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NUCLEAR WEAPONS COMPLEX

Issues Surrounding Consolidating Los Alamos and Lawrence Livermore National Laboratories

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Mr. Chairman and Members of the Committee:

We are pleased to be here today to testify on the Department of Energy's (DOE) nuclear weapons laboratories. As you requested, our testimony focuses on three areas: (1) the research, development, and testing (RD&T) capabilities of the Los Alamos and Livermore National Laboratories; (2) the recent trends in staffing and funding at DOE's weapons laboratories; and (3) options identified by the laboratories and DOE for consolidating the Los Alamos and Livermore RD&T programs. This testimony provides a baseline for future congressional deliberations on these issue.

Los Alamos and Lawrence Livermore National Laboratories maintain a deliberately redundant nuclear warhead research, development, and testing (RD&T) infrastructure.[1] The redundancy between Los Alamos and Livermore was intended to stimulate competition in the nation's efforts to design nuclear warheads. With the end of the Cold War, however, the nature of the nuclear warhead RD&T effort at the laboratories has been changing rapidly. Changes in the world, coupled with the possibility of substantial budget cuts in the nuclear weapons area, brings into question whether the nation still needs or can financially sustain the laboratories' current level of redundancy.

In summary, although Los Alamos and Livermore have duplicative RD&T capabilities in general, over the years their independent approaches have led to each developing specialized knowledge and capabilities. Over the past several years, both RD&T funding and staffing have declined significantly at the laboratories. With this recent and anticipated continued decline in resources devoted to nuclear weapons RD&T, some consolidation of the laboratories' functions has already occurred and more is in process. The laboratories believe the potential savings are small relative to the funds needed to maintain the entire nuclear weapons complex. The laboratories believe, however, that savings are possible by avoiding additional duplicative facilities in the future.

Both laboratories strongly prefer the current two-laboratory structure for weapons design. However, Los Alamos officials believe that if the nation is to maintain its nuclear competence in the event of further significant cuts in nuclear weapons RD&T, the current structure may need to be radically altered. In addition, they believe that any new configuration must maintain the current benefits of competition and peer review. As another alternative for dealing with RD&T funding reductions, DOE and the laboratories see benefit in broadening the laboratories' missions

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[1]Sandia supports both of these laboratories by designing the non-nuclear components of the weapons systems.

to research on waste management and modernization of the nuclear weapons complex.

BACKGROUND

Los Alamos National Laboratory, located in Los Alamos, New Mexico, was established in 1943 to develop the first atomic bombs. Lawrence Livermore National Laboratory, in Livermore, California, was established in 1952 to provide Los Alamos with design competition, to diversify expertise, and to handle the large volume of work anticipated in nuclear weapons development. The two laboratories design the nuclear explosive subsystems of nuclear weapons. Sandia National Laboratories, which has facilities in Albuquerque, New Mexico, and in Livermore, was established in 1945. It designs remaining components of the weapon, integrating the nuclear explosive component with many other components such as arming, fuzing and firing, and use control systems. The three laboratories are part of DOE's nuclear weapons complex, a network of facilities that collectively produce the nation's nuclear weapons.

Essentially, nuclear weapons research and development responds to requirements from the Department of Defense (DOD), although concepts for new or improved nuclear weapons generally originate with the weapons laboratories. When DOD authorizes work on a nuclear weapon beyond the conceptual stage, Los Alamos and Livermore compete with each other to develop designs for that weapon. In designing a weapon, both Los Alamos and Livermore work with Sandia. DOD and DOE evaluate the designs, and DOE assigns further development to either Los Alamos or Livermore.

RD&T CAPABILITIES

Although Los Alamos and Livermore have the same basic responsibilities--designing nuclear weapons--they have different design and testing approaches. Consequently, they have acquired different types of specialized knowledge and experience. In addition, the laboratories have designed facilities with different capabilities to support their different approaches. Officials at both laboratories credit these differences--both in scientific approach and in the knowledge gained--with advancing the state of nuclear weapons technology at both laboratories.

Both Los Alamos and Livermore are capable of initiating conceptual design studies and pursuing competing designs when DOD has identified specific warhead requirements and has requested subsequent research and development activities. Additionally, each laboratory is capable of pursuing formal development of a nuclear weapon, if assigned to do so by DOE. Hundreds of people and a vast array of sophisticated facilities enable the laboratories to carry out these activities.

DOE and weapons laboratory officials have identified about 60 areas of required capabilities for nuclear weapons RD&T. (These areas are listed in app. I.) For ease of discussion today, we have grouped these areas into five general categories: (1) nuclear weapons design, (2) materials research and fabrication, (3) high explosives technology, (4) weapons engineering and testing, and (5) nuclear testing. Evaluating the comparative technical aspects of the laboratories' RD&T capabilities was beyond the scope of our work. My testimony today will summarize the laboratories' similarities and differences in these general areas. Because Sandia's primary mission is to design and engineer non-nuclear components rather than nuclear components, Sandia's duplication with the other laboratories is limited.

Nuclear Weapons Design

A key weapons capability is understanding all aspects of nuclear weapons. This responsibility is the job of the nuclear weapons designer. The capabilities needed for maintaining weapons expertise require a broad range of knowledge in several fields including (1) computation--the development and implementation of theoretical models for predictive computer simulations of nuclear weapons designs; (2) weapons physics--the development of a detailed and thorough understanding of the basic physics of nuclear weapons; and (3) high explosives technology--the provision of data essential for calculating and designing explosive systems.

In terms of similarities, Los Alamos and Livermore each has about 40 experienced scientists who design the nuclear components of the weapons. These designers work closely with others, such as computational and materials scientists and engineers. Both laboratories also have the supercomputing facilities necessary to model the complex theoretical and mathematical simulations involved in weapons design.

Los Alamos and Livermore differ, however, in their design philosophies and approaches. These different philosophies and approaches require unique capabilities in areas such as weapons physics and materials technology. For example, both laboratories have been working to design and fabricate a nuclear component with a reduced risk of accidentally dispersing plutonium. To reach this safety goal, Los Alamos' design approach uses a component made of uranium instead of plutonium, while Livermore's design uses plutonium but separates the high explosive and fissionable materials.

Maintaining and strengthening each laboratory's nuclear design capability is a frequent consideration for DOE when it selects a laboratory to pursue a design. In addition, the laboratories have both benefitted from each other's designs:

Design approaches developed by one laboratory are sometimes incorporated into designs by the other laboratory. For example, Los Alamos is now pursuing further development of Livermore's fire-resistant nuclear component design. Similarly, Livermore's design for the "Peacekeeper" incorporated a major component of a Los Alamos design.

Materials Research and Fabrication

Nuclear weapons contain numerous types of nuclear and non-nuclear materials, including specially designed non-nuclear plastics and metals. Accordingly, laboratories that design nuclear weapons must have the capability to research and develop these materials and to fabricate components from them. This capability is currently important because of the need to understand the effects of aging and certain environments on these materials' performance.

In the area of materials research and development, Los Alamos and Livermore are alike in that each researches and develops nuclear materials such as plutonium, tritium, highly enriched uranium, and special salts (which increase weapons' yield). Each laboratory also researches and develops non-nuclear materials such as plastics, metals, and ceramics.

However, as with the design process, the two laboratories have different materials research and development approaches. For example, Los Alamos is developing a dry-machining process to fabricate plutonium components, while Livermore is developing a precision die-casting process to achieve the same end. With regard to other plutonium operations, Los Alamos has extensive plutonium processing capabilities while Livermore is focused on fabrication technologies.

For materials other than plutonium, the laboratories differ in their on-site research, development, and fabrication capabilities. That is, while Los Alamos has extensive on-site materials capabilities, Livermore relies primarily on commercial sources or on the facilities in the rest of the nuclear weapons complex.

High Explosives Technology

Modern nuclear weapons rely on high explosives for their operation. Because explosives detonation occurs at intervals of about a millionth of a second, testing requires specialized high-speed optical, electrical, and other diagnostics capabilities. Once small quantities of new explosives have been developed and tested, larger quantities must be produced and tested to determine the hydrodynamic effects--that is, how the explosives react with other materials within a weapon and whether the desired performance characteristics are achieved. Hydrodynamic

tests require special equipment, such as high-speed optical diagnostic equipment and radiographic diagnostic equipment. Radiographic diagnostic equipment allows researchers to obtain an x-ray picture of the inside of the exploding device.

The current emphasis on improved nuclear weapons safety has resulted in more research and development of insensitive high explosives (IHE). The IHE effort requires first developing new IHE molecules that contain the required insensitivity and energy and then developing quantities sufficient for testing. Both Los Alamos and Livermore are capable of developing and performing hydrodynamic testing on IHE, and both have a full range of diagnostic techniques to accomplish this testing.

However, each laboratory is investigating different molecules. Each laboratory also uses different diagnostic techniques and facilities to obtain data necessary to further the design. For example, Los Alamos is developing explosive compounds with a high nitrogen content, while Livermore is pursuing the development of paste explosives. Each laboratory's particular approach to designing these explosives determines the types of diagnostic tools that will be needed to evaluate the explosives' performance.

Associated capabilities, such as the development and testing of detonators, are also required. A large number of detonators must be manufactured and statistically tested to determine their reliability. Both laboratories design detonators. Los Alamos fabricates its own detonators for testing, while Livermore obtains its detonators for testing primarily from DOE's Mound plant or commercially if available. As for the explosives needed for testing, both laboratories design explosives. Los Alamos fabricates large quantities of explosives. Livermore has limited fabrication capabilities and often obtains the necessary quantities of explosives from DOE's Pantex Plant.

Weapons Engineering and Testing

Weapons engineering involves furthering the development of a nuclear weapon from design to production. To do so, components and subsystems must be assembled and tested to ensure that the weapon can withstand the environmental stresses it could undergo throughout its stockpile life and enroute to its target.

Both laboratories design, analyze, and assemble components and conduct environmental tests. Both laboratories have environmental testing facilities that subject components and subsystems to a variety of environmental conditions, such as temperature, shock, and vibration. Although both laboratories have environmental facilities, they both use the Sandia environmental testing facilities for some aspects of full-scale environmental testing.

Nuclear Testing

Calculations and laboratory experiments alone cannot adequately predict everything that occurs in nuclear weapons explosions. These explosions occur not only at temperatures and pressures exceeding those of the sun but also in reaction times on the order of less than a millionth of a second. Nuclear tests, conducted underground at the Nevada Test Site, provide data to detect problems that calculations and non-nuclear laboratory experiments cannot.

Diagnostic equipment must be designed to obtain data on various types of radioactive emissions from a nuclear explosion in the millionths of a second before the equipment is destroyed. After the tests, the radioactive remnants are extracted, taken back to the laboratory, and examined to help determine the weapon's yield and other characteristics.

Both Los Alamos and Livermore conduct tests at the Nevada Test Site and design diagnostic equipment to obtain the data necessary to further their weapons designs. As with hydrodynamic testing, each laboratory's particular design approach determines the specific types of diagnostic tools needed to evaluate the weapon's performance. Both laboratories employ a wide range of diagnostic techniques to evaluate weapon performance. In general, Los Alamos emphasizes data obtained from neutron emissions, while Livermore emphasizes data obtained from x-ray emissions. Both laboratories have the capability to examine the radioactive remnants of the nuclear explosions.

Because of decreased resources for underground testing and the potential for nuclear test restrictions, both laboratories have increasingly emphasized, above-ground non-nuclear laboratory testing. Although above-ground testing cannot supplant underground testing, it can provide experimental data to help compensate for reduced underground testing.

FUNDING AND STAFFING PROFILES

Los Alamos, Livermore, and Sandia were formed essentially to ensure excellence in the nation's nuclear weapons capabilities. Nuclear weapons RD&T and related programs, such as Inertial Confinement Fusion and Verification and Arms Control Technology, currently account for about half of the laboratories' funding. However, the laboratories have become multipurpose, with a wide variety of funding sources, including other DOE programs such as Energy Research, as well as other federal agencies, primarily the Department of Defense. (Detailed funding and staffing data for the three laboratories are contained in app. II.)

Over the past few years, total laboratory funding has decreased slightly at Los Alamos and Sandia and increased slightly at Livermore. However, in the past few years, funding for the RD&T program has decreased at all laboratories. (See app. II, fig.II.1) This has led the laboratories to seek alternate means of maintaining RD&T program capabilities. Thus, the RD&T program is now supported by other programs in DOE, DOD, and other government agencies.

In addition, the RD&T program is shrinking relative to the total laboratory budget. In 1983, RD&T formed 45 and 40 percent of Los Alamos' and Livermore's total budgets, respectively. By 1991, these percentages had declined to 30 and 29 percent.

Total laboratory staffing for 1991 was approximately 7,600 full-time-equivalents (FTEs) at Los Alamos and 7,900 at Livermore. As with funding, the number of staff directly supporting RD&T has declined since 1983. (See app. II, fig.II.2) In 1983, Los Alamos had about 1,700 FTEs and Livermore about 1,580 FTEs directly supporting RD&T. By 1991, Los Alamos had 1,280 FTEs and Livermore about 1,150 FTEs directly supporting RD&T. However, many laboratory staff who work on RD&T projects also work on other projects.

Over the past few years, total laboratory funding has decreased slightly at Los Alamos and increased slightly at Livermore. Over the last few years, Sandia has also experienced RD&T funding and staffing reductions, along with a reduction in total funding.

LABORATORY AND DOE CONSOLIDATION OPTIONS

With the world's changing political situation, and with progress in arms control negotiations, the number of nuclear weapons required in the stockpile is decreasing. To respond to these recent changes, DOE and laboratory officials believe that the national RD&T program will shift into new areas, including designing and testing safer, more secure weapons and supporting increased arms control and verification activities. In addition, DOE and the laboratories are pursuing several initiatives to modify both laboratory structure and missions to maintain technical capabilities at the laboratories.

In May 1991, recognizing that the future nuclear RD&T budget will be austere, DOE convened a Weapons Research, Development and Testing Consolidation Working Group, which was recommended by a larger DOE study of ways to reconfigure the entire nuclear weapons complex. The group included DOE officials and representatives of Los Alamos, Livermore, and Sandia, who provided technical assistance, as well as representatives from outside of DOE. The primary objective of the working group was to identify options that would help DOE satisfy essential RD&T

and production requirements while minimizing the costs to operate and modernize the RD&T portion of the nuclear weapons complex. A second major objective was to identify the extent to which independent peer review requires duplicative facilities and capabilities, as opposed to common resources shared by multiple working groups.

In August 1991, the laboratories recommended that even though laboratory independence should be maintained with regard to RD&T, consolidation in many areas should be examined. The laboratories' analysis estimated that $50 million to $100 million in annual operating costs could be saved within 3 to 5 years by consolidating components of selected RD&T functions related to plutonium, tritium, high explosives development and testing, and nuclear testing. A 1991 study anticipated that the consolidation of test and support operations at the Nevada Test Site will result in an estimated annual savings of up to $20 million.

As a result of these findings, DOE is currently studying consolidation alternatives and associated costs and savings in three major areas: plutonium, tritium, and hydrodynamic testing. Consolidation options include moving Livermore's plutonium activities to Los Alamos and consolidating tritium functions at Los Alamos and DOE's Savannah River Site.

During our work, we noted however, that the potential costs of consolidation have yet to be determined. For example, consolidating plutonium and tritium operations in fewer locations will involve capital costs for construction and equipment. In addition, DOE and the laboratories have noted that these costs may or may not be offset over time by decreased operating costs and that there are potential costs associated with decommissioning and decontaminating facilities being vacated.

In another effort to review the potential for consolidating facilities, DOE recently established an ad hoc panel of experts to review the future direction of one of the critical components of the nuclear weapons program--hydrodynamic testing. On the basis of information from the panel, DOE officials decided not to consolidate hydrodynamics testing at this time. However, DOE has asked Los Alamos to incorporate the diagnostics that Livermore needs into the design of a Los Alamos enhanced hydrodynamic test facility that is currently being designed, thus allowing for the potential for future joint use of the Los Alamos facility.

Both laboratories agree that there is potential for increased use of shared facilities and that future costs could be avoided by not constructing duplicative facilities. Each laboratory estimates that it will need over $1 billion to maintain its infrastructure and build new facilities over the next 20 years. However, for a single facility to meet the needs of the different approaches used by each laboratory's scientists,

the facility would need to be jointly designed by both laboratories.

The laboratories believe that while it is valuable to pursue the annual savings to be gained through consolidation, these savings will be small in relationship to the funds needed for the entire nuclear weapons complex. They also believe that further funding cuts and consolidation are not possible without affecting the essential character and independence of at least one of the laboratories and that further severe funding cuts would cause irreparable damage to the nation's nuclear competence. According to Los Alamos officials, a reduction of 25 percent of the total nuclear weapons RD&T budget (which includes the budgets for Los Alamos, Livermore, Sandia and the Nevada Test Site) would diminish capabilities so much that the current two-laboratory structure for weapons design could not be effectively sustained.

To help maintain the existing laboratory infrastructure despite the expected decline in RD&T funding, the laboratories believe that their role should be expanded beyond nuclear weapons RD&T. The laboratories believe they should have an increased role in designing manufacturing processes for DOE's Complex 21 initiative, which involves the design and construction of the future nuclear weapons complex. Finally, the laboratories believe they should have an increased role in waste management research. According to Los Alamos officials, new and more efficient waste management and manufacturing processes developed by the laboratories could eventually reduce the nuclear weapons complex's estimated $12 billion annual operating budget for atomic energy defense activities significantly. DOE and laboratory officials have begun discussing ways in which the laboratories' missions could be expanded to include such areas.

Los Alamos and Livermore officials believe that the current two-laboratory structure for design efforts has enormous benefits in the areas of competitive innovation and peer review, where there is no source of expertise outside of the laboratories. According to Los Alamos and Livermore officials, the laboratories have recently strengthened their inter-laboratory peer review process in response to the projected smaller stockpile, the reduced number of nuclear tests, and the need for assured safety and security.

While Los Alamos officials strongly prefer to maintain the current two-laboratory RD&T structure and to broaden the laboratories' mission to include Complex 21 and waste management issues, they have conducted preliminary studies on alternative configurations. If further RD&T funding cuts prevent continuance of the two-laboratory structure, they believe the following alternative configurations could maintain technical excellence in the nuclear weapons program:

-- Under the first alternative, both laboratories would continue to design weapons, but only one would engineer and test them. This alternative would maintain the current benefits of peer review and competition between Livermore and Los Alamos designers. The laboratory responsible for design, engineering, and testing would need a full array of facilities. Los Alamos officials estimate that this alternative approach would save from $150 million to $200 million a year in annual operating costs. However, the costs of relocating necessary staff and capabilities have not been studied.

-- The second alternative would use the experience of the French nuclear weapons laboratories as a model. Under the French structure, competition and peer review exist under a single program for nuclear weapons design. According to Los Alamos officials, their own experience with two independent design teams, to study alternative design safety approaches, has shown that this concept could work in some instances.

-- The third alternative would use the experience of the British Atomic Weapons Establishment as a model. The British have the option of using American design laboratories for competition and peer review. Los Alamos officials advanced the idea that, with a considerable relaxation of current limitations on exchanging information among national programs, a single American design laboratory could depend on the French and British laboratories for peer review and intellectual competition.

Livermore officials believe that maintaining the laboratories' scientific independence would be difficult in the face of extensive consolidation and severe funding cuts, which reduce the scope and capability of the RD&T program. Los Alamos officials believe that if RD&T funds continue to decrease and if no restructuring occurs, then laboratory capabilities will so erode that both Los Alamos and Livermore will become mediocre laboratories.

This concludes my prepared statement, Mr. Chairman. I would be pleased to answer any questions the Committee might have.

Weapon RD and T Capabilities

I. NUCLEAR DESIGN

Nuclear Design

- Primary Design
  - High Explosive Systems/Hydrodynamics
  - Neutronics
  - Burn and Boost
  - Codes and Code Development
  - Experimental Hydrodynamics
    - Devices
    - Test Facilities
    - Design
  - Radiation Transport
  - Equation of State for Weapon Materials

- Secondary Design
  - Radiation Transport
  - Opacity
  - Plasma Physics
  - Hydro and Instability
  - Thermonuclear Burn

Physics Laboratories

- Accelerators
- Other Facilities

Computations

- Computers (Mainframes and Operating Systems)
- Architecture and Computational Methods
- Device and Weapons Engineering

II. MATERIALS RESEARCH AND FABRICATION

Plutonium

- Metallurgy
- Part Fabrication
- Advanced Development Support
- Weaponization Program Support
- Processing/Waste Stream Control
- Stockpile Assessment
- Special Isotope Separation

Tritium

- Research and Development
- Test Program Support
- Gas Transfer System (Weapons)
- Materials Compatibility

Uranium

- Metallurgy
- Part Fabrication
- Processing/Manufacturing
- Waste Stream Control
- AVLIS
- Weaponization Program Support

Other Weapons Materials Activities

- Metal
- Plastics and Composites

III. HIGH EXPLOSIVES TECHNOLOGY

- Formulation
- Synthesis
- Detonation Properties/Characterization
- Processing/Machining
- Test Firing
- Detonators
- Actuators

IV. WEAPONS ENGINEERING

Weapons Engineering

- Engineering Design
- Production
- Stockpile Management
- Stockpile Surveillance
- Telemetry Systems

Weapons Testing

- Temperature
- Vibrations and Shock
- Aging
- Other

V. NUCLEAR TESTING

Nuclear Test

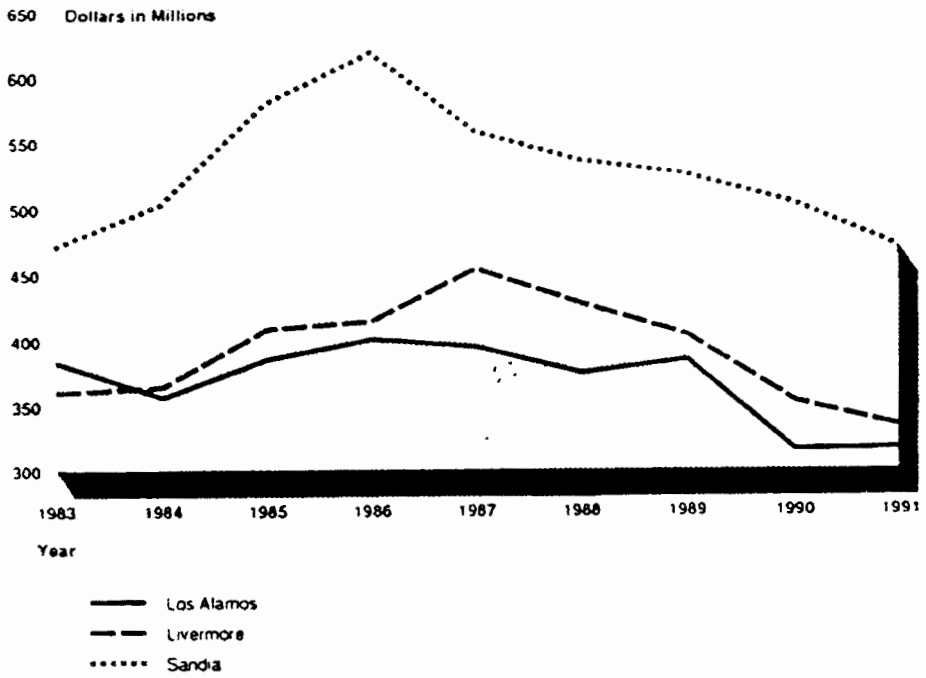
- Diagnostic Design Development
- Radiochemistry

- Nuclear Test Engineering
- Containment Evaluation
- Field Evaluation
- Emplacement Operations

Nuclear Effect Simulation Facilities

LABORATORY STAFFING AND FUNDING

Figure II.1: Research, Development, and Testing Funding Levels, 1983-1991



LABORATORY STAFFING AND FUNDING

Figure II.2: Research, Development, and Testing Staffing Levels, 1983-1991

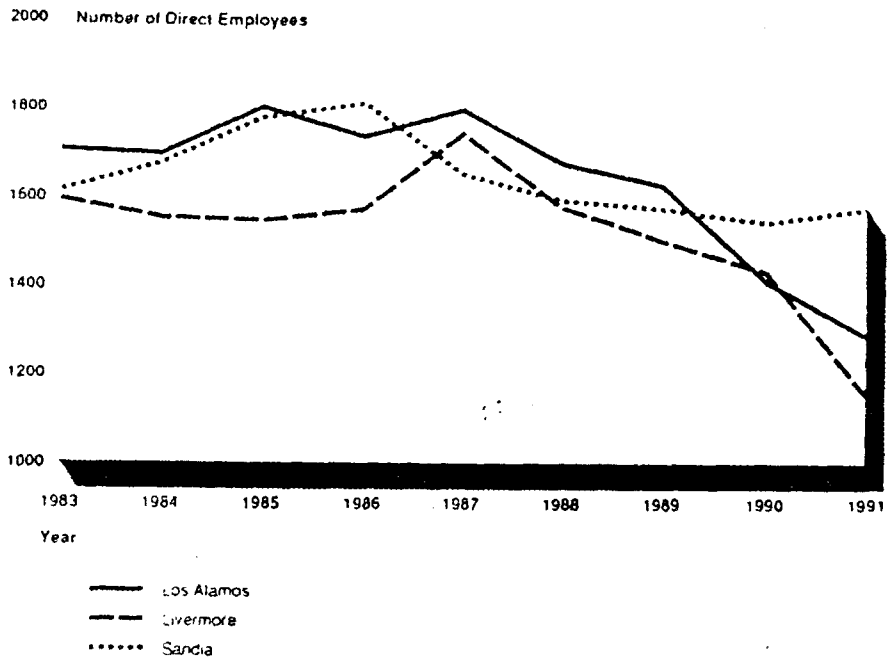


Table II.1: Los Alamos National Laboratory Funding and Staffing for Fiscal Year 1991

Funding and Staffing Category	Costs ($ in millions)	% of Total	Staff (in FTEs)	% of Total
Defense Programs				
Research, Development, and Test	316.4	30.2%	1283	17.0%
All Other Defense Programs[a]	182.3	17.5%	816	10.8%
Subtotal Defense Programs	498.7	47.8%	2099	27.8%
Other Department of Energy Funding				
Energy Research	117.0	11.2%	551	7.3%
Environmental Restoration	92.3	8.8%	307	4.1%
Nuclear Energy	20.1	1.9%	92	1.2%
Intelligence	18.3	1.8%	18	.2%
New Production Reactor	17.0	1.6%	63	.8%
Civilian Radioactive Waste	15.5	1.5%	61	.8%
Conservation and Renewable Energy	12.1	1.2%	53	.7%
Environment, Safety, and Health	4.0	.4%	22	.3%
Fossil Energy	1.0	.1%	4	.1%
Human Resources Mgmt and Administration	.6	.1%	0	0.0%
Policy, Planning, and Analysis	1.0	.1%	6	.1%
Subtotal Other DOE	298.9	28.6%	1177	15.6%
Reimbursables				
Department of Defense	159.0	15.2%	518	6.9%
Other DOE Installations	42.0	4.0%	146	1.9%
Nonfederal	17.0	1.6%	58	.9%
Other	16.0	1.5%	160	2.1%
Nuclear Regulatory Commission	2.0	.2%	10	.1%
Subtotal Reimbursables	236.0	22.6%	902	11.9%

Funding and Staffing Category	Costs ($ in millions)	% of Total	Staff (in FTEs)	% of Total
Other Miscellaneous and Indirect Sources				
General Plant Projects	10.6	1.0%	[b]	[b]
Overhead Personnel	[b]	[b]	1957	26.0%
Support	[b]	[b]	1283	17.0%
Construction and Operations Capitalized	[b]	[b]	147	1.9%
Subtotal Miscellaneous & Indirect	10.6	1.0%	3387	44.8%
Total Lab	1044.0	100.0%	7565	100.0%

[a]All other Defense Programs includes Inertial Confinement Fusion, Production and Surveillance, Program Direction, Verification and Arms Control Technology, Nuclear Safeguards and Security, Materials Production, and Defense Waste and Environment.

[b]Information accounted for in other categories.

Source: Extracted from Los Alamos Institutional Plans and operating statements. We did not independently verify these data.

Table II.2: Lawrence Livermore National Laboratory Funding and Staffing for Fiscal Year 1991

Funding and Staffing Category	Cost (dollars in Millions)	% of Total	Staff (in FTEs)	% of Total
Defense Programs				
Research, Development, and Test	$332.8	28.6%	1147	14.5%
All Other Defense Programs[a]	172.8	14.9%	621	7.9%
Subtotal Defense Programs	505.6	43.5%	1768	22.4%
Other Department of Energy Funding				
Nuclear Energy	135.6	11.7%	385	4.9%
Energy Research	82.9	7.1%	365	4.6%
Environmental Rest. and Waste Mgmt.	50.9	4.4%	154	1.9%
Civilian Radiation Waste	33.0	2.8%	55	.7%
Chief Financial Officer	.4	< .1%	2	< .1%
Intelligence	8.6	.7%	31	.4%
Fossil Energy	5.5	.5%	40	.5%
Security Affairs	3.0	.3%	12	.2%
Environment, Safety, and Health	3.5	.3%	9	.1%
Conservation and Renewable Energy	2.5	.2%	6	.1%
Policy, Planning, and Analysis	.3	< .1%	1	< .1%
Admin. and Human Resource Mgmt.	.3	< .1%	0	0.0%
Space	.1	< .1%	0	0.0%
Subtotal Other DOE	326.4	28.1%	1060	13.4%
Work for Other/Reimbursables				

Funding and Staffing Category	Cost (dollars in Millions)	% of Total	Staff (in FTEs)	% of Total
Department of Defense	253.3	21.8%	617	7.8%
Other DOE Installations	50.8	4.4%	174	2.2%
Other	8.1	.7%	28	.4%
NASA	5.4	.5%	19	.2%
Nuclear Regulatory Commission	3.8	.3%	13	.2%
Other Federal Agencies	2.4	.2%	8	.1%
Subtotal Work For Others	323.8	27.8%	859	10.9%
Other Miscellaneous and Indirect Sources				
General Plant Projects	7.3	.6%	[b]	[b]
Indirect Personnel	[b]	[b]	4111	52.1%
Department of Energy Capital	[b]	[b]	100	1.3%
Subtotal Misc. & Indirect	7.3	.6%	4211	53.3%
Total Lab	$1,163.0	100.0%	7898	100.0%

[a]All other Defense Programs include Inertial Confinement Fusion, Production and Surveillance, Program Direction, Verification and Control Technology, Safeguards and Security, Atmospheric Release Advisory Capability, and Materials Production.

[b]Information accounted for in other catergories.

Source: Extracted from Lawrence Livermore Institutional Plans. We did not independently verify these data.

Table II.3: Sandia National Laboratories Funding and Staffing For Fiscal Year 1991

Funding and Staffing Category	Costs (dollars in millions)	% of Total	Staff (in FTEs)	% of Total
Defense Programs				
Research, Development, and Test	$469.1	38%	1575	18.3%
All Other Defense Programs[a]	252.3	20.4%	987	11.5%
Subtotal Defense Programs	721.4	58.4%	2562	29.8%
Other Department of Energy Funding				
Environmental Rest. and Waste Mgmt.	58.1	4.7%	179	2.1%
Conservation and Renewable Energy	32.6	2.6%	117	1.4%
Energy Research	26.8	2.2%	108	1.3%
Civilian Radioactive Waste	26.3	2.1%	91	1.1%
Fossil Energy	8.6	.7%	42	.5%
New Production Reactors	5.4	.4%	28	.3%
Nuclear Energy	5.1	.4%	12	.1%
Subtotal Other DOE	162.9	13.2%	577	6.7%
Work Other Than for DOE/Work for Others				
Department of Defense	274.8	22.3%	917	10.7%
Other Federal Agencies	24.1	2%	103	1.2%
Other DOE Installations	14.4	1.2%	52	.6%
All Other	14.3	1.2%	40	.5%
Nuclear Regulatory Commission	13.9	1.1%	54	.6%
Subtotal Work For Other	341.5	27.7%	1166	13.6%
Other Miscellaneous and Indirect Sources				
General Plant Projects	8.8	.7%	[b]	[b]
Indirect Personnel	[b]	[b]	3074	35.7%
Direct Support	[b]	[b]	1221	14.2%
Subtotal Misc. & Indirect	8.8	.7%	4295	50.0%

Total Lab	$1,235.0	100.0%	8600	100.0%

[a]All other Defense Programs include Inertial Confinement Fusion, Production and Surveillance, Program Direction, Verification and Control Technology, Nuclear Materials Safeguards and Security, and Defense Waste.

[b]Information accounted for in other categories.

Source: Extracted from Sandia Institutional Plans. We did not independently verify these data.

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United States General Accounting Office

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Report to the Secretary of Energy

May 2001

NUCLEAR CLEANUP

DOE Should Reevaluate Waste Disposal Options Before Building New Facilities

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Accountability * Integrity * Reliability
United States General Accounting Office
Washington, DC 20548

May 25, 2001

The Honorable Spencer Abraham
Secretary of Energy

Dear Mr. Secretary:

As the Department of Energy (DOE) cleans up its contaminated nuclear sites, it must decide how best to dispose of huge volumes of low-level radioactive waste (low-level waste) generated in the cleanup process.[1] DOE estimates that 26 of its 144 nuclear production sites will need to dispose of at least 6.8 million cubic meters of cleanup wastes—primarily contaminated soil and building debris—over the next 70 years. This amount would fill a space as long and wide as a football field and almost one mile high. DOE generally allows its sites to select one of several available disposal locations, including existing on-site facilities, facilities at other DOE sites, or—depending on costs and other factors—off-site commercial facilities. Because some sites do not have existing on-site disposal facilities that can accommodate the projected volumes of cleanup wastes, they are in the process of developing new on-site facilities to specifically accommodate disposal of these wastes. Since 1996, three DOE sites—the Fernald Environmental Management Project (Ohio); the Oak Ridge Reservation (Tennessee); and the Idaho National Engineering and Environmental Laboratory (INEEL) (Idaho)—have decided to develop new on-site disposal facilities. To date, only the Fernald facility has disposed of any actual waste. At least one other site—the Paducah Gaseous Diffusion Plant (Kentucky)—is considering whether or not to develop an on-site disposal facility.

As part of ongoing reviews of DOE's cleanup program, we determined how each of the three sites decided to dispose of its low-level waste on-site rather than off-site. Our analysis addressed (1) the extent to which site officials took into account the comparative costs and risks associated with off-site waste disposal, and 2) the extent to which site officials revisited

[1] DOE defines low-level waste as any radioactive waste that does not fall within other classifications, such as high-level waste, spent nuclear fuel, transuranic waste and uranium mill tailings. As used in this report, low-level waste may include some mixed waste—that is, waste that contains hazardous as well as radioactive materials. DOE also manages low-level and other types of wastes generated from its activities relating to developing materials for nuclear weapons and research.

these cost and risk assessments after reaching their decisions to build on-site waste disposal facilities.

Results in Brief

Officials at the Fernald, Oak Ridge, and INEEL sites decided to develop new on-site disposal facilities after conducting detailed cost and risk assessments that compared, on the basis of the information then available, on-site and off-site disposal. The officials at each site (1) compared the estimated costs, projected risks to health and the environment, and other factors, and (2) incorporated comments and suggestions from the public and other interested parties through an open decision process. In each case, site officials concluded, and EPA agreed, that the projected cost savings from on-site disposal outweighed the uncertainties surrounding the long-term costs and safety risks associated with keeping the wastes on-site.

In the year or more between the decisions to develop on-site disposal facilities and groundbreaking for these facilities, circumstances at the three sites have changed in ways that could affect the earlier cost estimates for each site. For example, the projected volume of waste has often increased and cleanup schedules have changed. Good business practice suggests that site officials should reconfirm, on the basis of more current information and cost comparisons, that on-site disposal remains advantageous to DOE before constructing new disposal facilities. Recent federal guidance directing agencies to validate their capital investment decisions is consistent with this view. Officials at the three sites, however, made little effort to update and reevaluate their original on-site and off-site cost comparisons to determine whether on-site disposal remains the preferred alternative when both costs and risks are taken into account. Therefore, to ensure that on-site disposal decisions continue to be advantageous to DOE, this report is recommending that site officials reevaluate both on-site and off-site disposal options, especially when project scope or timeframes have changed dramatically, before making major investments in new on-site disposal facilities. We obtained written comments on a draft of our report from DOE. The agency supported our recommendation and noted that it had begun planning to address the issues raised in the report.

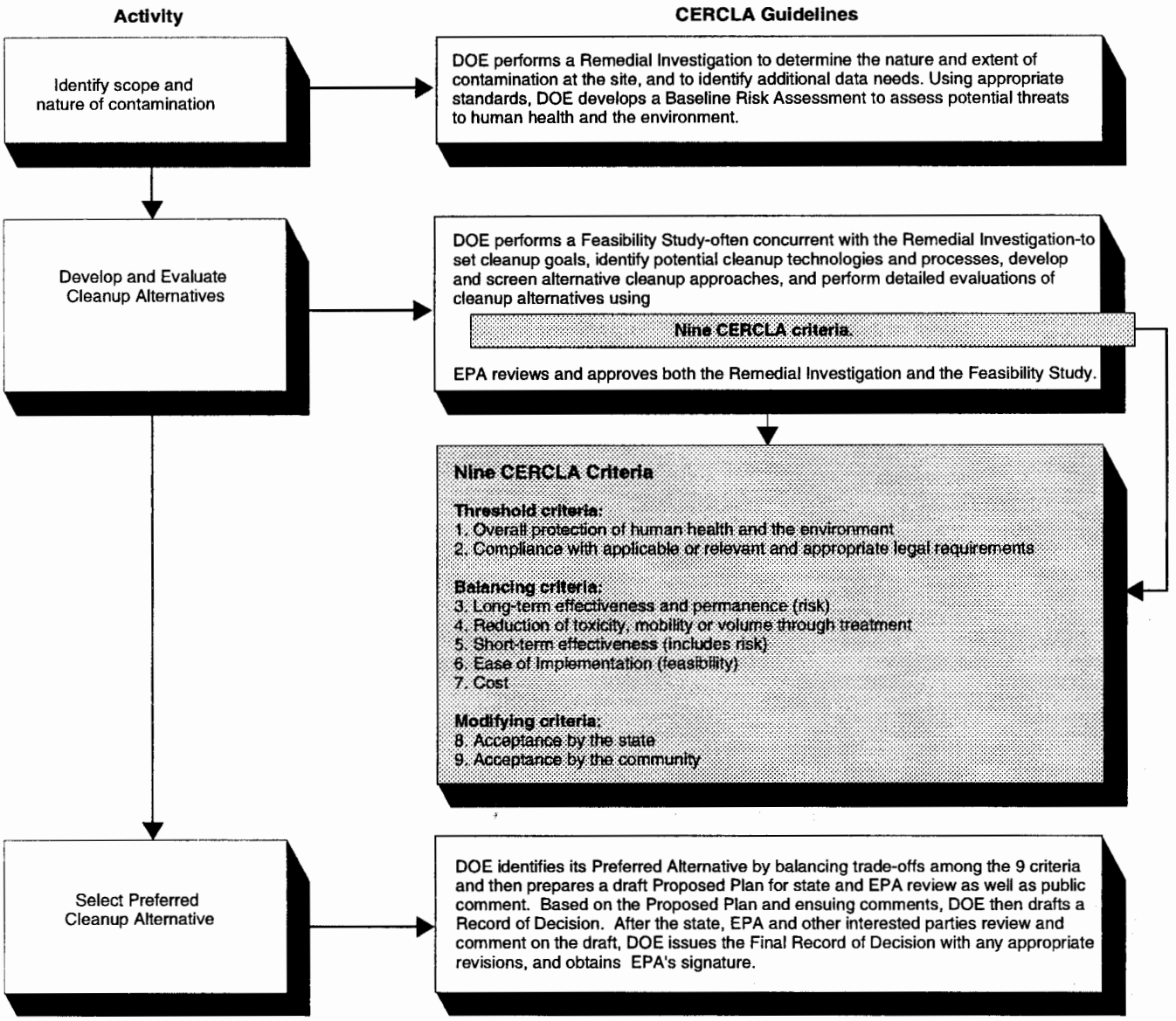
Background

DOE manages the disposal of cleanup wastes that come from remediation, decontamination, and demolition at sites where operations have been discontinued. Cleanup wastes are primarily subject to three laws: the Atomic Energy Act of 1954, as amended; the Resource Conservation and Recovery Act of 1976 as amended (RCRA); and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as

amended (CERCLA). DOE is responsible for the management of its own radioactive wastes under the Atomic Energy Act. Under RCRA, the Environmental Protection Agency (EPA) or states with programs authorized by EPA regulate the hazardous components of mixed wastes. The Congress enacted CERCLA to clean up the nation's most severely contaminated hazardous waste sites. Under CERCLA, which is administered by EPA, the parties responsible for the contamination are responsible for conducting or paying for the cleanup. The statute makes federal facilities subject to the same cleanup requirements as private industry.

For CERCLA projects, EPA has established a decision process designed to involve the public and EPA in identifying, evaluating, and choosing cleanup approaches. This process requires parties responsible for the cleanup (in this case DOE) to consider a range of cleanup alternatives. EPA uses nine specific criteria, including the estimated costs, feasibility, and risks for each alternative, to evaluate, compare, and balance tradeoffs among these alternatives (see fig. 1). Under these criteria, any selected cleanup alternative must adequately reduce long-term risks to human health and the environment. The chosen alternative—including the plan for disposing of the waste—is documented in a Record of Decision (ROD), which EPA must approve.

Figure 1: CERCLA Cleanup Decision Process



Sites Made Decisions Using Preliminary Information About Disposal Needs

Officials at the three sites we reviewed considered detailed estimates of the costs and risks associated with on-site and off-site waste disposal. Among other things, these estimates were based on preliminary determinations on the extent and type of contamination present at the site. In accordance with the CERCLA decision process, site officials also assessed how well each cleanup alternative addressed the nine CERCLA criteria. After balancing the tradeoffs among the criteria for each alternative, site officials selected an on-site disposal alternative based, at least in part, on their estimation that on-site disposal would cost less than off-site disposal (see table 1). To meet the CERCLA requirement that human health and the environment be adequately protected, DOE sites adopted accepted strategies, such as limiting the level of contamination allowed in the disposal facility, to mitigate long-term risks. DOE, EPA, and other stakeholders agreed that the benefits of on-site disposal, including cost savings, outweighed the remaining long-term risks.

Table 1: Comparison of On-site and Off-site Disposal Cost Estimates Used To Support the Record of Decision at Each Site

Present value in the year of the estimate, dollars in millions

				Extent to which off-site disposal cost estimates exceeded on-site estimates	
DOE Site	**Year of estimate**	**On-site estimate**	**Off-site estimate**	**Amount**	**Percent**
Fernald Environmental Management Facility[a]	1995	$578	$772	$194	34 %
Oak Ridge Reservation -- low volume [b]	1997	100	133	33	33 %
Oak Ridge Reservation --high volume [b]	1997	168	450	282	168 %
Idaho National Engineering and Environmental Laboratory (site-wide estimate)	1998	187	605	418	224 %

[a] Fernald estimates included significant costs to remediate the Great Miami Aquifer.

[b] Oak Ridge compared costs for scenarios at the low and high ends of their expected volume range.

Sites Identified the Extent of Cleanup Needed and Developed Alternative Cleanup Actions

In accordance with the first steps in EPA's CERCLA decision process, all three sites conducted remedial investigations to confirm and to quantify the nature and extent of contamination.[2] They examined site background and historical data, and used limited sampling to project the volumes and types of wastes that could be generated by cleanup activities. Based on

[2] For the cleanup decisions we reviewed, the CERCLA decision process and documentation focused on a cleanup decision for one contaminated area—not the entire DOE site. For sites like the three we reviewed, officials typically divide the site into a number of contaminated areas, in part because not all areas will be cleaned up at the same time.

this limited information, officials at each site developed a preliminary model describing the sources of contamination (such as soil or groundwater), possible ways the contaminants could be released, and whether human exposure would be likely. Using this model, they assessed the cancer and non-cancer risks to humans.[3]

Officials at each site also prepared a feasibility study that established cleanup goals, identified possible cleanup technologies and actions, and analyzed alternative cleanup approaches. For the contaminants of concern, officials set cleanup goals at contamination levels that posed acceptable risks according to their exposure model. The waste excavation and disposal approach, either on-site or off-site, was only one of many approaches available to officials to meet these cleanup goals. For example, each site considered leaving at least some waste in place and limiting human exposure to it by either capping the waste with clean cover materials or restricting access to the waste areas. Site officials developed their alternative cleanup approaches using the results of their remedial investigations and working closely with EPA and state reviewing officials.

Officials in Oak Ridge and Idaho determined that feasible cleanup approaches were likely to generate more waste than the existing disposal facilities at those sites could accommodate, and the Fernald site had no existing disposal facility. Therefore, when conducting their feasibility studies, officials at each of the three sites considered whether to dispose of their respective wastes in a new on-site facility or to ship them to an off-site disposal facility. Specifically, each site used the Envirocare facility in Utah as its representative off-site disposal facility. DOE and commercial generators of radioactive waste use this facility, which is located 80 miles west of Salt Lake City, to dispose of mildly contaminated soils and debris. In addition to the Envirocare facility, DOE sites that do not have existing on-site disposal facilities are now authorized to dispose of their low-level and mixed low-level wastes at DOE's disposal facilities for these types of

[3] Under CERCLA, EPA uses standards described in the National Contingency Plan, and accepts levels of contaminants present in sufficient concentrations to create an excess lifetime cancer risk within, or less than, the range of 1 chance in 10,000 (10^{-4}) to 1 chance in one million (10^{-6}). Non-cancer health effects are assessed in terms of a hazard index for each contaminant of concern. The calculated hazard index indicates the potential for the most sensitive individuals, such as children, to be adversely affected. Hazard indices are compared to a threshold value of 1, established by EPA as the level above which there is the potential of non-cancer effects on exposed individuals.

wastes at its Hanford Reservation in southeastern Washington and its Nevada Test Site in southern Nevada.[4]

Sites Used Nine CERCLA Criteria to Evaluate Cleanup Alternatives

Site officials assessed each proposed cleanup alternative against the cleanup goals, as well as nine decision criteria specified in EPA's CERCLA regulations and guidance. Following this guidance step-by-step, officials first considered the two threshold criteria, then evaluated qualifying alternatives against the five balancing criteria, and then applied the two modifying criteria. CERCLA threshold criteria require a cleanup approach to (1) achieve overall protection of human health and the environment and (2) meet all legal requirements, referred to as "applicable or relevant and appropriate requirements." Site officials discarded some alternatives, such as capping some contaminated areas in place, because they did not meet these threshold criteria. In some instances, waivers were needed to develop on-site disposal facilities. For example, the Fernald site obtained a waiver from the state of Ohio's prohibition on developing a disposal facility over a drinking water aquifer. Similarly, the Oak Ridge site obtained a waiver from EPA's minimum required distance from the bottom of a landfill that contained toxic chemicals to the underlying groundwater. Without these waivers, the sites would not have been able to develop on-site disposal facilities. (See appendix I.) In both instances, the host states and EPA agreed with site officials that the proposed facilities could be designed to meet equivalent safety standards.

After screening cleanup alternatives against the two threshold criteria, site officials developed more detailed feasibility studies to demonstrate how well the various surviving alternatives met each of five CERCLA balancing criteria. The sites used measures that employed varying degrees of data and subjectivity to evaluate how effectively an alternative met each criterion (see table 2).

[4] There are, however, roadblocks to fully using the disposal facilities at Hanford and the Nevada Test Site. The two host states may oppose increases in waste disposal at the sites, and DOE may need to obtain environmental permits from these states to dispose of out-of-state mixed wastes.

Table 2: Evaluation Methods Used to Assess CERCLA Balancing Criteria

CERCLA balancing criteria	Evaluation methods used by site officials
Long-term effectiveness and permanence	Performed extensive disposal facility and groundwater modeling to project the potential for disposed wastes to escape from an engineered facility and migrate, resulting in exposure risks that exceed CERCLA standards.
Reduction of toxicity, mobility, or volume through treatment	This balancing criterion was less applicable to the decision at all three sites. All three sites may consider any applicable new treatment technologies.
Short-term effectiveness	Considered, and to some extent quantified, risks to people from accidents and exposure during cleanup actions, including transportation options. Identified impacts to the community and environment from activities like excavation and road building.
Ease of implementation	Considered whether proposed technologies were untested or readily available. Considered logistical and political implications of shipping waste across the country, or leaving waste on-site.
Cost	Prepared detailed cost estimates that included costs for: planning, management, equipment, any on-site construction, annual operations, transportation, disposal fees for any waste sent off-site, and, for on-site alternatives only, facility closure and post closure activities for up to 100 years. Converted estimated costs to present worth dollars for comparisons, as required by CERCLA. Noted that costs contained significant uncertainties thought to approximate CERCLA guidelines of a –30 to a + 50 percent margin of error.

All three sites then used these evaluations to balance the criteria for on-site and off-site disposal alternatives. Generally, each alternative approach had strengths and weaknesses in some of the criteria, and the sites had to make tradeoffs according to their unique conditions and priorities. Table 3 lists the key tradeoffs each site cited in its comparative analysis between on-site and off-site alternatives of similar cleanup scope. (See appendix 1 for a description of each site's comparative analysis.)

Table 3: Key Tradeoffs in Each Site's Analysis of CERCLA Balancing Criteria

DOE Site	Comparative analysis of balancing criteria for on-site and off-site disposal alternatives
Fernald	Off-site disposal provided the most long-term protection at the Fernald site. However, on-site disposal of qualifying waste was selected because of reduced cross-country transportation risk,[a] slightly lower cost, and less dependence on the future availability of off-site disposal facilities.
Oak Ridge	Off-site disposal in an arid location provided better long-term protection of groundwater. However, an on-site disposal facility would not contribute substantially more to potential exposure, because other portions of the site are expected to remain contaminated. On-site disposal selected because of reduced risk from cross-country transportation,[a] lower costs for the highest estimated waste volume, and less dependence on the future availability of off-site disposal facilities.
INEEL	Both on-site and off-site disposal would be effective in the long term—provided the on-site facility remained protective of the groundwater. Off-site disposal would be more difficult to implement because it required long distance waste shipments and depended on the availability of off-site disposal capacity. (The Feasibility Study, however, provided minimal support for this conclusion.) On-site disposal selected because of lower costs for the projected waste types and volumes, as well as minor reductions in transportation risks.[a]

[a] the increased risks of physical accidents and injuries—not radiological exposure—was the differentiating factor

Officials at each site applied the two CERCLA modifying criteria—state and community acceptance—to its preferred alternative of on-site disposal for most of its waste. Each site involved state and community stakeholders early in the decision process. State environmental agencies participated in preliminary reviews and informal discussions from the start of the Remedial Investigation throughout the final cleanup decision. Generally, by the time site officials issued their Final Record of Decision, they had addressed, or had a plan to address, environmental concerns raised by the states. For example, the Ohio Environmental Protection Agency supported the development of an on-site facility in Fernald contingent upon specific restrictions on the source of and radioactivity in any waste accepted for disposal. The Record of Decision incorporated an approach to meet these restrictions.

Site officials also involved and informed community stakeholders, and received support for their decisions from groups such as the Fernald Citizens Task Force, the Oak Ridge Reservation Environmental Management Site Specific Advisory Board, and the INEEL Citizens Advisory Board. The Fernald Citizens Task Force, which is comprised of individuals with diverse interests in the future of the site, convened in 1993 to provide focused input on central cleanup issues at Fernald. A Task Force report issued in 1995 included recommendations on the site's future use, waste disposal options, and cleanup objectives and priorities. DOE's selected alternative mirrored these recommendations.

All three sites held public hearings on their Proposed Plan and ROD, and accepted comments for the time periods required under CERCLA. The

resulting comments and DOE responses were incorporated in the decision documents. In each case, host state environmental agencies concurred with the proposed decisions. Each DOE site and its respective EPA region then signed a Final ROD that documented the decision for an on-site disposal facility. This final decision allowed DOE sites to move forward with planning for site excavation and construction.

DOE Has Not Used Updated Information to Reassess Disposal Decisions Before Making Major Investments in On-site Facilities

After deciding to build new on-site disposal facilities, site officials continued to refine disposal needs and develop specific plans for these facilities for one or more years. During this time, significant changes occurred in site assumptions regarding the types and volume of wastes needing disposal, detailed design of on-site facilities, duration of the cleanup, and cost of off-site transportation and disposal. Under such circumstances, good business practice suggests that earlier cost estimates should be confirmed before construction begins. Likewise, 1997 guidance issued by the Office of Management and Budget (OMB) states that agencies should validate their earlier planning decisions with updated information before finalizing capital investments. However, the three sites conducted little further evaluation of off-site disposal options, despite changed circumstances that could narrow the cost difference between on-site and off-site disposal. At Oak Ridge, for example, a simple update of the projected waste volumes, transportation rates, and costs for off-site disposal of some types of waste effectively reduced the difference between on-site and off-site cost estimates by 51 percent. Such changes in relative costs could also affect the balancing of costs and other factors considered while making cleanup decisions. In particular, uncertainties about long-term stewardship needs become more significant as cost differences narrow. The elapsed time between the preparation of the initial cost estimates that were used to support the disposal decision and the commencement of construction of on-site disposal facilities argues for validating the initial cost comparisons before committing funds to construction of new facilities. DOE has not taken advantage of this time to update their cost comparisons at the three sites.

Assumptions Changed as Sites Refined Cleanup Plans

A year or more can elapse between the time the costs are estimated and the commencement of actual cleanup activities. During this period, officials at the three sites we reviewed continued to determine the extent and nature of contamination needing cleanup, and often changed their assumptions about waste volumes, waste types, cleanup duration, and the type of disposal facility needed. Although such changes can have major implications on cost estimates for both on-site and off-site disposal, officials at the sites applied the CERCLA process in a manner that

discouraged re-examination of costs for alternatives other than their previously selected approaches.

Waste Volume and Types Have Changed

At all three sites, the waste volumes used to compare on-site and off-site disposal costs were significantly less than the waste volume currently projected for on-site disposal. At two of the sites, site-wide cleanup plans and waste projections were not well defined when the cost estimates were prepared. Officials at those sites now expect to dispose of much more waste. Officials at the Fernald site noted that, although the site's cost estimate was based on 1.4 million cubic meters of waste from one operable unit, the overall decision making process was based on the site-wide estimate of 1.9 million cubic meters. (See table 4.) As the volume of waste grows, the potential need to construct additional disposal capacity to accommodate the waste also grows. At the time of our review, Oak Ridge officials stated that they would need to obtain further geologic surveys and regulatory approval before expanding the disposal facility to accommodate the larger waste volume now projected. Because the cost comparisons were largely limited to an earlier set of assumptions about waste volumes, without preparing updated cost estimates DOE is not in a position to assess whether these changes will have a substantial effect on the comparative costs of on-site and off-site disposal.

Table 4: Projected Waste Volumes for Disposal Used for the ROD and Current Estimate

Amounts in cubic meters

DOE Site	Waste volume used for comparing on- and off-site costs	Current projection of waste volume for disposal
Fernald	1,400,000	1,900,000[a]
Oak Ridge	170,000 – 840,000	2,200,000
INEEL[b] (Waste Area Group 3)	63,000	228,000
INEEL[b] (site-wide)	356,000	369,000[c]

[a] In its proposed plan, the Fernald site projected that approximately 1.9 million cubic meters of low-level waste generated site-wide would be consolidated in the disposal cell; however, the cost estimates were based on approximately 1.4 million cubic meters of waste projected under the ROD for Operable Unit 5.

[b] The cost estimate in the ROD for the INEEL on-site disposal facility was based on just 63,000 cubic meters of waste projected from cleanup of Waste Area Group 3. Altogether the INEEL site has 10 Waste Area Groups throughout the site. In their 1998 feasibility study, officials estimated costs for disposal of 356,000 cubic meters of waste projected site-wide.

[c] In addition, INEEL officials said that at least 312,000 more cubic meters of low-level soils waste will need remediation when the adjacent chemical plant and tank farms are dismantled after the year 2035—well after the planned on-site disposal cell is scheduled for closure.

Source: DOE

Further investigation of the contaminated areas at the sites also changed assumptions about the types of waste that will be generated. This is especially important because the disposal requirements—and therefore, the cleanup costs—vary by waste type. For example, mixed waste—waste that is radioactive and also contains hazardous substances—must be disposed of in facilities that meet more stringent RCRA standards. Because meeting RCRA standards increases disposal costs, the proportion of mixed waste in cleanup waste will affect overall cost estimates. Disposal fees at the Envirocare facility, for example, are much higher for mixed waste than for low-level waste. Also, cost estimates can be affected by how much of the waste is building debris, such as concrete or metal, and how much is soil. Building debris can cost more for disposal due to its awkward sizes and shapes. Sites may also need to obtain additional fill material to properly dispose of debris, or they may need to adjust their disposal schedules to ensure a proper mix of the two types of waste.[5] On-site facilities that need to increase their disposal capacity, purchase additional fill, or adjust disposal schedules will probably face higher costs than originally estimated.

Cleanup Schedules Remain in Flux

Since developing their cost comparisons, the three sites have continued to change their assumptions about the length of the cleanup. After finalizing their cleanup decisions and selecting on-site disposal, site officials revised their on-site cost estimates to provide justification for their annual budget proposals over the next few years. These revisions often resulted in changed assumptions about the time needed for cleanup operations. The revised on-site disposal estimates reflected project life cycles that accelerated cleanup schedules according to DOE's 1998 plan to complete cleanup at most of its sites by 2006.[6] The abbreviated schedules assumed that facilities would operate for fewer years, tending to reduce the original on-site estimates. For example, since preparing their first cost estimates, Oak Ridge officials have shortened their projected schedule for on-site

[5] Disposal cells are designed to have enough soil around the debris to fill in any voids to reduce the potential for subsidence (sinking) of the cell contents, which can weaken the cell's permanent cap. If enough contaminated soil is not available, the facility will need to obtain fill material to put around it. Oak Ridge is currently projecting a waste volume that may include as much as 35 percent clean fill; however, studies are underway to identify means of reducing or eliminating clean fill requirements. Similarly, waste disposal shipments need to be scheduled so that enough soil is available to fill around shipments of debris. Officials at the Fernald site noted that it has been necessary to coordinate decontamination and demolition projects around the site to have the debris ready for emplacement at the proper time.

[6] *Accelerating Cleanup: Paths to Closure*, DOE/EM-0362; June 1998

disposal from about 30 years to about 10 years and officials at Fernald decreased their operating schedule from about 20 years to 13 years. Officials at these sites did not update comparable estimates for off-site disposal because they no longer considered off-site disposal to be a viable option.

The sites' cleanup schedules remain in flux. The current operating schedules and related disposal cost estimates appear optimistic. Fernald officials, for example, state that funding constraints are already forcing a slowdown. In fiscal year 2001, Fernald plans to dispose of 60,000 cubic yards (after compaction), or 36 percent, of the 168,000 cubic yards called for in the project's baseline. Schedules at Oak Ridge and INEEL could face similar pressures. For example, the INEEL site estimated the operating costs for on-site disposal of site-wide cleanup wastes for approximately 10 years, even though site cleanup could be much longer, because cleanup schedules had not been finalized for all waste areas around the site. If current schedules prove unworkable, then the costs for on-site disposal will change. However, there will be no comparable analysis for off-site disposal.

Facility Designs Are Still Being Developed

As on-site and off-site cost comparisons were originally made, plans for on-site facilities were purely conceptual: design details, engineering drawings, and even the exact locations of the facilities were still being determined. Concurrent with improving information on the projected waste volume and types following their on-site disposal decisions, officials at the three sites also developed and refined engineering designs for their respective planned facilities. These refinements reflected changes in assumptions about such things as geologic features at the proposed facility location and the exact nature and level of contamination the disposal facility could safely accept. For example, additional geological surveys were needed at INEEL to determine how deep the cell could be built without hitting bedrock. Ultimately the cell depth will affect the area of land covered by the facility and thus the amount of material needed for the final cap. Another facility design feature that continues to evolve is the proper soil to debris ratio that was discussed above. DOE officials' opinions on the optimal ratio have varied from 1:1 to 8:1, and the final ratio will depend upon the physical condition of the debris.

As disposal facility plans become better defined, the resulting decisions are likely to have cost implications. For example, when INEEL developed its cost estimate, the tentative plans did not include a facility for sizing, sorting or treating the wastes. INEEL officials have since added plans to construct an on-site treatment facility, which they currently estimate will

cost $15 million. Similarly, since Fernald developed its on-site estimate, the site has added considerable costs to implement waste acceptance oversight activities, in response to stakeholder concerns. These increases in on-site disposal costs cannot be compared to any rigorous analysis of off-site disposal costs, however, because the sites dismissed off-site disposal alternatives several years ago.

Off-Site Disposal Costs Could Decrease

Since the three sites made their cost comparisons, some off-site disposal fees have decreased and volume discounts might be available for the higher waste volumes now projected. The three sites relied upon the best available--though preliminary--information and assumptions in preparing their original off-site cost estimates. For off-site disposal fees, the sites relied on historical rates, such as those in DOE's existing contract with Envirocare. Their estimates for off-site disposal ranged from $242 to $312 per cubic meter of waste disposed.[7] Such fees change over time, and the sites' estimates now appear unrealistically high, when compared with current fees for off-site disposal at Envirocare. That company now prices disposal of bulk rail shipments of soils classified as low-level wastes for as low as $180 per cubic meter. In addition, DOE's year 2000 contract with Envirocare provides for significant discounts—a price drop from $519 to $176 per cubic meter—for disposal of specified shipments of debris. Envirocare officials told us that, because the historical DOE contract rates for disposal of soils and debris had been negotiated for relatively small waste volumes, additional volume discounts might be available for the larger volumes of soil and debris now projected by the sites.

For their off-site cost estimates, site officials also used rail transportation rates that appeared high in some cases, but they have not revisited transportation options. DOE had little historical data on rail costs for low-level radioactive waste shipments, and each site used a different approach to estimate these costs. Because of the preliminary nature of the cost estimates, site officials made simplified assumptions about shipping configurations and rates. However, once they had better information regarding the amounts and timetables for waste disposal, officials did not fully reconsider alternative configurations or schedules to determine whether rail costs could be reduced. For example, they did not attempt to adjust rail costs for possible use of "dedicated" trains. At Fernald, dedicated trains now carry waste that is not qualified for on-site disposal directly to the Envirocare facility. These trains make fewer stops and

[7] For comparison, historical rates were converted to year 2000 dollars.

complete the trip in much less time. If DOE rents rail cars by the day, the overall cost for a train dedicated to low-level cleanup waste could be considerably less. Envirocare officials suggested that further savings were possible if DOE would consider proposals that bundle the rail transportation and disposal services into one package agreement. These officials stated that they have negotiated similar agreements with other customers.

Good Business Practice and Federal Guidance Suggest Reevaluation of Disposal Options

Good business practice suggests that early cost comparisons that are susceptible to uncertainties should be updated before major capital investments are made. This concept is embedded in recent OMB guidance that advocates such revalidation of planning estimates for capital investment decisions. OMB seeks to improve agency planning, budgeting for, and acquiring capital assets through guidance issued in Circular A-11, Part 3. This guidance states that agencies should make effective use of competition and consider alternative solutions. In this instance, the competition is between disposal options as well as potential contractors. For these sites, competition between on-site and off-site disposal options could provide several incentives. First, it provides an incentive to keep on-site disposal costs as low as possible. If off-site disposal is eliminated completely as an option, sites have less incentive to ensure that on-site disposal plans are as economical as possible. Second, it provides incentives for off-site disposal facility contractors to reduce rates and create more competition with on-site disposal.

OMB's 1997 supplement to Part 3 of Circular A-11, the *Capital Programming Guide*, provides even more definitive guidance. It states that once a capital project has been funded, an agency's first action is to validate that the planning phase decision is still appropriate. It further states that, because a year or more can elapse between the planning decision and commitment, agencies should review their needs and the capabilities of the market. DOE's own order implementing this guidance, issued in October 2000, calls for independent review of cost estimates and verification of mission need prior to final approval for construction funding. However, the order does not require the sites to re-validate, using independent reviews, the cost comparisons between on-site and off-site disposal alternatives.

Once site officials have refined their disposal project scope to the point where they can request contract proposals for construction, it appears reasonable for them to consider ways that the off-site disposal services market could compete with the on-site proposals. The CERCLA process allows for selection of acceptable alternatives when the business

environment changes, as long as these alternatives satisfy the regulatory standards for the cleanup. Moreover, the three sites left open the possibility for changes in their selected remedies. For example, the INEEL ROD calls for further evaluation of cost effectiveness of on-site or off-site disposal prior to excavation of contaminated areas, but does not specify that this should occur prior to major construction phases. EPA's CERCLA guidelines specifically address how agencies need to document changes they make from the alternative selected in the ROD. In some of EPA's examples, the guidelines suggest that large increases in the waste volumes, disposal costs, or a change in disposal location from on-site to off-site, should be documented in an Explanation of Significant Difference. EPA's guidelines state that more fundamental changes, such as the discovery that additional costly waste treatment will be needed prior to disposal, may require an amendment to the ROD that must reconsider the nine criteria and invite public comments. Both examples show that the built-in flexibility of the CERCLA process accommodates more cost-effective business decisions as well as improved cleanup technologies.

Changes in Cost Could Greatly Affect Earlier Balance of Costs and Risks

Changes in both on-site and off-site cost assumptions mean that the balance of costs and risks at each site may now be much different than when the comparisons were made. As a result, updated comparisons may show that, on a cost basis alone, off-site disposal is now a much more competitive alternative. However, because cost is only one factor that is considered when making disposal decisions, off-site disposal costs do not necessarily need to drop below on-site disposal costs for off-site disposal to emerge as the better alternative. To determine the relative advantages of the two alternatives, officials must also assess their respective long-term risks, the stewardship activities that will address these risks, and the estimated costs of these activities. These long-term stewardship risks are highly uncertain. As the gap between on-site and off-site disposal costs narrows, this uncertainty becomes relatively more significant to the balancing among CERCLA criteria. The elapsed time from the ROD until bidding and construction of an on-site disposal facility argues for DOE sites to use current information and ensure that the balance of cost and long-term risk remains favorable.

Comparison Updates Substantially Narrow Cost Gap

Changes in cost assumptions for off-site disposal indicate considerable potential for narrowing the cost gap between these disposal alternatives. Of the three sites, only Oak Ridge has updated its off-site cost analysis to reflect more recent circumstances or volume discounts, and even this estimate has been superceded by additional developments. Table 5 shows how much the gap between on-site and off-site disposal closed when off-site estimates were adjusted to reflect changes in commercial prices for

some off-site disposal fees and transportation costs, and in one case, changes in waste-type.

Table 5: The Effect of Current Prices for Low-level Waste Disposal on DOE's Off-site Estimates

	Estimates made by the site			Off-site update made by GAO		
Site	**Estimate for on-site disposal**	**Estimate for off-site disposal**	**Gap between on-site and off-site estimates**	**Amount of estimate[a]**	**Decrease in gap**	**Percentage decrease in gap**
Fernald [b]	$849 million	$1,126 million	$277 million (33% higher)	$1,026 million	$100 million	36 %
Oak Ridge [c]	$294 per cubic yard[e]	$770 per cubic yard	$476 (162 % higher)	$526 per cubic yard	$244 per cubic yard	51 %
INEEL [d]	$236 million	$713 million	$477 million (202% higher)	$610 million	$103 million	22 %

[a] GAO recomputed DOE's off-site estimates using the sites' own cost formulas, and substituting DOE's current contract price for commercial disposal of low-level bulk soil. For INEEL, rail transportation rates were also updated. For Oak Ridge, in addition to updating low-level disposal rates and transportation rates, the proportion of hazardous waste was lowered to reflect the site's current estimate.

[b] Amounts are in constant 1995 dollars.

[c] Amounts are in constant 1999 dollars.

[d] Amounts are in constant 1998 dollars.

[e] Unit prices are from Oak Ridge's high volume estimates, which represent the lowest unit costs.

Long-term Risk and Cost Uncertainties Become More Significant

When on-site and off-site disposal costs become more comparable, other factors begin to assume increased significance. Among these factors is the issue of retaining the waste on site, where it will pose a potential threat to human health and the environment, for all practical purposes, forever. The sites have attempted to incorporate the costs of long-term stewardship into their on-site estimates, but these cost estimates are based on extremely limited information.

Expected long-term stewardship costs are uncertain for several reasons. First, the sites develop these estimates before specific plans are drawn up for protecting the waste. Second, there is little historical information on which to base the preliminary estimates, because DOE has closed very few sites. Finally, the preliminary estimates at the three sites did not appear to provide any contingency amounts for non-routine problems that might arise, and some long-term issues are open-ended. For example, the post-closure plan for the Fernald site, issued in May 1997, states that the post-closure leachate collection and monitoring must continue until leachate is

no longer detected or ceases to pose a threat, with no mention of how long that might be.

These limitations are likely to persist. In its October 2000 report on long-term stewardship, DOE states: "Given the limitations of available data, considerable uncertainty will be associated with any long-term stewardship cost estimates." In another recent study, the National Research Council noted that long-term stewardship cost estimates have significant uncertainties due to controversies over such matters as discount rates and hidden costs. DOE is in the process of developing standardized guidance for estimating long-term stewardship costs, and anticipates that sites will include such estimates in their fiscal year 2003 budget process.

DOE is also examining alternative financing approaches for long-term stewardship. However, these approaches may not adequately cover the potentially high costs associated with any disposal facility failure and the consequent release of contamination into the environment. Furthermore, alternative financing may not be sufficient to cover all of the estimated post-closure costs. For example, according to site officials, the Oak Ridge site and the Tennessee Department of Environment and Conservation entered into an administrative agreement (Consent Order) to establish the Tennessee Perpetual Care Investment Fund. The Consent Order requires DOE to annually deposit $1 million into the fund for 14 years. The state will use fund income to cover costs of annual post-closure surveillance and maintenance of the disposal facility. Site officials had previously estimated these annual costs would range from about $684,000 to about $922,000 in year 2000 dollars. To generate income in this range, the fund principal—which is equivalent to about $11.3 million in year 2000 dollars—will need to earn an average return of roughly 6 to 8 percent annually. Considering that the average real treasury rate over the past decade was about 3.6 percent, the fund may not generate enough income to cover estimated post-closure costs.

Site officials pointed out that uncertainties surrounding long-term stewardship costs also affect the Envirocare facility. Envirocare maintains a trust fund, as required by Utah state rules implementing Nuclear Regulatory Commission requirements, to cover future closure and long-term stewardship costs in case the firm goes out of business. Under CERCLA, according to site officials, the federal government, which disposes of large quantities of waste at the Envirocare facility, would probably be liable in the event that these funds were insufficient. In our view, however, this point does not diminish the importance of evaluating

the risk for on-site disposal. For several reasons, potential increases in stewardship costs to DOE at the Envirocare facility are less likely than at the planned on-site disposal facilities, especially those in wetter climates. First, the Envirocare facility is located in a dry climate, which would restrict movement of contaminants from the facility to the underlying groundwater. Second, the groundwater beneath the site is not suitable for human consumption or even for watering livestock because of its high mineral content. Finally, the facility is in a location that is remote from population centers.

DOE Should Use Current Information to Validate Planning Decisions

The CERCLA decision process, culminating with the ROD, represents planning and agreement for remediation activities at the three sites. After the ROD is signed, project assumptions and timeframes are subject to change for an extended period, allowing DOE sites time to confirm their earlier conclusions that on-site disposal remains advantageous despite long-term cost and risk uncertainties. DOE sites could validate the early cost comparisons by re-estimating the off-site disposal costs using current disposal and transportation prices combined with baseline assumptions (about waste volumes and characteristics, for example) for the proposed on-site disposal facility. Another approach would be to solicit proposals for off-site disposal along with proposals requested for construction of an on-site facility. Generally, DOE sites plan to award several contracts over the life of the disposal project, each covering a specific construction phase. For example, Fernald site officials expect the final disposal facility to consist of 6 to 8 sub-units called cells. As of November 2000, the site has awarded three separate construction contracts covering construction for various phases of three cells. At Oak Ridge, the baseline budget for the on-site facility calls for two construction phases, with the second phase proceeding in six expansion steps. INEEL officials have stated that their planned on-site disposal facility may be expanded in a second phase to accommodate the large quantity of waste generated after its chemical plant—located adjacent to the on-site facility—is dismantled after 2035. Site officials stated that they will re-evaluate cost effectiveness at that time in accordance with ROD requirements. When sufficient time elapses between such contract phases, DOE could benefit from reevaluating the market for off-site disposal at each phase. Such competition could provide incentives for both on-site and off-site proposals to be as economical as possible. Once the DOE sites have these "real world" estimates in hand, they would be in a better position to evaluate the extent to which cost savings for on-site disposal continue to balance the long-term uncertainties.

Conclusion

Unless DOE revisits its disposal needs and its current options for disposing of wastes off-site, it could miss opportunities to reduce cleanup costs at the three sites and at other sites, such as Paducah, that might propose the development of new on-site facilities. Building in a decision checkpoint before major investment decisions are finalized could identify instances when the use of off-site disposal would be less expensive, or when the cost difference no longer outweighs the long-term risks associated with on-site disposal. Such validation of the cost comparison is especially important in instances where DOE is aware that the scope or timeframe of the cleanup effort has changed dramatically. Remaining open to new proposals for off-site disposal would also inject an element of competition into this process. Thus, even if the validation did nothing more than confirm the original decision to dispose of the wastes on-site, it has the potential to ensure that costs are kept to a minimum.

Recommendation

We recommend that, before constructing new or expanding existing facilities for disposal of cleanup waste at the Fernald, INEEL, and Oak Ridge sites, the Secretary of Energy revisit the cost comparisons for on-site and off-site disposal to determine if the cost estimates used to support the ROD remain valid. If cost advantages for on-site disposal have decreased, the Secretary should reassess whether expected cost savings from on-site disposal facilities outweigh the long-term risks associated with these proposed disposal facilities. We also recommend that DOE validate cost comparisons at any other sites that may decide to develop an on-site disposal facility.

Agency Comments

We provided a draft of this report to DOE for review and comment. DOE generally agreed with the report's conclusion and recommendation that assumptions used to select on-site disposal need to be re-validated before constructing or expanding on-site disposal facilities. DOE pointed out that reassessments are already planned for the disposal cell at the INEEL site in Idaho, which is currently in an early design phase. The Department also stated that it will consider whether to revisit plans to proceed with expansion of existing or construction of new disposal facilities as part of a comprehensive assessment of its Environmental Management program.

Appendix III presents DOE's comments on the report. DOE also suggested several technical clarifications which we have incorporated into the report as appropriate. DOE's technical comments included the observation that another factor to be considered when evaluating off-site disposal is the receiving facility's capacity to accommodate incoming waste volumes. GAO agrees that the coordination of multiple waste shipments to an off-

site facility would be a challenge that would need to be addressed during any contract negotiations.

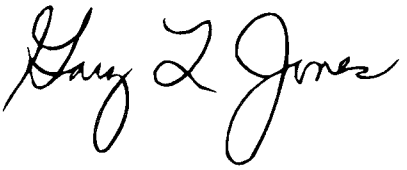
Scope and Methodology

We performed our review at DOE's Fernald, INEEL, and Oak Ridge sites. We interviewed DOE and contractor officials at each site who are familiar with the sites' decisions to develop on-site disposal facilities. To understand how site officials evaluated disposal alternatives, we reviewed each site's Record of Decision, Feasibility Study and other supporting documentation. To determine the extent of EPA and state participation in the decision process, we interviewed officials from regional EPA offices and state environmental agencies that reviewed and concurred with DOE's decision at each site. We also reviewed pertinent legislation and implementing regulations and guidance on disposal of radioactive and hazardous wastes, including planning for capital investments in new disposal facilities, and discussed waste disposal issues with officials at DOE headquarters and at the Defense Nuclear Facility Safety Board. To evaluate off-site disposal alternatives used for comparison at each site, we obtained and reviewed information on DOE's use of the Envirocare commercial disposal facility, and interviewed officials of that company to assess the availability of commercial facilities that dispose of low-level radioactive wastes. We also determined the extent to which DOE's cost comparisons depended upon the rates assumed for off-site transportation and commercial disposal fees. (See app. II for a further discussion of our scope and methodology.) We conducted our review from May 2000 through May 2001 in accordance with generally accepted government auditing standards.

This report contains a recommendation to you. As you know, 31 U.S.C. 720 requires the head of a federal agency to submit a written statement of the actions taken on our recommendations to the Senate Committee on Governmental Affairs and to the House Committee on Government Reform not later than 60 days from the date of this letter, and to the House and Senate Committees on Appropriations with the Agency's first request for appropriations made more than 60 days after the date of this letter.

Copies of this report are available on request. If you or your staff have any questions on this report, please call me at (202) 512-3841. Key contributors to this report are listed in appendix IV.

Sincerely yours,



(Ms.) Gary L. Jones
Director, Natural Resources
and Environment

Appendix I: DOE Sites' Analyses of the Primary Tradeoffs Between On-Site and Off-Site Disposal Alternatives

To select a cleanup alternative, officials at the Fernald, Oak Ridge and INEEL sites weighed the various cleanup approaches and made tradeoffs according to the site's unique conditions and priorities. Using CERCLA's five balancing criteria (see Table 6), site officials compared the advantages and disadvantages of their on-site and off-site disposal alternatives. Their analyses relied on site-specific information developed in their feasibility studies, and varied in depth according to the availability of data and the importance of each criterion at the site. Each site issued a Proposed Plan that summarized the comparative analysis and designated on-site disposal as the preferred alternative for the cleanup approach. After considering public comments on the Proposed Plan, each of the three sites issued a Record of Decision selecting an on-site disposal approach. The following brief summaries describe each site's analysis of the primary tradeoffs that were considered between its on-site and off-site alternatives of similar cleanup scope.

Table 6: CERCLA Balancing Criteria

CERCLA Balancing Criteria	Description
Long-term effectiveness and permanence	Risk to human health and the environment from exposure to contaminants remaining after site closure
Reduction of toxicity, mobility or volume through treatment	Extent to which the alternative uses treatment technologies or processes where possible
Short-term effectiveness	Duration of site cleanup and risks to human health and the environment from exposure to contaminants or from cleanup activities
Ease of Implementation	Technical, logistical and administrative ease or difficulty of construction and operations
Cost	Cost effectiveness with life cycle costs estimated at –30 to +50 percent

Fernald

According to the Fernald site's 1995 Proposed Plan, officials preferred the on-site disposal alternative after determining that this approach: 1) was reliable over the long term, 2) offered the lowest overall short-term risks, 3) was less costly in comparison to other alternatives, and 4) employed technologies that could be implemented. Although officials concluded that on-site disposal was reliable over the long term, their comparative analysis showed that the off-site alternative held an advantage for long-term effectiveness. This analysis pointed out that off-site disposal left the least amount of contamination at the site and did not require engineering and institutional controls to be reliable over the long term. In contrast, any on-site disposal facility at Fernald would need a design that ensured protection of the Great Miami Aquifer for thousands of years. Furthermore, Ohio's solid waste disposal restrictions prohibit building such a landfill over the aquifer, which was designated as a sole source

aquifer under the Safe Drinking Water Act. EPA and the Ohio EPA agreed to waive this restriction if the proposed on-site facility could be designed to meet equivalent safety standards.

To apply CERCLA criteria to the Fernald site, officials weighed the long-term advantage of disposing of all waste off-site against disadvantages of this approach, some of which were of significant concern to various stakeholders. These disadvantages appeared under three CERCLA criteria:

- Site officials judged short-term risks for the off-site disposal option to be higher overall based on increased risks associated with shipping large quantities of waste by rail across country. Officials quantified the increased transportation risks for the comparable off-site alternative in their site's feasibility study as approximately 10 injuries and 3 fatalities (for approximately 20,000 rail cars travelling to Utah and back).
- The site's comparison of life cycle costs showed that cleanup approaches depending mainly on off-site disposal were more expensive than approaches with an on-site disposal facility. Its detailed comparison of alternatives showed that, for disposal of similar waste volumes, the estimated cost for off-site disposal was 34 percent more than the on-site estimate. In their proposed plan, site officials noted that the accuracy of the cost estimates typically varied between –30 to +50 percent because of underlying uncertainties in the available information used to develop them. Site officials stated that other criteria, particularly the plan's implementability and community concerns about off-site rail transportation, played a more significant role in the site's final decision.
- Site officials questioned whether the off-site alternative could be successfully implemented if off-site disposal facilities became unavailable over the projected 22-year duration of the cleanup. Furthermore, they feared that opposition to shipping large volumes of radioactive waste to western states could hinder Fernald's access to off-site disposal for its more concentrated wastes, which cannot safely remain at the Fernald location.

Oak Ridge

The Oak Ridge site's proposed plan (January 1999) stated a preference for the on-site disposal alternative after showing that on-site disposal offered comparable protection at lower cost and less transportation risk than its off-site alternative. The plan noted that the cost advantage was only significant for estimates that used the high end of the projected range of the anticipated waste volumes requiring disposal. Similar to the Fernald plan, the Oak Ridge plan also notes that concerns by states receiving the

wastes for off-site disposal could hinder access to off-site disposal for large volumes of waste from the Oak Ridge Reservation.

Site officials concluded that an on-site disposal facility would provide adequate long-term protection if engineering barriers were designed to contain waste indefinitely. To ensure the long-term integrity of the facility, they adopted the following three strategies to: 1) design the disposal facility to meet or exceed long term safety requirements, 2) limit the level of contamination allowed in the facility so that any leaks would pose no unacceptable risks, and 3) provide for long-term monitoring and facility maintenance. The facility's design also addresses the need to provide groundwater protection equivalent to that required for landfills under the Toxic Substances Control Act of 1976. That act, as implemented by federal regulations, requires the bottom of a landfill liner to be 50 feet above the historical high groundwater table. Based on the protection afforded by the facility's location and design (predominantly aboveground), EPA agreed to waive this technical requirement.

Unlike the Fernald site, where the cleanup is expected to render most of the site accessible to the public, the Oak Ridge Reservation expects to restrict public access to many areas indefinitely and leave significant contamination on the site, including areas near the proposed on-site facility location. For various technical and safety reasons, DOE does not plan to excavate these areas. As a result, some contaminated areas around the Oak Ridge site will pose long-term risks regardless of whether an on-site disposal facility is constructed. Site officials performed a site-wide (composite) analysis of health risks, and estimated that the radiation from the proposed on-site facility would amount to approximately 1.1 millirem per year (after 1000 years). This amount represents roughly one-quarter of the estimated radiation dose from all sources within Bear Creek Valley after remediation, and according to site officials, is well within the established values for protection of human health and the environment.

Along with their conclusion that on-site disposal provided comparable protection to the off-site alternative, site officials found that two other CERCLA criteria gave the advantage to the on-site alternative:

- The comparison of estimated costs for on-site and off-site disposal showed that on-site disposal cost significantly less only under the high volume scenario. This high volume scenario envisioned more extensive site-wide cleanup at the Oak Ridge Reservation than DOE's baseline assumptions. By the time the ROD was issued in November 1999, site officials considered the high volume scenario to be the most realistic and selected

the on-site disposal alternative based, in part, on cost comparisons estimated for the higher waste volumes.

- Based on calculations in their feasibility study, site officials concluded that the on-site disposal alternative had significantly less transportation risk than the off-site disposal alternative. The feasibility study reported that the risk of transportation accident-related injuries or fatalities was highest for off-site scenarios that used trucks (111 injuries and 10 fatalities). For rail transport of the high-end waste volume to the off-site facility in Utah, the risks were 8.2 injuries and .07 fatalities, compared to 0.41 injuries and 0.003 fatalities for the small number of rail shipments required for the on-site alternative. According to the study, the risks from radiological exposure during transportation were very small for either alternative.

INEEL

The INEEL proposed plan (October 1998) proposed on-site disposal as the preferred alternative, stating that the on-site approach ensures long-term protection of human health and the environment, complies with applicable legal requirements, and is a permanent and cost-effective solution. According to the summary comparative analysis, three criteria differentiated between on-site and off-site disposal alternatives: short term effectiveness, implementability, and cost. The proposed plan does not differentiate between the long-term effectiveness for on-site and off-site disposal. It concludes that, when compared to alternatives that capped waste in place, the two cleanup approaches provided equivalent long-term protection because each excavated contaminated soils and disposed of them in an engineered disposal facility—regardless of the facility's location. The plan, and the subsequent ROD issued one year later, further noted that the on-site disposal facility would be designed to protect groundwater quality in the subterranean Snake River Plain Aquifer, as well as to prevent external exposure to radiation. Similar to the analysis by Oak Ridge officials, INEEL officials relied upon the adequacy of the facility's design, as well as other strategies intended to maintain protectiveness over the long-term, to reach its conclusion that on-site disposal is as protective as off-site disposal in the long-term.

When site officials evaluated three other CERCLA criteria, they found that the off-site disposal alternative had the following disadvantages when compared with the on-site alternative:

- In the short term, officials found that both on-site and off-site disposal alternatives posed minor risks to workers or the environment, and that the off-site alternative posed an additional minor risk to communities. The site's feasibility study stated more specifically that the off-site alternative would pose some increased risk to communities from transport and

potential railroad accidents. However, the study further noted that the rail lines passed through very rural communities, and stated that potential risk should be minimal.

- In the proposed plan, site officials concluded that the off-site disposal alternative would be the most difficult to implement because it would require the transport of "large volumes of contaminated soils great distances and depends upon the availability of off-site disposal capability." The feasibility study did not provide support for this concern, and stated that "off-site disposal...has been previously performed; therefore this alternative should be administratively feasible."
- In their proposed plan INEEL officials concluded that the off-site disposal alternative was the most expensive. They compared the estimated costs for excavation and disposal of 63,000 cubic meters of waste projected for the cleanup area under the Record of Decision. The off-site estimate was $221 million, 160 percent more costly than on-site estimate of $85 million. In the proposed plan, officials also noted that the on-site disposal facility would be constructed to accept contaminated cleanup materials from sites located throughout the INEEL site. They estimated that off-site disposal for the projected 356,000 cubic meters of site-wide waste would cost 224 percent more than an on-site alternative ($605 million versus $187 million). Site officials stated that they developed their site-wide cost estimates by modifying the original estimates for 63,000 cubic meters.

Appendix II: Scope and Methodology

In February 2000, DOE adopted a new policy allowing all DOE sites to dispose of low-level and mixed radioactive wastes at its facilities located at the Nevada Test Site and the Hanford Reservation. Sites can also use commercial off-site disposal facilities under certain circumstances. DOE's policy was aimed at containing low-level and mixed wastes generated from its past or ongoing operations. However, the Department expects to generate significantly larger quantities of low-level and mixed wastes from its cleanup operations. In 1996, the Hanford site opened a facility for disposal of its on-site cleanup wastes under the CERLA program. Since 1996, three other DOE sites have made decisions to develop new, on-site disposal facilities for their low-level cleanup wastes governed by CERCLA, and are in various stages of planning, constructing, and filling these facilities. These sites are: the Fernald Environmental Management Project (Ohio); the Oak Ridge Reservation (Tennessee); and the Idaho National Engineering and Environmental Laboratory (INEEL) (Idaho). Plans for the new facilities at these sites entail permanent on-site disposal of significant quantities of wastes that would otherwise qualify for disposal off-site under DOE's policies.[1] We reviewed the sites' decisions to determine (1) the extent that site officials considered the comparative costs and risks of off-site disposal options and (2) the extent that site officials revisited these cost and risk assessments as circumstances warranted. In addition, at least one other site, the Paducah Gaseous Diffusion Plant (Kentucky), is currently considering proposals to develop a new on-site facility. Our review covered the decisions already made at Fernald, Oak Ridge, and INEEL. We did not review the decision at Hanford because DOE's recent policy designates Hanford as one of two preferred sites for acceptance of DOE-wide low-level wastes.

We visited the three sites to observe the locations of the new disposal facilities and to determine what alternatives, if any, each site considered for disposal of their cleanup wastes. We interviewed site officials and reviewed decision documents to determine the factors that each site considered, including risks and costs of various disposal alternatives. We also interviewed officials from the state and Environmental Protection Agency offices that reviewed and concurred with DOE's decision at each site.

[1] DOE's recent policy allows the Oak Ridge and INEEL sites to continue disposal of their low-level wastes on-site to the extent practical. However, existing facilities at the two sites have no capacity for the projected quantities of cleanup wastes.

To understand Departmental and legal influences for the sites' waste disposal decisions, we consulted legislative and executive guidance on radioactive waste disposal and capital investment planning. We also interviewed federal officials at DOE headquarters as well as the Defense Nuclear Facility Safety Board.

In order to determine current off-site disposal prices for low-level radioactive wastes, we reviewed information on recent uses of commercial disposal by various DOE sites. We also reviewed DOE's disposal contracts with Envirocare and interviewed company officials.

We conducted a limited analysis to determine the extent that each site's cost comparison depended upon the rates used for off-site transportation and commercial disposal fees. To illustrate how much the gap between on-site and off-site disposal estimates can close when off-site rates are adjusted to reflect changes in commercial prices (and in one case, changes in projected waste-type), we adjusted off-site costs as follows:

- For Fernald and INEEL, we substituted the latest contract prices for disposing of low-level bulk soil waste off-site in place of the rates used by the sites' for low-level waste in their original estimates for cost comparison. (Neither Fernald nor INEEL had an updated version of the off-site estimate that we could have used to compare to current on-site estimates.) For INEEL, we also substituted transportation rates that were more in line with current prices. This exercise decreased the difference between on-site and off-site disposal costs by 36 percent at Fernald and 22 percent at INEEL.
- For Oak Ridge, we used the site's most recent cost comparison analysis, and substituted updated estimates of the type of wastes, as well as current prices for low-level waste disposal and commercial estimates of transportation rates. When Oak Ridge officials prepared their most recent off-site estimate in 1999, they assumed that 44 percent of the waste would be classified as hazardous for off-site disposal. They have since revised the figure to less than 1 percent. The combined effect of reducing the proportion of hazardous waste and applying the lower contract and transportation prices decreased the gap between on-site and off-site disposal cost estimates by 51 percent.

We conducted our review from May 2000 through May 2001 in accordance with generally accepted government auditing standards.

Appendix III: Comments From the Department of Energy

Department of Energy
Washington, DC 20585

May 9, 2001

Ms. Gary L. Jones, Director
Natural Resources and Environment Team
Resources, Community, and Economic Development
Division
U.S. General Accounting Office
Washington, DC 20548

Dear Ms. Jones:

The Department of Energy (DOE) appreciates the opportunity to review and comment on the General Accounting Office (GAO) draft report (GAO-01-1441) entitled *Nuclear Cleanup: DOE Should Reevaluate Waste Disposal Options Before Building New Facilities.*

The DOE supports the report's contention that the assumptions relied on in making the decision to build an on-site disposal cell need to be periodically revisited to ensure these decisions remain the most appropriate and cost-effective options. Such a reassessment already is planned for the disposal cell at Idaho; a reevaluation will be required at 90 percent design prior to construction, and again before a second cell is considered.

In recognition of the report's findings, this area will be addressed as part of the comprehensive top to bottom assessment of the Environmental Management program. Based on the results of the assessment, DOE will decide whether to revisit plans to proceed with expansion of existing cells or construction of new cells.

Enclosed for your information are copies of minor editorial changes to enhance the report's clarity and address factual inaccuracies. These attachments are also being provided electronically to Mr. Dwayne Weigel. The DOE hopes that our comments will be helpful in the preparation of the final report. If you have any questions, please contact me or have your staff contact Mr. Steve Lerner, Office of Congressional and Intergovernmental Affairs, at (202) 586-5470.

Sincerely,

Carolyn L. Huntoon

Carolyn L. Huntoon
Acting Assistant Secretary for
Environmental Management

Enclosure

Printed with soy ink on recycled paper

Appendix IV: GAO Contacts and Staff Acknowledgements

GAO Contacts

Dwayne Weigel, (202) 512-6876

Patricia Rennie, (206) 287-4843

Acknowledgements

In addition to those named above, John Cass, Linda Chu, Christine Colburn, Daniel Feehan, Hova Risen-Robertson and Stan Stenerson made key contributions to this report.

Related GAO Products

Low-Level Radioactive Wastes: Department of Energy Has Opportunities to Reduce Disposal Costs (GAO/RCED-00-64, *Apr. 12, 2000).*

Low-Level Radioactive Wastes: States Are Not Developing Disposal Facilities (GAO/RCED-99-238, Sept. 17, 1999).

Nuclear Waste: DOE's Accelerated Cleanup Strategy Has Benefits but Faces Uncertainties (GAO/RCED-99-129, Apr. 30, 1999).

Nuclear Waste: Corps of Engineers' Progress in Cleaning Up 22 Nuclear Sites (GAO/RCED-99-48, Feb. 26, 1999).

Department of Energy: Alternative Financing and Contracting Strategies for Cleanup Projects (GAO/RCED-98-169, May 29, 1998).

Radioactive Waste: Interior's Continuing Review of the Proposed Transfer of the Ward Valley Waste Site (GAO/RCED-97-184, July 15, 1997).

Department of Energy: Management and Oversight of Cleanup Activities at Fernald (GAO/RCED-97-63, Mar. 14, 1997).

Radioactive Waste: Status of Commercial Low-Level Waste Facilities (GAO/RCED-95-67, May 5, 1995).

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United States General Accounting Office

GAO

Fact Sheet for the Chairman, Committee on Governmental Affairs, U.S. Senate

September 1988

NUCLEAR WASTE

Supplementary Information on Problems at DOE's Inactive Waste Sites

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Resources, Community, and
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September 12, 1988

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

Dear Mr. Chairman:

On August 4, 1988, you requested information on the number of inactive waste sites and the extent of environmental contamination at three Department of Energy (DOE) installations--Feed Materials Production Center (FMPC), Ohio; Los Alamos National Laboratory (LANL), New Mexico; and Pantex Plant, Texas. This fact sheet responds to your request and supplements the information we provided to you in our August 3, 1988, report on DOE's inactive waste sites at six other major installations.[1]

The information we compiled on the three additional installations confirms the findings we reported to you in our earlier report, namely, that the waste disposal practices used by DOE and its predecessor agencies over the past 40 years have released hazardous radioactive and chemical substances into the environment. For example, each of the three installations have reported soil contamination resulting from their inactive waste sites--sometimes at levels hundreds to thousands of times those of background levels. Further, inactive waste sites at FMPC and the Pantex Plant are suspected sources of some of the groundwater contamination detected at these installations, and are under investigation by DOE.

Our followup work also showed that DOE's nationwide inventory of inactive waste sites now contains 3,276 sites at all DOE installations, as of August 17, 1988. This represents an increase of over 2,000 sites from the number we reported to you on August 3, 1988. This increase is due to a recent update by DOE headquarters of its site inventory at 15 of its installations, conducted in response to a congressional request. We previously recommended, in our August 3 report, that the Secretary of Energy update

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

the DOE headquarters' inventory to account for all inactive waste sites. In our opinion, DOE's inactive waste site total reported here could increase even further if DOE headquarters continually updated its inventory of sites at all DOE installations nationwide.

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In preparing this fact sheet, we relied upon DOE-generated assessments and other documents on DOE's inactive waste sites. We also interviewed officials in DOE headquarters and the three DOE field offices responsible for overseeing FMPC, LANL, and Pantex Plant operations.

We discussed the material presented in this fact sheet with DOE officials and incorporated their clarifications where appropriate. As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this fact sheet until 30 days from the date of this letter. At that time, we will send copies to appropriate Congressional committees; the Secretary of Energy; and the Director, Office of Management and Budget.

Sections I through III contain summaries of the results of our work on FMPC, LANL, and the Pantex Plant. Appendix I lists the major contributors to this fact sheet. If you have any questions or need additional information, please contact me on (202) 275-1441.

Sincerely yours,

Keith O. Fultz

Keith O. Fultz
Senior Associate Director

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ABBREVIATIONS

DOE	Department of Energy
FMPC	Feed Materials Production Center
GAO	General Accounting Office
LANL	Los Alamos National Laboratory

SECTION 1

FEED MATERIALS PRODUCTION CENTER, OHIO

FMPC, established in 1954, is a foundry-type facility that processes uranium into various metal forms for nuclear fuel. FMPC's operations have generated a variety of radioactive, hazardous, and mixed wastes including materials such as uranium, radium, solvents, magnesium fluoride, and nitrates. Over the years, these operations have caused environmental contamination at FMPC, including groundwater contamination with nitrates and chloride above federal drinking water standards and soil contamination with elevated levels of uranium, both on- and off-site.

FMPC's past disposal practices have resulted in 10 inactive waste sites, according to DOE headquarters records. These sites include waste disposal pits, burial grounds, underground storage tanks, and a sanitary landfill. Based on assessments performed to date, one of FMPC's inactive waste sites has contaminated the soil, and other inactive sites are suspected sources of groundwater, surface water, and soil contamination.

One of the more significant examples of FMPC's inactive sites is the waste pit storage area, which has contaminated the surrounding soil with uranium in concentrations as high as 80 times background levels. This inactive site--consisting of several solid and liquid waste pits located in the western section of the installation--received low-level radioactive waste solids such as uranium, thorium, and radium-226, and hazardous materials such as chromium, sulfates, and waste oils. DOE officials suspect that the waste pits are also a potential source of groundwater contamination in the western and southern areas of the installation, both on- and off-site. FMPC officials are conducting a Remedial Investigation/Feasibility Study of the entire FMPC installation, including this site, to characterize environmental impacts and risks and to develop remedial action alternatives.

SECTION 2

LOS ALAMOS NATIONAL LABORATORY, NEW MEXICO

LANL, established in 1943, is primarily devoted to nuclear weapons research and development. The laboratory also conducts basic and applied research in physics, chemistry, engineering, health and environmental sciences, and other areas. In over 40 years of operations, LANL activities have generated large amounts of wastes including hazardous materials such as acids, solvents, chemicals and high explosives; radioactive materials including low-level liquid and transuranic solid wastes; and mixed wastes such as lithium hydride contaminated with uranium. LANL's operations have resulted in soil contamination with radioactive materials. In some cases, the contamination was detected at levels hundreds to thousands of times background levels. LANL activities have also caused groundwater contamination with radioactive and hazardous materials at levels greater than drinking water standards.

LANL's past waste disposal practices have resulted in approximately 300 inactive waste sites, according to DOE headquarters records. These sites include unlined pits and ponds, lagoons, french drains, landfills, open dumps, abandoned underground storage tanks, contaminated buildings, spills, and unplanned releases. Many of these sites have contaminated the surrounding soil, in some instances at levels thousands of times background amounts.

For example, one liquid waste disposal site (Material Disposal Area T, TA-21), which received radioactive waste waters primarily during the 1945 to 1952 period, has contaminated the surrounding soil including an area potentially accessible to the public. According to DOE's Environmental Survey Preliminary Report, soil samples in this area have detected contamination with cesium-137 and strontium-90 at levels in excess of 7,000 times background levels and plutonium-239 at levels 100 times the background level, along with high levels of tritium. LANL officials plan to further investigate the full extent of contamination in this area.

SECTION 3

PANTEX PLANT, TEXAS

The Pantex Plant, established in 1951, fabricates high explosive devices and other nuclear weapons components; assembles new nuclear weapons; maintains, modifies, and tests existing weapons in the military stockpile; and retires or disassembles existing weapons from the stockpile. Over the years, Pantex Plant activities have generated hazardous, radioactive, and mixed wastes including such substances as high explosives, mercury, beryllium, and low-level radioactive materials. Pantex Plant operations have led to soil contamination with uranium at levels as high as 100 times background levels.

Past waste disposal practices at the Pantex Plant have resulted in 48 inactive waste sites, according to DOE headquarters records, including landfills, pits, ponds, leaching beds, spills, and tank leaks. Based on assessments performed to date, Pantex Plant officials have detected several instances of actual soil contamination, along with numerous areas of potential soil and/or groundwater contamination, from the plant's inactive waste sites.

An example of one of the more serious inactive waste problems at the plant is Landfill 1 which received contaminated ash from the burning of high explosives, waste chemicals, sanitary waste, and construction debris during the 1954 to 1967 period. The cover placed on this landfill is inadequate, thereby exposing debris on the surface. While soil analyses have not been completed, DOE's Environmental Survey Preliminary Report recognizes that surface soils in this area are potentially contaminated, causing concern because of the site's accessibility to local farmers who cultivate the land immediately surrounding the landfill. Pantex Plant officials are developing a corrective action plan which calls for removal of some of the waste and placement of an earthen cover over the landfill surface. This area is under investigation to assess the presence and extent of any potential environmental contamination.

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