DOE/EIS-0228

Dual Axis Radiographic Hydrodynamic Test Facility

Final Environmental Impact Statement

Volume 1: Chapters 1–6 & Appendixes A–K

Department of Energy
Albuquerque Operations Office
Los Alamos Area Office
Albuquerque, New Mexico

August 1995

Los Alamos National Laboratory

Los Alamos National Laboratory (LANL) is a research and technology development facility of the Department of Energy (DOE), operated under contract by the University of California.

DOE coordinates and administers the energy functions of the Federal government. Among other things, DOE is responsible for the nuclear weapons program, research and development of energy technologies, and basic science research.

The origin of DOE and LANL was the Army's Manhattan Engineer District formed in August 1942. Known as the Manhattan Project, this organization developed the original laboratory and production facilities, including LANL, that created the nuclear weapons used in World War II. In 1946 the Atomic Energy Commission (AEC) assumed these responsibilities. In 1974 part of the AEC functions were transferred to the Energy Research and Development Administration (ERDA); in 1977 the DOE was formed from ERDA and other organizations.

LANL was established in 1943 to provide research, design, and testing of nuclear weapons and nuclear materials. Along with Lawrence Livermore National Laboratory in Livermore, California, and Sandia National Laboratories headquartered in Albuquerque, New Mexico, LANL remains one of the three research laboratories in the DOE nuclear weapons complex.

Over the past 50 years, LANL's mission has expanded to include research in energy, materials science, nuclear safeguards and security, biomedical science, computational science, environmental protection and cleanup, and other basic science research. In addition to work done in support of DOE programs, LANL provides research and science services for other Federal agencies, universities, foreign countries, and private industry.

LANL is one of the largest multiprogram research laboratories in the world with an annual budget of about $1 billion and employs about 10,000 contractor and subcontractor personnel. LANL is located in north-central New Mexico and covers about 43 square miles of Federal land in Los Alamos and Santa Fe counties.

The DOE Assistant Secretary for Defense Programs is responsible for policy, planning, and managing the DOE nuclear weapons complex, including research, experiments, and technology development work for nuclear weapons. The DOE Los Alamos Area Office and its parent Albuquerque Operations Office provide oversight of LANL operations.

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COVER SHEET

RESPONSIBLE AGENCY:
U.S. Department of Energy (DOE)

TITLE:
Final Environmental Impact Statement (EIS), Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility (DOE/EIS-0228)

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ABSTRACT:
DOE proposes to provide enhanced high-resolution radiographic capability for hydrodynamic tests and dynamic experiments to help meet its mission to ensure the safety and reliability of the Nation's nuclear weapons. The DARHT Facility would include two electron accelerators to produce x-ray beams that intersect at a firing point to produce radiographs of exploding or imploding material. This EIS evaluates the potential environmental impacts of six alternatives: **No Action** (continue to operate the 30-year old Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility at the Los Alamos National Laboratory (LANL) and the Flash X-Ray (FXR) Facility at the Lawrence Livermore National Laboratory; **DARHT Baseline** (complete and operate the DARHT Facility at LANL); **Upgrade PHERMEX** (upgrade PHERMEX with enhanced radiography technology instead of completing the DARHT Facility); **Enhanced Containment** (in addition to containing all experiments involving plutonium, enclose most or all experiments under one of three options: **vessel containment, building containment**, or **phased containment**, which is the preferred alternative); **Plutonium Exclusion** (exclude any applications involving experiments with plutonium at the DARHT Facility); and **Single Axis** (complete and operate only a single axis of the DARHT Facility). The affected environment is primarily within LANL. Analyses indicate very little difference in the environmental impacts among the alternatives. The major discriminator would be contamination of soils near the firing points, health effects to workers, and amount of construction materials.

DOE issued a draft EIS on May 12, 1995, and held a formal public comment period on the draft through June 26, 1995. Two public meetings were held during the comment period. Comments received and DOE's response to those comments, are found in the second volume of this EIS. The final EIS reflects DOE's consideration of public comments.

This EIS includes a classified supplement. The draft classified supplement was made available for review by appropriately cleared parties with a need to know the classified information.

Department of Energy
Washington, DC 20585

AUG 25 1995

Dear Reader:

This is your copy of the final Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility Environmental Impact Statement (EIS). The EIS analyzes the environmental impacts that might occur if the Department of Energy (DOE) were to complete and operate the proposed DARHT facility at the Department's Los Alamos National Laboratory (LANL) in northern New Mexico. The DOE has identified as its preferred approach for this project two concurrent courses of action: (1) completing and operating the proposed DARHT facility; and (2) implementing an enhanced containment strategy for testing at the DARHT facility so that most tests would be conducted inside of steel vessels, to be phased in over five years. This would involve constructing and operating a vessel cleanout facility in addition to the DARHT facility.

The impacts that might occur from this proposal are weighed against the impacts of continuing to operate the Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) hydrodynamic testing facility at LANL. The hydrodynamic testing facility at the Lawrence Livermore National Laboratory in California is also discussed. The EIS analyzes four other alternative means to operate the DARHT or PHERMEX facilities.

This EIS takes into account the Department's consideration of comments on the May 1995 draft EIS received from the State of New Mexico, American Indian Tribal governments, local governments, other Federal agencies, and the general public. Additional mitigation measures have been developed to protect cultural resources of importance to local tribes and Federally-listed threatened species habitat. A complete set of the comments received and our responses to them are included in Volume II of the EIS.

We appreciate the time and assistance of everyone who reviewed the draft EIS and look forward to your continued interest as we reach our final decision on this proposal. For additional copies of this document or for more information on this environmental review, please contact Diana Webb, DARHT EIS Project Manager, DOE, Los Alamos Area Office, 528 35th Street, Los Alamos, New Mexico 87544, telephone (505) 665-6353, facsimile (505) 665-4872.

Sincerely,

[signature], for

Victor H. Reis
Assistant Secretary
for Defense Programs

Enclosures

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Executive Summary

EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE) proposes to provide enhanced high-resolution radiography capability for the purpose of performing hydrodynamic tests and dynamic experiments in support of the Department's historical mission and near-term stewardship of the nuclear weapons stockpile. This environmental impact statement (EIS) analyzes the environmental consequences of alternative ways to accomplish the proposed action. The DOE's preferred alternative for accomplishing the proposed action would be to complete and operate the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility at Los Alamos National Laboratory (LANL) in New Mexico and implement an enhanced approach to containing test materials in steel vessels, phased in over 10 years. In May 1995, DOE issued the draft EIS for review and invited comments from the State of New Mexico, affected American Indian tribes, county governments, other Federal agencies, and the general public. DOE has issued this final EIS to document the environmental consequences associated with the proposed action and alternatives and to respond to comments received on the draft EIS.

On August 11, 1995, announcing his decision to seek a zero-yield Comprehensive Test Ban Treaty (CTBT), President Clinton stated:

- "I consider the maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States."
- "I am assured by the Secretary of Energy and the Directors of our nuclear weapons laboratories that we can meet the challenge of maintaining our nuclear deterrent through a science-based stockpile stewardship program without nuclear testing. I directed the implementation of such a program almost two years ago."
- "The nuclear weapons in the United States arsenal are safe and reliable, and I am determined that our stockpile stewardship program will ensure they remain so in the absence of nuclear testing."
- "While I am optimistic that the stockpile stewardship program will be successful, as President I cannot dismiss the possibility, however unlikely, that the program will fall short of its objectives. Therefore, in addition to the new annual certification procedure for the nuclear weapons stockpile, I am also establishing concrete, specific safeguards that define the conditions under which the United States can enter into a CTBT."

One of the safeguards which condition U.S. entry into a CTBT is:

- "The conduct of a science-based stockpile stewardship program to ensure a high level of confidence in the safety and reliability of nuclear weapons in the active stockpile, including the conduct of a broad range of effective and continuing experimental programs."

(From Fact Sheet released by Office of the Press Secretary along with text of President Clinton's announcement)

PURPOSE AND NEED

DOE is responsible for ensuring that U.S. nuclear weapons remain safe, secure, and reliable. The DOE program that responds to Presidential and Congressional direction to ensure confidence in the nuclear weapons stockpile is called the Stockpile Stewardship and Management (SS&M) Program (DOE 1995). This is an ongoing program that has evolved over time and whose goals are redirected from two former DOE programs: weapons research, development, and testing and stockpile support. Today's SS&M Program has moved away from DOE's past reliance on direct observations of nuclear tests toward ensuring weapons safety and reliability through a more challenging "science-based" approach to develop a greater scientific understanding of nuclear weapons phenomena and better predictive models of performance.

Historically, hydrodynamic tests and dynamic experiments have been a requirement to support the DOE's (and its predecessor agencies') mission; they remain essential elements of the SS&M Program and assist in the understanding and evaluation of nuclear weapons performance. Dynamic experiments are used to gain information on the physical properties and dynamic behavior of materials used in nuclear weapons, including changes due to aging. Hydrodynamic tests are used to obtain diagnostic information on the behavior of a nuclear weapons primary (using simulant materials for the fissile materials in an actual weapon) and to evaluate the effects of aging on the nuclear weapons remaining in the greatly reduced stockpile. The information that comes from these types of tests and experiments cannot be obtained in any other way.

DOE's existing capability to obtain diagnostic information was designed and implemented at a time when the Agency could rely on direct observations of the results of underground nuclear tests to provide definitive answers to questions regarding nuclear weapons performance. Without the ability to verify weapons performance through nuclear tests, some remaining diagnostic tools are inadequate by themselves to provide sufficient information. Accordingly, as the Nation moves away from nuclear testing DOE must enhance its capability to use other tools to predict weapons safety, performance, and reliability. In particular, DOE must enhance its capability to perform hydrodynamic tests and dynamic experiments to assess the condition and behavior of nuclear weapons primaries.

Although the current U.S. stockpile is considered to be safe and reliable, the existing weapons are aging beyond their initial design lifetimes and, by the turn of the century, the average age of the stockpile will be older than at any time in the past. To ensure continued confidence in the safety and reliability of the U.S. nuclear weapons stockpile, DOE needs to improve its radiographic hydrodynamic testing capability as soon as possible. Uncertainty in the behavior of the aging weapons in the enduring stockpile will continue to increase with the passage of time because existing testing techniques, by themselves, are not adequate to assess the safety, performance, and reliability of the weapons primaries. Should DOE need to repair or replace any age-affected components, retrofit existing weapons, or apply new technologies to existing weapons, existing techniques are not adequate to assure weapons safety and reliability. In an era without nuclear testing DOE believes that it is probable that the existing weapons will require these types of repairs or retrofits in the foreseeable future. DOE has determined that no other currently available advanced techniques exist that could provide a level of information regarding nuclear weapons primaries comparable to that which could be obtained from enhanced radiographic hydrodynamic testing.

In addition to weapons work, DOE uses its radiographic testing facilities to support many other science missions and needs to maintain or improve its radiographic testing capability for this purpose. Hydrodynamic tests and dynamic experiments are important tools for evaluating conventional munitions; for studying hydrodynamics, materials physics, and high-speed impact phenomena; and for assessing and developing techniques for disabling weapons produced by outside interests.

Along with other stockpile stewardship responsibilities, DOE has assigned a hydrodynamic testing mission to its two nuclear weapons physics laboratories, LANL and Lawrence Livermore National Laboratory

(LLNL). The Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) is the existing radiographic hydrodynamic testing facility at LANL and the Flash X-Ray (FXR) is the existing radiographic hydrodynamic testing facility at Site 300 at LLNL.

PHERMEX has been in continuous operation since 1963. In addition to major, full-scale hydrodynamic tests, PHERMEX is used for smaller types of experiments, such as high-explosive tests or tests requiring static radiographs. Although PHERMEX was state of the art in the 1950s when it was designed, it is no longer adequate. It cannot provide the degree of resolution, intensity, rapid time sequencing, or three-dimensional views that are needed to provide answers to current questions regarding weapons condition or performance. Even if this type of diagnostic information were not needed, PHERMEX might not remain a viable test facility over an extended time because of anticipated increasing difficulty in maintaining the facility.

FXR has been in continuous operation since 1983; it is DOE's most advanced radiographic hydrodynamic testing facility. Although FXR uses linear induction accelerator technology for high-speed radiography, it cannot provide the degree of resolution, intensity, or three-dimensional views needed to address current questions. Additionally, DOE does not perform dynamic experiments with plutonium at LLNL because the necessary infrastructure is not in place. Neither PHERMEX nor FXR is adequate to provide the enhanced radiographic hydrodynamic testing capability that DOE now needs in the absence of nuclear weapons testing.

The Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility is proposed by DOE to acquire enhanced radiographic hydrodynamic testing capability. The DARHT Facility would consist of a new accelerator building with two accelerator halls, a firing point, and the associated support and diagnostic facilities. The firing point would be at the juncture of the x-ray beams produced by two electron beam accelerators oriented at right angles to each other to provide dual-axis, line-of-site radiographs. Construction of the DARHT Facility is about 34 percent complete, having been started under earlier environmental documentation. Construction is currently stopped under a U.S. District Court preliminary injunction issued on January 27, 1995, pending completion of this EIS and issuance of the Record of Decision.

DOE plans two other National Environmental Policy Act (NEPA) reviews regarding proposed actions at LANL related to the *Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility EIS* – the *LANL Sitewide Environmental Impact Statement* (SWEIS) and the *Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (PEIS).

EIS	Notice of Intent	Draft EIS	Final EIS	Record of Decision
DARHT EIS	Nov 94	May 95	Aug 95	Oct 95
LANL SWEIS	May 95	Apr 96	Dec 96	Mar 97
SS&M PEIS	Jun 95	Feb 96	Jul 96	Sep 96

Note: Dates are subject to change.

PROPOSED ACTION AND ALTERNATIVES

DOE is proposing to provide enhanced high-resolution radiographic capability to perform hydrodynamic tests and dynamic experiments in support of the Department's historical mission and near-term stewardship of the nuclear weapons stockpile. This EIS analyzes the following alternatives:

- **No Action Alternative:** DOE would continue to use PHERMEX at LANL and the FXR at LLNL in support of its stockpile stewardship mission. Construction of the DARHT Facility would not be completed although the building would be completed for other uses. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.
- **DARHT Baseline Alternative:** DOE would complete and operate the DARHT Facility and phase out operations at PHERMEX. DOE may delay operation of the second axis of DARHT until the accelerator equipment in the first axis is tested and proven. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.
- **Upgrade PHERMEX Alternative:** Construction of the DARHT Facility would not be completed although the building would be completed and put to other uses. Major upgrades would be constructed at PHERMEX, and the high-resolution radiographic technology planned for DARHT would be installed at PHERMEX, including a second accelerator for two-axis imaging. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.
- **Enhanced Containment Alternative:** Three options are considered under this alternative: 1) the Vessel Containment Option, 2) the Building Containment Option, and 3) the Phased Containment Option (preferred alternative). This alternative is similar to the DARHT Baseline Alternative except that most or all tests would be conducted in a containment vessel or containment structure. All tests would be contained if a containment structure were used. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.
- **Plutonium Exclusion Alternative:** This alternative is similar to the DARHT Baseline Alternative except that plutonium would not be used in any of the experiments at DARHT. In the future, DOE may perform some dynamic experiments with plutonium. Those involving radiography would be conducted at PHERMEX and would be conducted in double-walled containment vessels.
- **Single Axis Alternative:** This alternative is similar to the DARHT Baseline Alternative except that only one accelerator hall at DARHT would be completed and operated for hydrodynamic tests and dynamic experiments. The other hall would be completed for other uses. In the future, DOE may perform some dynamic experiments with plutonium; these would be conducted in double-walled containment vessels.

AFFECTED ENVIRONMENT

LANL occupies an area of approximately 28,000 ac (11,300 ha) on the Pajarito Plateau, in Los Alamos County in north central New Mexico. The alternatives analyzed (including no action) would all occur within Area III of Technical Area 15 situated in the south central portion of LANL, an area that has been dedicated to high explosives testing for over 50 years. The PHERMEX site and the DARHT site are about 1/2 mi apart and are ecologically similar, set in a ponderosa pine plant community. The only discriminators between the two sites are resources that are point-specific, such as specific archeological sites or specific existing facilities.

ENVIRONMENTAL CONSEQUENCES

The analyses in this EIS indicate that there would be very little difference in the environmental impacts among the alternatives analyzed. The major discriminator among alternatives would be potential impacts from depleted uranium contamination to soils and surface waters, which would be substantially less under the Enhanced Containment Alternative, and commitments of construction materials, which would be substantially greater under the Upgrade PHERMEX Alternative. Also, there is a projected increase in the estimated worker dose from radioactive materials under all options of the Enhanced Containment Alternative. This is a result of a potential increase in worker exposure to radiation as a result of vessel or building cleanout operations. Potential impacts from the use of plutonium would be essentially identical under all alternatives, with an extremely unlikely or incredible accident having consequences of up to 12 latent cancer fatalities in the exposed population. All tests using plutonium would be conducted using double-walled steel containment vessels. Likewise, impacts from the three options examined under the Enhanced Containment Alternative are similar to one another and often similar to the other alternatives. The Phased Containment (preferred alternative) and Vessel Containment options contain elements of both of the uncontained alternatives and elements of the Building Containment Option (representing full containment). Typically, the Phased Containment and Vessel Containment options have impacts that are more like the Building Containment Option than the uncontained alternatives. In general, the impacts from accidents involving single-walled containment vessels would be higher than those for uncontained tests, because the releases are more concentrated and are closer to the ground. Table S-1 presents a comparison of the environmental consequences for all alternatives analyzed in this EIS based on the assessments contained in chapter 5 of this EIS. The table provides direct comparisons of expected consequences for each environmental factor for the alternatives.

REGULATORY REQUIREMENTS

DOE has obtained operating permits for PHERMEX. The DARHT Facility (DARHT Baseline Alternative) has received septic tank permits, and cooling tower blowdown has been incorporated into the LANL Sitewide National Pollutant Discharge Elimination system permit. DOE has also received approval to construct from the Environmental Protection Agency under 40 CFR Part 61, Subpart A, regarding emissions of radionuclides from DOE facilities. Nonradioactive air emissions from DARHT would be covered by a LANL sitewide operating permit to be submitted to the New Mexico Environment Department (NMED) in late 1995. Emission of toxic air pollutants may require a permit from NMED. This is currently being evaluated. Permit modifications may be needed depending on the course of action selected in the Record of Decision.

DOE has consulted Federal, State, and Tribal agencies regarding wildlife habitat, threatened and endangered species, cultural resources protection, and other laws pertaining to Native American traditional

use of land and resources. The U.S. Fish and Wildlife Service concurred with DOE that the construction and operation of DARHT would not be likely to adversely affect the Mexican spotted owl, a federally listed threatened species. DOE has committed to take appropriate mitigation measures to minimize impacts to cultural and natural resources; no adverse effects to cultural resources are expected.

TABLE S-1.—*Summary of the Potential Environmental Impacts of the Alternatives*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Land Resources								
Acreage committed								
PHERMEX (ac)	11	11	11	11	11	11	11	11
DARHT (including RSL) (ac)	8	8	8	9[a]	8	9[a]	8	8
Air Quality								
Construction								
Maximum percent of standard[b]								
NO_2	1.6	3.3	3.3	3.3	3.3	3.3	3.3	3.3
PM_{10}	5	11	11	11	11	11	11	11
SO_2	1	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Operations								
Maximum percent of standard[b]								
NO_2	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
PM_{10}	2.2	2.2	2.2	2.2	0.2	2.2	2.2	2.2
SO_2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Be	0.00005	0.00005	0.00005	0.0002	0.0002	0.0002	0.00005	0.00005
Heavy Metal	0.005	0.005	0.005	0.02	0.02	0.02	0.005	0.005
Lead	0.001	0.001	0.001	0.007	0.007	0.007	0.001	0.001
Noise (qualitative)	Possible nuisance	Possible nuisance	Possible nuisance	75% reduction	Nuisance unlikely	Possible nuisance, phasing to 75% reduction	Possible nuisance	Possible nuisance
Water Resources								
Depleted uranium contamination, % drinking water standard (after millennia)	<1	<1	<1	<0.1	<0.1	<0.1	<1	<1

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.

[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.

[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).

[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.

[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.

[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.

[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE S-1.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Soils								
Depleted uranium contamination area (ac)	15	15	15	15	15	15	15	15
Max. concentration (approx.) (ppm)	9,000	5,000	9,000	2,000	1,000	3,000	5,000	5,000
Biotic Resources								
Habitat reduction[c] (ac)	None	None	None	1	1	1	None	None
Threatened, endangered and sensitive species	None	When mitigated, none	None	When mitigated, none	None	When mitigated, none	When mitigated, none	When mitigated, none
Disturbance by noise	Some	Some	Some	75% reduction	Near zero	Some, phasing to 75% reduction	Some	Some
Cultural Resources (qualitative)	None	When mitigated, none	None	When mitigated, none	None	When mitigated, none	When mitigated, none	When mitigated, none
Socioeconomics (Annual impacts, 1996 to 2002)								
Employment (FTE)	—[d]	191	199	321	238	253	273	104
Regional labor income (millions)	—[d]	$ 4.1	$ 4.3	$ 6.8	$ 5.1	$ 5.4	$ 4.9	$ 2.2
Regional goods & services (millions)	—[d]	$ 6.8	$ 6.9	$ 12.0	$ 8.4	$ 9.0	$ 8.6	$ 3.8

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.
[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.
[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).
[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.
[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.
[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.
[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE S-1.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Human Health								
Depleted Uranium								
Public, 30-yr life of project								
MEI dose (rem)	7×10^{-4}	7×10^{-4}	7×10^{-4}	5×10^{-4}	5×10^{-4}	6×10^{-4}	7×10^{-4}	7×10^{-4}
Population dose (person-rem)	30	30	30	13	8	17	30	30
Latent cancer fatalities	None	None	None	None	None	None	None	None
Workers, 30-yr life of project								
Average dose (rem)	0.3	0.3	0.3	0.6	0.6	0.6	0.3	0.3
Collective dose (person-rem)	9	9	9	60	60	60	9	9
Latent cancer fatalities	None	None	None	None	None	None	None	None
Plutonium								
Public, 30-yr life of project	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}	3×10^{-10}
MEI dose (rem)	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}	3×10^{-7}
Population dose (person-rem)	None	None	None	None	None	None	None	None
Latent cancer fatalities								
Noninvolved Workers, 30-yr life								
of project	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}	9×10^{-9}
Collective dose (person-rem)	None	None	None	None	None	None	None	None
Latent cancer fatalities	No impact	No impact	No impact	No impact	No impact	No impact	No impact	No impact
Workers								

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.

[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.

[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).

[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.

[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.

[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.

[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE S-1.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Facility Accidents								
Involved workers, worst case explosion related fatalities	15	15	15	15	15	15	15	15
Depleted Uranium								
Public								
MEI dose (rem)	6×10^{-4}	6×10^{-4}	6×10^{-4}	1×10^{-2}	1×10^{-3}	1×10^{-2}	6×10^{-4}	6×10^{-4}
Population dose (person-rem)	1.9	1.9	1.9	17	1.7	17	1.9	1.9
Latent cancer fatalities	None	None	None	None	None	None	None	None
Noninvolved worker dose (rem)	7×10^{-4}	7×10^{-4}	7×10^{-4}	5×10^{-2}	5×10^{-3}	5×10^{-2}	7×10^{-4}	7×10^{-4}
Plutonium								
Public (95th percentile meteorology)								
MEI dose (rem)	76	76	76	76	76	76	76	76
Population dose (person-rem)	24,000	24,000	24,000	24,000	24,000	24,000	24,000	24,000
Latent cancer fatalities	12	12	12	12	12	12	12	12
Noninvolved worker dose (rem)	160	160	160	160	160	160	160	160
Transportation								
Workers, 30-yr life of project								
Dose (rem)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Public, 30-yr life of project								
Population dose, (person-rem)	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}	3×10^{-9}
Latent cancer fatalities	None	None	None	None	None	None	None	None

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.

[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.

[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).

[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.

[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.

[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.

[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

TABLE S-1.—*Summary of the Potential Environmental Impacts of the Alternatives – Continued*

Factor, Measure	No Action	DARHT Baseline Alternative	Upgrade PHERMEX Alternative	Enhanced Containment Alternative			Plutonium Exclusion Alternative	Single Axis Alternative
				Vessel	Building	Phased		
Waste Generated, Annual								
Solid Sanitary Waste (ft^3) (non-hazardous, non-radioactive)	9,400	9,400	9,400	9,400	9,400	9,400	9,400	9,400
Hazardous (lb)								
Solid	310	310	310	310	310	310	310	310
Liquid	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Mixed Waste (55-gal drums)	1	1	1	1	1	1	1	1
Low-Level Waste (ft^3)	12,500	12,500	12,500	3,600	360	5,700[e,f]	12,500	12,500
TRU Waste (tons) (steel vessels)	2	2	2	2	2	2	2	2
Unavoidable Adverse Impacts	See soils	See soils	See soils	See soils	See soils	See soils	See soils	See soils
Irreversible and/or Irretrievable Commitment of Resources								
Construction								
Concrete (yd^3)	15,000	15,000	28,000	16,000	22,000	16,000	15,000	15,000
Diesel fuel (gal)	9,500	11,500	17,000	12,500	18,200	12,500	11,500	11,500
Electricity (MWh)	365	365	750	365	450	365	365	365
Operations								
Depleted uranium (lb/yr)	1,540	1,540	1,540	1,540	1,540	1,540	1,540	1,540
Natural gas (ft^3/yr)	8,700	10,400	13,000	13,300	14,800	12,600[e,g]	10,400	10,400
Electricity (MWh/yr)	550	2,250	2,500	2,600	2,900	2,500[e,g]	2,250	1,350
Long-term Productivity (qualitative)	None	None	None	None	None	None	None	None

[a] Includes 1 ac (0.4 ha) for the vessel cleanout facility.

[b] The values presented here represent the maximum pollutant concentrations as a percent of the respective standard. Impacts for NO_2, PM_{10}, and SO_2 are compared to 24-h, 24-h, and 3-h standards, respectively. Percentages of annual air quality standards are much less. Construction impacts are from fugitive dust or construction equipment emissions; operations impacts are from emissions from the natural gas boiler or hydrodynamic testing.

[c] Habitat reduction refers to the change of habitat to another use. Analyses of impacts was limited to future activities; therefore the 8 ac (2.4 ha) previously disturbed at the DARHT site are not reflected here. Only the Enhanced Containment Alternative would result in an additional use of land for the vessel cleanout facility (see footnote a).

[d] The calculated socioeconomic impacts are derived using PHERMEX operation figures as a baseline. Thus, under standard modeling procedures there are no additional impacts calculated.

[e] Annual average over 30-year operating life. The Phased Containment Option of the Enhanced Containment Alternative is divided into three distinct phases of operation: 1) the first five years of operation are marked by 5 percent containment, 2) the second five years of operation are marked by 40 percent containment, and 3) the final phase beginning in the 11th year of operation is marked by 75 percent containment.

[f] Maximum annual impact similar to the DARHT Baseline Alternative. Minimum annual impact similar to the Vessel Containment Option.

[g] Maximum annual impact similar to the Vessel Containment Option. Minimum annual impact similar to the DARHT Baseline Alternative.

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DARHT EIS

ACRONYMS AND ABBREVIATIONS

ac	acre
ACO	Access Control Office
ADM	action description memorandum
AHF	Advanced Hydrotest Facility
AIANAFP	American Indian and Alaska Native Area
AIRFA	American Indian Religious Freedom Act
Am	americium
AMAD	activity median aerodynamic diameter
AQCR	Air Quality Control Regulation
As	arsenic
Ba	barium
Be	beryllium
BEA	Bureau of Economic Analysis
CCNS	Concerned Citizens for Nuclear Safety
CEQ	Council on Environmental Quality
CETC	Contained Explosives Test Complex
CFR	Code of Federal Regulations
CHIEF	Clearinghouse Inventory of Emission Factors
Ci	curie
Ci/g	curie per gram
cm	centimeter
cm^2	square centimeter
Co	cobalt
CO	carbon monoxide
CO_2	carbon dioxide
CPS	current population survey
Cr	chromium
Cs	cesium
CTBT	Comprehensive Test Ban Treaty
Cu	copper
CX	categorical exclusion
D&D	decontamination and decommissioning
DAC	derived air concentrations
DARHT	Dual Axis Radiographic Hydrodynamic Test Facility, proposed to be operated at LANL
dB	decibel
dBA	A-weighted decibel
DCG	derived concentration guides
DFAIC	DARHT Feasibility Assessment Independent Consultants
DNAA	delayed neutron activation analysis
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/AL	DOE/Albuquerque Operations Office
DOI	U.S. Department of the Interior
DOL	U.S. Department of Labor
dose	unless otherwise specified, means effective dose equivalent
DOT	U.S. Department of Transportation

DU	depleted uranium
DX	dynamic experimentation
EDE	effective dose equivalent
EES	earth and environmental science
EIS	environmental impact statement
EM	environmental management
EPA	U.S. Environmental Protection Agency
ES	economic sectors
ESA	Endangered Species Act
F	fluorine
Fe	iron
ft	foot
ft^2	square foot
ft^3/min	cubic feet per minute
ft^3	cubic foot
ft^3/s	cubic feet per second
FIPS	Federal Information Procedures System
FR	*Federal Register*
FTE	full time equivalent personnel
FXR	Flash X-Ray Facility (located at LLNL)
FY	fiscal year
g	gram
G	acceleration due to gravity (seismology)
g/L	grams per liter
gal	gallon
gal/mo	gallon per month
$gal/d\text{-}ft^2$	gallons per day per square foot
gal/d-ft	gallons per day per foot
gal/min	gallons per minute
gal/min-ft	gallons per minute per foot
h	hour
H-3	tritium
ha	hectare
HE	high explosive
He-Ne laser	helium-neon laser
HEPA	high-efficiency particulate air (filter)
HFS	hydrotest firing site
HI	hazard index
HMX	cyclotetramethylenetetranitramine
HNO_3	nitric acid
HPAIC	Hydrotest Program Assessment Independent Consultants
HTO	tritiated water
HVAC	heating, ventilation, and air conditioning
I	iodine
ICRP	International Commission on Radiological Protection
IDLH	immediately dangerous to life or health
in	inch
in^2	square inch

in^3	cubic inch
INAA	instrument neutron activation analysis
ITS	Integrated Test Stand
kg/m^2	kilograms per square meter
kg	kilogram
kg/yr	kilograms per year
kJ	kilo Joule
km/h	kilometers per hour
km	kilometer
km^2	square kilometers
kPa	kilopascal
kV	kilovolt
kW	kilowatt
kWh	kilowatthour
kWh/gross ft^2	kilowatthour per gross square foot
kWh/gross m^2	kilowatthour per gross square meter
L	liter
LAAO	Los Alamos Area Office
LAMPF	Los Alamos Meson Physics Facility
LANSCE	Los Alamos Neutron Science Center
lb	pound
lb/yr	pounds per year
lb/in^2	pounds per square inch
LCF	latent cancer fatalities
LiH	lithium hydride
LiOH	lithium hydroxide
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
m	meter
m^2	square meter
m^3/s	cubic meters per second
m^3	cubic meter
MCL	maximum contaminant level
MCLG	maximum containment level guideline
MEI	maximally exposed individual
MEPAS	Multi-media Environmental Pollution Assessment System
MeV	million electron volt
mg	milligram
mg/L	milligram per liter
mi	mile
mi/h	miles per hour
mi^2	square mile
micron	micrometer (10^{-6} meter)
mL	milliliter
mrem	millirem (1/1000 rem)
mrem/yr	millirem per year
MSDS	material safety data sheets
MTF	memorandum to file
mV	millivolt

NA	not applicable
NAAQS	National Ambient Air Quality Standards
nCi/L	nanocurie per liter
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
ng/dry g	nanograms per gram of dry sample weight
ng/m^3	nanograms per cubic meter
Ni	nickel
NIPA	national income and product accounts
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NO_2	nitrogen dioxide
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRHP	National Register of Historic Places
NSC	National Security Council
nsec	nanosecond
NTS	Nevada Test Site
NTU	nominal turbidity units
ODS	ozone depleting substances
OSHA	Occupational Safety and Health Act or Occupational Safety and Health Administration
OU	operable unit
P	phosphorus
Pb	lead
PCB	polychlorinated biphenyls
pCi/dry g	picocuries per gram of dry sample
pCi/L	picocuries per liter
pCi/mL	picocuries per milliliter
PDL	public dose limit
PEIS	programmatic environmental impact statement
person-rem	unit collective population dose
PETN	pentaerythritoltetranitrate
PFS	PHERMEX Firing Site
pg/m^3	picograms per cubic meter
PHERMEX	Pulsed High Energy Radiation Machine Emitting X-Rays Facility (located at LANL)
PM	particulate matter
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PSD	prevention of significant deterioration
Pu	plutonium
R/pulse	roentgen per pulse
R	roentgen
rad	unit of absorbed dose
RCRA	Resource Conservation and Recovery Act
RDX	cyclotrimethylenetrinitramine
rem/yr	common unit of effective dose equivalent rate
RF	radio frequency

ROD	Record of Decision
ROI	region-of-interest
RPC	regional purchasing coefficient
RSL	Radiographic Support Laboratory, located at LANL
Se	selenium
SF_6	sulfur hexafluoride
SIC	Standard Industrial Classification
SO_2	sulfur dioxide
Sr	strontium
SS&M	stockpile stewardship and management
SST	safe secure transport
SVOC	semivolatile organic compound
SVR	standard visual range
SWEIS	site-wide environmental impact statement
T_2	two chemically bound tritium atoms
Ta	tantalum
TA	technical area
TATB	triaminotrinitrobenzene
TCLP	Toxicity Characteristics Leaching Procedure
TES	threatened, endangered, and sensitive (species)
Th	thorium
Tl	thallium
TLD	thermoluminescent dosimeters
TLV	threshold limit value
TNT	trinitrotoluene
TRU	transuranic
TU	tritium units
U	uranium
USFWS	United States Fish and Wildlife Service
V	vanadium
W	tungsten
WCFS	Woodward-Clyde Federal Services
WIPP	Waste Isolation Pilot Plant
WSS	weapons stockpile stewardship
yd^3	cubic yard
yr	year

MEASUREMENTS AND CONVERSIONS

The following information is provided to assist the reader in understanding certain concepts in this environmental impact statement (EIS). Definitions of technical terms can be found in this Glossary.

SCIENTIFIC NOTATION

Scientific notation is used in this report to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, using scientific notation, as 1×10^9. Translating from scientific notation to a more traditional number requires moving the decimal point either right (for a positive power of 10) or left (for a negative power of 10). If the value given is 2.0×10^3, move the decimal point three places (insert zeros if no numbers are given) to the right of its present location. The result would be 2,000. If the value given is 2.0×10^{-5}, move the decimal point five places to the left of its present location. The result would be 0.00002.

UNITS OF MEASUREMENT

The primary units used in this report are English units with metric equivalents enclosed in parentheses. Table MC-1 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

Many metric measurements presented include prefixes that denote a multiplication factor that is applied to the base standard (e.g., 1 kilometer = 1,000 meters). The following list presents these metric prefixes:

mega	1,000,000 (10^6; one million)
kilo	1,000 (10^3; one thousand)
hecto	100 (10^2; one hundred)
centi	0.01 (10^{-2}; one one-hundredth)
milli	0.001 (10^{-3}; one one-thousandth)
micro	0.000001 (10^{-6}; one one-millionth)
nano	0.000000001 (10^{-9}; one one-billionth)
pico	0.000000000001 (10^{-12}; one one-trillionth)

DOE Order 5900.2A, "Use of the Metric System of Measurement," prescribes the use of this system in DOE documents. Table MC-1 lists the mathematical values or formulas needed for conversion between English and metric units. Table MC-2 summarizes and defines the terms for units of measure and corresponding symbols found throughout this report.

RADIOACTIVITY UNITS

Part of this report deals with levels of radioactivity that might be found in various environmental media. Radioactivity is a property; the amount of a radioactive material is usually expressed as "activity" in curies (Ci) (Table MC-3). The curie is the basic unit used to describe the amount of substance present, and concentrations are generally expressed in terms of curies per unit mass or volume. One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. Disintegrations generally include emissions of alpha or beta particles, gamma radiation, or combinations of these.

RADIATION DOSE UNITS

The amount of ionizing radiation energy received by a living organism is expressed in terms of radiation dose. Radiation dose in this report is usually written in terms of effective dose equivalent and reported numerically in units of rem (Table MC-4). Rem is a term that relates ionizing radiation and biological effect or risk. A dose of 1 millirem (0.001 rem) has a biological effect similar to the dose received from about a 1-day exposure to natural background radiation. A list of the radionuclides discussed in this document and their half-lives is included in Table MC-5.

CHEMICAL ELEMENTS

A list of chemical elements, chemical constituents, and their nomenclature is presented in table MC-6.

TABLE MC-1. —*Conversion Table*

Multiply	By	To Obtain	Multiply	By	To Obtain
in	2.54	cm	cm	0.394	in
ft	0.305	m	m	3.28	ft
mi	1.61	km	km	0.621	mi
lb	0.454	kg	kg	2.205	lb
gal	3.785	L	L	0.264	gal
ft^2	0.093	m^2	m^2	10.76	ft^2
ac	0.405	ha	ha	2.47	ac
mi^2	2.59	km^2	km^2	0.386	mi^2
ft^3	0.028	m^3	m^3	35.7	ft^3
nCi	0.001	pCi	pCi	1,000	nCi
pCi/L	10^{-9}	μCi/mL	μCi/mL	10^9	pCi/L
pCi/m^3	10^{-12}	Ci/m^3	Ci/m^3	10^{12}	pCi/m^3
pCi/m^3	10^{-15}	mCi/cm^3	mCi/cm^3	10^{15}	pCi/m^3
mCi/km^2	1.0	nCi/m^2	nCi/m^2	1.0	mCi/km^2
ppb	0.001	ppm	ppm	1,000	ppb
°F	(°F - 32) x 5/9	°C	°C	(°C x 9/5) + 32	°F
g	0.035	oz	oz	28.349	g

TABLE MC-2. —*Names and Symbols for Units of Measure*

Length

Symbol	Name
cm	centimeter (1 x 10^{-2} m)
ft	foot
in	inch
km	kilometer (1 x 10^{3} m)
m	meter
mi	mile
mm	millimeter (1 x 10^{-3} m)
μm	micrometer (1 x 10^{-6} m)

Volume

Symbol	Name
cm^3	cubic centimeter
ft^3	cubic foot
gal	gallon
in^3	cubic inch
L	liter
m^3	cubic meter
mL	milliliter (1 x 10^{-3} L)
ppb	parts per billion
ppm	parts per million
yd^3	cubic yard

Rate

Symbol	Name
cm^3/s	cubic meters per second
ft^3/s	cubic feet per second
ft^3/min	cubic feet per minute
gpm	gallons per minute
km/h	kilometers per hour
mi/h	miles per hour

Numerical Relationships

Symbol	Meaning
<	less than
≤	less than or equal to
>	greater than
≥	greater than or equal to
2σ	two standard deviations

Time

Symbol	Name
d	day
h	hour
min	minute
nsec	nanosecond
s	second
yr	year

Area

Symbol	Name
ac	acre (640 per mi^2)
cm^2	square centimeter
ft^2	square foot
ha	hectare (1 x 10^4 m^2)
in^2	square inch
km^2	square kilometer
mi^2	square mile

Mass

Symbol	Name
g	gram
kg	kilogram (1 x 10^3 g)
mg	milligram (1 x 10^{-3} g)
μg	microgram (1 x 10^{-6} g)
ng	nanogram (1 x 10^{-9} g)
lb	pound
ton	ton (1 x 10^6 g)

Temperature

Symbol	Name
°C	degrees Centigrade
°F	degrees Fahrenheit
°K	degrees Kelvin

Sound

Symbol	Name
dB	decibel
dBA	A-weighted decibel

TABLE MC-3.—*Names and Symbols for Units of Radioactivity*

Radioactivity	
Symbol	Name
Ci	curie
cpm	counts per minute
mCi	millicurie (1×10^{-3} Ci)
μCi	microcurie (1×10^{-6} Ci)
nCi	nanocurie (1×10^{-9} Ci)
pCi	picocurie (1×10^{-12} Ci)

TABLE MC-4.—*Names and Symbols for Units of Radiation Dose*

Radiation Dose	
Symbol	Name
mrad	millirad (1×10^{-3} rad)
mrem	millirem (1×10^{-3} rem)
R	roentgen
mR	milliroentgen (1×10^{-3} R)
μR	microroentgen (1×10^{-6} R)

TABLE MC-5.—*Radionuclide Nomenclature*

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
Am-241	americium-241	432 yr	Pu-241	plutonium-241	14.4 yr
H-3	tritium	12.3 yr	Pu-242	plutonium-242	3.8×10^5 yr
Pa-234	protactinium-234	6.7 h	Pu-244	plutonium-244	8.2×10^7 yr
Pa-234m	protactinium-234m	1.17 min	Th-231	thorium-231	25.5 h
Pu-236	plutonium-236	2.9 yr	Th-234	thorium-234	24.1 d
Pu-238	plutonium-238	87.7 yr	U-234	uranium-234	2.4×10^5 yr
Pu-239	plutonium-239	2.4×10^4 yr	U-235	uranium-235	7×10^8 yr
Pu-240	plutonium-240	6.5×10^3 yr	U-238	uranium-238	4.5×10^9 yr

TABLE MC-6.—*Elemental and Chemical Constituent Nomenclature*

Symbol	Constituent	Symbol	Constituent
Ag	silver	Pa	protactinium
Al	aluminum	Pb	lead
B	boron	Pu	plutonium
Be	beryllium	SF_6	sulfur hexafluoride
CO	carbon monoxide	Si	silicon
CO_2	carbon dioxide	SO_2	sulfur dioxide
Cu	copper	Ta	tantalum
F^-	fluoride	Th	thorium
Fe	iron	Ti	titanium
N	nitrogen	U	uranium
Ni	nickel	V	vanadium
NO_2^-	nitrite	W	tungsten
NO_3^-	nitrate	Zn	zinc

Chapter 1
Introduction

CHAPTER 1
INTRODUCTION

This chapter outlines the environmental review for the *Dual Axis Radiographic Hydrodynamic Test Facility Environmental Impact Statement*.

1.1 OVERVIEW

The U. S. Department of Energy (DOE) proposes to provide enhanced high-resolution radiography capability to perform hydrodynamic tests and dynamic experiments in support of its historical mission and near-term stewardship of the nuclear weapons stockpile. This environmental impact statement (EIS) analyzes the environmental impacts of alternative ways to accomplish the proposed action. The DOE's preferred alternative would be to complete and operate the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility under the Phased Containment Option (a new option since the draft DARHT EIS) of the Enhanced Containment Alternative at its Los Alamos National Laboratory (LANL) in northern New Mexico. An artists' concept of the DARHT Facility is shown in figure 1-1.

This EIS has a classified supplement that provides additional information and analysis. Although the details of a nuclear weapon are classified, figure 1-2 provides an unclassified summary of a nuclear weapon.

DOE began the preliminary design for DARHT in the early 1980s and conducted a series of environmental reviews for the project between 1982 and 1989. DOE concluded that no significant environmental impact should result from constructing and

IMPORTANT TERMINOLOGY

Stockpile Stewardship and Management Program – DOE's single, highly integrated technical program for maintaining the safety and reliability of the U.S. nuclear stockpile in an era without nuclear testing and without new weapons development and production. To meet these requirements, a "science-based" program is being developed to increase understanding of the basic scientific phenomena associated with nuclear weapons.

Dynamic Experiment – An experiment to provide information regarding changes in materials under conditions caused by the detonation of high explosives.

Hydrodynamic Test – A dynamic, integrated systems test of a mock-up nuclear package (figure 1-2) during which the high explosives are detonated and the resulting motions and reactions of materials and components are observed and measured. The explosively generated high pressures and temperatures cause some of the materials to behave hydraulically (like a fluid).

Hydrodynamic Testing Facility – A facility in which to conduct dynamic and hydrodynamic testing for nuclear and conventional weapons research and assessment. Fast diagnostic systems that are available include radiographic, electrical, optical, laser, and microwave. The testing can provide both two- and three-dimensional information for performance evaluation.

Enhanced Radiography – A capability for producing extremely high-resolution, time-phased, photographic images of an opaque object by transmitting a beam of x-rays (or gamma rays) through it onto an adjacent photographic film; the image(s) results from variations in thickness, density, and chemical composition of the object.

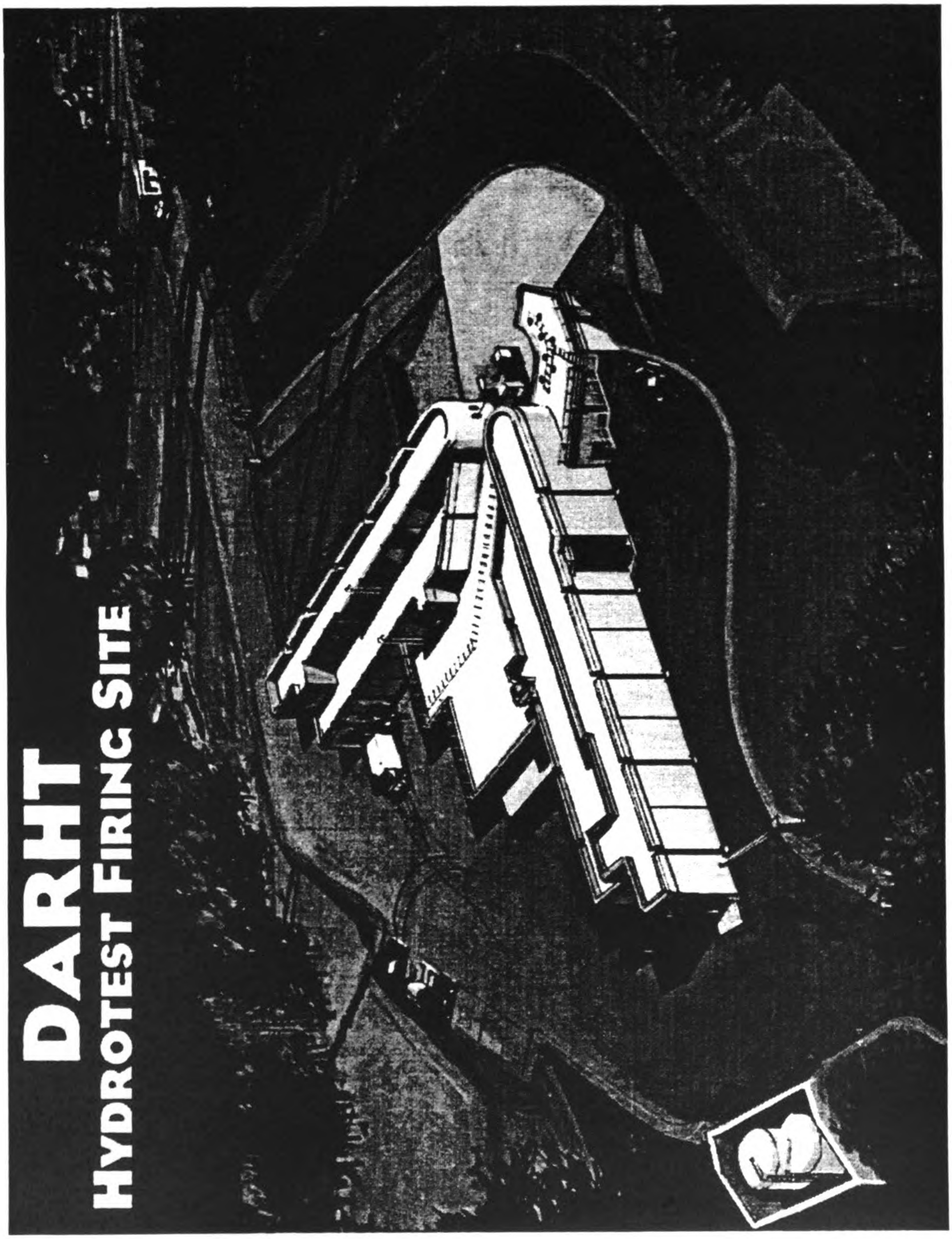
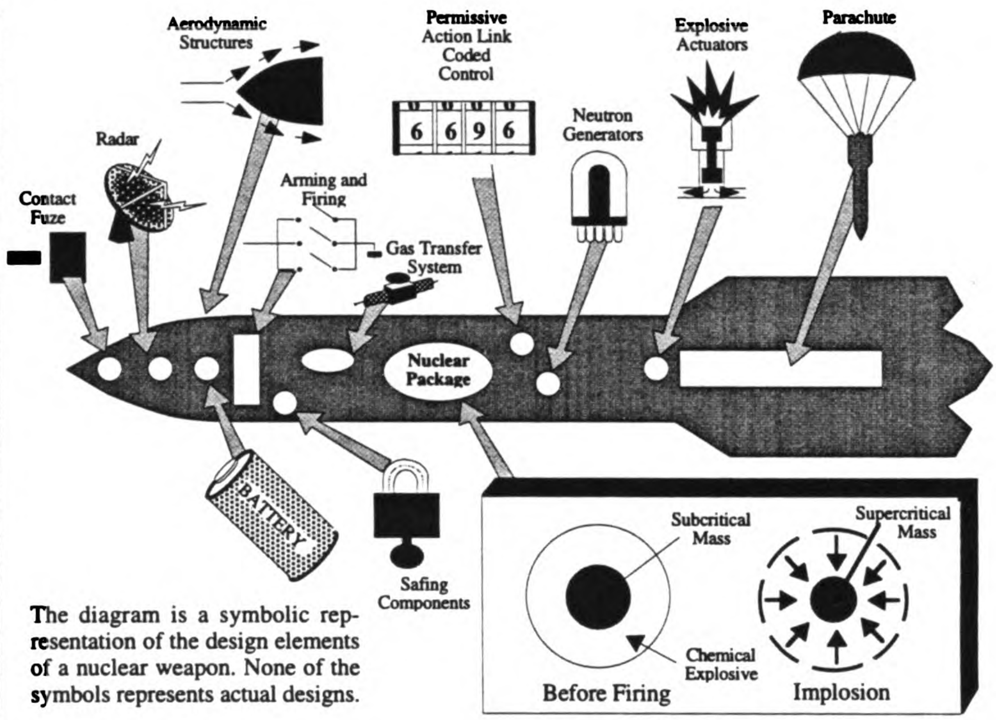


FIGURE 1-1.—*Architectural Rendering of the DARHT Facility (looking west).*

Nuclear explosions are produced by initiating and sustaining nuclear chain reactions in highly compressed material which can undergo both fission and fusion reactions. Modern strategic, and most tactical, nuclear weapons use a nuclear package with two assemblies: the primary assembly, which is used as the initial source of energy, and the secondary assembly, which provides additional explosive energy release. The primary assembly contains a central core, called the "pit," which is surrounded by a layer of high explosive. The "pit" is typically composed of plutonium-239 and/or highly enriched uranium (HEU), and other materials. HEU contains large fractions of the isotope uranium-235.



The diagram is a symbolic representation of the design elements of a nuclear weapon. None of the symbols represents actual designs.

Primary Detonation

The primary nuclear explosion is initiated by detonating the layer of chemical high explosive that surrounds the "pit," which, in turn, drives the pit material into a compressed mass at the center of the primary assembly. This implosion process is illustrated in the inset of the diagram.

Boosting

In order to achieve higher explosive yields from primaries with relatively small quantities of pit material, a technique called "boosting" is used. Boosting is accomplished by injecting a mixture of tritium (T) and deuterium (D) gas into the pit. The deuterium and tritium are stored in high-pressure reservoirs until the gas transfer system is initiated. The implosion of the pit, along with the onset of the fissioning process, heats the D-T mixture to the point that the D-T atoms undergo fusion. The fusion reaction produces large quantities of very high energy neutrons which flow through the compressed pit material and produce additional fission reactions.

Secondary Activation

The energy released by the primary explosion activates the secondary assembly. The secondary assembly is composed of lithium deuteride and other materials. As the secondary implodes, the lithium, in the isotopic form lithium-6, is converted to tritium by neutron interactions, and the tritium product in turn undergoes fusion with the deuterium to create the thermonuclear explosion.

Nonnuclear Components

Nonnuclear components include contact fuzes, radar components, aerodynamic structures, arming and firing systems, gas transfer systems, permissive action link coded controls, neutron generators, explosive actuators, safing components, batteries, and parachutes.

FIGURE 1-2.—*Nuclear Weapons Design.*

operating the facility. Funding for DARHT was authorized and appropriated by Congress in 1988. Construction of the DARHT Radiographic Support Laboratory began in 1988 and was completed in 1990. In 1993, DOE decided to fund the accelerator and x-ray equipment for the second axis of DARHT under a separate budget line item. Construction of the actual DARHT Facility began in April 1994.

In October 1994, three citizen groups wrote to the Secretary of Energy requesting, among other things, that DOE prepare an EIS on the DARHT Facility. They also requested that further construction of the facility be halted until an EIS was completed. On November 16, 1994, two of these groups (the Los Alamos Study Group and the Concerned Citizens for Nuclear Safety) filed a lawsuit in U.S. District Court, Albuquerque, New Mexico, to enjoin DOE from proceeding with the DARHT project until completion of the EIS and issuance of the Record of Decision (ROD). On November 22, 1994, DOE published a *Federal Register* notice of its intent to prepare this DARHT EIS [59 FR 60134]; see appendix A. On January 27, 1995, the court issued a preliminary injunction enjoining DOE from further construction of the DARHT Facility and related activities, such as procuring special facility equipment, pending completion of this EIS and the related ROD. The court entered a final judgment on May 5, 1995. Figure 1-3 is a photograph of the DARHT site, taken in May 1995, showing the condition of the DARHT Facility at the time of construction shutdown and when the site was secured in a standby condition. No construction has taken place since January 27, 1995.

Preparing an EIS at this time responds to public concern and allows for a full dialogue between DOE and the State, Tribal, county, and municipal governments; other Federal agencies; and the general public. The EIS will also provide the basis for appropriate mitigation measures, if needed, for the course of action selected.

1.2 ORGANIZATION OF THIS EIS

This EIS consists of six chapters.

- **Chapter 1 – Introduction**: DARHT background and the environmental analysis process.
- **Chapter 2 – Purpose and Need**: reasons why DOE needs to take action at this time.
- **Chapter 3 – Proposed Action and Alternatives**: the way DOE proposes to meet the specified need and alternative ways the specified need could be met. This chapter includes a summary of expected environmental impacts if any of the alternatives analyzed in this EIS were to be implemented.
- **Chapter 4 – Affected Environment**: aspects of the human environment (natural, built, and social) that might be affected by any of the alternatives analyzed in this EIS.
- **Chapter 5 – Environmental Consequences**: comparative analyses of the changes or impacts that any alternative would be expected to have on the affected elements of the human environment. Impacts are compared to the human environment that would be expected to exist if no action were taken (the No Action Alternative).
- **Chapter 6 – Regulatory Requirements**: agencies and individuals consulted, and environmental regulations that would apply if any of the alternatives analyzed in this EIS were to be implemented.

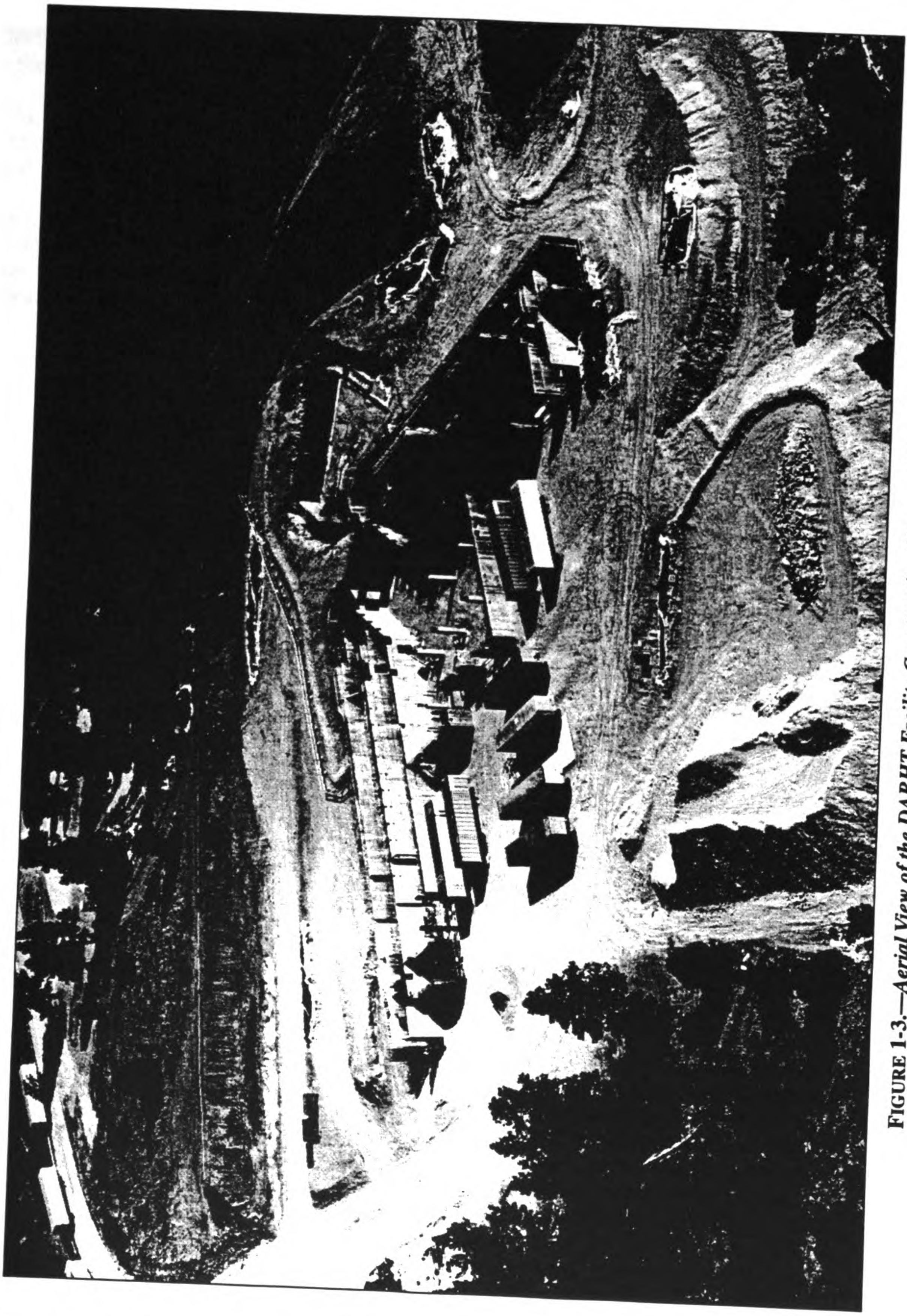


FIGURE 1-3.—*Aerial View of the DARHT Facility Construction Site, as of May 1995 (looking north).*

1.3 ALTERNATIVES ANALYZED

This EIS analyzes the environmental impacts associated with constructing and operating a facility that would provide the needed enhanced capability for hydrodynamic testing and dynamic experiments. Radiographic hydrodynamic testing is now conducted at two existing facilities within the DOE complex – the Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) Facility at LANL and the Flash X-Ray (FXR) Facility at Lawrence Livermore National Laboratory (LLNL) in California. The potential impacts of five operational alternatives also are analyzed in the EIS and compared to the expected impacts of the No Action Alternative (see box). DOE considered, but did not analyze, several other alternatives (see section 3.10).

THE PROPOSED ACTION

Provide enhanced high-resolution radiography capability to perform hydrodynamic tests and dynamic experiments.

DARHT EIS ALTERNATIVES

- **No Action:** Continue to operate PHERMEX at LANL and FXR at LLNL.
- **DARHT Baseline Alternative:** Complete and operate the DARHT Facility at LANL.
- **Upgrade PHERMEX:** Upgrade PHERMEX with the enhanced radiography technology instead of completing the DARHT Facility.
- **Enhanced Containment:** In addition to containing all experiments involving plutonium, enclose most or all experiments. Three containment options are considered under this alternative: 1) the Vessel Containment Option, 2) the Building Containment Option, and 3) the Phased Containment Option. The Phased Containment Option is the DOE's preferred alternative.
- **Plutonium Exclusion:** Exclude any applications involving experiments with plutonium at the DARHT Facility.
- **Single Axis:** Complete and operate only a single axis of the DARHT Facility.

1.4 LAWS AND REGULATIONS

This EIS is being prepared pursuant to the National Environmental Policy Act of 1969 (NEPA) [42 U.S.C. 4321 *et seq.*], the Council on Environmental Quality NEPA regulations [40 CFR 1500–1508], and DOE NEPA regulations [10 CFR 1021].

1.5 PUBLIC REVIEW OF DRAFT EIS

In May 1995, DOE made the draft DARHT EIS available for review and comment. Over 500 copies of the draft EIS were distributed. The draft was distributed to Congressional members and committees; the State of New Mexico; the Tribal governments of Cochiti, Jemez, Santa Clara, and San Ildefonso Pueblos; other tribal governments and American Indian Organizations; Los Alamos, Rio Arriba, and Santa Fe County governments; other Federal agencies; private consultants; public interest groups; and the general public.

DOE held public hearings on May 31 and June 1, 1995, in Los Alamos and Santa Fe, New Mexico, to afford the public and other parties an opportunity to provide spoken and written comments on the draft EIS. In addition, DOE extended invitations to the State of New Mexico; Cochiti, Jemez, Santa Clara, and San Ildefonso Pueblos; Los Alamos, Rio Arriba, and Santa Fe counties; certain other Federal agencies, [in particular the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (USFWS), the U.S. Department of the Interior, and the Department of Defense]; and New Mexico congressional members to participate in briefings regarding the DARHT EIS or specific issues related to the environmental analyses. During the public comment period on the draft EIS, DOE and LANL hosted several tours of the DARHT and PHERMEX sites for State personnel, Tribal officials, local government officials, other Federal agencies, and other interested parties.

The public comments received are included in their entirety in chapter 2 of volume 2; DOE responses to these comments are presented in chapter 3 of volume 2. DOE received written comments from 40 parties and oral comments from 48 individuals at its public hearing.

In addition to the unclassified portion of the draft DARHT EIS, DOE provided the draft classified supplement to the draft EIS for review by appropriately cleared parties with a need to know the classified material. These included the Department of Defense, the EPA, the State of New Mexico, and certain Tribal governments. The final classified supplement reflects the external reviews.

1.6 MAJOR CHANGES, DRAFT TO FINAL DARHT EIS

DOE has revised the draft EIS in response to public comments received, provided additional environmental baseline information, and discussed additional technical considerations. The major changes in this final EIS are noted in the box.

The final DARHT EIS also reflects the commitment made by the President on August 11, 1995, to seek a "zero-yield" Comprehensive Test Ban Treaty. A "zero-yield" treaty would ban any nuclear weapon test explosion or any other nuclear explosion. In committing the United States to this policy, the President stated that maintaining a safe and reliable nuclear weapons stockpile is a supreme interest of this country and that the Nation's Stockpile Stewardship and Management Program will ensure the safety and reliability of weapons in the enduring stockpile. The type of capability proposed for the DARHT Facility is essential to assuring the continued safety and reliability of the stockpile under a "zero-yield" test ban.

MAJOR CHANGES – DRAFT TO FINAL DARHT EIS

- DOE has added a Phased Containment Option to the Enhanced Containment Alternative.
- DOE's preferred alternative has changed from the DARHT Baseline Alternative to the Phased Containment Option of the Enhanced Containment Alternative.
- Two alternative sites within LANL have been identified as potential locations for the proposed vessel cleanout facility.
- Recent field surveys have confirmed the presence of a federally listed threatened species, the Mexican spotted owl, in the vicinity of the DARHT site. In consultation with the USFWS, measures have been identified to mitigate any adverse effect to the spotted owl.
- DOE has decided to propose to incorporate upgraded accelerator equipment within both the first and second axis of the proposed DARHT Facility.
- DOE has started preparation of the *Stockpile Stewardship and Management PEIS*.
- The final EIS includes unclassified aspects of the analysis contained in the classified supplement.

1.6.1 Phased Containment Option (Preferred Alternative)

The draft DARHT EIS indicated that DOE's preferred alternative for meeting its need for enhanced radiographic hydrodynamic testing was to complete and operate the DARHT Facility. Under this alternative, most tests and experiments would be uncontained tests – that is, the test assembly would be placed in the open air at the firing point, the high explosives would be detonated, and the DARHT Facility would be used to radiograph and measure the resulting explosion or implosion. The draft EIS also analyzed an Enhanced Containment Alternative with two options. Under the Vessel Containment Option, most tests and experiments would be conducted inside modular steel containers. Under the Building Containment Option, all tests and experiments would be conducted inside a concrete building that would enclose the firing point.

After reviewing the environmental impacts identified in the draft EIS, DOE reconsidered the advisability of conducting the majority of the future hydrodynamic testing program as uncontained tests. DOE noted that, over the past 50 years, the ongoing program of uncontained testing had contaminated the soil in the vicinity of the existing firing sites at TA-15, particularly as a result of tests with depleted uranium. DOE re-examined an earlier LANL suggestion to explore the use of modular steel containment vessels, which would require DOE to build a separate vessel cleanout facility to recycle the containers for repeated use.

At the same time, in response to DOE's invitation to comment on the draft DARHT EIS, many commenters indicated that they would prefer that more tests be contained. Many of the comments received agreed that further contamination from depleted uranium and other hazardous materials could be lessened if DOE would conduct most or all tests and experiments following one or the other of the Enhanced Containment Alternative options discussed in the draft EIS. Both the New Mexico Environment Department and the EPA expressed this point of view (see volume 2 of this EIS). In addition to public comments received, during consultations with American Indian Tribes and the USFWS, DOE agreed that containment would provide additional mitigation from flying shrapnel, which in turn could mitigate possible adverse impacts to cultural resource sites or wildlife.

The Enhanced Containment Alternative options analyzed in the draft EIS posed hypothetical "bounding" situations, where DOE based its analysis of environmental impacts on somewhat infeasible operating conditions. From a programmatic standpoint, however, either of these options would have serious design or operating limitations. For example, under the Building Containment Option the concrete containment structure would have to be very large in comparison to the firing site to contain the overpressure from an explosive test; DOE would forego the capability for experiments or tests using larger amounts of high explosives or some other specific types of large tests because of the structural limitations of the building. This option places limits on DOE's ability to conduct dynamic experiments with plutonium because of the difficulty in moving the large, double-walled steel containment vessels needed for plutonium experiments in and out of the containment building.

Under the Vessel Containment Option, the EIS analysis assumes that the DARHT Facility would begin operation with 75 percent of the tests and experiments conducted inside modular, single-walled steel containment vessels. However, the number of tests that could be conducted early in the operating life of the facility would be significantly reduced if this limitation were imposed. Although some conceptual work has been done, DOE has not yet designed the vessels. DOE would have to perfect a prototype vessel before fabricating all the vessels required. Also, the Vessel Containment Option depends on construction of a vessel cleanout facility; the design for this building could not be finalized until after the prototype vessels were perfected to determine the specific details of cleanout equipment, interface to the vessel, and other operational techniques. DOE estimates that it would take approximately 10 years beyond the availability date for the DARHT Facility to complete these activities and be able to conduct a full schedule of contained tests.

After considering the benefits of mitigation afforded by enhanced containment weighed against the programmatic constraints that would result from implementing either of the two Enhanced Containment Alternative options and in response to public comment on the draft EIS, DOE decided to analyze a third option, Phased Containment, and to designate this as the Agency's preferred course of action. Accordingly, in this final EIS the preferred alternative identified in the draft EIS (to complete and operate the DARHT Facility) has been renamed the DARHT Baseline Alternative; this alternative still serves as a starting point for other alternatives and provides a basis of comparison. The Phased Containment Option of the Enhanced Containment Alternative, now the DOE's preferred alternative, is essentially like the Vessel Containment Option except that implementation would be phased in over 10 years to reach the level of containment analyzed under the Vessel Containment Option. This would be accomplished in two 5-year increments over 10 years; the third phase would extend for the remainder of the operating life of the facility.

Implementing the Phased Containment Option would bring containment to the levels described in the Vessel Containment Option of the Enhanced Containment Alternative in the draft EIS for the last 20 years of the expected operating lifetime. This option would also allow DOE to proceed in the near-term to complete the DARHT Facility instead of waiting to design prototype vessels and the vessel cleanout facility, but would also allow DOE to take advantage of the additional environmental protection benefits of containing most tests and experiments in the future. DOE and LANL would develop operating procedures so that, if programmatic requirements so indicated, any given test or experiment could be performed uncontained (except for dynamic experiments with plutonium, which would always be contained in double-walled steel vessels). However, in the aggregate over the lifetime of the facility, most tests and experiments could be contained in vessels. The preferred alternative includes construction and operation of the vessel cleanout facility as part of DOE's proposal.

Because this EIS includes the proposed vessel cleanout facility as part of both the Vessel Containment Option and the Phased Containment Option (preferred alternative) of the Enhanced Containment Alternative, DOE has added site-specific details to this final EIS pertaining to the proposed cleanout facility. In the draft EIS, DOE mentioned generally that the facility would occupy about 1 ac (0.4 ha); in the final EIS, DOE identifies two specific 1-ac (0.4-ha) parcels and an access road location. DOE and LANL have conducted site-specific field surveys of the two parcels and the access road location to obtain additional environmental baseline data concerning cultural resources and biologic resources, specifically threatened and endangered species habitat. The two alternative sites and potential access road location are identified in section 3.7; environmental baseline information is identified in chapter 4 and analyzed in chapter 5.

1.6.2 Mexican Spotted Owl

The draft DARHT EIS included a discussion of federally listed threatened and endangered species, but did not mention the Mexican spotted owl, a species that was federally listed as threatened in November 1994. Just after the draft EIS was issued in May 1995, LANL biologists conducted their first field survey for the Mexican spotted owl and identified that suitable habitat existed in the vicinity of the DARHT site. Later in May, they documented field observations of two spotted owls and in June and July confirmed that the owls had successfully nested and fledged two owlets. The final EIS has been revised to include this information and the results of consultations between DOE and the USFWS.

The draft DARHT EIS stated that DOE had not yet started consultation with the USFWS under the requirements of Section 7 of the Endangered Species Act (ESA). Like NEPA, the ESA includes certain procedural provisions that a Federal agency must take to ensure that the habitat for threatened or endangered species is not jeopardized. Although NEPA regulations provide that a NEPA review should discuss the status of any consultations with the USFWS under the ESA, the NEPA review and the ESA process are independent regulatory requirements. The ESA review is initiated when an agency submits a completed biological assessment to the USFWS. DOE and LANL revised the draft biological assessment in May 1995 and included the new information on the Mexican spotted owls and the mitigation measures developed in consultation with the USFWS. DOE submitted the revised assessment to the USFWS in July 1995, and in August the USFWS concurred with DOE's finding that the DARHT Facility is not likely to adversely affect the Mexican spotted owl.

The final DARHT EIS includes updated information pertaining to the discovery of the Mexican spotted owls in the vicinity of the DARHT site (see section 4.5.4, chapter 5, and appendix K). It also includes a discussion of the process and results of the informal consultation between DOE and the USFWS (section 6.8 and appendix K). Mitigation measures agreed to between DOE, LANL, and the USFWS to protect the Mexican spotted owl and other wildlife and plant species are discussed in section 5.11.2 and appendix K.

1.6.3 Upgraded Accelerator Equipment

As part of the ongoing process for the development of technology for enhanced, high-resolution radiography capability, DOE has decided that it would be useful, cost-effective, and feasible to plan for upgraded accelerator and x-ray diagnostic equipment to be incorporated into all alternatives that propose to use accelerators as described in the DARHT Baseline. By extending the accelerators using existing designs to increase the minimum electron-beam energy, about 25 percent from a nominal 16 MeV to a nominal 20 MeV using new x-ray detection equipment, and by enhancing existing equipment to generate a higher current beam, DOE proposes to increase the output x-ray intensity by about 2 to 4 times while still maintaining the small x-ray spot size. The facilities proposed in the various alternatives in this EIS support the upgraded accelerator equipment without modifications in facility footprint or service. For the purposes of this EIS, DOE has decided to bound the impact analysis by considering electron beam energies of up to 30 MeV and output x-ray dose of up to 2,000 R. No additional environmental impacts have been identified between the draft EIS and the final EIS as a result of the proposed accelerator upgrade; however, project costs would be higher as shown in table 3-4.

1.6.4 Stockpile Stewardship and Management PEIS

The draft DARHT EIS was issued in May 1995, and although it referenced DOE's plans to prepare a *Stockpile Stewardship and Management Programmatic EIS* (PEIS), DOE did not formally issue its Notice of Intent to prepare the PEIS until June 1995. The text of the final EIS has been modified to reflect DOE's May 1995 report, *The Stockpile Stewardship and Management Program: Maintaining Confidence in the Safety and Reliability of the Enduring U.S. Nuclear Weapons Stockpile,* and the PEIS Notice of Intent (see section 2.6).

1.6.5 Unclassified Impacts for the Classified Supplement

DOE prepared a classified supplement as part of the DARHT EIS. The draft classified supplement was completed concurrently with the unclassified portion of the draft DARHT EIS in May 1995, and the final classified supplement was completed concurrently with this unclassified portion of the final EIS. After the draft EIS was issued and as part of its ongoing declassification efforts and normal classification reviews, DOE determined that most of the environmental impacts identified were not classified, although they depend on classified information. Accordingly, in May 1995, DOE issued an unclassified summary of the environmental impacts from the classified supplement. This was released after the draft EIS had already been distributed, but it was made available to the general public and was announced in the *Federal Register* and at the public hearings on the draft DARHT EIS. For the most part, this information discusses the potential for adverse impacts to workers and the public under routine and accident conditions during dynamic experiments with plutonium. Many people commented on the information contained in the unclassified summary (see volume 2). One commenter asked that DOE incorporate the results of the unclassified summary into this final EIS.

To provide the public with as full a disclosure as possible of the environmental impacts that will be considered by the DOE in deciding whether or not to proceed with the DARHT proposal, DOE has incorporated the results of the environmental impact analysis contained in the classified supplement into this unclassified portion of the final DARHT EIS. The human health impacts and accident scenarios analyzed are included in chapter 5 and appendixes H and I.

1.6.6 Other Changes

The final DARHT EIS reflects other changes made to update information, correct errors, and incorporate the suggestions and comments made by the state, tribes, other local governments and Federal agencies, the general public, and DOE and laboratory reviewers. Of note is information from two sources released just before this final EIS was issued: information from the President's statement of August 11, 1995, regarding this Nation's commitment to a Comprehensive Test Ban Treaty and moratorium on small-scale nuclear tests, and information from a report, *Stockpile Surveillance: Past and Future*, released August 7, 1995, by the three DOE weapons laboratories – LANL, LLNL, and Sandia National Laboratory (SNL) – that discusses the expected lifetimes of weapons systems in the enduring nuclear weapons stockpile and the potential for safety, reliability, or aging concerns based on past surveillance results.

1.7 NEXT STEPS

The ROD may be issued no sooner than 30 days after the final EIS. The ROD will explain all factors, including environmental impacts, that DOE considered in reaching its decision (see inside back cover). The ROD will specify the alternative or alternatives that are considered to be environmentally preferable. If the selected alternative is different from the environmentally preferred alternative, the ROD will present the rationale for its selection. DOE anticipates that, in addition to environmental impacts, the decision will be based on cost, technology, national security, and infrastructure considerations. If mitigation measures, monitoring, or other conditions are adopted as part of the Agency's decision, these will be summarized in the ROD as applicable, and included in a Mitigation Action Plan. The Mitigation Action Plan would explain how and when mitigation measures would be implemented, and how DOE would monitor the mitigation measures over time to judge their effectiveness. The Mitigation Action Plan must be in place prior to taking action that causes the impact. The ROD and Mitigation Action Plan also will be placed in the LANL Community Reading Room and will be available to interested parties upon request.

1.8 REFERENCE CITED IN CHAPTER 1

Johnson, K., et al., 1995, *Stockpile Surveillance: Past and Future*, August, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and Sandia National Laboratory.

Chapter 2
Purpose and Need for DOE Action

CHAPTER 2
PURPOSE AND NEED FOR DOE ACTION

This chapter specifies the underlying purpose and need for the Proposed Action.

2.1 OVERVIEW

One of the core responsibilities of the U.S. Department of Energy (DOE) is its role as steward of the Nation's nuclear weapons stockpile. The purpose and need for the proposed course of action analyzed in this EIS is part of that responsibility. The discussion in this chapter is augmented by the classified supplement to this EIS.

The President and Congress have directed that DOE ensure the safety, security, and reliability of the Nation's nuclear weapons stockpile. DOE and its predecessor agencies have held this responsibility for over 50 years, and DOE's custody of the nuclear weapons stockpile will continue for the foreseeable future. In response to the end of the cold war and changes in the world political regime, the emphasis of the U.S. nuclear weapons program has shifted dramatically over the past few years and the weapons stockpile is being greatly reduced.

For instance, the United States has halted the development and production of new nuclear weapons systems and has begun closing much of the former weapons production complex and consolidating the remaining elements. In addition, the

Date	*Event/Policy Change*
September 1991	The President made the first of three announcements on significant reductions in the nuclear weapons stockpile.
September 1992	The DOE performed the last underground nuclear test.
October 1992	The President signed a nine-month moratorium stopping all nuclear testing until July 1993.
July 1993	The President announced an extension of the moratorium on underground nuclear testing. The President directed DOE to develop alternative means for a stockpile stewardship program.
November 1993	A Presidential Decision Directive established the scope of the stockpile stewardship program and emphasized increased importance of hydrodynamic testing in the absence of nuclear testing. This was reaffirmed by the Secretary of Defense.
November 1993	In the National Defense Authorization Act [P.L. 103-160], Congress instructed the Secretary of Energy to "establish a stewardship program to ensure the preservation of the core intellectual and technical competencies of the United States in nuclear weapons."
July 1994	In the National Security Strategy, the President stated that the Nation would retain nuclear forces sufficient to deter foreign hostility and would also stem proliferation of nuclear weapons.
September 1994	The Secretary of Defense completed the Nuclear Posture Review and reaffirmed that nuclear weapons remain essential even though stockpiles will be reduced.
May 1995	Nonproliferation Treaty indefinitely extended.
August 1995	The President announces decision to seek zero-yield Comprehensive Test Ban Treaty and establishes conduct of science-based stockpile stewardship program as condition of U.S. Entry. Maintenance of a safe and reliable stockpile is considered "a supreme national interest of the United States."

Nation is observing a moratorium on underground testing of nuclear weapons (aboveground testing has been prohibited by treaty since 1963) and is pursuing a "zero-yield" international comprehensive test ban. Recent events and changes in U.S. policy that have affected the nuclear weapons program are summarized in the box on page 2-1.

The DOE program that responds to Presidential and Congressional direction to ensure confidence in the nuclear weapons stockpile is called the Stockpile Stewardship and Management (SS&M) Program (DOE 1995). This is an ongoing program that has evolved over time and whose goals are redirected from two former DOE programs: weapons research, development, and testing and stockpile support. Today's SS&M Program has moved away from DOE's past reliance on direct observations of nuclear tests toward ensuring weapons safety and reliability through a more challenging "science-based" approach to develop a greater scientific understanding of nuclear weapons phenomena and better predictive models of performance.

With the moratorium on nuclear testing, DOE now relies on advanced computational modeling and other types of experimental techniques, instead of direct observations of nuclear tests, to arrive at predictions of the safety and reliability over time for the weapons remaining in the nuclear weapons stockpile (LLNL 1994). DOE must use these tools to evaluate many issues regarding nuclear weapons, including:

- Age-related material changes discovered through routine stockpile surveillance
- Unexpected effects discovered with improved computer models
- Retrofits to existing weapons or components to improve safety or reliability
- New technologies applied to existing weapons or components to improve safety or reliability

Since the late 1940s, DOE and its predecessor agencies have used hydrodynamic tests and dynamic experiments in conjunction with nuclear tests to study and assess the performance and reliability of nuclear weapons primaries. In these types of experiments, test assemblies that mock the conditions of an actual nuclear weapon are detonated using high explosives. Radiographs (x-ray photographs) are used to obtain information on the resulting implosion; computer calculations based on these test results are used to predict how a nuclear weapon would perform.

Hydrodynamic tests and dynamic experiments have been an historical requirement to support the DOE's mission and remain essential elements of the SS&M Program, and they assist in the understanding and evaluation of nuclear weapons performance. Dynamic experiments are used to gain information on the physical properties and dynamic behavior of materials used in nuclear weapons, including changes due to aging. Hydrodynamic tests are used to obtain diagnostic information on the behavior of a nuclear weapons primary (using simulant materials for the fissile materials in an actual weapon) and to evaluate the effects of aging on the nuclear weapons remaining in the greatly reduced stockpile. The information that comes from these types of tests and experiments cannot be obtained in any other way.

DOE's existing capability to obtain diagnostic information was designed and implemented at a time when the agency could rely on direct observations of the results of underground nuclear tests to provide definitive answers to questions regarding nuclear weapons performance. Without the ability to verify weapons performance through nuclear tests, some remaining diagnostic tools are inadequate by themselves to provide sufficient information. Accordingly, as the Nation moves away from nuclear testing DOE must nhance its capability to use other tools to predict weapons safety, performance, and reliability. In articular, DOE must enhance its capability to perform hydrodynamic tests and dynamic experiments to ssess the condition and behavior of nuclear veapons primaries.

> On August 11, 1995, announcing his decision to seek a zero-yield Comprehensive Test Ban Treaty (CTBT), President Clinton stated:
>
> - "I consider the maintenance of a safe and reliable nuclear stockpile to be a supreme national interest of the United States."
> - "I am assured by the Secretary of Energy and the Directors of our nuclear weapons laboratories that we can meet the challenge of maintaining our nuclear deterrent through a science-based stockpile stewardship program without nuclear testing. I directed the implementation of such a program almost two years ago."
> - "The nuclear weapons in the United States arsenal are safe and reliable, and I am determined that our stockpile stewardship program will ensure they remain so in the absence of nuclear testing."
> - "While I am optimistic that the stockpile stewardship program will be successful, as President I cannot dismiss the possibility, however unlikely, that the program will fall short of its objectives. Therefore, in addition to the new annual certification procedure for the nuclear weapons stockpile, I am also establishing concrete, specific safeguards that define the conditions under which the United States can enter into a CTBT."
>
> One of the safeguards which condition U.S. entry into a CTBT is:
>
> - "The conduct of a science-based stockpile stewardship program to ensure a high level of confidence in the safety and reliability of nuclear weapons in the active stockpile, including the conduct of a broad range of effective and continuing experimental programs." *(From Fact Sheet released by Office of the Press Secretary along with text of President Clinton's announcement)*

lthough the current U.S. stockpile is nsidered to be safe and reliable, the existing eapons are aging beyond their initial design etimes and, by the turn of the century, the erage age of the stockpile will be older than any time in the past. To ensure continued nfidence in the safety and reliability of the S. nuclear weapons stockpile, DOE needs improve its radiographic hydrodynamic ting capability as soon as possible. icertainty in the behavior of the aging apons in the enduring stockpile will itinue to increase with the passage of time ause existing testing techniques, by mselves, are not adequate to assess the ety, performance, and reliability of the apons primaries. Should DOE need to air or replace any age-affected iponents, retrofit existing weapons, or ly new technologies to existing weapons, ting techniques are not adequate to assure pons safety and reliability in an era iout nuclear testing; DOE believes that it robable that the existing weapons will ire these types of repairs or retrofits in foreseeable future. DOE has determined no other currently available advanced niques exist that could provide a level of mation regarding nuclear weapons aries comparable to that which could be ined from enhanced radiographic odynamic testing.

ldition to weapons work, DOE uses its graphic testing facilities to support many science missions and needs to maintain iprove its radiographic testing capability iis purpose. Hydrodynamic tests and nic experiments are important tools for evaluating conventional munitions; for studying dynamics, materials physics, and high-speed impact phenomena; and for assessing and developing iques for disabling weapons produced by outside interests.

2.2 POLICY CONSIDERATIONS

In responding to the Nation's need to ensure safety, security, and reliability of the nuclear weapons stockpile, DOE must consider national policy regarding nuclear deterrence and stockpile stewardship.

2.2.1 Nuclear Deterrence

Nuclear deterrence remains a cornerstone of U.S. policy, and this Nation will continue to rely on DOE to maintain a safe, secure, and a reliable nuclear weapons stockpile. In the past, DOE has been able to accomplish that mission by retiring weapons before the end of their design life and by upgrading or redesigning weapons, if potential problems were detected, through nuclear testing and hydrodynamic tests and dynamic experiments (see figure 2-1). However, the President has discontinued underground nuclear testing and has decided that the United States will not build new nuclear weapons for the foreseeable future (even to replace those removed when past their useful life). Thus, under current U.S. policy, DOE would not produce new-design nuclear weapons.

Now DOE must rely more than ever on the data from hydrodynamic tests and dynamic experiments to ensure the safety and reliability of the weapons. The level of information received from underground nuclear testing cannot be fully replaced by current or upgraded hydrodynamic testing facilities. However, information that would be obtained from enhanced hydrodynamic capability would provide a higher level of confidence in maintaining the nuclear weapons stockpile in the absence of underground nuclear testing.

2.2.2 Stockpile Stewardship and Management

Since the 1940s, DOE and its predecessor agencies have been responsible for ensuring the

Secretary of Energy O'Leary, in April, 1995, stated to the U.S. Senate Committee on Armed Services:

- "In the past, our confidence in the stockpile was ensured through weapon research and development in the laboratories and underground nuclear testing at the Nevada Test Site. In July 1993, the President announced a moratorium on underground nuclear testing that he recently extended until September 1996..."
- "The current stockpile is safe, secure, and reliable. However, the history of the stockpile has shown that continuous surveillance, repair, and replacement of components and subsystems is commonplace. In fact, the seven weapons that will be in the enduring START II stockpile have already been retrofitted to varying degrees and some have had major components of the nuclear system replaced. We cannot predict with any certainty whether or when such problems will arise in the future, but we must be equipped to respond effectively should they materialize."

The Nuclear Posture Review, completed by the Secretary of Defense in September 1994, reaffirmed that in today's security environment nuclear weapons remain essential even though nuclear weapons stockpiles will be reduced. The Review outlined:

- A future nuclear posture with a focus on maintaining good stewardship of the weapons remaining in the national stockpile
- A continuing relationship between DOE and the Department of Defense under the aegis of the SS&M Program to maintain a reliable, safe, and secure nuclear stockpile
- Actions to ensure a stockpile stewardship program within the bounds of a future comprehensive test ban treaty
- The Department of Defense requirements for DOE to, among other things, maintain nuclear weapons capability (without underground nuclear testing or fissile material production), while emphasizing that there is no foreseeable need for new-design nuclear warhead production

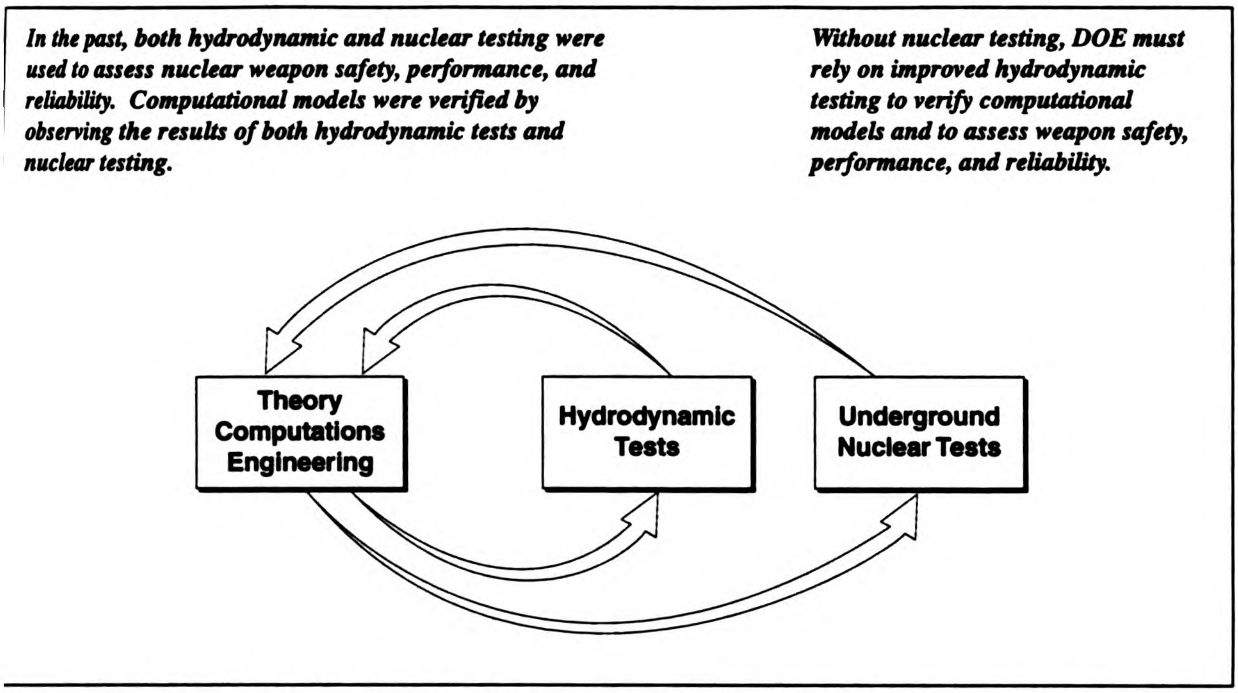


FIGURE 2-1.—*Prior Relationship of Hydrodynamic Tests and Underground Nuclear Tests to Nuclear Weapon Safety, Performance, and Reliability Assessments.*

:ty, security, and reliability of the lear weapons in the stockpile. s stockpile stewardship assign- ıt has always required hydro- amic testing and was included in Atomic Energy Act U.S.C. 2011 et seq.], along with responsibility to design, ufacture, and certify nuclear pons. DOE now intends to mplish this mission through the :M Program. The SS&M ram is a single, highly integrated ıical program for maintaining the y and reliability of the U.S. :ar stockpile in an era without :ar testing and without new ›ons development and produc- This new approach must rely :ientific understanding and :ment, not on nuclear testing and evelopment of new weapons to ct, identify, and correct prob- affecting the safety and relia- of the stockpile (DOE 1995).

> ***STOCKPILE STEWARDSHIP & MANAGEMENT***
>
> ***Stockpile Stewardship*** – Includes activities required to maintain a high level of confidence in the safety, reliability, and performance of nuclear weapons in the absence of underground nuclear testing.
>
> ***Stockpile Management*** – Includes activities required to dismantle, maintain, evaluate, and repair or replace nuclear weapons in the existing stockpile.

> President Clinton, in the National Security Strategy, July 1994, stated:
>
> - "Even with the Cold War over, our nation must ... deter diverse threats."
> - "We will retain strategic nuclear forces sufficient to deter any future hostile foreign leadership ... Therefore we will continue to maintain nuclear forces of sufficient size and capability to hold at risk a broad range of assets valued by such political and military leaders."
> - "A critical priority for the United States is to stem the proliferation of nuclear weapons and other weapons of mass destruction and their missile delivery systems."

DOE's three weapons laboratories [Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Sandia National Laboratories (SNL)] perform the stockpile stewardship mission. These laboratories are asked to identify, develop, and implement selected tools – programs and facilities – needed to achieve their assigned responsibilities. Through the directors of the weapons laboratories, DOE must certify that nuclear weapons will not accidentally detonate during storage and handling (safety), that the weapons would thwart any attempts for unauthorized use (security), and that they would function as designed in the event of authorized use (performance and reliability).

> President Clinton, in the Presidential Decision Directive of November 1993, stated:
>
> - Stockpile stewardship will use past nuclear test data in combination with future nonnuclear test data, along with computational modeling, experimental facilities, and simulators to further comprehensive understanding of nuclear weapons.
> - Stockpile stewardship will include stockpile surveillance, experimental research, development and engineering programs, and maintaining a production capability to support stockpile requirements.
> - Achieving stockpile stewardship objectives will require continued use of current facilities and programs, a limited set of new experimental facilities and computational facilities and programs, and periodic review and evaluation of program elements.
> - In the absence of nuclear testing, hydrodynamic testing programs have increased in importance. These programs include developing baseline hydrodynamic experimental data for the enduring stockpile and increasing the number of hydrodynamic experiments as part of the stockpile sampling and aging evaluation programs.
> - Hydrodynamic testing is also needed to support a development program necessary to help retain and exercise weapon design engineering skills and to examine safety modifications in existing nuclear warhead designs that could be introduced into the stockpile without nuclear testing in case they are needed in the future.
> - The future hydrodynamic testing program requires ongoing support from the DOE and Department of Defense for research, development and testing activities; the program requires increased funding for constructing upgraded experimental facilities as well.

For almost 50 years, nuclear tests were key to gathering data used for developing nuclear weapons and certifying their safety, reliability, and performance. Nuclear tests were also used to evaluate the effectiveness and certify performance of weapons that were redesigned. Since the 1992 moratorium on nuclear tests, DOE has recognized that a new approach, based on scientific understanding and expert judgment, is needed to ensure confidence in a nuclear deterrent and the U.S. stockpile. Given the moratorium on nuclear testing, the termination of new weapons development, and closure of weapons manufacturing and production facilities, this confidence will depend on the competence of the people who must make the scientific and technical judgments related to the safety and reliability of U.S. nuclear weapons. Those people must have a fundamental understanding of the basic scientific phenomena associated with nuclear weapons.

DOE's SS&M Program has been developed to meet three particular challenges (DOE 1995).

- Fully support the Nation's nuclear deterrent while transitioning to a more appropriate nuclear weapons complex.
- Preserve the core intellectual and technical competencies of the weapons laboratories.
- Ensure that stewardship and management activities are compatible with the Nation's arms-control and nonproliferation objectives.

)OE identified five critical issues and strategies to address them (DOE 1995). Two of the strategies ;peak directly to DOE's continuing need for enhanced radiographic hydrodynamic testing capability.

- **Enhanced experimental and computational capabilities:** These include aboveground experimental capabilities to study technical issues regarding weapons primaries, specifically high-resolution, multiple-time, multiple-view hydrodynamic experiments using simulant materials.
- **Enhanced weapons and materials surveillance technologies:** These include hydrodynamic testing on test units built, when possible, with aged stockpile components (with modified pits using simulant materials) to provide important data on the effects of aging on weapons safety and performance.

)E must be able to preserve the current high confidence in the safety and performance of the U.S. ›ckpile. Confidence is subjective; rests on the judgement of people; and is based on information, perience, and trust. In some cases, the Nation might be willing to forego the means to ensure a higher gree of confidence in the condition of its nuclear weapons in favor of some other value, as was the case ıen the Nation decided to accept a moratorium on underground nuclear testing. Preserving high ıfidence in the enduring stockpile without nuclear testing will require an improved, more complete, and re accurate understanding of the underlying physical principles involved in nuclear weapons and new or ıanced experimental capabilities (DOE 1995). DOE has determined that to ensure the continued ıfidence in the safety and reliability of the enduring stockpile, its hydrodynamic testing programs have reased in importance. They are an essential means to develop baseline experimental data, to determine effects of aging, and to use as a tool for stockpile sampling; therefore, an enhanced radiographic rodynamic capability is needed as soon as possible.

NEED FOR ENHANCED RADIOGRAPHIC CAPABILITY

: has determined that it needs to obtain an enhanced capability to conduct radiographic hydrodynamic and dynamic experiments. The capability to obtain high-resolution, multiple-time, multiple-view mation is needed to assess safety, performance, and reliability of weapons; evaluate aging weapons; n information about plutonium through dynamic experiments; and for other uses.

)OE's determination has been independently confirmed by a panel of technical experts who studied equirements for the DOE SS&M Program (JASON 1994). DOE has determined that aboveground, graphic diagnostics are the best means – and for some parameters, the only known means – to obtain eeded information, and that linear induction accelerators (the technology proposed for DARHT) ent the best available technology to produce the high-speed, high-resolution, deeply penetrating graphs that are needed. In addition, DOE has determined that no other advanced technology is ıtly available that could provide a comparable level of information. DOE's conclusions have been endently verified by panels of consultants convened to consider these issues (JASON 1994; HPAIC DFAIC 1992; and DOE 1993). The major points considered in these reviews included the ability of to penetrate ultra-dense materials at the late stages of an implosion, temporal resolution of the moving materials, spatial resolutions in the resulting image, and the need for an additional axis (or o provide three-dimensional information. The capabilities and limitations of current facilities are ›ed in section 2.4.

2.3.1 Assessing Weapons Safety, Performance, and Reliability

Purpose of SS&M Program Critical Issues and Strategies

- Maintaining stockpile confidence without nuclear testing – enhanced experimental and computational capability
- Reducing the vulnerability of a smaller stockpile – enhanced weapon and materials surveillance
- Providing an effective and efficient production complex – consolidated/downsized and new manufacturing approaches
- Providing long-range stockpile support – greater emphasis on preventive versus corrective maintenance
- Ensuring an adequate tritium supply

To ensure the continued viability of the smaller stockpile, DOE must improve its scientific understanding of the physics of a nuclear weapon beyond its design life, and develop a better understanding of how a nuclear weapon behaves during the complex interactions that occur in the brief interval between high-explosive detonation and nuclear explosion. This information is needed to assure the continued safety, performance, and reliability of existing weapons. Two examples of specific problems that involve both a fundamental understanding of weapons reliability and potential issues concerning stockpile aging are the process and efficiency with which boosting occurs (see figure 1-2), and the critical configurations required for materials at late stages of implosion. Both of these examples are best studied with the high-energy, high-dose, short-pulse capabilities planned for DARHT.

DOE has not yet determined how to predict with sufficient accuracy, from computer calculations alone, the rapidly changing shape of a weapons primary during the last stages of implosion. However, this information is essential to predict the safety, performance, and reliability of a nuclear weapon. At this time, the highest priority issues for stockpiled primaries are those that affect the successful ignition of the deuterium-tritium boost gas. DOE needs to be able to predict the implosion movement of the three-dimensional weapons assembly to provide an integral measure of the expected performance of the fission drive, to assess nuclear safety in accidents, and for render-safe and disablement effectiveness. Current diagnostic capabilities are insufficient to make all of the necessary types of measurements of an imploding primary or to make refined measurements at the high level of detail needed. Therefore, DOE needs to establish an enhanced diagnostic capability to make the necessary types of measurements at the desired level of detail. These kinds of technology issues would also arise in weapons design; but, under current U.S. policy, DOE does not develop or produce new-design weapons systems.

The safety aspect of DOE's stockpile mission arises from concerns about how a primary would behave if the high explosives were unexpectedly detonated in scenarios such as a transportation accident, damage from a projectile, or a nearby fire or explosion. In these instances, the high explosive would not be detonated in the manner required to trigger a nuclear explosion; but such an explosion could affect the primary. Even if nuclear yield did not result, an accidental detonation of the high explosives within a nuclear weapon could result in vaporizing or scattering plutonium metal or other hazardous materials. Assuring safety requires knowing how the primary materials might be affected by these explosion conditions.

Prior to the President's moratorium on nuclear testing, the United States used both hydrodynamic and nuclear testing to obtain information needed to assess nuclear weapons safety, performance, and reliability. Nuclear testing at appropriate nuclear yields allowed DOE to maintain the stockpile and its nuclear xpertise with very high confidence; the erformance and safety of the enduring tockpile was validated by such tests. lecause of the moratorium on nuclear sting, DOE did not complete all of the nderground nuclear tests that had been anned. Certain types of data gaps, hich the design laboratories expected be partially filled by analyzing the sults of nuclear tests, remain unfilled.

ithout nuclear testing, mathematical culations based on experimental data uld be the only way to obtain needed ormation on weapons performance l reliability. However, theoretical thematical calculations alone cannot relied on to predict the behavior of a lear weapons primary; the ulations must be verified against al experimental data. DOE siders enhanced radiographic rodynamic testing to be the best (and me areas, the only known) tool to in certain types of information rding weapons primaries. These are needed to verify and refine ictive analytical models.

era during which nuclear testing iot be performed, DOE will have to s weapons safety, performance, and ility in other ways. Enhanced graphic hydrodynamic testing l provide a powerful tool for menting the SS&M Program. ier or not this approach will fully the need for stockpile assurance it nuclear testing is not completely ; and, it will not be known for l years after an enhanced lynamic capability, among other s put into place and test results are analyzed. The possibility exists that, without nuclear testing, the cannot ensure the continued viability of a nuclear deterrent based on the existing weapons in the weapons stockpile. The sooner DOE can obtain better diagnostic information, the sooner the can determine if its existing nuclear deterrent is sufficient. Conversely, the longer the Nation waits an enhanced capability is achieved, the greater the chance that a problem will arise that cannot be

CHANGES CAN AFFECT PRIMARIES

A nuclear weapons primary is part of the weapons' nuclear package (see figure 1-2). The primary is where the nuclear fission process starts. Many complex physical and chemical interactions occur during the split second that the primary operates. If the primary does not work properly, the secondary will not work properly. The interactions in a weapons primary are extremely complex. Changes as small as thousandths of an inch, or less than millionths of a second, can affect its margin of safety or performance.

High Explosives (HE). The primary contains HE which surrounds a metal pit. When a weapon is detonated a series of steps occur very rapidly in a controlled sequence. First the HE is detonated. After the detonators are triggered, a wave of detonation passes through the main HE charge. The HE burn and the detonation wave can be affected by the type of explosive and its chemistry, the grain size, impurities, manufacturing method, and gaps in the HE assembly, among other things. If the HE does not detonate as designed, the pit may not implode properly but may still blow apart, scattering plutonium metal or other materials.

Pit Implosion. The pressure caused by the detonating HE causes a shock wave to travel through the pit material. The pit responds in a complex set of interactions as it implodes radially to a compact shape. As the shock wave crosses the pit, small amounts of material may be ejected from each interface, which may or may not affect the implosion. The response of the pit – how the metal moves, flows, or melts, for example – is complex and depends on dynamic materials properties which can be affected by factors associated with component fabrication as well as by the intrinsic properties of specific materials (particularly plutonium). DOE has limited data on some aspects of the properties of plutonium and other pit materials, especially at the high strain rates associated with pit implosion. If the pit does not implode properly, the boosting process may be affected.

Boosting. The tritium-deuterium boost gas is heated by the pit implosion and the onset of the fissioning process. The heated boost gas undergoes nuclear fusion and generates large numbers of high-energy neutrons. These enter the fissile pit material and cause subsequent fissioning. These boost-induced nuclear interactions generate additional fission yield, "boosting" the nuclear yield of the primary. If boosting does not occur properly or is inadequate, weapons performance may be dramatically decreased.

addressed with the current capability, in a manner that is sufficient to ensure the necessary level of confidence in the nuclear weapons stockpile. Such circumstances could lead, pursuant to a Presidential announcement in August 1995, to U.S. withdrawal from a Comprehensive Test Ban Treaty (CTBT) under a "supreme national interest" clause to conduct necessary nuclear tests.

Baseline research is expected to take several years and will involve many different types of calculations, tests, and experiments performed at different DOE weapons facilities, primarily LANL, LLNL, and SNL. Baselining to document the correct physical status of the weapons systems will involve a broad range of observations, measurements, and tests. Hydrodynamic testing is one activity that would support baseline research and supply specific information needed to answer particular questions about the safety and performance of nuclear weapons. The extent and duration of these activities will depend on the nature of the results, but several years is the best early estimate.

2.3.2 Evaluating Aging Weapons

Although the U.S. nuclear weapons stockpile is presently safe and reliable, the nuclear weapons in today's U.S. stockpile are aging. Existing weapons, on the average, are about 15 years old, and in about 5 years, many weapons will begin exceeding their original design lifetime. In the past, individual weapons in the stockpile were replaced by new-design, upgraded, or replacement weapons before they approached the end of their design life. However, because the United States is not currently producing new nuclear weapons, DOE does not anticipate replacing the weapons now in the stockpile before the end of their original design life. This creates uncertainty about the safety and performance capability of the remaining weapons as they continue to age because DOE does not know how the weapons will behave over the long term.

DOE believes that inventorying or benchmarking the condition of weapons and their expected performance characteristics is needed as soon as possible. This would provide a baseline for comparing future surveillance observations and performance tests over the period of time that the weapons will eventually be called upon to serve in the stockpile. DOE would use many diagnostic tools at several of its sites to assist with benchmarking the inventory, which is expected to take several years. DOE would use enhanced radiographic hydrodynamic testing capability to accurately benchmark weapons primaries. The sooner that benchmarking takes place, the sooner DOE would have more reliable data and could be more certain about the condition of the weapons remaining in the stockpile. DOE would expect that aging or other types of problems would be discovered through surveillance activities, including "static" radiographs of weapons and components. These "static" radiographs can use long x-ray exposure times and, therefore, can be

> In August, 1995, an independent panel of experts, the JASONS, stated:
>
> To maintain high confidence in the safety, reliability, and performance of the individual types of weapons in the enduring stockpile for several decades under a Comprehensive Test Ban Treaty (CTBT), the United States must provide continuing and steady support for a focused, multifaceted program to increase understanding of the enduring stockpile; to detect, anticipate and evaluate potential aging problems; and to plan for refurbishment and remanufacture, as required. In addition the U.S. must maintain a significant industrial infrastructure in the nuclear program to do the required replenishing, refurbishing, or remanufacturing, of age-affected components, and to evaluate the resulting product; for example, the high explosive, the boost gas system, the tritium loading, etc.

obtained without using DARHT facilities. Static radiographs, are also taken in preparation for dynamic experiment or hydrodynamic tests, before the high explosive charge is detonated and aligned. The static radiograph provides a picture of the initial condition of the test assembly and hence, defines the initial condition of an experiment.

As materials age, particularly those used in nuclear weapons, they tend to change. DOE weapons personnel can predict some types of changes that would be expected to occur over time in the materials that make up the weapons. However, other effects, which aging may bring about on the performance and reliability of these weapons and on their behavior under certain postulated accident conditions, are largely unknown. DOE needs to ensure that aging weapons remain safe and reliable. Should systems in aging weapons need to be reengineered or replaced, DOE needs a capability to validate that the replacement systems would not compromise weapons safety, reliability, or performance. Sophisticated manufacturing processes are not always easy to replicate once they have been dismantled. If weapons components are to be remanufactured, testing (nonnuclear) the products from this process is an important tool for reducing uncertainty about any significant differences from the original product. DOE also must be able to predict the physics behavior that would be expected from an aging weapon under abnormal conditions, such as those that might occur in an accident or those that might lead to changes in the material properties.

Many complex systems, including some weapons systems, experience a

Stewardship of Nuclear Weapons Primaries

Confidence in the weapons in the enduring stockpile is based to a large extent on ensuring the safety and reliability of the weapons' primary. The boost, yield and implosion of the primary are key concerns regarding reliability. The primary contains the main high explosive (HE) charge and plutonium that would be the focus of safety concerns.

Age Related Changes

Material degradation and imperfections caused by aging can profoundly affect the performance of the primary. Every component in a nuclear weapon may exhibit changes as the weapon grows older. It is relatively easy to replace many of the weapons' electrical parts or other components. However, nuclear components can not be readily repaired or exchanged without taking the entire weapon apart, replacing the nuclear components with remanufactured or retrofitted parts, and reassembling the weapon. This could require that DOE recertify that the weapon is safe and reliable. Replacing nuclear components and recertifying a weapon is expensive.

Age-related changes that can affect a nuclear weapons primary include:

- Structural or chemical degradation of the HE leading to a change in explosives performance, or migration of HE.
- Changes in plutonium properties as impurities build up inside the material due to radioactive decay.
- Corrosion along interfaces, joints and welds.
- Chemical or physical degradation of other materials or components.

Weapons Safety and Reliability

The effects of aging on weapons components can affect their long-term safety and reliability. Safety may be affected by chemical or structural changes in the HE or detonators, which may lead to altered response to impact or fire. Corrosion or cracking may compromise fire-resistant layers in an accident. The reliability of the primary could be affected by changes that might perturb the primary implosion, and their effect on boosting.

If the effect of aging on the weapons' components is serious enough to require that the part be replaced, it is possible that the steps that would need to be taken to correct the problem could introduce additional changes that could affect the weapons' performance or safety. DOE must be able to ensure that the safety or reliability of the primary would not be compromised if the components were replaced. This requires the same special skills and expert judgment needed for a new design. Even very small changes in a weapons primary could dramatically affect the weapons performance, and remanufacturing or replacing the primary components could introduce these types of changes.

WHY RETROFIT EXISTING WEAPONS?

A nuclear weapon may contain over 6,000 parts; the nuclear package, which contains the weapons primary and secondary assemblies, has about 300 parts (see figure 1-2). DOE continually monitors the condition of nuclear weapons through its surveillance program, where weapons are returned from the stockpile, taken apart, and examined. Some parts are tested and damaged or destroyed in the testing process. Through the surveillance program, DOE may find that any one of the thousands of parts in a weapon is defective. There may have been a miscalculation in the original design, a manufacturing error, or a part may have expanded, cracked, shifted, or deteriorated over time. In addition to observations through the surveillance program, new or improved computer codes may disclose that a weapon component may be defective or may not function as intended. Sometimes defective parts may be limited to a small number of warheads, and sometimes the defect may extend through an entire series of weapons ("common mode failure").

DOE must be able to replace parts that are destroyed through the surveillance process; and, if the examination reveals that a weapons part is defective or has changed, DOE must be able to decide whether to replace the part, redesign the part, or leave the part in place if the safety or performance of the weapon is still acceptable.

When the weapons were built, DOE manufactured some spare parts to replace those expected to be used up in surveillance testing. DOE did not manufacture spare parts for all components and could not foresee which components might need to be replaced.

Based on past experience, DOE expects that in the future some replacement parts will need to be manufactured, particularly as the existing weapons get older and the original parts degrade or change over time. In some cases, replacement parts will have to be redesigned or reengineered to solve defects or other problems uncovered by the surveillance program. In addition, DOE expects that as new technologies are developed, some parts will be replaced to take advantage of these improvements. DOE must be able to ensure that repaired, replaced, or newly developed parts will perform as expected and will not cause an unexpected problem within the entire weapons system. Hydrodynamic tests and dynamic experiments would continue to be one tool that DOE would use to ensure the safety, performance, and reliability of weapons in the enduring stockpile.

At first, it might seem that further testing of weapons systems would be unnecessary if DOE would remanufacture replacement parts to the original design specifications. However, this process would be impractical and would not avoid the need for future tests. Many weapons components were manufactured using machinery, such as large metal presses or milling equipment, that were cost-effective only for large production runs at facilities that now have been shut down, such as the DOE Rocky Flats Plant. In some cases the process lines, materials, tools, and equipment that were used for the original parts are no longer available. Manufacturing processes that were state-of-the-art when the original weapons were manufactured are now obsolete. Manufacturing specifications are never all-inclusive and some details of practice that were employed or manufacturing conditions (such as temperature or humidity) may not have been fully documented or would be difficult to reconstruct. DOE could not realistically expect the exact duplication of all production processes and practices and could not expect an exact replication of certain components. Therefore, the parts would still need to be tested.

Remanufacturing is, of course, only of interest for those cases when the original design specifications were correct. In those instances when the original design or manufacturing processes were faulty, there would be little incentive to duplicate them.

Based on these considerations, DOE has concluded that remanufacturing alone is not sufficient to maintain the enduring nuclear weapons stockpile and that remanufacturing would not offer an alternative approach to stockpile maintenance that would avoid future weapons testing.

story of early problems, but their number and frequency decrease with time. This downward trend is a sult of experience. Later, these same systems will show the effects of aging and the trend for problems ay increase. Currently, most existing stockpile systems are believed to benefit from the experience ctor, but are not yet suffering the increased problems due to aging. The potential for an eventual crease in problems is normal and expected.

)E has considerable evidence to indicate that, as weapons age, problems related to the deterioration of apons components can and do occur. Before the recent changes in policy, most weapons were replaced newer systems before their design life had been exceeded. Therefore, most of the historical ormation on safety, reliability, or performance of stockpiled weapons was related to issues that arose expectedly before the end of their design lifetime. DOE has 50 years of experience in solving a wide ersity of issues (e.g., the large number of ways that materials can crack, corrode, or otherwise degrade) l in increasing its understanding of plausible accident scenarios. This experience helps prevent exact urrences of past problems, but it does not prevent new issues from arising.

E operates direct surveillance programs that have been ongoing for more than 40 years. Under one of e programs, every system in the stockpile is examined each year; a given number of weapons for each em are taken as a representative sample and examined. The direct surveillance program may detect s of failures that could affect the dynamic performance of either the high explosives or other primary erials during the implosion process.

tself, weapons surveillance is not adequate to predict and resolve performance or reliability problems. ertify a weapons system, prototype systems were tested extensively, using both nuclear testing and odynamic tests, before any production of stockpile weapons was authorized. DOE relies on its cpile surveillance program to observe post-production problems for weapons in the stockpile. Once a lem is discovered, DOE must determine the impact that the problem might have on weapons safety or rmance and reliability. The probable impact of an observed change is calculated based on known uter codes and then corroborated with experimental testing.

ugh certain limited-life components were designed to be replaced (such as batteries) or replenished as tritium gas reservoirs), other essential components of weapons were presumed to last the life of eapon. High explosives, primaries, secondaries, and radiation cases were not designed to be replaced s testing programs indicated that a problem existed with a given component. However, the metals, explosives, and other materials that make up the weapons in the existing stockpile are known to he possibility of becoming brittle, cracked, or otherwise show changes in their material properties xtended periods of time. The question faced by weapons personnel is whether these changes, if they would affect the safe handling characteristics or performance reliability of the weapons.

ree weapons laboratories (LLNL, LANL, and SNL) conducted a study, *Stockpile Surveillance: Past uture* (Johnson et al. 1995), to review the results of past surveillance and make recommendations for actions needed to ensure the safety and reliability of the stockpile. The report notes that, in the ignificant problems have been found in the stockpile and that changes to stockpiled weapons have nade to assure safety, performance, and reliability; it also notes that problems have been found in f the weapons types expected to be in the stockpile in the year 2000. The study concludes that it is ible to expect that problems will continue to arise in the stockpile at the rate of one or two defects r that would require action as the stockpile ages beyond the original design expectations.

The nuclear weapons stockpile, projected for the year 2003 and beyond, would be smaller than the U.S. has had at any time since 1959. The newest weapons in the future stockpile would have been built in 1990, the average age of the stockpile in 2005 would be 20 years, and the oldest weapons would be about 28 years old. Under the present plans for continued downsizing, some weapons will remain in the stockpile for more than 40 years. Until the past few years, there has been no expectation that weapons would remain in the stockpile longer than they have in the past (about 20 years or less). Continuous modernization to improve the safety, reliability, and performance kept the stockpile relatively young as new weapons types replace old ones. With no new weapons entering the stockpile, the existing nuclear deterrent is steadily aging (Johnson et al. 1995).

The three weapons laboratories have updated their "Defects Database," which now contains more than 2,400 entries. Although specific details are classified, more than 370 cases have resulted in some kind of action due to safety or reliability concerns; 46 of the 50 weapons-types studied have had at least one problem; and problems not requiring actions to the nuclear components affected 39 weapons types (Johnson et al. 1995).

Until 1992, the U.S. used underground nuclear tests to test the full operation of a weapons system and to assure that the nuclear package would operate as intended. These tests contributed to a broad range of weapons research and design activities, from development of new weapons to stockpile confidence tests (tests to verify performance of already-manufactured weapons that have entered the stockpile). In the past, nuclear tests identified certain classes of problems not observed through the surveillance program, such as the lack of one-point safety for several weapons types previously deployed in the stockpile. In addition, nuclear tests were used to resolve issues raised by the surveillance program such as whether a particular corrosion problem would affect nuclear yield. They have been used to verify the efficiency of design changes, such as the adequacy of certain mechanical safing techniques. Nuclear testing also was used to prove that a potential problem that could have been expensive or difficult to fix did not exist (Johnson et al. 1995).

There have been 17 stockpile confidence tests since 1972, including a test of each of the weapons types expected to remain in the stockpile well into the next century. In addition, there have been at least 51 additional underground nuclear tests since 1972 involving nuclear components from the stockpile, weapons production lines, or specification builds. Five of these tests revealed or confirmed a problem that required corrective action. Six tests confirmed a fix to an identified problem; and five tests investigated safety concerns affecting three warhead types and confirmed that a problem did not exist (Johnson et al. 1995).

In a future without nuclear testing, DOE's ability to assess nuclear components will be more difficult and DOE must rely on other testing means to compensate for having set aside nuclear testing. This comes at the same time that the Nation has accepted reliance on a smaller, older, stockpile to serve as a nuclear deterrent for the foreseeable future. At this juncture of fewer diagnostic tools, and when confidence in the long-term capability of the stockpile becomes more uncertain, DOE needs to enhance its capability to make the best use of proven techniques.

DOE cannot predict with certainty when safety or reliability concerns will arise in the future, but DOE anticipates that problems will be discovered more frequently as weapons become older and exceed their original design lifetime. Because the weapons will become older than any weapons with which DOE has had experience, there will be a need to address and correct problems not previously encountered. Of the weapons types introduced since 1970, nearly one-half required nuclear testing following their development (either while they were deployed or still being produced) to verify, resolve, or certify that problems relating to safety or reliability were resolved. A majority of these problems involved the primary stage of the weapon. Since 1970, several thousand weapons have been removed from the active stockpile for major modification or have been accelerated on their path to retirement, to fully resolve such safety or performance reliability concerns.

One example of unanticipated problems is the now-retired W68 warhead for a submarine-launched ballistic missile. Routine surveillance disclosed a premature degradation of the warhead's high explosive. Without modification, the problem ultimately would have rendered the weapon inoperable. Consequently, the weapons were disassembled and the high explosive replaced with a more chemically stable formulation. In addition, because some of the materials used in the original production were no longer available commercially, some additional changes were made in the rebuilt weapon. Nuclear test data were used to assure that the high explosive and other changes would not compromise adequate performance of the weapons. DOE performed a nuclear test to verify that the rebuilt weapons would perform as designed and was surprised to find that the weapon yield was degraded. However, DOE decided that the lower yield was acceptable. This example and others have been summarized in a 1987 unclassified report to Congress by Drs. George Miller, Carol Alonso, and Paul Brown (Miller et al. 1987).

The Miller report describes a number of weapons systems that have been in the Nations's stockpile. This report documents several examples of unanticipated problems that arose following deployment of a weapons system to the stockpile. This report is valuable because it provides historical examples of some problems with systems in the stockpile. However, the Miller report and several similar reports in the open literature have some important limitations. They cannot present classified information, which is especially important for the more recent systems in the enduring stockpile. As a result, these reports do not provide good bases for statistical conclusions about the rates or types of problems encountered. Still, the examples given will portray the existence of unanticipated problems in post-deployment systems.

Following publication of the Miller report, a one-point safety problem was identified in the W79 systems by way of nuclear testing. One-point safety implies that a device will not produce nuclear yield if its high explosive is detonated at any single place. This one-point safety greatly limits the impacts from a broad range of accident scenarios.

In the absence of nuclear testing, DOE must rely more heavily on hydrodynamic testing to provide the same assurance of safety, performance, and reliability – particularly to verify, resolve, or validate fixes to problems in existing systems. DOE considers enhanced radiographic hydrodynamic testing to be a crucial tool for producing information on the effects of aging within weapons primaries.

2.3.3 Dynamic Experiments with Plutonium

Some components of nuclear weapons contain plutonium, which is a material with unique behavioral characteristics. As part of its effort to better understand the materials science aspect of nuclear weapons aging and performance, DOE needs to develop a better understanding of the physical properties of plutonium. In metal form, plutonium is an extremely heavy, dense silvery metal; it is sometimes stored as an oxide or in solution. Any form of plutonium may react with water, plastics, metals, or other materials with which it comes into contact. It is important that the DOE weapons laboratories have the tools to study the various forms of plutonium and its physical properties and have an ability to evaluate and predict plutonium behavior under dynamic conditions (conditions involving very rapid motion).

Currently, the body of knowledge regarding the behavior of plutonium is inadequate for assuring weapons reliability and safety of weapons within the stockpile as they age beyond their design life. DOE needs:

- A better understanding of the properties of plutonium
- More accurate equations-of-state to predict the behavior of plutonium, especially at high pressures and temperatures
- More information regarding the behavior of the plutonium surface following a physical shock

Since radiographic dynamic experiments are the best tool to obtain this information, DOE must have the capability to conduct dynamic experiments with plutonium using enhanced high-resolution radiography. As a matter of policy, dynamic experiments involving plutonium, would always be conducted in double-walled containment vessels. Accordingly, DOE also needs the capability to stage, maintain, and clean out the plutonium containment vessels.

2.3.4 Other Needs

DOE also needs more information on other issues related to nuclear deterrence and nuclear weapons materials science.

- The United States must be able to continue to assist other nations, under nuclear cooperation agreements, in evaluating the condition, safety, and expected performance of their weapons and weapons designs under current international agreements.
- The United States must be able to assess the condition, safety, and performance reliability of other nuclear weapons, such as those designed by a nonfriendly nation or a terrorist. The Emergency Response Program is used to assess threats of foreign systems well in advance of an emergency.
- DOE must be able to continue to assist the U.S. Department of Defense with evaluation of conventional weapons and other military equipment.
- DOE must be able to study explosives-driven materials and high-velocity impact phenomena for nonweapon applications and other uses of interest to industry.
- The accelerator technology developed for high-resolution radiography may have other science and industry applications.

In 1991, the President stated that the United States would not design new nuclear weapons in the foreseeable future. However, in the event that this Nation decides, as a matter of policy, that new nuclear weapons should again be developed, DOE would use all appropriate means at its disposal to accomplish this. Hydrodynamic testing, along with many other tools, could be used to assist in weapons development. However, any decision to develop new nuclear weapons would be made by the President and be subject to Congressional review and approval.

2.4 LIMITATIONS OF EXISTING FACILITIES

Along with other stockpile stewardship responsibilities, DOE has assigned a hydrodynamic testing mission to its two nuclear weapons physics laboratories, LANL and LLNL. The Pulsed High Energy Radiation Machine Emitting X-Rays (PHERMEX) is the existing radiographic hydrodynamic testing facility at LANL and the Flash X-Ray (FXR) is the existing radiographic hydrodynamic testing facility at site 300 at LLNL.

PHERMEX has been in continuous operation since 1963. In addition to major, full-scale hydrodynamic tests, PHERMEX is used for smaller types of experiments, such as high-explosive tests or tests requiring static radiographs. Although PHERMEX was state of the art in the 1950s when it was designed, it is no longer adequate. It cannot provide the degree of resolution, intensity, rapid time sequencing, or three-dimensional views that are needed to provide answers to current questions regarding weapons condition or performance. Even if this type of diagnostic information were not needed, PHERMEX might not remain a viable test facility over an extended time because of anticipated increasing difficulty in maintaining the facility.

A set of upgrades recently have been started at PHERMEX. These upgrades comprise a modification to safety systems in compliance with 10 CFR 835, Occupational Radiation Protection; a modification to the PHERMEX accelerator that required removal of large amounts of depleted uranium [176 lb (80 kg)] from shield; and a final modification, scheduled for completion in 1996, will provide for two reduced-intensity pulses and, hence, two radiographs, although at greatly reduced x-ray intensity. The removal of the uranium had an additional effect of reducing interference with the beam that increased the penetrating ability. These upgrades, still in progress, will have served to increase some of the capability of PHERMEX; however, enhanced radiographic capability, sufficient to meet DOE's purpose and need as described by the proposed action, is not attained. For example, the PHERMEX spot size and, therefore, degree of resolution will remain approximately the same as it has been.

FXR has been in continuous operation since 1983; it is DOE's most advanced radiographic hydrodynamic testing facility. Although FXR uses linear induction accelerator technology for high-speed radiography, it cannot provide the degree of resolution, intensity, or three-dimensional views needed to address current questions. Additionally, DOE does not perform dynamic experiments with plutonium at LLNL because the necessary infrastructure is not in place at site 300.

Neither PHERMEX nor FXR is adequate to provide the enhanced radiographic hydrodynamic testing capability that DOE now needs in the absence of nuclear weapons testing. At present, both PHERMEX and FXR can take only one image at a time. If planned upgrades are completed, PHERMEX and FXR may soon have the capability to make sequential radiographs up to 100 μs apart (referred to as double-pulse capability), but without improvement in x-ray dose or spot size. In fact, in producing the sequential radiograph, there is a noticeable reduction in x-ray dose, thus reducing the degree of penetration of the x-ray beam. While this capability allows DOE to obtain more information than the original PHERMEX or FXR design, the level of information obtained from these radiographs does not satisfy DOE's need for enhanced radiography. These machines are not capable of producing a high x-ray dose coupled with a small beam spot size to provide the diagnostic capability that DOE now needs. Neither machine is capable of taking very high-resolution radiographs, which is dependent on the accelerator beam spot size, nor are they capable of producing x-ray beams with the intensity required, which is principally dependent on x-ray dose strength. They do not have the capability to obtain three-dimensional information for one test event, which requires the ability to take pictures from more than one point of view. To obtain three-dimensional data at PHERMEX or FXR, laboratory personnel must make up more than one test assembly, explode them one at a time, and rotate each subsequent device to obtain an additional point of view. Besides increasing cost – a full-scale hydrodynamic test costs $1.5 to $2 million, with the cost multiplied by the number of views tested – it is difficult to reproduce precise dimensions and alignments (within hundredths of an inch) to replicate test results for components in a series of tests. The confidence in the resulting data is also limited because of the uncertainties of using sequential tests. DOE's observations regarding the limitations of PHERMEX and FXR, even after planned upgrades have been incorporated, have also been reflected by independent researchers (JASON 1994).

NATION'S COMMITMENT TO NONPROLIFERATION

- On May 11, 1995, 178 nations agreed to permanently extend the expiring nuclear Nonproliferation Treaty and accept a set of "principles and objectives" that include specific steps to turn back the nuclear arms race. The five nuclear states also agreed to work toward a comprehensive test ban by 1996 and rapid negotiation of a treaty to end production of nuclear bomb material.
- On August 11, 1995 President Clinton announced that the United States would seek a "zero-yield" Comprehensive Test Ban Treaty:

  "One of my Administration's highest priorities is to negotiate a Comprehensive Test Ban Treaty (CTBT) to reduce the danger posed by nuclear weapons proliferation. To advance that goal and secure the strongest possible treaty, I am announcing today my decision to seek a "zero" yield CTBT. A zero yield CTBT would ban any nuclear weapon test explosion or any other nuclear explosion immediately upon entry into force. I hope it will lead to an early consensus among all states at the negotiating table."
- The United States has entered the START I treaty into force, and the Administration is working closely with the Senate and the Russian government to ratify START II.

2.5 NONPROLIFERATION

DOE has determined that enhanced hydrodynamic testing capability in support of its SS&M Program would be consistent with the U.S. policy on nonproliferation.

The President is committed to curbing the proliferation of nuclear weapons. The DOE SS&M Program is a key component of the U.S. nonproliferation strategy. This Nation's commitment to nonproliferation is evident by our support for an indefinite extension of the Nonproliferation Treaty in force since 1970; [21 UST 483] (see box). In support of these goals, the SS&M Program provides a means to assure the safety and reliability of the Nation's remaining stockpile of nuclear weapons under a continuing testing moratorium and a future comprehensive test ban.

On August 11, 1995 the President announced his commitment to seek a "zero-yield" CTBT (see box). The President also established several safeguards that condition the United States entry into a CTBT. One of these safeguards is the conduct of a science-based Stockpile Stewardship and Management Program, including the conduct of experimental programs. This safeguard enables the Nation to enter into such a treaty while maintaining a safe and reliable nuclear stockpile consistent with National security strategy (see box section 2.2).

One global benefit of science-based stockpile stewardship is to demonstrate the U.S. commitment to Nonproliferation Treaty goals; however, the U.S. nuclear posture is not the only factor that might affect whether or not other nations might develop nuclear weapons of their own. Some nations that are not declared nuclear states have the ability to develop nuclear weapons. Many of these nations rely on the U.S. nuclear deterrent for security assurance. The loss of confidence in the safety or reliability of the weapons in the U.S. stockpile could result in a corresponding loss of credibility of the Nation's ability to provide a nuclear deterrent and could provide an incentive to other nations to develop their own nuclear weapons program.

The United States has halted the development of new nuclear weapons systems. The Nuclear Posture Review commits the United States to maintaining a safe and reliable nuclear deterrent. The hydrodynamic testing program, when used to assess the safety and reliability of the nuclear weapons primaries in the remaining stockpile, does not constitute proliferation. The results of such testing are classified and could not lead to proliferation without a breach of security. Nonproliferation verification would not be affected by a choice to perform hydrodynamic testing in open-air shots or containment. The levels of energy release from high explosives in hydrodynamic testing is far from adequate for clandestine nuclear testing of weapons, even very-low-yield nuclear testing. Because the United States is already a nuclear weapons state and has had a hydrodynamic testing program for several decades, continuing to maintain a hydrodynamic testing capability does not change our Nation's status regarding proliferation. Lack of hydrodynamic testing capability, while seriously impacting our ability to ensure the continued safety and reliability of the stockpile, also would not change the status of the United States in terms of proliferation – we would remain a nuclear weapons state. Proliferation drivers for other states, such as international competition or the desire to deter conventional armed forces, would remain unchanged regardless of whether DOE implemented the proposed action analyzed in this EIS.

Most of the component technology used for hydrodynamic testing is unclassified and is available in the open literature; many other nations have developed a considerable accelerator technology capability. Accelerator-based radiographic technology is currently used by other weapons states for many of the same reasons it is used by the United States. In the NPT the parties agree to not transfer nuclear weapons, other devices, or control over them, and to not assist, encourage, or induce nonnuclear states to acquire them. However, the treaty does not invoke stockpile reductions by nuclear states, and it does not address actions of nuclear states in maintaining their stockpiles. Article VI obligates each of the parties to negotiate in good faith on the "cessation of the nuclear arms race at an early date and to nuclear disarmament..." The concept of hydrodynamic testing is known to all the signatories, and the capability exists with several of the nuclear states. Such capability is said to have been an important factor for the nuclear states to have entered into the treaty and to agree to further negotiate for a CTBT.

2.6 RELATIONSHIP OF THE DARHT EIS TO OTHER DOE EISs

DOE plans two other National Environmental Policy Act (NEPA) reviews regarding proposed actions at LANL related to the *Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility Environmental Impact Statement* (EIS) – the *LANL Sitewide Environmental Impact Statement* (SWEIS) and the *Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (PEIS).

EIS	NOI	Draft EIS	Final EIS	ROD
DARHT EIS	Nov 94	May 95	Aug 95	Oct 95
LANL SWEIS	May 95	Apr 96	Dec 96	Mar 97
SS&M PEIS	Jun 95	Jan 96	Jul 96	Aug 96

Note: Dates are subject to change.

DOE is in the process of preparing the SWEIS for LANL [Notice of Intent, 60 FR 25697]; the public comment period on the scope of the SWEIS ended on June 30, 1995. The purpose of the SWEIS is to provide DOE and its stakeholders a comprehensive look at the cumulative environmental impacts of ongoing and reasonably foreseeable future operations at LANL. The SWEIS will focus on impacts of current LANL activities and activities proposed or anticipated to occur 5 to 10 years into the future. It will replace the prior SWEIS that was completed in 1979. The SWEIS will include all activities at LANL and will incorporate the results of any related environmental impact analyses in any current NEPA documents, which will be combined with impact analyses performed specifically for the SWEIS. Under current schedules, the DOE plans to issue the Record of Decision (ROD) on the DARHT EIS prior to issuing the draft SWEIS. Information on the environmental impacts of the course of action selected in the DARHT ROD will be included in the analysis of cumulative impacts for the SWEIS.

DOE gave preliminary notice of its intent to prepare the *Stockpile Stewardship and Management PEIS* in October 1994 [59 FR 54175]. DOE's report, *The Stockpile Stewardship and Management Program: Maintaining Confidence in the Safety and Reliability of the Enduring U.S. Nuclear Weapons Stockpile*, (DOE 1995), provides a framework for the issues to be considered in the PEIS. DOE started the PEIS in June 1995 [Notice of Intent, 60 FR 31291]; the public comment period on the scope of the PEIS ended August 11, 1995. The PEIS will assess the environmental impacts of alternatives for conducting the SS&M Program, will assist with decisions to identify specific capabilities and facilities for conducting the program, and will help determine the configuration (sites for facilities) of the nuclear weapons complex that would most efficiently implement the SS&M Program. The environmental impact analysis of the course of action selected in the DARHT ROD will be incorporated into the PEIS.

Proceeding with the DARHT EIS in advance of the completion of either the SWEIS or the PEIS is necessary because a decision on whether to proceed with the DOE's preferred alternative to implement DARHT, or pursue another alternative course of action, is needed as soon as possible to help ensure the continued safety and reliability of the nuclear weapons stockpile. As a matter of policy and in response to Presidential and Congressional direction, DOE will continue to maintain and improve its hydrodynamic testing capability regardless of the outcome of either the SWEIS or the PEIS. Thus, the alternatives analyzed in this DARHT EIS are not dependent on the decisions expected to flow from either the SWEIS or PEIS.

Under NEPA regulations, while work on a required program environmental impact statement is in progress, a Federal agency may not undertake in the interim any major action covered by the program unless the action:

- Is justified independently of the program
- Is itself accompanied by an EIS
- Will not prejudice the ultimate decision on the program, including determining subsequent development of the program or limiting programmatic alternatives [40 CFR 1506.1 (c)]

DOE believes that any course of action selected after completion of the DARHT EIS would meet this standard. Chapter 2 of the EIS provides the technical justification for providing enhanced hydrodynamic testing capability. This conclusion has been supported by the President and Congress who have directed DOE to rely on hydrodynamic testing to ensure the safety, performance, and reliability of the stockpile in the absence of underground nuclear testing. This determination is unrelated to, and would not depend on, any other stockpile stewardship actions which may be proposed as part of the SS&M program. Under any course of action to be analyzed in the SS&M PEIS, DOE would still need to continue hydrodynamic testing and would still need to acquire enhanced radiographic capability.

Similarly, because enhanced hydrodynamic capability is needed in the near term regardless of the alternatives to be analyzed in the SS&M PEIS or the decisions that will result from the SS&M ROD, DOE believes that a decision to implement any of the alternatives analyzed in this DARHT EIS would not prejudice any ultimate decisions regarding the SS&M program. Hydrodynamic testing and dynamic experiments at LANL as an ongoing mission will continue in support of stockpile stewardship, and this fact will be one of the baseline assumptions for the SS&M PEIS. The proposal contained in the DARHT EIS would not render more or less reasonable any of the alternative courses of action to be considered in the SS&M PEIS, nor would it affect any decisions expected from the SS&M ROD. DOE believes that the DARHT EIS adequately identifies and analyzes the proposed action and the reasonable alternative means to achieve it. Therefore, DOE believes that its proposal to acquire enhanced radiographic capability meets the regulatory requirements for interim actions, and that any actions decided upon in the DARHT ROD would not be limited pending completion of the SS&M PEIS.

The DARHT project is likewise a permissible interim action pending completion of the LANL Sitewide EIS. DOE's need for enhanced radiographic capability to conduct science-based stockpile stewardship as directed by the President and Congress provides the independent justification for the project. That capability can be provided by implementing any of the alternatives analyzed in the DARHT EIS without requiring additional new facilities or changes in operation for existing facilities at LANL, since radiographic hydrotesting is an ongoing mission for LANL. Thus, deciding whether and how to provide enhanced radiographic capability will not prejudice any decisions resulting from the LANL Sitewide EIS.

2.7 REFERENCES CITED IN CHAPTER 2

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