoing.
Combustion Engineering, Windsor, Conn.	Low-enriched uranium	Operating.
Combustion Engineering, Hematite, Mo.	High- and low-enriched uranium	High-enriched uranium facility decontaminated. Low-enriched fuel operation ongoing.
Advanced Nuclear Fuels Corp., Richland, Wash.	Low-enriched uranium/plutonium	Plutonium building essentially decommissioned. Low-enriched fuel operations ongoing.
GA Technologies, San Diego, Calif.	High- and low-enriched uranium	Facility in standby status.
General Electric, Wilmington, N.C.	Low-enriched uranium	Operating.
Cimarron Corp. (Kerr-McGee), Crescent, Okla.	Low-enriched uranium	Facility partially decommissioned. Company plans to decommission entire site within a few years.

(continued)

[2]Humboldt Bay 3, California; Fermi 1, Michigan; Indian Point 1, New York; Vallecitos Boiling Water Reactor, California; Dresden 1, Illinois; Peach Bottom 1, Pennsylvania; and LaCrosse, Wisconsin.

Type/licensee/location	Type of material primarily processed	Status
Nuclear Fuel Services, Erwin, Tenn.	High- and low-enriched uranium/plutonium	Plutonium facility and some uranium buildings being decommissioned. Other processes ongoing.
Texas Instruments, Attleboro, Mass.	High-enriched uranium	Facility being decommissioned. Company plans to decommission entire site.
United Nuclear, Montville, Conn.	High-enriched uranium	Operating.
United Nuclear, Wood River Junction, R.I.	High-enriched uranium	Facilities being decommissioned. Company plans to decommission entire site.
Westinghouse, Columbia, S.C.	Low-enriched uranium	Operating.
Plutonium fabrication plants:		
Babcock and Wilcox, Lynchburg, Va.	Plutonium	Plutonium facilities decontaminated. Facility being used for reactor service instrumentation.
Babcock and Wilcox, Parks Township, Pa.	Plutonium	Plutonium facility being decontaminated. Other processes ongoing.
Battelle Columbus Division, Columbus, Ohio	Plutonium	Plutonium facility decommissioned. Company plans to decommission entire site.
Energy Systems Group (Rockwell), Canoga Park, Calif.	Plutonium	Plutonium facility being decontaminated. Other activities ongoing.
General Electric, Vallecitos, Calif.	Plutonium	Plutonium facility decommissioned. Other processes ongoing.
Cimarron Corp. (Kerr-McGee), Crescent, Okla.	Plutonium	Plutonium facility being decommissioned. Company plans to decommission entire site.
Westinghouse, Cheswick, Pa.	Plutonium	Plutonium facility decontaminated. Other activities ongoing.

Source: NRC, Fuel Cycle Safety Branch, Office of Nuclear Material Safety and Safeguards.

NRC's Organization for Regulating Nuclear Facilities

Under the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, as amended, NRC regulates the possession and use of radioactive material and ensures that the public is protected from the hazards of the material. NRC regulations for commercial power plants and fuel cycle facilities are primarily set forth in 10 CFR Parts 20, 40, 50, and 70. To carry out its responsibilities, NRC sets standards and makes rules, conducts or contracts for technical reviews and studies, issues licenses, and conducts inspections. Within NRC, the Office of Nuclear Reactor Regulation regulates utilities with nuclear power plants; the Office of Nuclear Material Safety and Safeguards regulates fuel cycle operators.

Until recently, NRC did not have specific regulations for decommissioning nuclear facilities. On July 27, 1988, new regulations took effect that set out technical and financial criteria for decommissioning licensed nuclear facilities. The regulations addressed decommissioning planning,

timing, funding methods, and environmental review requirements. The regulations do not include the removal and disposal of spent (used) fuel or nonradioactive structures and materials as decommissioning activities. In a July 1988 report, we assessed the adequacy of NRC's decommissioning cost estimates and the methods that utilities and fuel cycle operators can use to set aside funds for these activities.[3]

Other Federal Agencies Involved in Decommissioning

NRC is not the only federal agency involved in the decommissioning process. For example, since 1970 the Environmental Protection Agency (EPA) has been responsible for developing standards for acceptable levels of residual radiation that can remain after a licensee completes decommissioning activities. According to EPA officials, the criteria will address residual contamination (1) in soil, (2) on interior building surfaces and equipment, and (3) for materials that can be reused, such as piping, chemicals, or mixing containers. In this regard, EPA issued an advanced notice of proposed rulemaking in the June 18, 1986, Federal Register. EPA radiation program officials do not expect to have a final rule until 1992. NRC will then incorporate the rule into its regulations.

In addition to EPA, the Occupational Safety and Health Administration sets standards for worker protection, such as the use of protective clothing. Further, the Department of Transportation regulates the safe transportation of waste, equipment, and other materials from the plants to disposal sites.

NRC's Decommissioning Criteria

Until EPA finalizes its residual radiation standards, NRC will continue to use guidelines developed in the early 1970s to determine whether a portion or all of a facility should be released for unrestricted use. The guides describe the methods and procedures that NRC considers acceptable for licensees who want to terminate their licenses. For many radioactive substances, the guides specify acceptable levels of residual contamination that can remain after NRC terminates the license. Further, the guides state that a licensee should make a reasonable effort to eliminate residual radiation and survey the facility to determine that the levels of radioactivity are within NRC's limits.

The surveys should (1) identify the specific buildings and/or properties that will be released, (2) describe the scope and procedures followed to

[3] Nuclear Regulation: NRC's Decommissioning Cost Estimates Appear Low (GAO/RCED-88-184, July 29, 1988).

clean up the facilities, and (3) list the amounts of radioactive material that remain. Upon receiving the survey results, NRC reviews them and, in most cases, has used a contractor, primarily Oak Ridge Associated Universities (ORAU), to conduct a confirmatory survey to verify the survey results. In all cases, according to NRC staff, NRC evaluates both the licensee's and ORAU's results and draws appropriate conclusions.

To determine acceptable levels of contamination on building surfaces, NRC uses Regulatory Guide 1.86 (June 1974) for nuclear reactors and an unnumbered guide initially developed in April 1970 and revised in May 1973, November 1976, and August 1987 for fuel cycle facilities and other licensees (Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials[4]). In addition, since 1981 NRC has used a branch technical position to determine acceptable levels of uranium and thorium contamination that can remain in the soil on the sites. Prior to 1981, NRC set soil contamination limits on a case-by-case basis. NRC uses the technical position for fuel cycle plants; it specifies maximum concentrations of uranium and thorium that can remain after NRC terminates the license. However, some fuel cycle operators conducted activities using plutonium; the technical position does not address this or other types of radioactive contamination.

Under the technical position, licensees have four options concerning the clean up of contaminated soil. The options address different concentrations of material that can remain in the soil. Option 1, for instance, allows NRC to release a site for unrestricted use if soil contamination is between 10 and 35 picocuries[5] per gram (depending on the type of material). Option 4, on the other hand, allows for higher concentrations (200 to 3,000 picocuries per gram, depending on the type of material) that can remain. Under option 4, however, the title documents must state that the land (1) contains buried radioactive material and (2) cannot be used for residential or agricultural purposes.

NRC also uses a 1983 Standard Review Plan to terminate fuel cycle facility licenses. The Standard Review Plan provides guidance to staff responsible for reviewing applications for terminating licenses and

[4]According to NRC staff, they refer to these guidelines as Annex C in all fuel cycle facility licenses. For purposes of this report, when discussing the unnumbered guidelines, we will refer to them as Annex C.

[5]A curie is a measure of the rate of radioactive decay. A picocurie is equivalent to one-trillionth of a curie.

releasing facilities for unrestricted use. The plan sets forth areas of responsibility among NRC organizations to ensure that a facility licensed to possess or use radioactive material has been adequately decontaminated to levels consistent with NRC's unrestricted use guidelines.

Objectives, Scope, and Methodology

On July 22, 1987, the Chairman, Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked us to determine the mechanisms NRC uses to ensure that utilities with nuclear power plants and operators of fuel cycle facilities appropriately provide for the eventual decommissioning of their facilities. In July 1988, we reported on the adequacy of NRC's decommissioning cost estimates and the methods utilities and/or operators can use to ensure that funds would be available. This report discusses other decommissioning issues, including the actions licensees take to comply with NRC's residual radiation guides and NRC's assessment of facilities prior to terminating the license.

To obtain the information needed, we reviewed the Atomic Energy Act, the Energy Reorganization Act, and NRC's regulations, guidelines, and inspection reports. We also reviewed licensee environmental impact statements, environmental assessment reports, and radiological survey reports prepared by the licensees or ORAU as well as NRC's July 1988 decommissioning regulations and over 50 reports or articles that addressed decommissioning. Some of the studies that we reviewed included a 1983 Nuclear Management and Resources Council report An Overview of Decommissioning Nuclear Power Plants, NRC's January 1981 draft and 1988 final "Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities," and an April 1985 Public Citizen Environmental Action report, Dismantling the Myths about Nuclear Decommissioning. In addition, we attended a 1987 international decommissioning symposium in Pittsburgh, Pennsylvania. We also used information in two of our reports and evaluated the actions that NRC took in response to the recommendations made.[6]

Further, we met with NRC staff in the Offices of Nuclear Material Safety and Safeguards, Nuclear Regulatory Research, Nuclear Reactor Regulation, and General Counsel; a DOE official in the Office of Remedial Action

[6]See Cleaning Up the Remains of Nuclear Facilities—A Multibillion Dollar Problem (EMD-77-46, June 16, 1977) and Cleaning Up Nuclear Facilities—An Aggressive and Unified Federal Program Is Needed (EMD-82-40, May 25, 1982).

and Waste Technology; the former Director, Shippingport decommissioning project; and officials from Westinghouse Electric Corporation, Cheswick, Pennsylvania; Kerr-McGee Corporation, Crescent, Oklahoma; and Nuclear Fuels Services Corporation, Erwin, Tennessee. We also discussed decommissioning issues with a wide spectrum of knowledgeable experts from the Edison Electric Institute, National Association of Regulatory Utility Commissioners, TLG Engineering, Inc., Worldwatch Institute, Nuclear Management and Resources Council, and ORAU.

To determine the decommissioning methods that fuel cycle facility operators use, we obtained a list of 22 licenses that NRC had with 13 companies as of June 1987. We reviewed 19 decommissioning plans (3 licensees did not submit these plans) and selected 8 licensees for detailed review (app. I summarizes the 8 cases). We selected two of the eight licensees because NRC had terminated at least one license at the site or released all the land and/or buildings for unrestricted use, five because they were in the process of conducting decommissioning activities and had some part of their facility released by NRC for unrestricted use, and one that recently started to decommission its facilities. For all eight cases, we reviewed the actions that the licensees took to comply with NRC's requirements and, where applicable, NRC's actions prior to terminating a license.

In addition, we visited three licensees—Cimarron Corporation, Westinghouse Corporation, and Nuclear Fuel Services–to tour the facilities, observe the operations conducted and radioactive waste disposal methods used, and discuss their ongoing decommissioning activities. We also met with ORAU officials to determine the activities they perform for NRC, the results of their analyses, and their views on the adequacy of licensees' decontamination activities. We also reviewed NRC's Standard Review Plan for terminating fuel cycle facility licenses and inspection reports of licensee decontamination efforts.

Because no utility has decommissioned a commercial nuclear power plant, we did not review in detail NRC's process for terminating these licenses. However, we did review decommissioning plans submitted by five utilities to determine the methods they plan to use. The plants included Humboldt Bay 3, California; Indian Point 1, New York; Peach Bottom 1, Pennsylvania; Vallecitos Boiling Water Reactor, California; and Fermi 1, Michigan. We selected these five because decommissioning plans were available.

To evaluate the reasonableness of the criteria NRC uses to release facilities and land for unrestricted use, we compared NRC's Regulatory Guide 1.86, Annex C of fuel cycle facility licenses, and NRC's branch technical position with criteria being developed by the American National Standards Institute (ANSI). We also spoke with the Chairman, Health Physics Society Standards Committee, the group that developed the criteria under consideration by ANSI, and EPA radiation program officials responsible for developing the residual radiation regulations.

Further, we obtained NRC's regulations (10 CFR Parts 20.201, 20.302, 20.304, and 20.401) concerning the burial of radioactive waste by fuel cycle operators and met with NRC staff in the Offices of Nuclear Material Safety and Safeguards and General Counsel to discuss those requirements. We also obtained information on the types and amount of waste that licensees could bury on their property, the recordkeeping requirements for such disposal, and NRC's requirements and licensees' plans to clean up the contamination and/or monitor the waste to ensure that it does not migrate (move). We also spoke with the coauthor of a 1980 report, Identification of Technical Problems Encountered in the Shallow Land Burial of Low-Level Radioactive Wastes (ORNL/SUB-80/13619/1), as well as ORAU officials regarding the technical problems that have been encountered with buried low-level radioactive waste, the likelihood that the waste could migrate and contaminate the environment, and the results of the radiological surveys they have conducted at buried waste sites. We also reviewed an Electric Power Research Institute report on migration of plutonium waste. On the basis of all the data gathered, we conducted a limited assessment of NRC's internal controls related to the procedures used to terminate fuel cycle facility licenses.

We discussed the facts presented in this report with NRC staff in the Offices of Nuclear Material Safety and Safeguards, Nuclear Reactor Regulation, Nuclear Regulatory Research, and General Counsel. Generally, they agreed with the facts but offered some clarifications that were incorporated where appropriate. As requested, we did not ask NRC to review and comment officially on this report. Our work was conducted between August 1987 and October 1988 in accordance with generally accepted government auditing standards.

NRC Does Not Ensure the Cleanup of All Radioactive Material

In two of the eight cases that we reviewed, NRC fully or partially released sites for unrestricted use that had radioactive contamination higher than NRC's guidelines. In one case, the contamination ranged from about 3 to 320 times higher; in the other, from 1.5 to 4.4 times higher. We could not determine if additional contamination existed at these sites or if similar problems occurred in the remaining six cases because NRC either did not have information, such as the licensees' radiological surveys, or the information it did have was incomplete.

Further, because the long-term effects of exposure to low-levels of radiation are not well known, a need exists for licensees to make a reasonable effort to eliminate residual contamination. However, in the eight cases we reviewed, the licensees generally did not do so. NRC inspection reports and ORAU confirmatory surveys show numerous instances where NRC required licensees to conduct additional decontamination activities at their facilities. Because no large nuclear power plant has been decommissioned, we could not assess utilities' practices in this area. However, our review of decommissioning plans for five plants showed that the utilities did not discuss the methods to be used to eliminate residual contamination. Rather, they primarily concentrated on the safe on-site storage of the plant until the time the utility would start to decommission it.

NRC's Actions Resulted in the Government's Incurring Cleanup Costs

In July 1975, NRC terminated a license held by Gulf United Nuclear Corporation (GUNC) in New York.[1] Subsequently, radiation in excess of NRC's guidelines was found. As a result, the purchaser of the site—the National Park Service—has spent about $80,500 to clean up the site and may have to incur total costs of at least $388,000 before the site meets NRC's guidelines.

In 1958, GUNC received a license to fabricate and/or test uranium oxide, thorium, and plutonium fuels. The facility, located near Pawling, New York, included about 1,170 acres of land, about 9 buildings, and a 55-acre lake (Nuclear Lake). GUNC stopped all operations in 1972 and contracted with Atcor Incorporated to decontaminate and survey the site. Atcor, however, did not take adequate soil or any lake sediment samples as part of the survey. After receiving the survey results, NRC inspected the site and performed a confirmatory survey to verify that it could release the site for unrestricted use. NRC took building and soil samples

[1]From 1958 until 1975, various companies had been involved with the license—Nuclear Development Corporation of America, United Nuclear Corporation, GUNC, and the General Atomic Company. For this report, we refer to the various licensees as GUNC since NRC documents continue to refer to this company as the prior licensee.

and found several areas that required further cleanup by the licensee. After GUNC notified NRC that the areas had been decontaminated, NRC terminated the license on July 14, 1975.

Subsequently, GUNC sold the site to Harpoon, Inc., which in June 1979 sold the property to the U.S. Department of the Interior's National Park Service for relocating part of the Appalachian National Scenic Trail. After the National Park Service acquired the property, it contracted with Nuclear Energy Services to survey portions of the site. Nuclear Energy Services' July 1984 survey report showed residual contamination in a small area of the waste disposal building that was 35 times higher than NRC's guidelines.

After making various studies and reviews, a local group, the Nuclear Lake Management Committee, raised concerns regarding residual contamination in building drains, septic tank and drain systems, and various buildings. The committee was also concerned that radioactive or hazardous wastes may have been disposed of in the lake. To resolve some of these concerns, the National Park Service contracted with ORAU to survey the site. ORAU found that the contamination in building drains, septic systems, and the lake were within NRC's guidelines. However, ORAU found surface contamination in two buildings and soil contamination outside one building that ranged from about 3 to 320 times higher than NRC's guidelines and over 50 unidentified objects on the lake bottom that needed to be investigated further. Table 2.1 shows NRC's release limits and the contamination levels found by ORAU.

Table 2.1: Comparison of NRC's Release Limits With Contamination Levels Found by ORAU

NRC guidelines[a]	Facilities or areas exceeding guidelines	Remarks
Surface contamination:		
Plutonium-239, 2,500/dpm/ 100 cm^2	Plutonium Building—radiation levels were almost four times higher	Contaminated floors in five rooms
Cesium-137, 1.0 mrad/hr.	Plutonium Building—radiation levels were as much as 320 times higher	Floor area in two rooms
Cesium-137, 1.0 mrad/hr.	Multiple Failure Building—radiation levels were almost three times higher	Two areas in one room
Soil concentration:		
Plutonium-239, 2 dpm/g	Areas around Plutonium and Waste Disposal Buildings—radiation level at 1 area was 100 times higher	Twelve contaminated areas around the buildings.

[a]NRC's guidelines in effect in 1975.

As of December 1, 1988, no certainty existed that all the radioactive contamination had been removed from the site. According to ORAU's project manager responsible for surveying the site, ORAU took only a few measurements in each building, primarily at locations where previous surveys had shown elevated contamination levels. The official believes that additional contamination would have been found if ORAU had conducted a more in-depth survey. In its final report, ORAU identified several areas where cleanup is needed or further assessments are necessary to fully characterize conditions. According to the official, the National Park Service did not ask ORAU to do a more extensive survey.

ORAU's project manager said that he believed NRC should not have released the site for unrestricted use because subsequent surveys showed that much higher radioactivity existed than NRC allowed at the time the site was released. For example, although no formal criterion existed for soil contamination, the licensee agreed to limit plutonium contamination to two disintegrations[2] per minute per gram. ORAU found a few areas that were up to 100 times higher than the limit. The project manager said that information provided by the licensee's contractor (Atcor Inc.) was insufficient because no lake sediment samples had been taken, even though some radioactive process waste appeared to have been released into the lake. Over time, however, contamination can build

[2]A measure of the intensity of radiation given off by radioactive material.

up and concentrate in the sediments. Although ORAU readings showed that the sediments were generally within NRC's limits, the project manager said that because of the apparent release of radioactive material into the lake, it would have been appropriate for NRC to determine whether contamination existed in the sediment.

Because complete information on the extent of the contamination at the site is not available, neither NRC, the National Park Service, nor ORAU could estimate the cost to clean up the site and lake to meet today's standards. To date, the National Park Service has spent about $80,500 to clean up the site and an official estimates that the total cost could be $388,000 or higher if ORAU finds additional contamination. The official also said that ORAU has recommended that it conduct a thorough site survey at a cost of about $108,000. As a result, the National Park Service is now considering a number of cleanup options for the site.

Some Contaminated Soil Exceeded NRC's Guidelines

Since 1980, NRC has been releasing land at the Nuclear Fuel Services (NFS) site in Tennessee for unrestricted use. NRC released the land, although contamination in some soil ranged from 1.5 to 4.4 higher than its guidelines allowed.

NFS received a license in 1958 to convert uranium hexafluoride gas to fuel for reactors, fabricate reactor fuel using thorium and plutonium, and recover both uranium and thorium from the processes conducted. The site covers 58 acres in eastern Tennessee and includes over 20 buildings as well as 3 ponds and 3 burial sites, which had been used to dispose of liquid and solid low-level radioactive waste, respectively. Between 1958 and 1968, NFS discharged liquid uranium and thorium waste to holding ponds which, in turn, discharged into a small stream (Banner Spring) that flows through the site. The stream also flowed through property owned by the Clinchfield Railroad. In 1968, NFS diverted the flow of Banner Spring.

In 1980, NFS asked NRC to release some of the land for unrestricted use. The land included the stream bed of the Banner Spring before NFS diverted its flow. As required, NFS conducted a radiological survey of the land and concluded that the contaminated soil was within NRC's guidelines. However, NRC's confirmatory survey found contamination that was between 1.5 and 4.4 times higher than allowable levels. Despite this finding, in a September 1980 letter, NRC released about 36,250 square feet of land adjacent to Clinchfield's property for unrestricted use. NRC documents show that a number of factors caused NRC to release the land

even though the contamination exceeded its release guidelines. For example, NRC concluded that (1) its guidelines merely set a "target" value rather than an absolute value that must be achieved, (2) the contaminated soil would be covered with approximately 7 feet of dirt, essentially eliminating the exposure pathway, and (3) the average concentration of the contaminated soil was within NRC's guidelines.

Further, in 1984 NFS asked NRC to release additional land from its license. Again the land was on the Clinchfield property and the site of the old Banner Spring stream bed. NFS surveyed the property; NRC made a confirmatory survey. On July 24, 1987, NRC released the land even though some soil contamination was almost 3 times higher than NRC's guidelines. NRC did not require the cleanup of all the contaminated soil because the staff concluded that the contamination level was low and would not adversely affect public health and safety because the land was only used by the railroad.

Information Lacking to Determine if Other Problems Occurred

We could not determine whether the Pawling and NFS cases demonstrated isolated instances of poor regulatory oversight by NRC or systemic problems with NRC's process to ensure that licensees appropriately decontaminate and decommission their sites. In the other cases that we reviewed, NRC has released buildings, land, and parts of buildings. However, NRC either did not have information, such as licensees' radiological surveys or NRC's confirmatory surveys, or the information it had was incomplete. The following four cases illustrate various deficiencies in NRC's practices to ensure that licensees appropriately decontaminate and/or decommission their facilities.

Westinghouse Electric Corporation, Cheswick, Pennsylvania

In 1959 Westinghouse received a license to make fuel for commercial nuclear power plants; NRC terminated the license on August 20, 1974. According to NRC staff, Westinghouse conducted fuel fabrication activities in three buildings (5B, 5D, and a laboratory in 5A). However, when NRC terminated the license, it neither specified the buildings nor land that was released. As a result, we had to rely on inspection reports, letters, or memoranda to identify the buildings that NRC may have released for unrestricted use when it terminated the license. For example, NRC referred to a June 1974 inspection report of a uranium fabrication facility where licensed activities were conducted. The inspection report does not state whether this facility was building 5B, 5D, some other building, or a combination of buildings. In addition, neither NRC nor Westinghouse

could provide us with the company's radiological survey for two buildings (5B and 5D) or the soil around them. Without this information, we could not determine whether Westinghouse complied with NRC's procedures or a basis existed for NRC to terminate the license.

General Electric Company, San Jose, California

General Electric (GE) received a license in 1967 to make fuel for nuclear power plants. In 1982 the company notified NRC that it wanted to terminate the license; NRC did so on August 20, 1985. GE's site contained a number of buildings, but according to NRC documents, most of the radioactive contamination appeared to have occurred in buildings H and J, which were used to convert uranium hexafluoride gas to a form suitable for fuel and assemble the fuel following the conversion process.

NRC terminated the license in August 1985, and at the same time, transferred responsibility for the license to the state of California. Before the state accepted this responsibility, NRC required GE to decontaminate buildings H and J and submit the results to NRC. According to NRC documents, GE surveyed buildings H and J; NRC conducted a confirmatory survey and concluded that the contamination in the two buildings was below NRC's guidelines. However, NRC's files did not contain GE's survey reports for the two buildings. At our request, NRC searched its files and found some GE draft surveys and a brief NRC summary of GE's final survey for building J. According to NRC's guidelines, the company should have conducted, and NRC should have retained, the radiation survey reports.

In addition to the San Jose location, GE's license covered activities performed at other locations. NRC's files did not show if GE had surveyed those locations or provided any type of confirmation that, if they were contaminated, they did not exceed NRC's guidelines for release.

United Nuclear Corporation, New Haven and Montville, Connecticut

On February 28, 1969, United Nuclear Corporation (UNC) received a license to fabricate fuel for the naval reactor program at two sites: New Haven and Montville, Connecticut. The New Haven site included about 12 buildings; the Montville site encompassed about 235 acres on the Thames River about 50 miles northeast of New Haven. UNC stopped operating the New Haven facility in 1975 but continues to operate the Montville site.

According to available documentation, UNC decontaminated many buildings and some land at New Haven in 1975 and 1976. However, NRC's files

did not contain UNC's radiological surveys for three buildings (5E, 6E, and 18H). According to a UNC official, the company did not survey buildings 5E and 6E because they were used only for administrative and engineering activities and, monitoring conducted while the facility operated, showed that the contamination was well within NRC's guidelines. NRC staff confirmed this information. However, NRC's files did not contain any information concerning a radiological survey for building 18H. According to NRC staff, a company official told them that the building was used for administrative purposes; NRC did not verify this information. NRC did acknowledge that UNC should have surveyed the building to determine if contamination existed, and NRC should have some documentation supporting the findings.

In addition, UNC's survey report for nine buildings located at New Haven stated that the company had taken soil samples at five locations and water samples from on-site storm basins. However, the report did not provide the results of the samples but stated that the information would be provided to NRC later. NRC files did not have this information. According to NRC staff, they do not know if UNC took the samples or sent the results to NRC.

Gulf United Nuclear Corporation, Pawling, New York

In 1975, when NRC terminated its license with GUNC at Pawling, New York, it also released three buildings (19H, 41H, and 50H) located at New Haven, Connecticut, and facilities located in Eastview and White Plains, New York, that had been transferred to GUNC around 1974. For these locations, NRC had only one radiological survey that addressed two buildings (19H and 50H); building 41H and the Eastview and White Plains locations were not addressed. Further, the survey may not be complete because it only discussed parts of buildings 19H and 50H, not the entire buildings. NRC staff could not tell us if the licensee had surveyed the entire buildings and only reported on those areas that were contaminated or if the licensee merely surveyed portions of the buildings. In addition, NRC staff pointed out that regulatory responsibility for the Eastview site was transferred to the state of New York. An NRC staff member does remember that the licensee surveyed the Eastview site but could not recall the results or whether the state or NRC did a confirmatory survey before the license was terminated. For White Plains, NRC staff do not know when the facility was released, whether the licensee performed a survey, or whether NRC verified the results.

However, the concern over inadequate or incomplete NRC information is not new. For example, in 1976 we took a random sample of NRC files and

found that documentation was lacking or inadequate to demonstrate that all terminated licenses had been accompanied by adequate decontamination and/or radiological surveys. In a September 1976 letter, we provided this information to NRC. Subsequently, NRC asked DOE's Oak Ridge National Laboratory to review the matter. In its June 1980 report, Oak Ridge also found that some licensees' files (including fuel cycle facilities) contained no site decommissioning or final survey documents. As a result of the laboratory's findings, NRC reexamined its terminated license files and found that 54 out of 668 were questionable because of inadequate or incomplete information.

Further, in 1982 we again found that NRC did not have adequate information, records, or files on which to base its license termination decisions.[3] This occurred because NRC could not locate all files and, in many cases, the files did not contain information on the cleanup activities required or the licensees' actions to decontaminate the facilities. For example, we found that NRC did not have (1) radiological surveys and other pertinent data, (2) information showing the methods that licensees used to dispose of radioactive material, and (3) appropriate site identification data. Our current review of NRC records for eight fuel cycle licensees showed similar weaknesses.

According to NRC staff, they are required to keep decommissioning records for about 10 years after terminating a license. NRC does not have a similar requirement for former licensees. In some cases, such as burials of licensed materials or disposal of waste to sanitary sewage systems, NRC requires licensees to retain records until NRC authorizes their disposition. In other cases, however—such as licensee radiological surveys, NRC's and ORAU's confirmatory surveys, and information on buildings, land, and equipment that were contaminated during the license—NRC only requires the licensee to keep records until the license is terminated.

Some Licensees Do Not Effectively Decontaminate Facilities

In addition to NRC's terminating some licenses without complete information, NRC confirmatory surveys and ORAU survey reports showed instances where licensees did not effectively decontaminate their facilities to meet NRC's guidelines. For example, in January 1983, Texas Instruments (TI) submitted a radiological survey to NRC for its Attleboro, Massachusetts, facility. TI's survey showed that the quantities of radioactive materials buried at the site were sufficiently low to justify their

[3]See EMD-82-40, May 25, 1982.

being left in place. However, an April 1984 ORAU survey found some areas of surface and subsurface contamination that were between 7 and 68 times higher, respectively, than NRC's guidelines. The contamination was located primarily within the boundaries of a suspected burial site and in a few locations around one building. In addition, a sample from a groundwater monitoring well showed radioactive contamination that was six times higher than EPA's drinking water standards.[4] According to NRC officials, the buried materials have been stabilized and the matter is still being reviewed by NRC.

Further, prior to terminating its license, GE surveyed its San Jose, California, site and concluded that the contamination for buildings H and J was below NRC's limits; NRC's confirmatory surveys proved otherwise. Between August 1982 and September 1984, NRC surveyed the buildings at least five times. During four of the surveys, NRC identified locations where contamination exceeded its guidelines and required GE to conduct further decontamination activities. For example, in the J building, GE had to remove interior walls, concrete floors, drainage lines, and portions of the roof to reduce contamination. In addition, in the H building, NRC found some contamination that was eight times higher than its guidelines allowed. GE reduced the contamination by removing part of the building. Further, NRC collected 13 soil samples and found that 4 contained contamination ranging from 1 to 77 times higher than its guidelines. To bring the concentrations within NRC's guidelines, GE had to do further decontamination work. NRC's documents were silent, however, on the methods GE used to carry out its efforts.

Also, NRC directs licensees to decontaminate their facilities to levels lower than NRC's release guidelines if it is cost/beneficial to do so. If NRC later institutes more restrictive release criteria, the facilities may already meet them, and additional decontamination work would not be needed. Our review of 19 fuel cycle facility decommissioning plans showed, however, that 11 did not discuss the actions that licensees would take to reduce residual contamination below NRC's guidelines. The remaining eight plans stated that the licensees would make a reasonable effort, and three of the eight provided details on the actions to be taken. Further, our review of decommissioning plans for five nuclear power plants showed that the utilities expect to meet NRC's guidelines but do not plan to reduce contamination below the limits established.

[4]EPA's drinking water standards establish a limit of 15 and 50 picocuries per liter for gross alpha and gross beta, respectively. NRC's Standard Review Plan suggests that NRC staff use EPA's drinking water standards to determine whether radiation levels in groundwater are acceptable for unrestricted use.

Federal Criteria Needed for Acceptable Levels of Residual Radiation

Although residual radiation standards would provide a sound decision-making basis for the types and extent of decommissioning activities required, no federal regulations exist concerning acceptable levels of contamination that can remain after NRC terminates a license. As a result, NRC uses guidelines developed in the early 1970s to determine that it can terminate a license and/or release a site for unrestricted use. However, a professional group, the Health Physics Society Standards Committee, has been developing residual radiation standards that, for some substances, are 3 to 50 times higher and, for other substances, 3 to 5 times lower than NRC's guidelines. In addition, since 1970 EPA has been mandated to develop residual radiation standards. EPA began to develop these standards in 1984 but does not expect to finalize them until 1992.

Need for Federal Residual Radiation Standards

EPA is responsible for setting off-site radiation dose limits and developing residual radiation standards to protect public health and safety and the environment. Although EPA started to develop residual radiation standards in 1984, it does not plan to finalize them until 1992 at the earliest. As a result, licensees are decommissioning their facilities using NRC regulations and guidance that could change once EPA promulgates its standards.

NRC's radiation protection regulations are primarily set out in 10 CFR Part 20, Standards for Protection Against Radiation, which apply to both operating and decommissioning a nuclear facility. The regulations set exposure rates of 500 millirem (mrem)[1] per year for the maximally exposed individual and 170 mrem per year for the general public. As of May 1989, NRC's commissioners were reviewing a revision to 10 CFR Part 20 that would lower exposure rates for the public to 100 mrem per year. However, if reasonable to do so, NRC suggests that the owners and/or operators of nuclear facilities reduce exposures below NRC guidelines and requires them to comply with EPA's public exposure limit of 25 mrem year during decommissioning activities.

NRC's policies implementing the regulations are found in regulatory guides, general guidance, or internal memoranda. For example, Regulatory Guide 1.86 for nuclear power plants and Annex C for fuel cycle licenses set residual contamination levels for surfaces of equipment and facilities. The guides do not relate contamination levels to exposure rates for the public because NRC considers them to be sufficiently low to

[1]Rem (Roentgen Equivalent Man) is a measurement used to quantify the effects of radiation on man. A millirem is a thousandth of a rem.

be of negligible significance to public health and safety, yet practical to attain and measure. For soil contamination, NRC uses a 1981 branch technical position for the safe storage and/or disposal of uranium and thorium as well as a 1981 internal memorandum for allowable concentrations of americium-241—a highly toxic, cancer-causing radioactive material.

To estimate exposure, a number of factors must be considered. These include the type of radioactive material, length of exposure, and part of the body receiving the exposure. Although the effects of large radiation doses are well known, considerable controversy exists over the risks associated with long-term or continual exposure to small doses of radiation. As a result, different federal agencies use various criteria. For example, NRC uses 500 mrem/year as the maximum whole body dose that an off-site individual could receive; by contrast, EPA uses 25 mrem/year. In addition, other criteria exist for radiation doses to various organs, such as the lungs, gonads, and thyroid.

When commenting on NRC's 1988 decommissioning rule, many organizations pointed out that a need exists for the federal government to develop consistent residual radiation standards. For example, the Electric Power Research Institute stated that a great deal of uncertainty exists for a utility to determine levels of residual radioactivity that will be allowed when NRC releases a site for unrestricted use. In addition, some of those commenting suggested levels for NRC's consideration. The Public Citizen Environmental Action group, for example, wanted NRC to establish a maximum whole body dose of 10 millirems per year. Likewise, the preamble to NRC's decommissioning regulations states that many have expressed concerns about the lack of residual radiation limits and urged NRC to develop such levels as quickly as possible.

In addition, prior GAO reports have addressed the need for federal residual radiation criteria. In 1977, we pointed out that a decommissioning strategy could not be developed until NRC established acceptable residual radiation limits.[2] As a result, we recommended that NRC determine acceptable levels for residual radiation and surface contamination consistent with standards being developed by EPA. In 1982, we again pointed out that radiation standards are needed to guide decommissioning programs.[3]

[2]See EMD-77-46, June 16, 1977.

[3]See EMD-82-40, May 25, 1982.

At that time, we noted that standards prescribing acceptable levels of residual radiation are needed to identify appropriate cleanup methods, their costs, and the amounts of radioactive waste to be disposed of to protect the public from unacceptable risks. We also pointed out that licensees were concerned that they may have to conduct additional cleanup activities if final EPA residual radiation standards are more stringent than those used by NRC. Conversely, if EPA's final standards are less stringent than NRC's, the licensees may have conducted unnecessary cleanup and incurred unneeded costs. As a result, we recommended that EPA reevaluate the low priority it assigned to developing radiation standards and present a plan to responsible congressional committees for issuing them. We also suggested that the Congress transfer responsibility for setting certain radiation standards from EPA to NRC. EPA disagreed and stated that such action would further delay developing the standards.

Nevertheless, 12 years after we first recommended that a need exists for governmentwide residual radiation standards, none exist. On June 18, 1986, EPA published in the Federal Register an advanced notice of proposed rulemaking to develop the standards. In the notice, EPA states that the cleanup of contaminated soil and facilities should be such that the sites may be used without any restrictions. NRC is participating in an interagency working group organized by EPA to develop federal guidance regarding acceptable residual radiation levels that would permit property to be released for unrestricted use. According to the project leader for this effort, EPA probably will not publish a final rule for comment until 1991, and the rule would not take effect until 1992 at the earliest. According to NRC staff, they are not going to wait for EPA to finalize its standards and have been developing residual radiation limits for about 250 substances that can remain in the soil and on surfaces and structures. The staff estimate that they will present their proposal to the commission by December 1989.

Although EPA has not issued residual radiation standards, in November 1977 EPA proposed such standards for plutonium that would have set a maximum dose to the lungs and bone of 1 millirad[4] and 3 millirads per year, respectively. According to the project leader, EPA never finalized the regulations because of politics and hierarchy delays. In addition, in October 1983 EPA issued standards for acceptable concentrations of radium and thorium at uranium mill tailing sites. For both substances, the amount of radioactive material from the top 6 inches of soil cannot

[4]A rad is measure of radiation dose. A millirad is equivalent to one-thousandth of a rad.

exceed 5 picocuries per gram and 15 picocuries per gram for 6 inches of soil below the first level.

NRC and EPA are not the only organizations concerned about residual radiation levels. In 1971 the Health Physics Society Standards Committee, working with ANSI, established a subcommittee to develop permissible levels of residual radioactivity on materials, equipment, and facilities. For 16 years, the subcommittee debated the appropriate residual radiation levels for more than 18 substances, met with government and industry representatives, and reviewed available documents on the long-term effects of radiation. In December 1986, the subcommittee approved residual radiation standards for surface contamination (ANSI N13.12); ANSI has not yet approved them. In January 1989, ANSI asked the subcommittee to analyze the effects of the proposed standards on exposures to the public. According to an ANSI official, the subcommittee is to complete its review by March 1991.

Some of the proposed standards are lower or higher than NRC's regulatory guides. For example, acceptable residual radiation levels for transuranics,[5] radium-226, radium-228, strontium-90, iodine-125, and iodine-129 range from 3 to 50 times higher than NRC's limits, while others, such as natural uranium, uranium-235, and uranium-238, are 3 to 5 times lower than NRC's limits. Overall, the largest change in the proposed standards would be a 50-fold increase in acceptable levels of iodine-125 and iodine-129.

According to NRC staff, they based Regulatory Guide 1.86 on ANSI standards that had been proposed in 1974. The health physics committee chairman responsible for developing the new standards told us that a number of factors have changed since then. For example, the committee now believes that uranium is more harmful than it did in 1974. The chairman agreed that NRC's guidance is based on proposed ANSI or Health Physics Society standards that never made it through the ANSI approval process because of their controversial nature. According to the chairman, no guarantee exists that ANSI will approve the new standards, but he believes they represent achievable limits and are more appropriate than the limits NRC now uses for decommissioning nuclear facilities.

[5]Man-made radioactive elements that remain hazardous for thousands of years.

Monitoring of Buried Waste Needs to Be Improved

NRC does not generally require licensees to monitor groundwater or soil contamination from buried waste during the time a facility operates or after NRC terminates a license. NRC staff do not believe that the buried waste has caused significant environmental contamination. Until January 1981, NRC allowed all licensees to bury radioactive waste on-site without prior NRC approval. Five of the eight licensees that we reviewed buried waste—in four cases neither NRC nor the licensees has complete information on the location of the buried waste or the substances or amounts buried. In one case, NRC terminated a license and 10 years later learned that the licensee had buried waste at the site.

In addition, all five licensees have found groundwater contaminated with radioactive substances. At one site, the contamination was 400 times higher than the levels that EPA's drinking water standards allowed and at another, 12 to 96 times higher. Another site had groundwater contamination 730 times higher than the levels that EPA's drinking water standards allowed, but available documentation did not state if the contamination resulted from buried waste or other activities.

Further, NRC staff believe they can require additional cleanup activities after terminating a license because the Atomic Energy Act authorizes NRC to take actions it considers necessary to protect public health and safety. However, the Commission's regulations do not address the actions that NRC could take against a former licensee. According to NRC staff, they believe it would be very difficult to force a former licensee to clean up future contamination without regulations allowing NRC to take such actions. As a result, the staff plan to propose regulations to implement NRC's authority in this area; they could not estimate when they would do so.

NRC Regulations Do Not Require Soil or Groundwater Monitoring

According to NRC staff, they generally do not require fuel cycle facility licensees to monitor either soil or groundwater contamination from buried waste during the time a facility operates or decommissioning activities occur. NRC does require licensees to monitor air emissions, water effluent, and soil contamination (10 CFR 70.22(a)(7)(8)) during the time a facility operates, but these requirements apply to radioactive releases from plant operations rather than to releases that occur from specific waste disposal areas. According to NRC staff, the regulations preclude terminating a license until NRC has assurance that soil contamination is within NRC release guidelines. However, NRC has no similar requirement concerning groundwater contamination.

Between 1957 and January 1981, NRC allowed all licensees to bury radioactive waste on-site without prior NRC approval (10 CFR 20.304). Five fuel cycle licensees disposed of waste in this manner. However, NRC imposed only minimal requirements for on-site burial and did not set concentration limits. Rather, the regulations provided that a licensee could bury waste if the

- total quantity of each burial did not exceed 1,000 times the amounts specified in the regulations for various radioactive material; for example, the limit on americium-241 and plutonium-239 was 0.01 microcurie;
- waste was buried 4 feet or more below the surface; and
- burials were at least 6 feet apart, and the number of burials did not exceed 12 in any year.

The regulations did not, however, require the licensees to provide burial records to NRC. As a result, NRC has limited information on the types and amounts of waste buried. Although the regulations required the licensees to retain this information, our review of NRC's files and information provided by NRC staff for five licensees shows that four either did not keep these data or they are incomplete. In one case, NRC terminated a license and 10 years later learned that the company had buried waste on the site. The following describes this case.

Westinghouse Electric Corporation

NRC terminated a license (SNM-338) with Westinghouse in 1974. In June 1984, a Westinghouse employee telephoned NRC stating that radioactive waste had been buried at the Cheswick, Pennsylvania, site. Westinghouse still operates the site under another NRC license and subsequently found three buried waste sites—one was underneath an employees' softball field. Although the company had no records showing the number of burials that occurred, types and amount of substances buried, or part of the process that generated the waste, officials believe the disposal in one area occurred in 1966. However, the officials do not know when the other burials took place.

Westinghouse excavated the waste and found (1) 55-gallon drums containing waste solutions, sludge, gloves, and building rubble in one area, (2) building rubble in another, and (3) plastic bottles, duct work material, and building rubble under the ballfield. According to NRC staff, they do not plan to take any enforcement action against the company because Westinghouse is taking corrective action by removing the waste and sending it to an NRC-licensed disposal site.

However, no certainty exists that Westinghouse discovered all previously used burial sites. According to company officials, they do not know whether all buried waste sites have been found, but they are taking steps to make this determination. For example, the company has been digging up parts of the facility that have the highest potential as buried waste sites, such as areas located near buildings or in close proximity to the three sites already found. Despite the lack of disposal records, Westinghouse officials do not believe that the waste posed an environmental or health and safety concern and could have safely been left on the property.

NRC Policy Change

In 1978, NRC staff recommended that the Commission change the regulations and require licensees to obtain NRC approval before burying waste. According to the staff, this change would allow NRC to better protect public health and safety by encouraging licensees to send radioactive waste to an NRC-licensed disposal site and improve NRC's knowledge about the types, amounts, and locations of the buried waste. The staff made this recommendation because several states had expressed concern about the risks associated with licensees' burying radioactive waste without prior NRC notification or approval. NRC agreed with the states and on October 30, 1980, amended its regulations by deleting Section 10 CFR 20.304; the regulations took effect on January 28, 1981.

Under the revised regulations, licensees can still bury waste, but they have to obtain NRC's approval to do so. In addition, the licensees must provide NRC with a description of the (1) quantity and types of materials, (2) levels of radioactivity, (3) proposed disposal method and an environmental analysis of the topography, geology, and hydrology, (4) ground and surface water use in the area, and (5) procedures to minimize the risk of unplanned releases and/or exposures.

Environmental Degradation From Buried Waste

NRC does not generally require licensees to monitor groundwater contamination from buried waste sites. Nevertheless, NRC staff do not believe that any contamination from, or movement of, the waste occurs. NRC bases its position on radiological surveys conducted at Babcock and Wilcox's Parks Township, Pennsylvania, facility; Combustion Engineering's site at Hematite, Missouri; and NFS' site at Erwin, Tennessee, between December 1982 to September 1987. These surveys showed that no significant migration of the buried waste had occurred, and the buried materials were essentially stable. According to NRC staff, a low

probability exists that buried waste has or will contaminate groundwater because of the waste form (solid). The staff stated that they are more concerned about the potential for migration of radioactive waste from previously used ponds or lagoons.

Although NRC staff are generally not concerned that buried waste can migrate, evidence exists that buried waste can present environmental and/or health and safety problems. For example, a 1976 report by the Electric Power Research Institute stated that plutonium, because of its long half-life, must be regarded as a permanent contaminant, although it migrates very slowly. In addition, the coauthor of a 1980 report, Identification of Technical Problems Encountered in the Shallow Land Burial of Low-Level Radioactive Wastes, told us that the possibility for migration of radioactive wastes increases depending on soil composition and the amount of rainfall experienced. According to the report, water seeped into burial trenches at 6 of 11 commercial and government low-level waste sites, and the operators had to temporarily close 2 because of the problems found. Also, in August 1988 we reported that buried waste can (1) migrate into rivers and streams, (2) migrate into groundwater supplies, or (3) inadvertently be disturbed by people or animals.[1]

In addition, iodine-129 from defense production waste buried on DOE's Hanford Reservation in Washington State has migrated to the groundwater, and hazardous waste buried at DOE's Savannah River, South Carolina, plant has contaminated an aquifer underlying the site. Further, a study has shown that radioactive waste that also contains hazardous chemicals can migrate faster than radioactive waste alone. Some fuel cycle operations may have used hazardous chemicals, such as solvents and leachates. Five of the eight licensees we reviewed buried waste onsite; five have found groundwater contaminated with radioactive substances. Four of the cases are discussed below.

Nuclear Fuel Services, Inc.

NFS used three burial sites and three ponds to dispose of radioactive waste. Although the company had some records showing the types and amount of waste disposed, the records were not complete. For example, one burial site had two trenches, but NFS does not have information showing when it used the trenches, a description of items disposed, or the radioactive material or quantities in the waste. NFS subsequently removed much of the waste from the trenches, decontaminated it, and sold it to a local organization.

[1] Problems Associated With DOE's Inactive Waste Sites (GAO/RCED-88-169, Aug. 3, 1988).

For another disposal site, however, neither NFS nor NRC knows the types and amounts of substances buried in it. According to company officials, they believe that natural uranium or thorium, not enriched uranium or plutonium, was disposed of at this site. NFS plans to address the possibility of cleaning up the burial site at a later date, but company officials could not estimate when this would occur. According to NFS officials, they believe the waste was buried by the previous owner of the site and was "probably" allowed under a state permit. NRC staff said they have no record of a previous owner; NRC issued NFS a license in the late 1950s.

Because NFS did not have complete solid or liquid waste disposal records, in October 1983 NRC required NFS to take monthly samples from 14 groundwater monitoring wells to determine the radioactive and hazardous substances they contain. Sample results in 1987 showed radioactive contamination in six wells that was higher than EPA's drinking water standards allowed. In one well, the contamination was 730 times higher. NFS could not determine if the contamination was from the buried waste sites or other plant operations. To make this determination, NFS installed 22 additional monitoring wells.

Further, in 1986 NRC contracted with ORAU to characterize the substances in NFS' buried waste sites, determine the possibility for waste migration, and assess the environmental impacts that could occur from such migration. In its September 1987 report, ORAU pointed out that buried waste had resulted in significant soil and some groundwater contamination. Although the buried waste did not pose any danger, ORAU said that contamination could migrate off-site through storm runoff and other activities that disturb the surface soil.

Combustion Engineering, Inc.

In 1982, NRC contracted with Radiation Management Corporation to conduct a radiological survey of the burial waste site at Combustion Engineering's Hematite, Missouri, facility. In a July 1983 report, NRC confirmed that small quantities of uranium (uranium-235, uranium-238, and uranium-234) had been buried at the facility. NRC's soil samples showed contamination that was 40 times higher than its guidelines for uranium-234 allow. In addition, samples from two groundwater monitoring wells appear to show some contamination from the burial sites that ranged from 1 to 12 times higher than EPA's drinking water standards allow—earlier sample results appear to show contamination from the ponds and/or the burial sites that was 96 times higher than EPA's drinking water standards allow. The report also pointed out that all buried

waste sites may not have been identified and/or surveyed because Combustion Engineering did not have complete information on the number or locations of the sites. Further, the report stated that locating low-level buried waste is almost impossible when using only surface measurement techniques.

Cimarron Corporation

Cimarron Corporation, owned by Kerr-McGee Nuclear Corporation, received a license around 1965 to fabricate uranium fuel and in 1970 to fabricate plutonium fuel. Cimarron used five settling ponds and a burial site to dispose of radioactive waste generated from its uranium/plutonium operations. The burial area included four trenches. In 1985 the company began to excavate, package, and ship the waste to an NRC-licensed disposal facility. As of January 1989, Cimarron had removed more than 6,400 drums of waste and plans to complete the removal process by 1991. Cimarron's environmental monitoring reports between 1985 and 1987 showed groundwater contamination from the burial area that was between 208 and 360 times higher than EPA's drinking water standards allow. In June 1988, NRC recommended that the company obtain additional information about the groundwater under the site. In August 1988, ORAU found groundwater contaminated from the buried waste to be as much as 400 times higher than EPA's drinking water standards allow.

Texas Instruments, Inc.

Until 1959, the Texas Instruments, Inc. (TI) facility, located about 30 miles south of Boston, Massachusetts, was owned and operated by Metals and Controls, Inc. In 1955 the company received a license to fabricate fuel for research reactors and in 1959 merged with TI, which continued these operations under the same license. The company stopped all licensed activities and in 1982 asked NRC to terminate the license. As of May 1989, NRC had not done so.

In January 1983, TI provided NRC with a radiological survey report to support its termination request. The report showed that waste had been buried on the site between 1958 and 1960 but that the radioactivity was below NRC's release limits. In December 1983, NRC requested ORAU to survey portions of the site. ORAU found isolated areas of soil contamination and groundwater contamination that was more than six times higher than EPA's drinking water standards allow.

NRC Lacks Regulations to Require Cleanup After Terminating a License

According to NRC staff, if they terminate a license and subsequently find buried waste sites or contamination above levels that NRC guidelines allow, they believe that NRC can require the company to conduct additional cleanup activities because section 161 of the Atomic Energy Act authorizes NRC to take actions it considers necessary to protect the public from the hazards of radioactive materials. According to NRC's Office of General Counsel staff, the Commission, under the broad discretion granted by section 161, can issue orders requiring additional cleanup after terminating a license. However, NRC does not have regulations implementing that authority and specifying the enforcement actions that can be taken once it has released a site for unrestricted use and terminated the license. Therefore, the staff believe that enforcing corrective actions on a former licensee without regulations would be difficult. As a result, NRC plans to draft regulations to implement its general authority. The staff could not estimate when they would publish the proposed rules for public comments or when a final rule could be expected. In the past, however, NRC has taken a long time to issue regulatory changes. For example, NRC took over 10 years to issue new decommissioning regulations.

Conclusions and Recommendations

Conclusions

Only very limited decommissioning activities have occurred at large commercial nuclear power plants because no disposal facility exists for the high-level waste generated from their operations. Instead, utilities expect to partially decontaminate the plants and place them in storage for several decades to allow the radioactive material to decay. However, the same is not true for fuel cycle facilities. Some operators of these facilities have fully decommissioned some or all of their sites or are now decommissioning them.

Although only one fuel cycle facility that we reviewed had been completely decommissioned, the activities that have occurred with others provide some perspective on the manner in which NRC carries out its regulatory responsibilities in this area. In this regard, we found a number of areas in which NRC can play a stronger role in ensuring that all land, buildings, and equipment that it releases for unrestrictive use meet the guidelines that it has established.

For example, NRC can provide only limited assurance that licensees have fully decontaminated their facilities and accurately reflected the results of these activities in their radiological surveys. NRC and ORAU confirmatory surveys show that in many instances, excessive radiation remained after the licensees' completed initial decontamination activities. In some cases, the contamination was hundreds of times higher than NRC allowed. In other cases, the licensees did not, as regulations require, make a reasonable effort to decontaminate their facilities below the levels that NRC's guidelines allowed.

In addition, NRC does not require licensees to keep decommissioning records after it terminates a license. Although NRC is required to keep such information for at least 10 years beyond the termination of the license, NRC either did not have such information or the records that it did have were incomplete or ambiguous. Since both the Pawling and Westinghouse cases illustrate that problems can occur many years after NRC terminates a license, NRC must ensure that it obtains and keeps information on licensees' decommissioning activities.

Also, no federal standards exist for acceptable levels of radioactivity that can remain after NRC releases a site for unrestricted use. The need for such standards was raised almost 20 years ago. To date, neither NRC nor EPA has resolved the issue. In the interim, NRC uses criteria developed in the early 1970s. Since that time, the Health Physics Society Standards Committee has concluded that some radioactive materials are more hazardous than experts believed 15 years ago. The lack of federal

standards also raises the specter that decontamination activities conducted today may not meet requirements set in the future. Thus, nuclear facility owners and operators should decontaminate their facilities not only to meet NRC's guidelines but also to comply with its guidance to reduce contamination below the guidelines if reasonably achievable to do so.

Further, many fuel cycle facility licensees buried radioactive waste onsite. However, in four of the five cases that we reviewed, neither NRC nor the licensee had comprehensive information on the location or the types and amounts of substances buried. Further, although NRC does not believe the buried waste has caused environmental damage, five sites have groundwater contamination in excess of federal drinking water standards. For four of the sites, the contamination appears to have come from the buried waste. Further, licensees' monitoring programs are generally not sufficient to define radiological conditions within the buried waste in the future. Therefore, NRC should require licensees either to (1) monitor and/or characterize the waste while the facility operates or (2) conduct a thorough radiological survey before releasing a site for unrestricted use or terminating a license. In addition, requiring licensees to monitor groundwater and soil around the buried waste will give NRC a better basis to decide whether to terminate a license. Without such information, NRC cannot provide the public with reasonable assurance that the remaining contamination is safe enough for unrestricted use.

Recommendations to the Chairman, NRC

To enhance NRC's regulatory oversight of nuclear facilities decommissioning efforts, we recommend that the Chairman, NRC,

- require licensees to specifically list in one document all land, buildings, and equipment involved with their licensed operations;
- ensure that the licensees decontaminate their facilities in accordance with NRC's guidelines before NRC fully or partially releases a site for unrestricted use;
- determine if NRC's residual radiation criteria should be revised on the basis of the standards proposed by the Health Physics Society Standards Committee;
- ensure that licensees appropriately monitor buried waste sites to determine the extent of environmental contamination; and
- ensure that NRC obtains and keeps for more than 10 years decommissioning information such as licensee radiological surveys and certification of materials disposed, NRC's or other organizations' confirmatory surveys,

and specifics on land, buildings, and equipment that were contaminated over the life of the license.

In addition, since NRC believes that it has authority to require additional cleanup activities after terminating a license and to ensure that it has a mechanism to enforce orders requiring such activities, the Chairman, NRC, should act expeditiously to issue regulations governing such actions. In the interim, the Chairman should also ensure that all contamination at a site has been cleaned up so that it is below the levels that NRC's guidelines allow before releasing all or part of a site for unrestricted use.

Information on Eight Fuel Cycle Facilities

Cimarron Corporation, Crescent, Oklahoma

The Cimarron Corporation facility, located on about 1,000 acres in central Oklahoma, is owned by the Kerr-McGee Nuclear Corporation. Cimarron received a license around 1965 to fabricate uranium fuel (SNM-928) and in April 1970 to fabricate plutonium fuel (SNM-1174). To dispose of the radioactive waste generated by these operations, Cimarron used five settling ponds (two unlined and three lined) and a small burial site (about 1 acre), and around 1979 built a sanitary lagoon over three of the settling ponds that had been used to dispose of radioactive waste. In the fall of 1975, Cimarron decided to terminate all operations at the site. Since that time, the company has decontaminated and NRC has released parts of the facility for unrestricted use. As of May 1989, NRC had not terminated the licenses.

NRC's files show that the company stopped using the five ponds in December 1975. The company allowed the liquid to evaporate, removed the remaining sludge and mixed it with cement, and sent it to an NRC-licensed waste disposal site. In addition, after removing the sludge, Cimarron analyzed the top 6 inches of soil in the ponds. In August 1977, the company provided NRC with a plan for releasing the five ponds by backfilling them with dirt. On July 10, 1978, NRC authorized Cimarron to take this action and released the ponds for unrestricted use.

According to NRC staff, they did not observe the licensee backfilling the ponds, and they had no criteria for the levels of radioactivity that could remain after the company decommissioned the ponds. In October 1981, NRC issued guidelines for decommissioning soil contaminated with uranium and thorium. Available documentation shows that radioactive contamination in 2 ponds ranged from 6 to 10 times higher than the guidelines allowed. Cimarron does not plan to take further actions on the ponds because NRC released them before issuing the guidelines, but company officials told us that they may include disposal information when they prepare a final decommissioning plan for the site.

In addition to the ponds, from 1966 to 1970, Cimarron buried radioactive waste that had been generated in the uranium facility. The burial area included at least four trenches. Although Cimarron disposal records showed the date, type of waste, and levels of radioactivity for each burial, they did not specify the trenches in which the waste was buried. In 1985 the company began to excavate, package, and ship the waste to an NRC-licensed disposal facility. As of January 1989, Cimarron had removed more than 6,400 drums of waste from four trenches and plans to complete the removal process by 1991. However, the company has not removed all contaminated soil in or around the trenches.

As a result, in September 1987, Cimarron submitted a license amendment application to NRC that addressed specific options for the contaminated soil. The company proposed to (1) leave soil in place that contains uranium and thorium that are at levels below NRC's guidelines, (2) move to a designated on-site area about 400,000 cubic feet of soil that exceeds NRC's guidelines, and (3) leave about 3 million cubic feet of soil that is more than 4 feet below the surface in place. If the company can demonstrate that the soil will not contaminate the groundwater, NRC's guidelines allow the company to take the proposed actions, and NRC could release the property for unrestricted use. However, Cimarron's environmental monitoring reports between 1985 and 1987 show groundwater contamination from the burial area that was between 208 and 360 times higher than EPA's drinking water standards allow. Further, a June 1988 NRC inspection report recommended that the company obtain additional information on the groundwater under the site. Also, samples taken by ORAU in August 1988 showed that groundwater contamination from the buried waste was as much as 400 times higher than drinking water standards allow. As of May 1989, NRC had not approved Cimarron's plan for the contaminated soil.

By December 1989, the company expects to complete all decontamination activities at the site and ask NRC to terminate the license. In the process, the company would decontaminate both the plutonium and uranium buildings and two lagoons that had received wash, shower, sanitary, and laundry water during the time the facility operated. Since sediment samples from the lagoons show radioactive contamination that is more than 40 times higher than NRC's guidelines allow, the company plans to remove the sediment and send it either to an NRC-licensed disposal facility or a designated on-site burial area.

Combustion Engineering, Inc., Hematite, Missouri

The Combustion Engineering, Inc. (CE) facility is located about 35 miles south of St. Louis, Missouri, and is the oldest commercial reactor fuel production plant. Since 1956, NRC has licensed five companies to operate the facility—Mallinckrodt Chemical Works, from 1956 until 1961; United Nuclear Corporation, from 1961 until 1971; Gulf Oil Company, from 1971 until 1973; Gulf Nuclear Fuel Corporation, from 1973 until 1974; and CE, from March 1974 to the present to produce high- and low-enriched uranium fuel and conduct other activities. In January 1979, CE submitted a site decommissioning plan to NRC. However, the plan was not complete; it did not discuss the need to clean up buried waste sites, liquid waste disposal ponds, or contaminated limestone rock and soil that are present at the site.

Nevertheless, in 1974 the company began decontamination activities at the site. It has decontaminated two warehouse buildings and is decontaminating two liquid waste disposal ponds. It has also been assessing various disposal options for contaminated limestone rock that had been used to filter air emissions and had been used as backfill material at the site.

In the late 1950s and early 1960s, both Mallinckrodt and United Nuclear buried small quantities of uranium waste within the licensed boundaries of the site. However, neither CE nor NRC have specific information on the size of the burial area, the number of trenches it contained, or the amount and types of substances disposed in them. In 1982 NRC contracted with Radiation Management Corporation to survey the buried waste site. In July 1983, NRC reported that (1) three types of uranium (uranium-234, uranium-235, and uranium-238), radium, and thorium waste had been buried, (2) soil samples showed uranium-234 contamination that was 40 times higher than NRC's guidelines allow, and (3) samples from two on-site groundwater-monitoring wells appeared to show that contamination from the burial grounds ranged from 1 to 12 times higher than EPA's drinking water standards allow. The report also concluded that all sites may not have been identified and/or surveyed because CE did not have complete information on the number or locations of burial sites.

In addition to buried waste, until 1978, CE used two settling ponds for handling radiological liquid wastes from its processing operations. The company allowed the liquid to evaporate and has been removing the remaining sludge and dirt from the ponds. CE plans to send the sludge and soil to an NRC-licensed disposal site. Once these activities are complete, the remaining contamination is expected to be between six and seven times higher than NRC's guidelines for releasing soil for unrestricted use. As a result, the company plans to cover the ponds with clean fill dirt to bring the contamination closer to NRC's guidelines for unrestricted release. However, NRC documents indicate that the two ponds and/or the burial grounds have contaminated the groundwater under the site. For example, samples taken in 1977 and 1978 from two on-site groundwater monitoring wells appear to show contamination from the ponds and/or burial grounds that was 96 times higher than EPA's drinking water standards allow.

In a related matter, in 1979 NRC authorized CE to use limestone rock chips to filter corrosive gases used in its process before releasing the gas to the atmosphere. NRC also allowed the company to use the stone as on-

site fill material if the radioactive contamination was below background levels. CE used the stone as backfill in two on-site landfill areas and is storing the remainder in two piles on the site.

In 1984 the company instituted a monitoring program to determine whether the limestone presented environmental problems. Also, in 1984 CE asked NRC to allow the company to dispose of some of the limestone in an on-site burial area. NRC did not authorize CE to do so but stated that the limestone should be sent to a licensed disposal facility. According to NRC staff, CE is conducting a study to determine whether on-site disposal of the limestone would meet NRC guidelines.

On October 12, 1988, CE asked NRC to release two warehouse buildings from its license. Along with the request, CE sent NRC the results of its radiological survey for the buildings. The report stated that the remaining contamination in the two buildings was below levels that NRC's guidelines allowed. However, the report did not include information related to contaminated soil around the buildings or contamination that may be present in drainage systems associated with them. On October 31, 1988, NRC released the two buildings but did not release the land around them. CE subsequently submitted information regarding soil contamination and said that the remaining contamination was within levels that NRC's guidelines allowed. ORAU did a confirmatory survey in January 1989 and found five areas where the contaminated soil apparently exceeded levels that NRC's guidelines allowed. CE removed some soil, and ORAU's followup review indicated that CE's actions eliminated or reduced the elevated levels to within levels that NRC's guidelines allowed.

General Electric Company, San Jose, California

GE received a license in 1967 to make fuel for nuclear power plants. The facility, located on 78 acres south of San Jose, California, included a number of buildings but, according to NRC documents, most of the radioactive contamination appeared to have occurred in buildings H and J, which were used to convert uranium hexafluoride gas to a form suitable for fuel and assemble the fuel following the conversion process. NRC terminated the license on August 20, 1985, but, at the same time, transferred responsibility for the license to the state of California. Before the state would accept responsibility, however, NRC required GE to decontaminate buildings H and J and submit its survey results to NRC. However, NRC's files did not contain the survey results. NRC staff did provide us with some draft surveys and a brief NRC summary of GE's final survey for building J. According to NRC's guidelines, the company should have conducted a comprehensive radiation survey to determine the extent of

decontamination and reported its findings to NRC, and NRC should have retained the information.

Between August 1982 and September 1984, NRC surveyed building J or H at least five times. During four of the surveys, NRC identified locations where contamination exceeded its guidelines and required GE to conduct further decontamination. For example, in the J building, GE had to remove interior walls, concrete floors, drainage lines, and portions of the roof. In addition, NRC found some contamination in the H building that was eight times higher than its guidelines allowed. GE reduced the contamination by removing part of the building. Further, NRC collected 13 soil samples and found that 4 contained contamination ranging from 1 to 77 times higher than the guidelines allowed.

In addition to the San Jose location, GE's license covered activities performed off-site. Under NRC's guidelines, GE should have documented that remaining contamination, if any, was low enough for unrestricted use. However, NRC did not have documentation in its files showing whether (1) GE surveyed the off-site locations, (2) NRC inspected them and/or confirmed the survey results, or (3) the levels of contamination that remained when NRC transferred the license to the state were below NRC's release limits.

Gulf United Nuclear Corporation, Pawling, New York

In 1958 Gulf United Nuclear Corporation (GUNC) received a license to fabricate and/or test uranium oxide, thorium, and plutonium fuel in several small research reactors. The facility, located near Pawling, New York, included about 1,170 acres of land, about 9 buildings, and a 55-acre lake (Nuclear Lake). GUNC stopped all operations in 1972 and contracted with Atcor Incorporated to decontaminate and survey the site. After receiving the survey results, NRC inspected the site and performed a confirmatory survey to verify that it could release the site for unrestricted use. NRC took building and soil samples and found several areas that required further cleanup by the licensee. After GUNC notified NRC that the areas had been decontaminated, NRC terminated the license on July 14, 1975.

Subsequently, GUNC sold the site to Harpoon, Inc., which in June 1979 sold the property to the U.S. Department of the Interior's National Park Service for relocating part of the Appalachian National Scenic Trail. After the National Park Service acquired the property, it contracted with Nuclear Energy Services for radiological surveys of portions of the

site. The July 1984 survey report showed residual contamination in one building that was 35 times higher than NRC's guidelines allowed.

After making various studies and reviews, a local group, the Nuclear Lake Management Committee, raised concerns regarding residual contamination in building drains, septic tank and drain systems, and various buildings. The committee was also concerned that radioactive or hazardous wastes may have been disposed of in the lake. To resolve some of these concerns, the National Park Service contracted with ORAU to survey the site.

ORAU found that the contamination in building drains, septic systems, and the lake were within levels that NRC's guidelines allowed. However, ORAU found some small areas of surface contamination in 2 buildings and soil contamination outside 1 building that ranged from about 3 to 320 times higher than levels that NRC's guidelines allowed and over 50 unidentified objects on the lake bottom that needed to be investigated further. However, ORAU took only a few measurements in each building, primarily at locations where previous surveys had shown elevated contamination levels. ORAU's project manager responsible for surveying the site believes that additional contamination would have been found if ORAU had conducted a more in-depth survey.

At about the same time that NRC terminated GUNC's license for the Pawling site, it also released three buildings that had been transferred to GUNC around 1974. In September 1974, GUNC provided its radiological survey results to NRC. The survey, however, addressed only parts of two buildings (19H and 50H). NRC's files included no information on the third building (41H), which had been used to ship, receive, and store radioactive material. In addition, two other locations (Eastview and White Plains, New York) were places of authorized use under NRC's license. However, NRC's files did not contain the licensee's radiological survey or a confirmatory survey by NRC for the Eastview and White Plains facilities.

Nuclear Fuel Services, Inc., Erwin, Tennessee

NFS received a license in 1958 to convert uranium hexafluoride gas to fuel for commercial and naval reactors, fabricate various materials using thorium, recover both uranium and thorium from the processes conducted, and produce plutonium fuel. The facility covers 58 acres in eastern Tennessee and includes over 20 buildings as well as 3 ponds and 3 burial sites, which had been used to dispose of liquid and solid low-

level radioactive waste, respectively. Between 1958 and 1968, NFS discharged liquid uranium and thorium waste to holding ponds, which, in turn, discharged the clarified solution to a small stream (Banner Spring) that flowed through the site. The stream also flowed through property owned by the Clinchfield Railroad. In 1968 NFS diverted the flow of Banner Spring.

In 1973 NFS stopped using the plutonium facilities and began to decommission them in the late 1970s. NFS later stopped these activities because no commercial disposal site was available for the transuranic waste resulting from the decommissioning activities. In 1986 DOE and NFS reached an agreement to send the waste to DOE's Idaho National Engineering Laboratory. As a result of the agreement, NFS resumed decommissioning activities on the plutonium facilities; the company expects to complete these activities by 1992.

In 1978 NFS initially prepared a plan for the future decommissioning of 18 buildings used to process high- and low-enriched uranium. According to the plan, the company expects to eventually remove about 310,000 cubic feet of contaminated material representing approximately 450 shipments to an NRC-licensed disposal site, probably Barnwell, South Carolina. The company has started to decommission three buildings and is deciding the most appropriate method to decommission three unlined ponds that had been used from 1958 until 1978 to dispose of liquid low-level waste from various plant operations. According to NRC's Executive Director for Operations, NFS has been working closely with NRC and the state and expects to provide a decommissioning plan for the ponds by July 1989.

To develop the decommissioning plan, NFS will use information from its monitoring program. In October 1983, NRC required NFS to take monthly samples from 14 groundwater monitoring wells to determine the radioactive and hazardous substances they contain. Sample results in 1987 showed radioactively contaminated groundwater in six wells at levels higher than EPA's drinking water standards allow. In one well the contamination was 730 times higher than these standards. Although the wells were located to monitor waste migration from the ponds and burial sites, NRC found that they did not do so. As a result, NRC required NFS to upgrade its monitoring program by drilling 22 new groundwater monitoring wells. Most of the wells were located near the ponds; NFS completed the wells in the fall of 1986.

NFS also has three solid waste burial sites—two on its property and one on property owned by the Clinchfield Railroad and leased to NFS. The main burial site, located in the northeast corner of NFS' property, contains about 26 trenches; 21 were used to dispose of radioactive waste. The area is covered with grass and trees. At the second site, NFS has found radioactive contamination that company officials believe is natural uranium or thorium. However, NFS does not have information showing the type of waste buried at the site. The third burial site, located on Clinchfield's property, contains two trenches that NFS used in 1969 to dispose of contaminated metal. The company later removed the metal, decontaminated it, and sold it as scrap. In September 1987, ORAU found uranium contamination and some contaminated debris at the site that exceeded NRC's guidelines.

In 1986 NRC contracted with ORAU to characterize the substances in the buried waste sites, determine the possibility for waste migration, and assess the environmental impacts that could occur from such migration. In its September 1987 report, ORAU points out that some of the buried waste had migrated and contaminated the groundwater. Soil samples taken from the periphery of the burial sites indicated that the buried waste had not migrated off-site. However, ORAU pointed out that the potential existed for the contamination to migrate off-site in the future through storm runoff or other activities that would disturb the surface soil.

Since 1980, NRC has been releasing some of the land identified in NFS' license. In 1980 NFS notified NRC that it wanted to release some land that included the stream bed of the Banner Spring before NFS diverted its flow. NFS conducted a radiological survey of the old stream bed on Clinchfield's property. The survey concluded that the level of contamination in the soil was within NRC's guidelines. However, NRC's confirmatory survey found contamination that was between 1.5 and 4.4 times higher than its guidelines allowed. Nevertheless, NRC released about 36,250 square feet of land adjacent to Clinchfield's property for unrestricted use. NRC documents show that a number of factors caused NRC to release the land prior to NFS' taking actions to remove the contaminated soil. For example, NRC concluded that (1) its guidelines merely set a "target" value rather than an absolute value that must be achieved, (2) the contaminated soil would be covered with approximately 7 feet of dirt, essentially eliminating the exposure pathway, and (3) the average concentration of the contaminated soil was within NRC's guidelines.

In 1984 NFS asked NRC to release additional land from its license. Again the land was on the Clinchfield property and the site of the old Banner Spring stream bed. NFS surveyed the property and found that, with the exception of one area, the soil contamination met NRC's release guidelines. On July 24, 1987, NRC released the land even though a small portion exceeded NRC's guidelines for unrestricted use—the contamination was about three times higher than NRC's guidelines allowed, and NRC did not require NFS to remove the contaminated soil. According to an NRC document supporting the release, NRC concluded that the contamination level was low and would not adversely affect public health and safety because the land was used by the railroad only.

Texas Instruments, Inc., Attleboro, Massachusetts

Until 1959, the Texas Instruments, Inc. (TI) facility, located about 30 miles south of Boston, Massachusetts, was owned and operated by Metals and Controls, Inc. In 1955, the company received a license to fabricate fuel for research reactors. In 1959, the company merged with TI, which continued these operations under the same license.

In 1968, TI began to cut back its operations. In May 1982, TI requested that NRC terminate the license and release the building used for these activities for unrestricted use. Along with the request, TI submitted a radiological survey to NRC showing that the building met NRC's guidelines. NRC subsequently inspected the building and concluded that the remaining contamination was within NRC's guidelines. In 1983, NRC released the building from the license.

In January 1983, TI asked NRC to release a burial area that had been used to dispose of low-level radioactive waste. According to TI's 1964 health and safety manual, uranium- and thorium-contaminated noncombustible scrap material and machinery were put in 55-gallon drums and buried on-site between 1958 and 1960 under 10 CFR 20.304. TI provided NRC with a radiological survey report to support its request to release the land and terminate its license. The company took test samples of the waste and concluded that the level of radioactivity was so low that no one should receive a radiation dose in excess of 1 millirad per year to the lung or 3 millirads per year to the bone from inhalation or ingestion. These doses are within EPA's radiation protection standards. The report also pointed out that the radioactive material would only be accessible by digging into the soil. As a result, TI concluded that the waste should remain in place and that removing the large volume of contaminated soil (over 160,000 cubic yards) and transporting it to a licensed disposal site would neither be practical nor justifiable for public health reasons.

In December 1983, NRC requested ORAU to survey portions of TI's site. To conduct the survey, ORAU took ground surveys, walkover scans, subsurface water samples, and soil samples to provide a comprehensive assessment of the radiological conditions on the site. ORAU's 1985 report showed isolated areas of surface and subsurface contamination. The contamination occurred primarily within the burial site and around the building that had been used to fabricate the research reactor fuel. In addition, ORAU found groundwater contamination that was more than six times higher than EPA's drinking water standards allow.

United Nuclear Corporation, New Haven, Connecticut

UNC received a license on February 28, 1969, to fabricate fuel for the naval reactor program at two sites: New Haven and Montville, Connecticut. The New Haven site included about 12 buildings; the Montville site encompassed about 235 acres on the Thames River about 50 miles northeast of New Haven. UNC stopped operating the New Haven facility in 1975 and continues to operate the Montville site and use other authorized locations. According to UNC documents, the company used at least 16 different buildings at the various sites—the initial license did not specify these locations but rather stated that the New Haven site was the "authorized place of use." However, in a 1964 license amendment, NRC specifically listed four buildings and a storage vault.

According to available documentation, UNC decontaminated many of its buildings and land at New Haven and other locations in 1975 and 1976 and provided NRC with radiological surveys for some of them. However, the company did not survey one building listed in the 1964 license amendment. In addition, UNC's survey report for part of the New Haven facility stated that the company had taken soil samples at five locations and water samples from on-site storm basins. The company did not provide the sample results in its report to NRC but stated that the information would be provided later. NRC's files did not contain this information. Nevertheless, NRC released all the buildings and land for unrestricted use after conducting some inspections to ensure that the residual contamination was within NRC's guidelines.

Westinghouse Electric Corporation, Cheswick, Pennsylvania

In 1959 Westinghouse Electric Corporation received a license (SNM-338) to fabricate fuel for commercial and research reactors at its Cheswick, Pennsylvania, facility. Westinghouse performed these activities in four buildings—one was later transferred to another license that Westinghouse received from NRC. On August 20, 1974, NRC terminated the license but did not specify either the buildings or land that were released for unrestricted use.

On March 7, 1969, NRC issued Westinghouse a second license (SNM-1120) to perform research and development on mixed plutonium-uranium and uranium oxide fuels. Westinghouse used at least three buildings for these activities. The license is still active although Westinghouse has decontaminated two buildings, and NRC has released them for unrestricted use. Westinghouse used the buildings (7 and 8) to develop and fabricate the fuels. Building 7 was used for about 15 years, contained a plutonium and uranium laboratory, and was originally under license SNM-338. Building 8 was used for about 10 years to produce commercial and breeder reactor fuels on a developmental basis. In addition to the two buildings, NRC released other buildings and land under this license between September 1982 and June 1984.

After NRC terminated license SNM-338 in 1974, three previously unknown buried waste sites were found. According to Westinghouse officials, they have no records showing the number of burials that occurred, types and amount of substances buried, or part of the process that generated the waste. However, they found (1) 55-gallon drums containing gloves and building rubble in one area, (2) building rubble in another, and (3) plastic bottles, duct work material, and building rubble under an employees' softball field. According to NRC staff, they do not plan to take any enforcement action against the company because Westinghouse is taking corrective action by removing the waste and sending it to an NRC-licensed disposal site.

However, no certainty exists that Westinghouse discovered all previously used disposal sites. According to company officials, they do not know whether all buried waste sites have been found, but they are taking steps to make this determination. For example, the company has been digging up parts of the facility that have the highest potential as buried waste sites, such as areas located near buildings or in close proximity to the three sites already found. Despite the lack of disposal records, Westinghouse officials do not believe that the waste posed an environmental or health and safety concern.

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