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Volume I

U.S. Department of Energy
Office of Environmental Management

The 1996 Baseline Environmental Management Report

June 1996

1.0 INTRODUCTION

During World War II and the Cold War, the United States developed a massive industrial complex to research, produce, and test nuclear weapons. This nuclear weapons complex included uranium mining, nuclear reactors, chemical processing buildings, metal machining plants, laboratories, and maintenance facilities that manufactured tens of thousands of nuclear warheads, and conducted more than one thousand nuclear explosion tests.

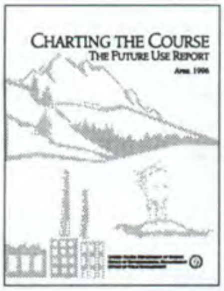
Weapons production stopped in the late 1980s, initially to correct widespread environmental and safety problems, and was later ended indefinitely because of the end of Cold War. The work remaining, and the subject of this analysis, is the legacy of thousands of contaminated areas and buildings, and large volumes of "backlog" waste and special nuclear materials requiring treatment, stabilization, and disposal. (See Appendix B for a further discussion of the causes of the environmental legacy being addressed by the Environmental Management program.) Approximately one-half million cubic meters of radioactive high-level, mixed, and low-level waste must be stabilized, safeguarded, and dispositioned, including a quantity of plutonium sufficient to fabricate thousands of nuclear weapons. Therefore, the security as well as the safety of this material is of paramount importance. Moreover, because plutonium can spontaneously ignite in certain circumstances when in contact with moist air, careful attention must be paid to handling and storage safety.

In 1989, the Department of Energy established the Environmental Restoration and Waste Management program, now called the Environmental Management program, to consolidate ongoing activities and accelerate efforts to address the inactive production facilities and sites and the accumulated waste, contamination, and materials. Six years later, this program is responsible for the maintenance and stabilization as well as the environmental restoration and waste management work at virtually the entire nuclear weapons complex not being used for continued weapons activities. The Environmental Management program is the largest environmental stewardship program in the world, with 150 sites in approximately 30 states and Puerto Rico.

1.1 THE 1996 BASELINE ENVIRONMENTAL MANAGEMENT REPORT

The primary mission of the Department of Energy's Environmental Management program is to reduce health and safety risks from radioactive waste and environmental contamination resulting from developing, producing, and testing nuclear material for weapons. The 1996 Baseline Environmental Management Report provides a total life-cycle cost estimate and anticipated schedule of the projects and activities necessary to carry out the Environmental Management program's missions for environmental remediation, waste management, basic science, technology development, the transition of operational facilities to safe shutdown status, and the safeguarding and security of special nuclear materials.

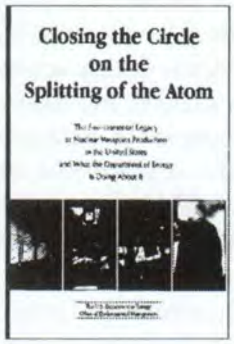
For more comprehensive information about the Environmental Management program and a description of program accomplishments and other related initiatives, see the following published reports:



Charting the Course: The Future Use Report (April 1996) provides results of the Department-wide Future Use Project and discusses the future-use planning efforts under way at 20 Department research and former nuclear weapons production sites. Sixteen of the 20 participating sites, in collaboration with Tribal and local governments and stakeholders, developed recommendations regarding the future use of site land and facilities.

Environmental Management 1996 (April 1996) is the Office of Environmental Management's annual report on the program's progress. It assesses the program's performance in 1995 compared with 1994.

Taking Stock: A Look at the Opportunities and Challenges Posed by Inventories from the Cold War Era (January 1996) reports on a Department-wide effort to improve management and disposition and to reduce costs for materials that no longer have clearly defined or immediate uses.



Closing the Circle on the Splitting of the Atom (January 1996, second printing) describes existing environmental, safety, and health problems throughout the nuclear weapons complex, and what the Department of Energy is doing to remedy the problems.

Risks and the Risk Debate: Searching for Common Ground, "The First Step" (June 1995) details the findings of the Department's first effort to develop a consistent approach to evaluating risks throughout the nuclear weapons complex. This draft risk report provides a qualitative risk evaluation of 1,199 environmental management activities planned for FY 1996. This report will be finalized in Summer 1996.

To obtain copies of these reports, or for more information on the Environmental Management program, please contact the Center for Environmental Management Information at 1-800-7-EM-DATA.

The Department of Energy prepared this report as an analytical tool to help guide Departmental decisions and to provide an accounting of the Department's progress, spending, and plans. In addition, federal law requires the Secretary of Energy to regularly submit a Baseline Environmental Management Report. The 1996 Baseline Environmental Management Report (Baseline Report) is the second of these reports. In addition, the report serves as a benchmark - or starting point - in the development of new "Ten-Year Plans" that are being prepared to define new, near-term cleanup objectives and greatly accelerate the pace and reduce the costs of cleanup over current plans.

The first report, prepared in 1995, estimated that the total cost of the Environmental Management program's mission will be between $200 and $350 billion over a 75-year period. Significant decisions made over the past 12 months have changed the projected scope of the Environmental Management program presented in the 1995 report. For example, new technical approaches at the Hanford Site in Washington, the Idaho National Engineering Laboratory, and the Rocky Flats Environmental Technology Site in Colorado have affected the cost and schedule estimates for these sites. The 1996 Baseline Report highlights these changes, both at the site level and at the national level. Guided by a new ten-year planning process, we are confident that we can further reduce the costs and accelerate the pace of cleanup through better coordination between sites, use of "breakthrough management" and use of new technologies.

Because the program is only seven years into a life cycle that spans over 75 years, many decisions will be made that can dramatically change the direction of the program. In addition to illustrating the assumed path forward, the 1996 Baseline Report presents policy analyses that examine the consequences of modifying key program assumptions. The analyses presented include answers to the following questions:

- **Land Use –** What effect will future land-use decisions have on the overall scope, cost, and schedule of cleanup for Environmental Management sites?

- **Program and Project Scheduling –** What are the cost consequences of delaying or accelerating programs and projects? What is the relationship between program pace, schedule, and waste volumes?

- **A "Minimal Action" Scenario –** What is the minimum funding necessary to prevent risks to human health or the environment from increasing for 75 years in the absence of the constraints of current legal requirements?

THE 1996 BASELINE REPORT IS:

- A life-cycle cost estimate for the entire Environmental Management Program
- A policy analysis tool that explores the potential consequences of several policy alternatives
- A description of environmental management activities expected to be necessary to address the Department's legacy and projected future activities

THE 1996 BASELINE REPORT IS NOT:

- A definitive basis for planning specific projects
- A budget document
- A funding request
- A description of long-term priorities

The 1996 Baseline Report is based on current (as of late 1995) national and site-level assumptions regarding the actions or activities that are most likely to occur in the future. It is expected that these projected activities will change in the future. In fact, one of the principal purposes of this report is to inform a national debate on what the best future course should be.

BASELINE REPORT BACKGROUND

The Department prepared the 1995 Baseline Report in response to a Congressional mandate made in the 1994 National Defense Authorization Act (Appendix A.1). Congress directed the Department to:

- estimate the total cost of the Environmental Management program,
- describe each project or activity at each site,
- describe the environmental problem addressed by each project or activity,
- specify the proposed remedy or solution to the problem, if known,
- estimate the cost for completing each project or activity (in five-year increments where appropriate), and
- estimate the schedule for completing each project or activity (with five-year milestones).

Congress included additional requirements in the 1995 National Defense Authorization Act (Appendix A.2), which directed the Department to:

- describe personnel and facilities required to complete each project or activity,
- increase stakeholder involvement,
- expand the pollution prevention discussion, and
- describe the research and development necessary to develop the technologies for environmental restoration and waste management projects or activities.

1.2 OVERVIEW OF THE 1996 BASELINE REPORT

The 1996 Baseline Report consists of an executive summary and three volumes: Volume I, the *1996 Baseline Environmental Management Report*, and Volumes II and III, *Site Summaries for the 1996 Baseline Environment Management Report.*

Volume I contains eight chapters:

Chapter 1 introduces and provides an overview of the 1996 Baseline Report.

Chapter 2 describes how the Environmental Management program is organized to provide remedies to the environmental legacy of the nuclear weapons complex. Six functional areas are described: environmental restoration, waste management, nuclear material and facility stabilization, science and technology development, landlord, and national program planning and management.

Chapter 3 defines the "Base Case," which is a long-range projection of costs, schedules and activities that describe the Environmental Management program from its current state to completion. This chapter describes the challenges involved in developing a life-cycle cost estimate for the Environmental Management program and outlines the general methodology and key assumptions used to develop the Base Case. The key Base Case assumptions are divided into four main categories: funding, scheduling/site completion, land use, and functional area.

Chapter 4 summarizes the Base Case results. These results represent a new baseline for the Environmental Management program and depict the most likely scenario for the program based on current assumptions. This chapter also includes summary results of two Base Case analyses: science and technology development and pollution prevention.

Chapter 5 compares the 1995 and 1996 Base Case results and describes how the Base Case changed since last year.

Chapter 6 examines alternative scenarios that are built on the Base Case. These alternative scenarios examine the impacts to cost and schedule estimates that result from varying program assumptions. Included are three scenarios: land use, program and project scheduling, and minimal action.

Chapter 7 compares the results of the Base Case and the alternative scenarios in three areas: life-cycle cost estimates, program end states, and overall benefits and losses. This chapter provides side-by-side comparisons of the results that are presented separately in Chapters 4 and 6.

Chapter 8 discusses the various conclusions of this year's report and how baseline planning exercises will continue in the Environmental Management program.

Volume I also contains several appendices:

Appendix A contains the Baseline Environmental Management Report requirements in the National Defense Authorization Acts for FY 1994 and FY 1995.

Appendix B describes the sources of the environmental legacy being addressed by the Environmental Management program, such as the steps in the nuclear weapons production process and the resulting contamination.

Appendix C describes the Baseline Report methodology and presents a detailed discussion of the following areas: setting assumptions; defining activities and projects for major program elements; developing categories for personnel requirements; gathering and assembling data; conducting integration analyses; estimating program improvements; developing documentation; and involving stakeholders.

Appendix D provides supporting information for the land-use scenario analysis.

Appendix E discusses the effects of productivity and discounting on the Base Case estimate.

Appendix F describes the methodology for the analysis of the effects of technology development on the Base Case Estimate.

Appendix G describes the methodology for the analysis of the effects of pollution prevention efforts on the Base Case estimate.

Appendix H lists the various Department of Energy reading rooms where copies of this report and other Departmental information may be obtained.

Volumes II and III contain summaries for each site included in the Base Case estimate. The site summaries provide specific information about the activities and projected costs at each site as requested by the National Defense Authorization Act. The site summaries are organized by state. Each summary provides a brief discussion of the site's current and future missions, followed by discussions of the projects and activities necessary to remediate the site. The summaries also provide more detail about the site-specific assumptions used to develop the Base Case.

Construction of the first high-level waste tanks at Hanford Site, Washington, 1944. *Designed for a useful life of 25 years, these tanks contain intensely radioactive acids and solvents resulting from reprocessing spent nuclear reactor fuel elements to extract plutonium and uranium. Approximately half of the 177 tanks were a "single shell", such as these, while others were "double shell" tanks. Because workers during the Cold War typically filled the tanks without sampling the waste and without recordkeeping that would meet today's standards, the Department is now undertaking a complex and hazardous effort to characterize the waste already in the tanks.*

Installing a mixing pump in tank 101-SY at Hanford Site, Washington, 1993. *This custom-built pump was critical in controlling the buildup of explosive gases in the tank, which was identified as one of the most urgent safety risks in the former nuclear weapons complex at the time. The ongoing cost for simply averting serious safety problems in these tanks is approximately $300 million per year. Beyond this routine safety operation, the Department is planning to remove the waste from the tank, which is the focus of a top-priority multibillion dollar, multidecade effort. The cost and complexity of dealing with these tanks provides excellent examples of the benefits of life-cycle planning and cost estimation. Characterizing the waste and treating it for disposal, after many years of storage, is significantly more expensive, complex, and hazardous than if the work was done as part of the production process.*

2.0 THE ENVIRONMENTAL MANAGEMENT PROGRAM

The Department established the Environmental Management program in 1989 to address the environmental legacy of nuclear weapons production and other sources of potential pollutants such as nuclear research. The Environmental Management program encompasses six major functional areas: (1) environmental restoration, (2) waste management, (3) nuclear material and facility stabilization, (4) science and technology development (5) landlord, and (6) national program planning and management. These six areas are all interrelated. Figure 2.1 graphically depicts the scope of the Environmental Management program and the key interrelationships of the six major areas. Waste management involves the safe treatment, storage, and disposal of existing waste and waste yet to be generated. Environmental restoration activities address remediation of contaminated soil and water as well as decommissioning of contaminated surplus facilities. Nuclear material and facility stabilization involves stabilizing and consolidating special nuclear materials such as plutonium and highly enriched uranium and deactivating surplus facilities to a safe, low maintenance condition while awaiting final decommissioning. Science and technology development refers to a variety of basic and applied research activities that explore more effective and less expensive remedies

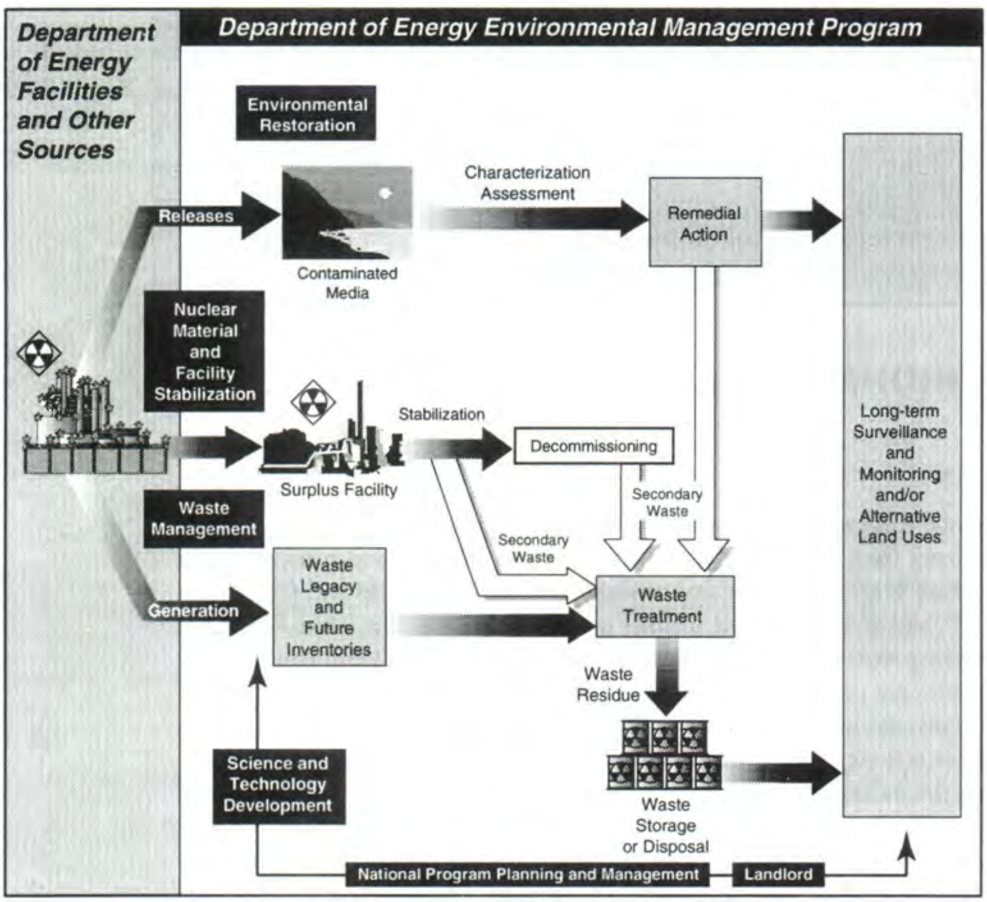


Figure 2.1. Overview of Environmental Management Activities

to address the environmental and safety problems of the Environmental Management program. Landlord functions represent crosscutting site-wide support activities such as road maintenance and fire and ambulance services. National program planning and management encompasses Headquarters functions. The following subsections describe each major area.

The U.S. Department of Energy requires management of its sites and facilities in compliance with applicable federal, state, and local regulations. The Base Case described in this report is a "compliance case" (that is, based on compliance with all applicable provisions of laws, permits, regulations, orders, and agreements) in effect throughout the Department of Energy complex. The following box provides a list of the major federal laws that directly influence the functional area strategies outlined in this chapter.

LEGAL REQUIREMENTS DRIVING THE ENVIRONMENTAL MANAGEMENT PROGRAM

- Resource Conservation and Recovery Act, as amended
- Comprehensive Environmental Response, Compensation, and Liability Act, as amended
- National Environmental Policy Act
- Federal Facility Compliance Act
- Clean Air Act, as amended
- Clean Water Act, as amended
- Safe Drinking Water Act, as amended
- Toxic Substances Control Act, as amended
- Atomic Energy Act, as amended
- Uranium Mill Tailings Radiation Control Act
- Low-level Waste Policy Act, as amended

2.1 ENVIRONMENTAL RESTORATION

Mission

The Environmental Restoration program's overall mission is to protect human health and the environment from risks posed by inactive, surplus facilities and contaminated areas. The program is accomplishing this mission by remediating sites and facilities in the most cost-efficient and responsible manner possible to provide for future beneficial use while complying with applicable environmental regulations. Environmental restoration activities are prioritized based upon various factors, including the goals of reducing risks at all sites and compliance with existing laws, regulations, and agreements. Most actions are designed to either clean up or contain contamination in the environment (including soil, ground water, and surface water) or to decommission contaminated buildings (including reactors and chemical processing buildings). Related activities conducted to support these actions may include immediate treatment of contaminated soils or ground water, packaging of waste for commercial treatment and/or disposal, and onsite disposal of consolidated contaminated media such as soils or building rubble.

Cleanup goals and remedies for each contaminated area are decided through processes established by federal and state laws and other legal agreements. These processes involve decisionmakers outside of the Department such as the states, the U.S. Environmental Protection Agency, and the U.S. Nuclear Regulatory Commission. The environmental restoration process described below is a generic approach based primarily on requirements of the Comprehensive Environmental Response, Compensation, and Liability Act, as amended. Other statutes that influence the process include the Resource Conservation and Recovery Act, as amended, and the National Environmental Policy Act.

The Remediation Process

Initially, the Department characterizes a contaminated area to identify contaminants, determine the extent of contamination, and assess potential threats to public health and the environment. If a significant contamination problem is indicated, and a fast and limited cleanup or containment action could mitigate this problem, the Department may conduct an expedited response action or interim action. To date, the Department has completed over 500 such limited actions, avoiding larger contamination problems that could have resulted from delay.

Upon completion of characterization, the Department performs a detailed analysis to quantify existing risks and evaluate remedial alternatives. The analysis is followed by a formal decision process, including public meetings and a formal comment period. If the results of the analysis indicate that a contaminated area does not pose a threat to public health or the environment, or that a previously completed limited action adequately remediated the contamination, the Department makes a decision to take "No Further Action," in conjunction with the regulators, the U.S. Environmental Protection Agency, and the host state. If, however, a threat is deemed to be present, the Department identifies and implements the appropriate remedial action.

The Department of Energy reviews potential activities to determine how much waste will be generated in the cleanup and makes provisions for its storage, treatment, and/or disposal. If actual cleanup (for example, a removal action) is not practical, or not required because of decisions regarding future land use, the Department may take steps to stop or slow the spread of contamination by implementing containment technologies. Actions depend on the contaminants and the medium (for example, soil and ground water) in which they are found. Contaminants such as hazardous organic chemicals or fuel oil are often highly mobile but can be effectively removed from the media and destroyed. Heavy metals and radioactive materials are often less mobile but cannot be destroyed, even when it is possible to remove them from the media.

Radioactivity will decay naturally over time, but it can take from a few days to tens of thousands of years to become less harmful. During this time, heavy metal contaminated soils and radioactive waste that pose threats to public health and the environment must be contained, stabilized, or moved to a safer place. Containment structures associated with contamination that has not been fully remediated or that has been stabilized in place must be continuously monitored and maintained.

To date, the Department has completed 119 remedial action projects. Another 111 projects are under way. These projects have included cleanup of contaminated soils, construction of ground-water treatment facilities, and retrieval of buried waste. The Department is positioned to accomplish even more cleanup in the near term as many characterization activities are complete or nearing completion, and many formal cleanup decisions will be made over the next few years.

The Decommissioning Process

Decommissioning of surplus facilities involves a decisionmaking process similar to the process used for environmental remediation: characterization followed by detailed analysis of alternatives and formal remedy selection. Based on a joint policy between the Environmental Protection Agency and the Department of Energy, provisions of the Comprehensive Environmental Response, Compensation, and Liability Act generally govern decommissioning activities, which are conducted as "non-time critical removal actions."

Decommissioning activities, which occur after facilities have been stabilized and deactivated, address contamination that is already contained within buildings. Building deterioration, however, may pose a substantial hazard to surveillance and decommissioning workers, and the recurring costs associated with maintaining surplus facilities absorb resources that could be better spent on remediation. These issues raise important policy and planning questions.

Of the 3,500 contaminated facilities that are surplus, or projected to be surplus within the next ten years, the Department has decommissioned 100 facilities to date. In spite of its modest beginnings, the program has placed a priority on minimizing secondary waste and has recycled 7.24 million kilograms (16 million pounds) of scrap metal from dismantled facilities and equipment.

2.2 WASTE MANAGEMENT

Mission

The Waste Management program's mission is to treat, store, and dispose of waste generated during past and future Department of Energy activities. This includes managing large volumes of "backlog" waste that currently exist at various facilities throughout the United States. For example, at the end of 1995, approximately 600,000 cubic meters (786,000 cubic yards) of radioactive waste were stored in facilities at various Department of Energy installations. Additional waste is expected from environmental restoration and nuclear material and facility stabilization activities and from other ongoing activities within the Department.

Based on definitions contained in regulations, waste is divided into categories that include high-level, transuranic, mixed transuranic, low-level, low-level mixed, uranium mill tailings, hazardous, sanitary, and special case waste. See the following box for a brief description of each waste type. Because they have specific requirements for treatment, storage, and disposal, each waste type requires a different management strategy.

Strategies

Even more than environmental restoration processes, waste management strategies depend on following detailed regulatory requirements. These include the Resource Conservation and Recovery Act, as implemented through permits, compliance agreements, and consent orders into which the Department has entered with host states and the U.S. Environmental Protection Agency. For example, the Federal Facility Compliance Act of 1992, which amended the Resource Conservation and Recovery Act, waives sovereign immunity for all federal agencies and specifically requires the Department to submit Site Treatment Plans and enter into compliance agreements with the states specifying treatment plans and schedules for mixed waste (including high-level, transuranic, and low-level mixed waste). As a result of this Act, the Department has entered into negotiated compliance orders between state regulators and/or the U.S. Environmental Protection Agency for 29 states and is currently negotiating orders for six sites.

High-Level Waste

Approximately 350,000 cubic meters (459,000 cubic yards) of high-level waste is currently stored at four sites: Hanford Site, Idaho National Engineering Laboratory, Savannah River Site, and West Valley Demonstration Project. The Department has ended production operations involving special nuclear materials and is phasing out chemical processing of spent nuclear fuel. As a result, the Department does not expect large volumes of high-level waste to be generated in the future. Small amounts, however, will be generated during nuclear material and facility stabilization activities.

Two statutes provide the principal regulatory basis for high-level waste. The Atomic Energy Act governs the radioactive constituents of high-level waste and Subtitle C of the Resource Conservation and Recovery Act governs the hazardous constituents. Based on regulatory requirements, liquid high-level waste must be converted to a durable, stable, solid form for disposal. The preferred treatment for most high-level waste is vitrification (that is, mixing liquid high-level waste with glass frit and heating it to create glass that is solidified inside steel canisters). A vitrification facility at the Savannah River Site in South Carolina recently began operations, and a facility at the West Valley Demonstration Project in western New York plans to begin operating in 1996.

Presently, no disposal facility for high-level waste is available. The Department will oversee the placement of high-level waste in a national geologic repository developed by the Department of Energy's Office of Civilian Radioactive Waste Management. This office currently plans to have a repository available for high-level waste shipments by 2015. However, based on site scheduling assumptions, this report assumes that a high-level waste repository will be available to accept Department of Energy waste in approximately 2016.

DESCRIPTIONS OF WASTE TYPES

High-level waste: highly radioactive material resulting from reprocessing spent nuclear fuel and irradiated targets, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations. Most of the Department's high-level waste came from the production of plutonium. A smaller fraction is related to recovering enriched uranium from naval reactor fuel. This waste typically contains highly radioactive, short-lived fission products as well as long-lived isotopes, hazardous chemicals, and heavy metals. It must be isolated from the environment for thousands of years. Liquid high-level waste is typically stored in large tanks, while waste in powdered form is stored in bins. All high-level waste is managed as mixed waste.

Transuranic and mixed transuranic waste: waste generated during nuclear weapons production, fuel reprocessing, and other activities involving long-lived transuranic elements. It contains plutonium, americium, and other elements with atomic numbers higher than that of uranium. Some of these isotopes have half-lives of tens of thousands of years, and therefore require long-term isolation. Since 1970, transuranic waste has been stored temporarily in drums at sites throughout the complex. Mixed transuranic waste contains both radioactive and hazardous waste.

Low-level waste: any radioactive waste that is not classified as high-level waste, transuranic waste, spent nuclear fuel or byproduct tailings containing uranium or thorium from processed ore. It is produced by every process involving radioactive materials. Low-level waste has a wide range of characteristics, but most of it contains small amounts of radioactivity in large volumes of materials. Some waste in this category (for example, irradiated metal parts from reactors) can have more radioactivity per unit volume than the average high-level waste from nuclear weapons production. Most low-level waste has been buried in shallow trenches. A limited inventory remains stored in boxes and drums.

Low-level mixed waste: low-level radioactive waste that also contains hazardous waste. A significant portion of the Department's mixed waste is low-level mixed waste.

Uranium mill tailings: large volumes of material left from uranium mining and milling. While this material is not categorized as waste, tailings are of concern because they emit radon and because they are usually contaminated with toxic heavy metals, including lead, vanadium, and molybdenum.

Hazardous waste: waste that is regulated under Subtitle C of the Resource Conservation and Recovery Act. It contains hazardous constituents but no radionuclides. Hazardous waste is generated at most Department of Energy installations in a variety of quantities and forms (for example, laboratory solutions, acids, bases, and degreasing agents).

Sanitary waste: waste that includes solid sanitary waste (for example, garbage, rubble, or debris) regulated under Subtitle D of the Resource Conservation and Recovery Act and liquid sanitary waste regulated under the Clean Water Act.

Special case waste: waste that is not high-level or transuranic, but requires greater confinement than shallow land burial.

Transuranic and Mixed Transuranic Waste

Pending the availability of a geologic repository, many sites store transuranic waste, including the Hanford Site, Idaho National Engineering Laboratory, Los Alamos National Laboratory, Nevada Test Site, Oak Ridge Reservation, Rocky Flats Environmental Technology Site, and Savannah River Site. Storage facilities for transuranic waste are upgraded or built to comply with requirements under Subtitle C of the Resource Conservation and Recovery Act. Before 1970, this waste was buried in shallow trenches, mostly at the Idaho National Engineering Laboratory and the Hanford Site. Some burial site retrieval actions are now determined by the Environmental Restoration program through a process that is specified by the Comprehensive Environmental Response, Compensation, and Liability Act.

Treatment of mixed transuranic waste (radioactive and hazardous) to remove, or reduce to acceptable levels, the constituents in the waste restricted by land disposal restrictions, may be required under the Resource Conservation and Recovery Act. Mixed transuranic waste treatment requirements are being assessed as part of the Waste Isolation Pilot Plant test phase. The Waste Isolation Pilot Plant is a deep geologic repository that the Department excavated in the 1980s for disposal of transuranic waste. The Plant is located in a salt bed 640 meters (2,100 feet) below the surface in southern New Mexico. The Department plans to use this facility to dispose of transuranic waste beginning in 1998, pending completion of regulatory compliance demonstrations.

Low-Level Waste

Low-level waste ranges from low-activity waste that can be disposed of by shallow land disposal techniques to high-activity waste that requires disposal techniques providing greater confinement. Over 30 installations currently generate low-level waste. The Hanford Site, Idaho National Engineering Laboratory, Los Alamos National Laboratory, Nevada Test Site, Oak Ridge Reservation, and Savannah River Site store low-level waste on a long-term basis.

Low-level waste generally undergoes minimum treatment (that is, volume reduction, solidification of liquids, and packaging) before transportation and disposal. Low-level waste storage is kept to a minimum because disposal operations are ongoing at six installations. Waste radioactivity levels (low-level waste can have high or low levels of radioactivity) and geohydrological conditions influence disposal methods (for example, shallow land burial or engineered vaults).

In response to a recommendation from the Defense Facilities Nuclear Safety Board, the Department is taking steps to integrate low-level waste management and determine the future disposal configuration.

Low-Level Mixed Waste

Until the late 1980s, most low-level mixed waste was routinely disposed of by shallow land burial. However, enactment of the Resource Conservation and Recovery Act limited land disposal of low-level mixed waste, which is subject to land disposal restrictions, unless treatment standards are met or a variance is granted. As a result, the

Department currently plans to treat most low-level mixed waste at Department of Energy sites.

Treatment strategies for low-level mixed waste have been developed through interactions between the Department, states, and stakeholders. Disposal locations will be determined in conjunction with the Waste Management Programmatic Environmental Impact Statement; site-specific Environmental Impact Statements; state regulators; and local stakeholders. For purposes of this analysis, the Department assumed that mixed low-level waste will be disposed of at the existing low-level waste sites: Hanford Site, Idaho National Engineering Laboratory, Los Alamos National Laboratory, Nevada Test Site, Oak Ridge Reservation, Savannah River Site, and commercial facilities.

Hazardous Waste

Hazardous waste includes materials identified as hazardous or requiring regulatory control as stipulated by Subtitle C of the Resource Conservation and Recovery Act. For purposes of this report, the definition of hazarious waste includes Toxic Substances Control Act-regulated material, such as asbestos and polychlorinated biphenyls. Land disposal restrictions under the Resource Conservation and Recovery Act require treatment of the hazardous constituents of waste to specific concentration levels before disposal. These regulations are implemented by the states and the Environmental Protection Agency regions and apply to local Department of Energy operations. All waste management facilities must meet stringent waste acceptance criteria.

In general, hazardous waste generated by the Environmental Management program is sent to commercial treatment and disposal facilities. Permitted commercial facilities manage approximately 10,000 cubic meters (13,100 cubic yards) of the Department's hazardous waste annually. Small amounts of hazardous waste await treatment and disposal, except for waste being accumulated for shipment to commercial facilities.

Sanitary Waste

Sanitary waste includes materials that are not hazardous or radioactive. There are essentially two types of sanitary waste: solid and liquid. Solid sanitary waste includes garbage, rubble, and other nonhazardous debris routinely generated by construction or other activities. It is regulated under Subtitle D of the Resource Conservation and Recovery Act and is typically disposed of in onsite sanitary landfills or shipped offsite to municipal landfills. Liquid sanitary waste includes sewage and industrial wastewater that is regulated by the Clean Water Act and the National Pollutant Discharge Elimination System. Treatment of liquid sanitary waste is usually accomplished at onsite or municipally-owned facilities. Industrial wastewater undergoes pretreatment processes before being discharged.

Special Case Waste

Special case waste is waste that is not high-level or transuranic, but requires greater confinement than shallow land burial. This waste is similar to Greater-Than-Class C waste regulated by the Nuclear Regulatory Commission. Only a few sites contain special case waste. These sites include the Hanford Site, Idaho National Engineering Laboratory and Grand Junction Projects Office. A decision has not been made regarding disposal of special case waste. However, the Department is considering several disposal options, including disposal onsite and in a national repository.

Spent Nuclear Fuel

Spent nuclear fuel is not regulated as a waste material. It consists of nuclear materials or heavy metals such as uranium, plutonium, or thorium withdrawn from a nuclear reactor or another neutron irradiation facility. Spent nuclear fuel exists primarily in solid form as metal-clad rods that require no treatment for near-term storage. However, broken or punctured rods must be overpacked to contain the radioactive material. Most spent fuel is stored in water pools (for example, at Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site). This traditional storage method requires constant maintenance, such as water purification, to prevent corrosion of the fuel rods. Some spent fuel is stored in dry casks (for example, at Oak Ridge Reservation). The Department is developing dry above-ground facilities to provide safer and more efficient storage. Some treatment of spent nuclear fuel may be required before final disposal in a geologic repository. Until a repository is available, the Department will provide for the management of spent nuclear fuel and related facilities, including interim activities necessary to ensure safe storage.

Spent nuclear fuel includes all nuclear fuel generated by Department of Energy production reactors, university and government research reactors, foreign research reactors that use fuel of U.S. origin, and naval nuclear propulsion reactors (including training, prototype, and service reactors). Except for a few special cases (for example, Three Mile Island), the Environmental Management program is not responsible for managing spent nuclear fuel from commercial reactors.

In January 1996, the Environmental Management program transferred management of spent nuclear fuel from the Waste Management program to the Nuclear Material and Facility Stabilization program. This shift occurred because spent nuclear fuel is closely related to the special nuclear materials already managed by the Nuclear Material and Facility Stabilization program. For purposes of the 1996 Baseline Report, spent nuclear fuel is included in the Waste Management program's cost estimates and functional element discussion. Future reports will address spent nuclear fuel with the Nuclear Material and Facility Stabilization program.

WASTE MINIMIZATION AND POLLUTION PREVENTION

The Department of Energy has instituted a waste minimization program, administered by the Environmental Management program, at all of its facilities. Waste minimization and pollution prevention means preventing or reducing the generation of pollutants, contaminants, hazardous substances, or waste at its source or reducing the amount of waste requiring treatment, storage, and/or disposal through recycling. These objectives are achievable by administrative and procedural changes, design features incorporated into new facilities, modifications to existing facilities, increased use of existing technologies, and expanded technology development efforts. For example, wastewater treatment has been improved by replacing antiquated equipment and processes and site-wide programs have begun to recycle materials such as aluminum, paper, lead, oil, tires, and excess chemicals. Chapter 4 and Appendix G provide additional information on the Department's pollution prevention program and the results of an analysis of pollution prevention efforts on the Base Case estimate.

2.3 NUCLEAR MATERIAL AND FACILITY STABILIZATION

Mission

The mission of the Nuclear Material and Facility Stabilization program consists of three primary elements: stabilizing and storing nuclear materials prior to final disposition, deactivating surplus facilities, and managing spent nuclear fuel treatment and storage. Integral within each element is a surveillance and maintenance function. Surveillance and maintenance encompasses all actions required to ensure that adequate material and facility safety and security requirements are met.

The program is responsible for a large number of geographically dispersed sites and facilities; large quantities of radioactive, hazardous, and toxic materials in a variety of chemical and physical forms and storage configurations; and an aging complex of processing and production facilities historically used for chemical and physical processing of many different types of nuclear material. The following summary of major facilities and materials that are under the purview of the Nuclear Material and Facility Stabilization program illustrates the breadth and complexity of the program's mission:

- 13 nuclear reactors;
- 41 radioactive processing facilities;
- approximately 3,000 surplus buildings contaminated with and generally containing radioactive, hazardous, and toxic materials;
- 39 million liters (10.1 million gallons) of acids containing radioactive contaminants;
- nearly 3,000 metric tons (3,300 tons)of spent nuclear fuel;
- several thousand kilograms of plutonium in various forms and locations;

- 37,000 packages of plutonium materials and related waste products;
- 75 million curies of cesium and strontium; and
- a large inventory of nuclear materials awaiting long-term storage and final disposition decisions.

Strategy

Nuclear material and facility stabilization activities manage and mitigate many of the urgent risks facing the Department. These risks are associated with a wide variety of materials and facilities, including various forms of plutonium, uranium and spent fuel; high-activity cesium capsules; aging facilities; hazardous chemicals; and special isotopes. The broad scope and potential impacts on the public and workers associated with these risks reinforce the need for risk-based planning to address the risks posed by the material and facilities.

Nuclear material and facility stabilization activities are also instrumental in reducing the overall scope of materials and facilities that the Environmental Management program must address. Because many special nuclear materials and surplus facilities require significant resource expenditures for maintenance in a safe and secure condition, the program's stabilization, consolidation, and material removal activities are essential to reduce the need for major facility systems and to reduce security perimeters (and other surveillance and maintenance requirements). These actions significantly decrease the annual cost required to maintain materials and facilities in a safe and secure manner, thereby reducing the estimated life-cycle cost of the Environmental Management program.

Nuclear Material Stabilization

The end of the Cold War resulted in an abrupt halt to nuclear material production facilities and reactor operations, leaving nuclear material in a variety of chemical and physical forms, packaging configurations, and geographical locations. Stabilization activities reduce near-term risks associated with current storage configurations by placing these materials in a condition that is suitable for long-term storage. The principal materials of concern include plutonium (solutions, metals, oxides, and residues), uranium (solutions, solids, and gaseous compounds) and special isotopes (americium, curium, neptunium, and plutonium-242). In some cases, stabilization also involves long-term storage of nuclear materials prior to their ultimate disposition.

Facility Deactivation

Upon completion of stabilization activities, the Department undertakes deactivation activities to remove materials, shut down facility systems, and remove or de-energize equipment. Deactivation activities reduce physical risks and hazards to the public, workers, and the environment by placing surplus facilities in a safe, stable condition. Once hazards associated with surplus facilities are mitigated, costs for maintaining the facilities can be significantly reduced.

2.4 SCIENCE AND TECHNOLOGY DEVELOPMENT

Mission

Developing new technologies to address the environmental challenges in the former nuclear weapons complex is an integral part of the Environmental Management program. The mission of the technology development program is to develop new technologies that will allow the Department to reduce risks to people and the environment, reduce cleanup costs, and address environmental problems for which no solutions currently exist.

The Department has targeted five major remediation and waste management "focus areas" for action on the basis of risk, prevalence, or environmental requirements and regulations. (See the following box). The focus area strategy is to identify and develop specific technologies to clean up the nuclear weapons complex and manage waste more quickly, more safely, and at a lower cost, using the best capabilities available in industry, academia, and Department laboratories. Focus area management teams include stakeholders and representatives from across the Environmental Management program.

TECHNOLOGY DEVELOPMENT FOCUS AREAS

Treat and Dispose of Mixed Waste. The Department is pursuing versatile treatment methods such as plasma, vitrification, molten metal, and nonthermal techniques. These activities are being coordinated closely with waste management activities to meet Federal Facility Compliance Act requirements.

Retrieve and Process Tank Waste. The Department is initiating full-scale demonstrations of technology systems to retrieve and process high-level tank waste for permanent disposal safely and efficiently. The Department is also developing tank structural analysis and waste content analysis methods.

Remediate Contaminated Soils and Ground Water. The Department has initiated full-scale demonstrations of technology systems to characterize, contain, and remediate contaminated plumes in soils and ground water. In-place treatment of dense nonaqueous phase liquids is an example of activities in this area.

Stabilize Landfills. Containment and in-place treatment methods for buried waste are being developed. The Department is also pursuing technology systems for retrieving, characterizing, and treating landfill waste.

Stabilize, Decontaminate, and Decommission Facilities. The Department will conduct a full-scale demonstration of the development of facility stabilization and decommissioning technologies that emphasize materials recycling.

In 1996, the Department initiated an Environmental Management Science program to develop a targeted long-term basic research agenda for environmental problems. One of the goals of the program is to ensure that "transformational" or breakthrough approaches lead to significantly reduced cleanup costs and risks to workers and the public. The program will "bridge the gap" between broad fundamental research performed in the Department of Energy's Office of Energy Research, and needs-driven applied technology development historically conducted by the Environmental Management program. This effort will stimulate the nation's science infrastructure to focus on critical national environmental management problems. Also included in the Office of Science and Technology is the Risk Policy program. The goal of this program is to conduct and integrate risk management and analysis activities into the Environmental Management decisionmaking process.

2.5 LANDLORD FUNCTIONS

In addition to the four major functional areas discussed above, the Environmental Management program must perform landlord (infrastructure support) activities that are both directly and indirectly related to its mission. Landlord functions include cross-cutting, site-wide activities such as managing electrical systems, laboratory support, road maintenance and upgrades, fire protection, quality assurance, safety and environmental monitoring, sanitary sewer systems, laundry services (for contaminated clothing and other materials), utilities, roadways, and security reviews. Landlord functions are required to keep communication, transportation, and security systems operational at environmental management sites and, in many cases, to meet environmental regulatory requirements.

Some of the sites under the purview of the Environmental Management program cover hundreds of miles of land, and contain hundreds of buildings and facilities. For example, the 1,450-square kilometer (560-square mile) Hanford Site in Washington State has its own fire department, security force, and medical center. The program maintains a utility infrastructure at Hanford that provides steam and sewage treatment, maintains grounds and roads, and provides onsite mass transit.

In some instances, the Environmental Management program has landlord responsibilities for entire sites. In general, infrastructure-related costs are typical at large sites where the majority of program costs are incurred. For example, Hanford Site, Idaho National Engineering Laboratory, Oak Ridge K-25 Site, Rocky Flats Environmental Technology Site, and the Savannah River Site have large landlord programs.

2.6 NATIONAL PROGRAM PLANNING AND MANAGEMENT

In addition to its presence at Department of Energy sites, the Environmental Management program performs several functions at Headquarters. These functions are primarily focused on planning, management, and oversight. Specific roles of Headquarters personnel include establishing policy and conducting program reviews to ensure adherence to policy; preparing program-wide budgets based upon field input; coordinating with Congress and other federal agencies; coordinating with national stakeholder organizations; managing national initiatives; overseeing site safety programs; establishing and tracking program performance measures; preparing national reports; and developing program strategic plans.

Uranium mining, United States Atomic Energy Commission, Colorado, 1958. *Uranium mining expanded dramatically in the United States after World War II, from 38,000 tons in 1948 to 5.2 million tons in 1958 -- nearly all of it for nuclear weapons production. The United States mined about 60 million tons of ore to produce its uranium.*

Excavation of uranium mill tailings from a residential septic system, Grand Junction, Colorado, 1993. *Uranium mining produced large volumes of a sandlike byproduct called "mill tailings," containing both toxic heavy metals and radioactive radium and thorium. Uranium-mill tailings account for a small fraction of the radioactivity in the byproducts of weapons production, but they constitute 96 percent of the total volume of radioactive byproducts for which the Environmental Management program is responsible. Because uranium mills typically piled tailings without covers or containment, some material was spread by wind or water. Life-cycle planning is an effective way to understand and predict the importance of such precautions and, ultimately, is an effective method for ensuring long-term cost savings.*

3.0 WHAT IS THE BASE CASE?

This chapter presents the assumptions that define the Base Case cost estimate for the 1996 Baseline Report.

The Environmental Management Base Case is a long-range projection of activities, schedules, and associated costs that describes the current Environmental Management program from its present state to completion (see "Why Life-Cycle Estimates") based upon compliance with current laws, regulations, and agreements. The Base Case looks to the future based on the knowledge, information, and assumptions that are available today. Because these inputs are rapidly changing, the 1996 Base Case is essentially a snapshot in time of a dynamic and complex program. In addition, this analysis helps identify missing information necessary for effective planning. The Base Case is ***not*** a budget estimate or a program funding request. Nor is it intended to provide details on specific projects.

Section 3.1 describes the Environmental Management Base Case and discusses the challenges inherent in developing it. Sections 3.2 and 3.3 provide an overview of the Base Case development methodology and key Base Case assumptions. Section 3.4 discusses support costs. (For further methodology details, see Appendix C, which provides a detailed explanation of the Base Case development process. For site-specific assumptions, see the site narratives in the 1996 Baseline Report, Volumes II and III.)

WHY LIFE-CYCLE ESTIMATES?

The purpose of life-cycle cost analyses, put simply, is to understand the full "costs of doing business." This includes an estimate of the total direct, indirect, recurring, nonrecurring, and related costs incurred -- or estimated to be incurred -- for a project. The life-cycle cost estimate encompasses all costs of a project, including those related to characterization, design, remediation, operation, maintenance, support, deactivation and disposition over the anticipated life span of that project.

Traditionally, cost estimates have often failed to include all related costs necessary for the full life cycle of that project, particularly the "externalities" such as waste disposal, decommissioning and decontamination costs. Moreover, life-cycle estimates help identify activities that have the most significant financial impact on a project during its life span and provide information for effective strategic planning, budgeting, execution, and control of project activities. While near-term planning remains critical for budgeting and tasking purposes, it is incapable of identifying the long-term implications of issues and the strategies posed to resolve them. Life-cycle planning is also critical to ensure that issues affecting sites throughout the complex are addressed in a programmatically efficient way.

The information in the Base Case falls into four categories: (1) descriptions of Environmental Management activities; (2) estimates of their annual costs; (3) estimates of the annual waste volumes generated by each activity and (4) initial schedule estimates for each activity, including starting dates and duration. "Activities" are specific sets of actions taken to manage special nuclear materials or contaminated facilities, remediate contaminated areas, manage waste, maintain federal lands and facilities, and manage the programs individually and collectively in an integrated manner.

3.1 LIMITATIONS OF A LIFE-CYCLE ESTIMATE

Developing a life-cycle estimate for the Environmental Management program involves a number of challenges related to the length, scope, and complexity of the cleanup effort and the uncertain and changeable nature of the program. The purpose of outlining the challenges is to explain the element of uncertainty in the Base Case estimates and the development of Base Case assumptions (addressed later in this chapter).

Projecting future activities and costs is always fraught with uncertainty. This uncertainty is compounded when projecting the path of an unprecedented program such as stabilizing and remediating the facilities and residues of the nuclear weapons complex, which is expected to last decades and will be affected by unpredictable factors, such as the development of new technologies and laws, and is extremely controversial. Nonetheless, these are also some of the reasons why good program management and good public policy require that such an estimate be compiled. The following is a list of specific limitations of the life-cycle Base Case for the Environmental Management program:

- The program has a large *unknown* scope for which the nature and extent of existing waste have not been identified and an approach for decontamination or remediation has not been defined. The largest and most significant of the program's 10,500 release sites are characterized and preliminary information is available for a large portion of the balance, but incomplete characterization still results in a significant information gap.

- The program faces challenges resulting from the production of nuclear materials that are inherent only to the Department of Energy. The contaminants tied to the nuclear weapons complex are largely unknown to commercial industry and differ from site to site. The program must, therefore, develop new approaches and technologies to address unique environmental cleanup problems.

- The program is responsible for environmental management problems for which there are no current effective remedies now or on the horizon (defined as "infeasible"). Some are infeasible for technological reasons (no available technology); others are infeasible because addressing them will result in unacceptable levels of ecological damage. The Base Case does not include costs for undertaking infeasible projects. See Section 3.3.3 for a list of excluded remediation challenges. In addition, the Base Case does not include liabilities due to potential natural resources damage claims. Insufficient information currently exists to provide a meaningful estimate of these potential liabilities.

- The estimate must project how long short-term interim measures will be used to address problems for which no long-term solutions are available. For example, to ensure safe storage of transuranic waste that is currently packaged in corroding or leaking drums, the program is building new storage facilities and placing older drums into larger drums to provide secondary containment until a geologic repository is available.

In addition to technical issues that result from the program's unprecedented nature, the Base Case estimates must also address uncertainties that stem from legal and institutional issues. Department of Energy policy requires management of its facilities in compliance with applicable federal, state, and local regulations. This requirement, combined with the fact that a large portion of the environmental management activities are legally driven by over 100 compliance agreements, creates a substantial inventory of legal obligations. The major federal regulations driving the program are listed in Chapter 2. Congress has targeted many of these laws, including the Comprehensive Environmental Response, Compensation, and Liability Act, the Clean Water Act, and the Clean Air Act for reauthorization. Changes to these laws will likely affect the Environmental Management program, although the timing, substance, and extent of the changes are currently unclear.

Site-specific cleanup and compliance agreements, developed with the U.S. Environmental Protection Agency and states that host Department of Energy facilities, are a primary means for the Department to implement the provisions of federal, state, and local regulations. However, because regulators make final decisions about the choice of remedial action and the satisfactory completion of each action, the process adds complexity and uncertainty to the Department's planning processes. In some cases, final agreements are not yet concluded. In other cases, agreements are signed, but subsequent information and events require that these agreements be renegotiated. Two major agreements that have already been renegotiated include the Hanford Tri-Party Agreement and the Rocky Flats Compliance Agreement.

These issues pose significant uncertainties and challenges to the Base Case development process. The assumptions described below address many of these issues with "best estimate" scenarios based on the information and knowledge that is currently available.

3.2 BASE CASE METHODOLOGY

The Department used a five-step process to develop the cost and schedule estimates for the 1996 Report (see "Steps in the General Methodology" box). Appendix C presents a detailed description of these steps. In developing the Base Case estimate, every effort was made to ensure that personnel at individual sites were fully involved with the data collection and analysis. The overall scope of the Base Case and the national assumptions underlying the estimates were consistent across the program, but each site developed its own, fully integrated, cost and schedule estimates, using their most current data. Once these estimates were complete, the Department conducted a complex-wide integration process to ensure that the interdependencies across sites (for example, waste transfers) were fully understood. (See "Environmental Management Cost Reporting" box for an explanation of how the estimates were structured based on environmental management functional elements.) Volumes II and III of this report present the final estimates for each site.

The Department maintained an active stakeholder involvement process throughout the development of this report. Their objective was to ensure public input to the overall scope and framework for the 1996 estimate and the site-specific assumptions and estimating methods. The Department also sought stakeholder input to ensure that Base Case assumptions were consistent with other Departmental initiatives (for example, future land-use planning). Appendix C outlines the stakeholder involvement process.

STEPS IN THE GENERAL METHODOLOGY

The Department implemented the following steps to develop the Base Case. Stakeholders were involved in all steps, providing continuous input and ensuring that the process reflected public values and concerns.

1. Define the Study: Establish the scope, framework, and general assumptions for the estimates. Seek input from stakeholders.
2. Gather and Assemble Data: Collect, verify, and document cost, waste volume, and schedule data.
3. Perform Site- and Complex-Wide Integration: Ensure that costs remain within assumed funding limits and all waste transfers are accounted for.
4. Estimate Program Improvements: Evaluate the impacts of technology development, pollution prevention, and productivity improvements.
5. Develop Documentation: Prepare the 1996 report.

The Base Case development process described above is distinct from the budget process. The Base Case methodology was implemented to develop a ***life-cycle*** cost estimate for the program based on compliance with existing legal requirements and other current assumptions. Budget estimates are also compliance-based but they are near-term estimates that reflect federal resource constraints. In addition, budget estimates are more focused on the next fiscal year, for which they are more accurate and up-to-date then the Base Case. The Baseline Report is not intended to focus on the near term, but rather to compel project managers to think about the broader implications of actions.

SITE-BASED COST ESTIMATES: "BOTTOM UP" APPROACH

The 1996 Base Case cost estimates were developed through the use of a "bottom up" estimating approach. Detailed cost estimates developed for specific projects were aggregated into sequentially larger groupings. This approach, in which project and site managers take responsibility for estimating costs at the site level, offers several advantages: increased estimate credibility (due to involvement of staff that best understands the work); traceability of summary estimates to detailed data; availability of detailed estimates for Headquarters to analyze issues at a national level; and development of analytical tools that can be used for improved site and program management. This method is in contrast to a "top down" method that uses field data in a centralized cost estimation model. Because of a lack of adequately developed life-cycle cost estimates from the field, this " top down" method was used for roughly half of the cost data in the 1995 Baseline Report.

ENVIRONMENTAL MANAGEMENT COST REPORTING: DISTINCT FUNCTIONAL AREAS ARE REFLECTED IN DIFFERENT COST REPORTING STRUCTURES

The Environmental Management functional elements (also referred to as "programs") conduct "activities;" however, because their functions are inherently different, each has had its own structure for collecting cost estimates and reporting baseline data. The waste management activities are structured by waste type and waste management function (storage, treatment, and disposal). The environmental restoration activities are reported at the project level and are divided by activity phase (assessment, remedial action/decommissioning, surveillance and monitoring, program management, landlord, site treatment, storage and disposal.) The basic building block for reporting environmental restoration baseline data is the project. Nuclear material and facility stabilization is based on "Scheduling/Transfer Units." These are the basis for grouping facilities and scheduling transfer of projects from deactivation to decommissioning. Each Scheduling/Transfer Unit represents a grouping of facilities that is similar in historical use and cleanup timing and delineated by activity phase, surveillance and maintenance, stabilization, and deactivation. In part as a result of this Baseline analysis, the program structure has become much more integrated.

3.3 ASSUMPTIONS IN THE BASE CASE

A variety of factors significantly affect the estimated scope, schedule, and total cost of the Environmental Management program. This section describes the key assumptions that were used to derive the 1996 Baseline Report estimates. They are divided into four main categories: funding, scheduling/site completion, land use, and functional program element (presented in six categories: environmental restoration, waste management, nuclear material and facility stabilization, science and technology development, landlord, and national program planning and management). In addition, site personnel developed detailed, site-specific assumptions for each factor to estimate their costs. Volumes II and III of the 1996 Baseline Report describe these site-specific assumptions.

Assumptions change over time because of revisions to current federal, state, or local regulations; renegotiated compliance agreements; shifts in national budget priorities; and development or application of new technologies. Assumptions also provide a foundation for estimates that reflect, at a given point in time, the strategy intended for use at a site. The 1996 Baseline Report endeavors to capture all costs that occur during the life of the cleanup effort (to approximately 2070). Because of the long timeframe involved, there will be many opportunities for changes that will affect the Environmental Management program. Nonetheless, the Base Case is built on a set of stated assumptions that bound the estimates. If major changes to these assumptions occur, the Base Case estimates will likely be affected. Future Baseline Reports will reflect those changes. The type and extent of the change will determine the degree of the impact. For purpose of this report, all assumptions are based on program plans and capabilities as of October 1995; some of which have changed because of renegotiated agreements, new information, etc. Changes in these plans or capabilities since that time are not reflected in this report.

SITES INCLUDED IN THE ANALYSIS

The Environmental Management program is responsible for activities at 150 sites. For purposes of the 1996 Baseline Report, these sites are divided into three main categories: (1) Individually reported sites (107) (102 sites excluding the Albuquerque, Chicago, Oak Ridge, Oakland, and Ohio Operations Offices which have no contamination), (2) Aggregated sites (17 sites included in the cost estimates of other sites), and (3) Completed sites (26). The following list presents the individually reported sites, sorted by state.

Alaska
- Amchitka Island Test Site

Arizona
- Monument Valley
- Tuba City

California
- Energy Technology Engineering Center
- General Atomics
- General Electric Vallecitos Nuclear Center
- Geothermal Test Facility
- Laboratory for Energy Related Health Research
- Lawrence Berkeley Laboratory
- Lawrence Livermore National Laboratory
- Oakland Operations Office
- Oxnard Site
- Sandia National Laboratories/California
- Stanford Linear Accelerator Center

Colorado
- Durango
- Grand Junction Projects Office
- Grand Junction Uranium Mill Tailings Remedial Action Site
- Gunnison
- Maybell
- Slick Rock (Union Carbide Corporation and Old North Continent Sites)
- Naturita
- New Rifle Site
- Project Rio Blanco and Rulison Sites
- Rocky Flats Environmental Technology Site

Connecticut
- CE

Florida
- Pinellas Plant

Idaho
- Argonne National Laboratory - West
- Idaho National Engineering Laboratory
- Lowman

Illinois
- Argonne National Laboratory - East
- Chicago Operations Office
- Fermi National Accelerator Laboratory
- Madison
- Site A/Plot M, Palos Forest Preserve

Iowa
- Ames Laboratory

Kentucky
- Maxey Flats Disposal Site
- Paducah Gaseous Diffusion Plant

Maryland/District of Columbia
- Environmental Management Program Headquarters
- W.R. Grace & Company

Massachusetts
- Shpack Landfill
- Ventron

Mississippi
- Salmon Test Site

Missouri
- Kansas City Plant
- Latty Avenue Properties
- St. Louis Airport Site
- St. Louis Airport Site Vicinity Properties
- St. Louis Downtown Site
- Weldon Spring Site Remedial Action Project

Nebraska
- Hallam Nuclear Power Facility

Nevada
- Central Nevada Test Area and Project Shoal Site
- Nevada Test Site and Tonopah Test Range

New Jersey
- DuPont & Company
- Maywood Chemical Works
- Middlesex Sampling Plant
- New Brunswick Site
- Princeton Plasma Physics Laboratory
- Wayne Interim Storage Site

New Mexico
- Albuquerque Operations Office
- Ambrosia Lake
- Inhalation Toxicology Research Institute
- Los Alamos National Laboratory
- Project Gasbuggy and Gnome-Coach Sites
- Sandia National Laboratories/New Mexico
- Shiprock
- South Valley Superfund Site
- Waste Isolation Pilot Plant

New York
- Ashland Oil #1
- Ashland Oil #2
- Bliss and Laughlin Steel
- Brookhaven National Laboratory
- Colonie Site
- Linde Air Products
- Niagara Falls Storage Site
- Seaway Industrial Park
- Separations Process Research Unit
- West Valley Demonstration Project

North Dakota
- Belfield
- Bowman

Ohio
- B&T Metals
- Baker Brothers
- Battelle Columbus Laboratory
- Fernald Environmental Management Project
- Luckey
- Mound Plant
- Ohio Operations Office
- Painesville
- Piqua Nuclear Power Facility
- Portsmouth Gaseous Diffusion Plant
- Reactive Metals, Inc.

Oregon
- Lakeview

Pennsylvania
- Canonsburg

South Carolina
- Savannah River Site

Tennessee
- Oak Ridge Associated Universities
- Oak Ridge K-25 Site
- Oak Ridge National Laboratory
- Oak Ridge Operations Office
- Oak Ridge Reservation Offsite
- Oak Ridge Y-12 Plant

Texas
- Falls City
- Pantex Plant

Utah
- Green River
- Mexican Hat
- Monticello Remedial Action Project
- Salt Lake City

Washington
- Hanford Site

Wyoming
- Riverton
- Spook

Figure 3.1. The U.S. Department of Energy Environmental Management Program: Responsibilities from Coast-to-Coast and Beyond

SITES INCLUDED IN THE ANALYSIS (continued)

For purposes of the 1996 Baseline Report, the cost and schedule estimates for 17 of the 150 Environmental Management sites are aggregated with other site estimates.

- **Included in Other Site Estimates.** Estimates for 17 sites are included in estimates for other sites: Pittsburgh Energy Technology Center (Pennsylvania), Morgantown Energy Technology Center (West Virginia), and Western Environment Technology Office (Montana) are included in estimates for Department of Energy Headquarters. The Center for Energy and Environment Research (Puerto Rico) is included in the estimate for the Oak Ridge Operations Office. Salton Sea Test Base (California), Kauai Test Facility (Hawaii), and Holloman Air Force Base (New Mexico) are included in the estimates for Sandia National Laboratories (New Mexico). The Pinellas 4.5 Acre Site (Florida) is included in the estimates for Pinellas Plant (Florida). The estimates for Climax Mill Site (Colorado) are included in Grand Junction Uranium Mill Tailings Remedial Action Sites (Colorado). Old Rifle Site (Colorado) and New Rifle Site (Colorado) estimates are combined. The estimates for Peak Petroleum Oil Refinery (Florida) appear in Albuquerque Operations Office (New Mexico). Project Gnome-Coach Test Site (New Mexico) and Project Gasbuggy Site (New Mexico) are addressed as one site. Project Rulison Site (Colorado) estimates are rolled into Project Rio Blanco (Colorado). Project Shoal Test Site (Nevada) and the Central Nevada Test Area (Nevada) are also addressed as one site summary. Tonopah Test Range (Nevada) estimates appear in Nevada Test Site (Nevada). Estimates for Union Carbide Corporation (Colorado) and Old North Continent (Colorado) are combined to form the Slick Rock Site summary. Costs for Oak Ridge Reservation are apportioned to other Tennessee sites.

This report excludes 26 sites because they have been completed.

- **Completed Sites.** Completed sites include Cape Thompson (Alaska), Project Chariot (Alaska), University of California Gilman Hall (California), Seymour Specialty Wire Company (Connecticut), Chapman Valve (Massachusetts), Granite City (Illinois), Illinois National Guard Armory (Illinois), University of Chicago (Illinois), General Motors (Michigan), Kellex/Pierpont (New Jersey), Middlesex Municipal Landfill (New Jersey), Acid/Pueblo Canyon (New Mexico), Bayo Canyon (New Mexico), Chupadera Mesa (New Mexico), Pagano Salvage Yard (New Mexico), Baker and Williams Warehouse (New York), Associated Aircraft (Ohio), Alba Craft (Ohio), HHM Safe Co. (Ohio), Niagara Falls Storage Site Vicinity Property (New York), Albany Research Center (Oregon), Aliquippa Forge (Pennsylvania), C.H. Schnoor (Pennsylvania), Shippingport Atomic Power Station (Pennsylvania), Edgemont Vicinity Properties (South Dakota), and Elza Gate Site (Tennessee).

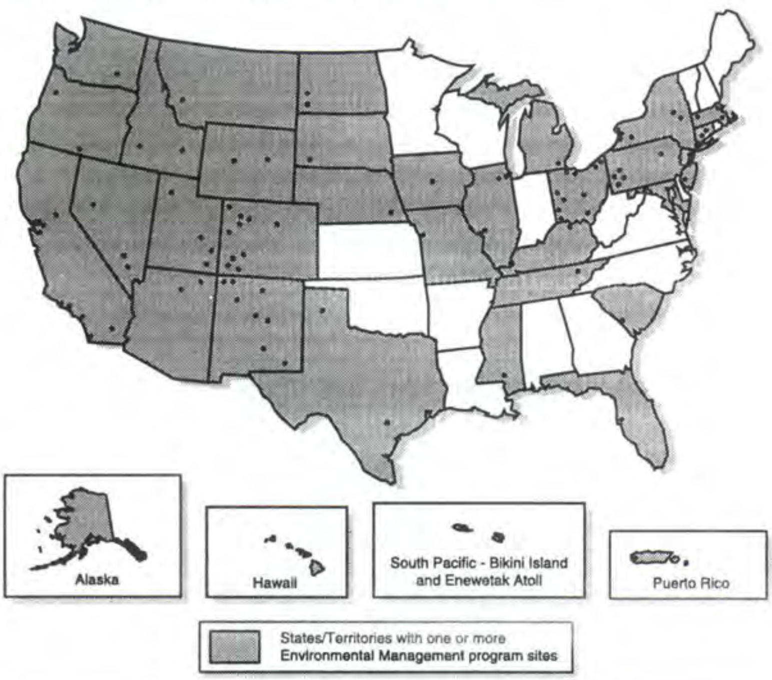


Figure 3.1. The U.S. Department of Energy Environmental Management Program: Responsibilities from Coast-to-Coast and Beyond (Continued)

3.3.1 Base Case Funding Assumptions

As specified by Congress, site personnel projected the cost for meeting the requirements of applicable provisions of law, permits, regulations, Department of Energy orders, and agreements. This approach involves estimating the cost of meeting the milestones in existing compliance agreements in effect throughout the complex or reasonably anticipated requirements up to FY 2000. For activities that will be required but are not yet specified by milestones in existing compliance agreements, other assumptions were needed to complete the analysis. The annual site costs beyond 2000 were "capped" at the site's FY 2000 estimate of compliance funding, unless cost increases were dictated by existing compliance agreements. See the box below for an example of a site that exceeded the FY 2000 funding cap. This provided for an analysis that accommodated full funding for compliance commitments while ensuring that the program's funding scenario was realistic in light of other national priorities.

EXAMPLE OF AN EXCEPTION TO THE FY 2000 FUNDING CAP

The Base Case cost estimate for the Idaho National Engineering Laboratory exceeded the funding cap beyond FY 2000 because of the need to include activities required under a settlement agreement between the Department of Energy and the State of Idaho. For example, the agreement requires the Department of Energy to remove all spent nuclear fuel from the State by 2035 (15 years earlier than previous estimates), and to begin transuranic waste shipments to the Waste Isolation Pilot Plant by April 30, 1999.

The compliance case represented by the Base Case does not incorporate recently established budget targets. The Department of Energy, and hence the Environmental Management program, operates under the same funding pressures as other Departments and federal agencies. It is not possible to predict the level of funding that will be available to support the program over the next several decades. Budget reductions may force difficult choices about cleanup priorities. These choices will require a national discussion of risks, costs, and trade-offs and a management infrastructure that supports analysis of various policy options. The Environmental Management Base Case and the analytical infrastructure established to support its development are positive steps in this direction. (The alternative case analyses in Chapter 6 provide examples of decision analyses that compare program options.)

3.3.2 Schedule/Site Completion Assumptions

There are three site completion categories: (1) sites that are complete (these are the 26 sites listed on the previous page) and have no ongoing surveillance and monitoring activities; (2) sites that are complete but have ongoing surveillance and monitoring activities; and (3) sites that are complete but have ongoing operations outside of their environmental management mission that generate waste (for example, national laboratories). For the remainder of this report, a site is considered "complete" when the following criteria have been met: the site has been remediated to the extent specified in land-use plans; all facilities have been properly stabilized and dispositioned; and all legacy waste has been safely disposed. Where it is assumed that restricted areas (for example, waste disposal sites or nuclear materials storage) will remain, annual surveillance and monitoring costs are assumed to be incurred after "completion."

3.3.3 Environmental Activities Generally Excluded from the Base Case

The 1996 Base Case covers the majority of the activities that must be carried out to fully clean up and manage all newly generated and legacy waste associated with the nuclear weapons complex. However, some activities are excluded from the 1996 Base Case. The exclusions fall into several categories. First, cost estimates for remediation that is either not technically possible or not planned are excluded from the Base Case. These exclusions are typically remediation problems involving contaminants that will naturally attenuate; that currently have no feasible remediation approach; or that, if addressed, will result in collateral ecological damage. The excluded activities in this category are further described in Table 3.1.

Table 3.1. Examples of Environmental Media Activities Excluded from the Base Case

Installation	Project	Reason Excluded
Hanford Site	Columbia River, Hanford Reach	No feasible remediation approach available
	Ground Water	Limited pump-and-treat followed by natural attenuation and monitoring
Oak Ridge Reservation (Y-12, K-25, Associated Universities)	Clinch River Watts Bar Reservoir Poplar Creek Embayment White Oak Creek	No feasible remediation approach available
Oak Ridge National Laboratory	Deep Hydrofracture Grout Sheet	No feasible remediation approach available
Savannah River Site	L Lake Savannah River Swamp Par Pond	No feasible remedy without causing collateral ecological damage
Fernald Plant	Great Miami River	No feasible remediation approach available
Idaho National Engineering Laboratory	Snake River Plain Aquifer	Limited pump-and-treat followed by natural attenuation and monitoring
Rocky Flats Environmental Technology Site	Walnut Creek Woman Creek Great Western Reservoir Stanley Lake	No feasible remedy without causing collateral ecological damage
Nevada Test Site	Underground Test Areas	No feasible remediation approach available
Sandia National Laboratory/New Mexico	Chemical Waste Landfill Ground Water	Natural attenuation and monitoring assumed

Second, cost estimates for sites and/or facilities with ongoing missions (e.g., Defense Programs, Nuclear Energy, Energy Research) are excluded from the Base Case. For purposes of this report, facilities that are not declared "surplus" in the Surplus Facilities Inventory Assessment are assumed to remain operational in support of ongoing mission activities. The costs for cleanup of these facilities are assumed to be the responsibility of the operating programs. A similar responsibility is assumed for management of the chemical and radioactive substances that they generate. At facilities with ongoing missions, (e.g., Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge Y-12 Plant, Pantex Plant, and Savannah River Site) two types of costs are excluded: (1) stabilization, deactivation, and decommissioning of facilities involved in ongoing mission activities; and, (2) treatment, storage, and disposal of chemical and radioactive substances that result from ongoing mission activities. At two sites (Paducah Gaseous Diffusion Plant, Kentucky, and the Portsmouth Gaseous Diffusion Plant, Ohio), facility stabilization and deactivation costs are excluded from the Base Case. The specific allocation of responsibility for these costs is subject to an agreement between the United States Enrichment Corporation and the Department of Energy, which assigns these responsibilities to the United States Enrichment Corporation.

Third, cost estimates for annual long-term, post-closure surveillance and monitoring for the Environmental Management program are also excluded from the Base Case because of the indefinite and ongoing nature of the costs. For purposes of this report, these long-term activities are reported separately from the Base Case as annual costs after the Base Case period (beyond 2070). These activities include the long-term, post-closure surveillance and monitoring of onsite disposal facilities, continued environmental monitoring, and the safeguard and security associated with special nuclear material. There are a few instances where cost estimates for post-closure site cleanup related to waste management activities are excluded from the Base Case (for example, the West Valley Demonstration Project, New York).

Fourth, the Base Case does not include costs incurred during the first six years of the Environmental Management program (1989-1995), approximately \$28.5 billion (\$31.8 billion in constant 1996 dollars).

Fifth, the Base Case does not include cost estimates for potential liabilities due to natural resources damages claims. There is the potential that claims for natural resources damages could be filed against the Department of Energy after selection of the remedial action at some of the Department's sites. If any such claims result in payment of a damage claim, this liability would be additive to the costs estimated in the report.

Lastly, the cost (or revenue) for disposition of stockpiled special nuclear materials (e.g., plutonium) or other materials in inventory (e.g., depleted uranium or lithium) (See *"Taking Stock: A Look at the Opportunities and Challenges Posed by Inventory from the Cold War Era,"* January 1996) are excluded from the Base Case. Although most costs are generally included in the Base Case for sites where the Environmental Management program serves as "landlord," such as the Rocky Flats and Fernald sites, the responsibility for and cost of disposition of these materials will be assumed by another Office of the Department of Energy or by another office that has not yet been determined.

As a result of these exclusions, the Baseline Report is an incomplete estimate of the "Cold War mortgage" as the title of the 1995 version of the report suggested. The Cold War mortgage may be defined as the total life-cycle cost of cleaning up and safely disposing of all waste, contamination, buildings, and other materials associated with the production and testing of nuclear weapons. The cost estimate in the 1996 Baseline

Report is incomplete in several important respects as described above. In terms of fundamental methodological assumptions, the Baseline reports are similar to the previous Department of Energy estimate of total environmental liabilities, the 1988 report entitled *"Environmental, Safety, and Health Needs of the U.S. Department of Energy."* Both the Baseline reports and the 1988 analysis used the institutional and mission assumptions that existed when the analyses were performed. In 1988, the analyses assumed that most of the facilities would continue operation for nuclear weapons purposes, and that the activities for which costs were estimated were those necessary to bring facilities into compliance with environmental requirements to allow continued operation. For example, no decommissioning costs were included for most facilities. By contrast, the 1995 and 1996 Baseline reports include these costs for a much greater number of facilities and types of activities. The Baseline reports, however, continue to exclude the deactivation and decommissioning costs for facilities that are expected to continue to operate for ongoing Defense Programs, Nuclear Energy, and Energy Research Missions. The additional costs necessary to conduct these activities may be included in future Baseline analyses or as part of the Department of Energy's Consolidated Financial Statement.

3.3.4 General Assumptions

All sites must develop a vision for the completion of their environmental mission to develop a cleanup strategy and assumptions. It is essential to have assumptions regarding future land use to formulate such an end-state vision. The future uses and the associated cleanup levels reflected in the following table and represented elsewhere in this report were developed for estimating purposes. These land-use and cleanup assumptions do not necessarily reflect decisions. All sites are involved in discussions with local stakeholders and regulators to reach a consensus on these issues. It is likely that final decisions will differ somewhat from what is depicted in this report. Subsequent versions of the Baseline Report will update those assumptions appropriately.

The Department developed a standard set of land-use definitions to conduct the land-use analysis discussed in Chapter 6. A discussion of the land-use standards appears in Appendix D. Volumes II and III depict the site land-use assumptions using the standard definitions. Table 3.2 provides a summary of the assumptions for the five Environmental Management sites with the highest life-cycle cost estimates.

Table 3.2. Base Case Land-Use Assumptions for the Five Highest-Cost Sites

Site	Land Area	Future Land-Use Assumptions
Idaho National Engineering Laboratory	• 230,000 hectares (570,000 acres) • Environmental management activities in 8 Waste Area Groupings	• Most currently used land will continue to support Industrial uses • A limited area around the perimeter of the site will allow cattle grazing (Agricultural use) • Most uncontaminated areas will support Open Space/Wildlife Management
Oak Ridge Reservation	• 14,140 hectares (35,000 acres) including 3 major production facilities Oak Ridge National Laboratory • 1,170 hectares (2,900 acres) in the Bethel and Melton Valleys	Oak Ridge National Laboratory • Lab will support Department of Energy and privatized Industrial uses in both Bethel and Melton Valley facilities • Melton Valley waste management areas will remain Controlled Access • Undeveloped areas in Melton Valley will support Open Space/Wildlife Management uses
	K-25 Site • 600 hectares (1,500 acres) including main plant, process area and external areas	K-25 Site • Short-term continuing missions exist, but Base Case costs assume that all buildings will be demolished (unless a use is identified), and the site will be remediated to support Industrial use. • Buried waste areas will remain Controlled Access
	Y-12 Site • 330-hectare (811-acre) plant on Upper East Fork Poplar Creek plus Bear Creek Valley and Chestnut Ridge	Y-12 Site • Upper East Fork Poplar Creek will support continued Department of Energy Industrial use • Bear Creek Valley will support both Controlled Access and Open Space/Wildlife Management uses • Chestnut Ridge assumes continued Controlled Access for waste management uses and Open Space/Wildlife Management
Rocky Flats Environmental Technology Site	• 2,510 hectares (6,216 acres) • Site can be divided into a 155-hectare (384-acre) core area and an approximately 2,355-hectare (5,832-acre) buffer zone	• Buffer zone contains an inner and outer buffer area and both can support Open Space/Wildlife Management use after cleanup is completed • Inner buffer will remain Controlled Access as long as plutonium remains stored at the site • Core area contains a protected area and an industrial area that will be remediated to an industrial standard. Some infrastructure and buildings will remain to support environmental technology development activities, and the protected area will contain two large disposal cells (Controlled Access)
Savannah River Site	• 80,000 hectares (198,000 acres) • Environmental management activities divided into six Waste Area Groupings organized around the production areas	• Majority of production areas assumed to support Industrial uses • Five reactor areas and the F and H areas (including chemical processing buildings and buried waste areas) will remain Controlled Access after cleanup activities are completed • Land outside of production areas is assumed to support a range of Open Space/Wildlife and Recreational uses with limitations on surface and ground-water use

Table 3.2. Base Case Land-Use Assumptions for the Five Highest-Cost Sites (continued)

Site	Land Area	Future Land-Use Assumptions
Hanford Site	• 145,000 hectares (358,500 acres) • Environmental management activities divided into five major areas • Arid Lands Ecology Reserve (ALE) and North Slope areas are uncontaminated	• 100 Area is cleaned to meet residential standards but will likely support Open Space/Wildlife Management use • 200 Area will remain a Controlled Access area for permanent waste use • 300, 400, and 1100 areas will support Industrial and some Recreational/Disposal uses • ALE and North Slope areas are clean and will support Recreational and Wildlife Management uses

3.3.5 Environmental Restoration Assumptions

Environmental Restoration costs comprise approximately one-third of the current FY 1996 annual program costs. This part of the program is affected by a large number of often site-specific factors. The environmental restoration Base Case encompasses environmental remediation or containment activities at nearly all 150 sites included in this Baseline Report. These sites involve 10,500 potential release sites that can be aggregated into subprojects or operable units. The Baseline Report groups these units into 295 geographically based activities. These groupings are the basis for tracking the cost estimates reported in Volumes II and III.

Virtually all of the 10,500 potential release sites have been at least partially characterized, approximately 46 percent have been fully characterized and regulatory decisions have been made for substantially fewer sites. For this reason, the environmental restoration cost estimate is largely based on two factors: site-specific assumptions regarding program scope (that is, the amount and type of contamination) and the remediation technologies that will be selected (according to applicable regulatory guidelines). Assumptions are essential for cost estimators to have a basis on which to project life-cycle costs. Volume II and III site narratives detail the site-specific assumptions and provide planning information that has resulted from completed regulatory processes.

REMEDIAL STRATEGIES FOR ENVIRONMENTAL CONTAMINATION

The Environmental Restoration Base Case generally assumes containment technologies instead of removal at two types of sites: large isolated facilities and those likely to be used for industrial purposes. In some instances, wide areas of lightly contaminated soil may be consolidated in a smaller area and sealed with an engineered cap. These containment approaches have several advantages: they are less costly than removal techniques, protect the public and workers from exposure to the contaminants, and give protection while providing access to the land's surface area for appropriate reuse. Hanford Site, Idaho National Engineering Laboratory, Nevada Test Site and the Savannah River Site are the highest-cost sites in this category.

The Base Case assumes that most buried waste remains in place. In some cases, because proper techniques were not used when establishing burial sites, contaminant releases have occurred or are likely to occur in the future. These problem sites will be uncovered, and the contained waste will be segregated and properly treated or disposed. An example of such a project is Pit 9 at the Idaho National Engineering Laboratory, where transuranic waste encountered in the segregation process will be treated, repackaged, and transported to the Waste Isolation Pilot Plant for disposal. Mixed radioactive and hazardous waste will then be treated to remove hazardous components to the extent possible, and remaining low-level contaminated soil will be returned to the pit and properly capped.

Remediating ground-water contamination at Department of Energy sites poses a challenge. In general, eliminating the sources of ground-water contamination at sites, is, or will be, a high priority action. Source elimination generally entails removing or capping contaminated soils or burial sites. For ground-water contamination that can be effectively reduced or eliminated by pump-and-treat technology or other "in place" technologies such as bioremediation, technologies will be applied for a limited time period (generally five years in the case of pump-and-treat). Limited application of these technologies is cost-effective because a large volume of contaminants is removed early in the process; however, the efficiency of these technologies declines significantly over time as the total amount of contamination is reduced.

At sites where ground-water flow is relatively slow, natural reduction (referred to as "attenuation") of contaminants may occur prior to passing under the boundary of federally controlled lands. At sites with faster flowing ground water, it may be necessary to contain or slow the migration of the contaminants with hydraulic control techniques such as barriers and pumping (to redirect flows). Ground-water contamination that cannot be eliminated is monitored. The Base Case estimate assumes that all ground-water contamination will be contained within Department of Energy sites.

The Base Case generally assumes that removing sediments will remediate contamination in small ponds and streams. Releases of contaminants to larger surface water bodies, such as the Savannah River in South Carolina and the Clinch River/Watts Bar Reservoir in Tennessee, pose extreme problems for which there are no currently feasible solutions. The course of rivers would need to be diverted at great expense to remediate contaminants present in sediments. The threat posed by present contamination, largely trapped in sediment, does not justify the ecological damage that would be caused by feasible remedies. Lacking a solution, the Department continues to monitor the levels of contaminants in these surface waters and their effect on the living things that depend on them for survival.

DECOMMISSIONING STRATEGIES

The Base Case estimate assumes that large highly contaminated buildings are not fully decontaminated but are contained by entombment (that is, filling voids and engineering a structure to envelop it) or by collapsing and capping with soil or other materials. Entombment approaches provide opportunities for cost-effective use of contaminated waste from other projects as void material. Both containment approaches eliminate the need for handling and transporting large amounts of contaminated rubble.

The Base Case assumes that smaller buildings will be fully decontaminated and demolished or reused for storage or treatment of waste, and that surplus laboratory facilities will be decontaminated and demolished by the Environmental Management program. The Department's laboratory missions, however, are assumed to continue indefinitely. The decontamination costs associated with contaminated facilities slated for reuse in research missions are, therefore, outside of the scope of this report.

3.3.6 Waste Management Assumptions

The Base Case estimates for waste management include costs for: (1) existing inventories from past generation, (2) waste streams from environmental restoration activities, (3) waste from facility stabilization and maintenance activities, (4) additional waste generated by waste management activities, and (5) newly generated waste from Department of Energy programs other than environmental management (e.g., Defense Programs, Nuclear Energy, and Energy Research). Activities for waste management are defined as treatment, storage (and handling), and disposal of waste. Volumes II and III discuss significant projects within these activities.

Table 3.3 highlights the Base Case treatment, storage, and disposal assumptions detailed by waste type. Table 3.4 details these assumptions for spent nuclear fuel. The remainder of this section includes scheduling, transportation, and decontamination and decommissioning assumptions.

Table 3.3. Base Case Waste Management Assumptions

Waste Type	Activity		
	Storage	**Treatment**	**Disposal**
High-Level Waste	• Continued storage in tanks at Hanford Site, Savannah River Site, West Valley Demonstration Project, & Idaho National Engineering Laboratory • Continued storage of calcine in bins at Idaho National Engineering Laboratory	• Vitrification at Hanford site, Savannah River Site, and West Valley Demonstration Project	• Availability of a geologic repository
Transuranic and Mixed Transuranic Waste	• Onsite storage	• Treatment to Waste Isolation Pilot Plant waste acceptance criteria, if required	• Waste Isolation Pilot Plant (beginning in 1998)
Low-Level Waste	• Onsite storage at generator sites while awaiting treatment and disposal at six Department of Energy sites	• Treatment to meet transport and disposal criteria	• Disposal at seven sites: Hanford Site, Oak Ridge Reservation, Idaho National Engineering Laboratory, Los Alamos National Laboratory, Nevada Test Site, Savannah River Site and Rocky Flats Environmental Technology Site and also at commercial facilities

Table 3.3. Base Case Waste Management Assumptions (continued)

Waste Type	Activity		
	Storage	Treatment	Disposal
Low-Level Mixed Waste	• Storage at 30 generator sites	• Treatment to meet land disposal restrictions • Treatment performed in accordance with the Federal Facility Compliance Act	• Disposal at seven sites: Hanford Site, Oak Ridge Reservation, Idaho National Engineering Laboratory, Los Alamos National Laboratory, Nevada Test Site, Rocky Flats Environmental Technology Site and Savannah River Site, and also at commercial facilities
Hazardous Waste	• Onsite storage for accumulation prior to treatment	• Treatment mostly at commercial facilities	• Commercial facilities
Sanitary Waste	• No storage	• Treatment at point of generation as needed	• Commercial or onsite disposal depending on the site
Special Case Waste	• Onsite storage	• Treatment as required	• Disposal onsite or in a national geologic repository

Table 3.4. Base Case Assumptions for Spent Nuclear Fuel

Spent Nuclear Fuel Activity		
Storage	Treatment	Disposal
• Consolidation of storage at Savannah River Site and Idaho National Engineering Laboratory; continued storage at Hanford Site • Cost of building new storage facilities included • Compatibility with the Record of Decision for the Spent Nuclear Fuel Final Environmental Impact Statement	• No reprocessing	• Availability of a geologic repository assumed

SCHEDULE ASSUMPTIONS

- A national geologic repository for high-level waste, special case waste, and spent nuclear fuel will be available to accept Department of Energy waste beginning in 2016. (It will not accept spent nuclear fuel until much later than 2016.) Disposal fees for the repository are included in the costs of the shipping site.

- The current analysis assumes that future generation of low-level waste, low-level mixed waste, and transuranic waste will match mission assumptions on a site-by-site basis.

- The Waste Isolation Pilot Plant will be available to accept transuranic and transuranic mixed waste in 1998.

TRANSPORTATION ASSUMPTIONS

- No major regulatory changes will occur to further restrict the offsite shipments of hazardous and radioactive materials.

- New packaging designs will be required. Department of Transportation / Nuclear Regulatory Commission certification will require three years following preliminary design.

- Site roadways and railways will be upgraded or replaced as necessary to accommodate higher shipping frequencies and larger/heavier items.

- These and all other transportation costs will be included in the facility life-cycle operating and disposal/remediation cost estimates submitted by the various programs.

DECONTAMINATION AND DECOMMISSIONING/SAFE SHUT DOWN ASSUMPTIONS

- Cost estimates associated with decontamination and decommissioning and safe shutdown of existing treatment, storage, and disposal facilities are included in waste management estimates in most cases. In some cases, sites have included these costs in their environmental restoration estimates.

3.3.7 Nuclear Material and Facility Stabilization Assumptions

The total life-cycle cost and schedule estimate for the Nuclear Material and Facility Stabilization program is based upon a defined "universe" of materials and facilities. This "universe" includes a list of facilities that the Department has declared, or will declare, surplus. The Base Case development process involved validating a list of facilities scheduled to undergo stabilization and deactivation in the 1995 Baseline Report. This list was based on the Surplus Facility Inventory and Assessment conducted by the Department in FY 1994. This assessment identified those facilities that are currently surplus or will be surplus within the next three years (prior to FY 1999).

Other facilities are still operating and currently have no scheduled date for shutdown or transfer. These facilities are considered outside the Environmental Management program's planning horizon and are not reflected in the 1996 Base Case. Typically, these facilities are associated with ongoing nuclear weapons activities.

Activities for the Nuclear Material and Facility Stabilization program include material stabilization, facility deactivation, and surveillance and maintenance. Stabilization entails placing nuclear materials into a condition suitable for long-term storage. In some instances, Base Case stabilization costs include storage costs for nuclear materials. For example, at the Rocky Flats Environmental Technology Site, storage costs constitute a significant portion of the stabilization estimate. Deactivation, which usually occurs after completion of stabilization, focuses on removing material, shutting down facility systems, and removing or de-energizing equipment to reduce potential facility hazards.

Surveillance and maintenance activities encompass all actions required to ensure adequate material and facility requirements for safety and security. Surveillance and maintenance activities are assumed to continue during the stabilization and deactivation phases (as well as before and between these phases). The Base Case captures surveillance and maintenance costs that are incurred before and after stabilization and after deactivation activities. Facilities may go directly to stabilization or deactivation, or from stabilization to deactivation, depending on risks associated with the facilities, timing of projects or other priorities such as outyear funding availability. Pre-stabilization surveillance and maintenance costs represent a "holding" cost prior to accomplishing facility stabilization. Post-stabilization surveillance and maintenance costs represent a "holding" cost prior to accomplishing facility deactivation. Post-deactivation surveillance and maintenance costs are associated with maintaining the facility in a safe and cost-effective manner once all material and facility hazards have been removed. The Nuclear Material and Facility Stabilization program incurs post-deactivation surveillance and maintenance costs for two years prior to transfer to the Environmental Restoration program for ultimate disposition.

The Nuclear Material and Facility Stabilization program, established in 1992, is the newest of the Environmental Management programs. As a result, the Department developed the program's cost and schedule estimates for the 1995 Baseline Report using parametric cost-estimating techniques at Headquarters rather than through field-developed estimates. This year's Base Case estimates were developed by field personnel at four large sites (Hanford Site, Idaho National Engineering Laboratory, Rocky Flats Environmental Technology Site and Savannah River Site). Estimates for nuclear materials and facility stabilization costs at other sites (mainly at surplus facilities that have been identified, but not yet transferred into the Environmental Management program), were generated by Headquarters personnel using parametric cost-estimating techniques and site-specific data.

In instances where parametric cost estimating techniques were used, the following hypothetical scheduling scenario was assumed (in this sequence): seven years of surveillance and maintenance after transfer of a facility to the Environmental Management program, three years of stabilization activities, three years of post-stabilization surveillance and maintenance, two years of deactivation activities, and two years of post-deactivation surveillance and maintenance prior to transfer to the Environmental Restoration program for final disposition.

If field-generated estimates were unavailable, facilities already in the Environmental Management program were also scheduled according to this hypothetical scenario. Those facilities not yet in the program were assigned arbitrary transfer dates, typically selected to fit funding constraints assumed in the Base Case. Insufficient data were available to guide scheduling of these facilities according to risk or other priorities. Therefore, although estimates were generated uniformly using the "7-3-3-2-2" scheduling scenario, the scenario does not necessarily represent the way these individual facilities will ultimately be addressed. Rather, it is representative of complex-wide scheduling assumptions.

3.3.8 Science and Technology Development Assumptions

The Science and Technology Development program was established to conduct an aggressive national program of basic and applied research, development, demonstration, testing, and evaluation for innovative environmental cleanup solutions. The program seeks to develop technologies that facilitate compliance with applicable laws, regulations, and agreements; minimize generation of waste; and clean up Environmental Management sites in a manner that is safer, faster, and less expensive than baseline technologies. In many cases, the development of new technologies is critical for providing a method of significantly reducing long-term risks to the environment and improved safety for workers and the public, within realistic financial constraints.

The science and technology development assumptions included in the Base Case are as follows:

- Current Base Case cost estimates for the Environmental Management program are based upon the use of existing technologies. This assumption allows one to calculate future savings resulting from the use of emerging technologies against the baseline.

- Science and technology development funding is currently six percent of the Environmental Management Base Case and is assumed to remain a constant percentage (six percent) annually of the total Environmental Management program through 2030.

The Science and Technology Development program conducts applied and basic research related to environmental cleanup technologies. Applied research is directed toward specific focus areas such as tanks, mixed waste, and plumes containment (See discussion in Appendix F). Basic research is part of a teaming effort with the Department of Energy's Office of Energy Research. Basic research concentrates, at a broader level, on applying essential sciences such as physics and chemistry to environmental problems. Appendix F presents an analysis of projected cost savings from science and technology development activities.

3.3.9 Landlord Assumptions

In developing landlord cost estimates, site personnel first determined a schedule for performing direct mission activities. Then, based on this time profile, they determined the required amount and cost of landlord activities on an annual basis. Specifically, site personnel determined FY 1996 costs for landlord activities, then assessed how these levels might change over time as several factors change: maturity of the program, level of annual direct mission activities performed, cleanup completeness, and other factors relevant to the site. Based on this analysis, the site personnel forecasted landlord costs.

3.3.10 National Program Planning and Management Assumptions

Headquarters personnel used a simple model to estimate the costs for national program planning and management. As part of this process, independent cost estimates were developed for program direction and program management. Program direction costs include salaries, benefits, travel, and training for federal employees. For the purposes of this report, Headquarters assumed that these costs will remain at a constant percentage of total cost over the life-cycle of the program. Hence, as program funding decreases over time, program direction will decrease proportionally. Program management costs fund contractors that support federal employees. Headquarters assumed that program management costs will decrease as a percentage of total cost as the program matures and becomes better defined. These costs have already dropped 55 percent from FY 1994 to FY 1996.

3.4 SUPPORT COSTS

The 1996 Baseline Report focuses on answering several basic questions: what activities will the Environmental Management program perform, how much will these activities cost, and how long will it take for them to be completed? Previous sections of this report focus on the methods and assumptions that were used to estimate the costs for "direct mission" activities. These activities are represented by the six functional areas described in Chapter 2 (including environmental restoration, waste management, nuclear material and facility stabilization, landlord, and national program planning and management).

In addition to direct mission activities, the Environmental Management program, like private firms and other public agencies, also must perform "support" activities. These activities fall into six main categories:

- Management;
- Finance and Administrative Services;
- Environment, Safety, and Health;
- Infrastructure;
- Safeguards and Security; and
- Stakeholder and Regulatory Interactions, and Other.

Support activities are not extraneous; they are vital to maintaining sites and ensuring environmental cleanup progress. For example, it is necessary to conduct environment, safety, and health activities and to provide safeguards and security at all sites, particularly those storing uranium, plutonium, and other nuclear materials.

The benefits of support activities are shared across projects within a functional area. Therefore, the Baseline Report does not

EXAMPLES OF SUPPORT COST RELATIONSHIPS

Consolidation of special nuclear material will lead to large decreases in safeguards and security costs by minimizing the area where these materials must be protected and monitored.

Program management costs in the Environmental Restoration program are highest in the assessment phase of a project and decrease as projects enter actual remediation.

Program management costs for specific waste types (for example, spent nuclear fuel) or major projects (for example, the Tank Waste Remediation System) disappear when the specific project or program reaches completion.

identify support costs as a separate category (except for cost estimating purposes). Rather, support costs in this report are spread across the direct mission activities within each appropriate functional area.

ESTIMATION OF SUPPORT COSTS

The level of direct mission activities affects the amount of support activities and costs required at a site. This relationship is similar to the relationship between direct mission activities and landlord costs discussed in Section 3.3.8. The estimation process is also similar. To develop support cost estimates, site personnel first developed a time profile for their direct mission activities. Then, based upon this profile, site personnel estimated the level of support activities that they would need on an annual basis and the associated costs. Specifically, site personnel determined FY 1996 costs for support activities, then assessed how these levels might change over time based on changes to several factors: maturity of the program, level of annual cleanup activity performed, completeness of cleanup, and any other factors relevant to the site.

Nuclear explosion, known as Operation Teapot, Test Shot "MET," at the Nevada Test Site, 1955. *Above ground tests were conducted at the site until 1963. Some tests were conducted to improve understanding of plutonium dispersal. As a result, the top 3 to 6 inches of soil is contaminated with plutonium in a 580-acre area of the site known as "Plutonium Valley".*

Top soil remover being tested for potential use at Nevada Test Site, Nevada, 1993. (Courtesy, Desert Research Institute). *The decision to clean up contaminated soils from nuclear tests has not yet been made because of concerns about technical feasibility and high cost estimates. The 1996 Baseline Report includes cost estimates for some of this soil remediation, although remediation of underground nuclear tests is excluded from the analysis because no feasible remedy is available or planned. Future analyses will need to address such areas through full life-cycle consideration of remediations costs, long-term surveillance and monitoring costs, and/or potential natural resource damages liability.*

4.0 RESULTS

This chapter summarizes the projected life-cycle costs for the Environmental Management Program based on plans and capabilities as of October 1995. The results in this chapter summarize information provided in Volumes II and III of the 1996 Baseline Report and provide several crosscutting analyses and perspectives.

> ***THE BASELINE REPORT IS NOT A BUDGET DOCUMENT***
>
> The Baseline Report is not intended to be a budget document and none of the estimates in the report are intended as federal budget requests. Similarly, the schedule of activities presented in the Baseline Report should *not* be interpreted as establishing specific long-term priorities or as serving as a definitive basis for planning specific projects.

The Base Case results reflect costs for the Environmental Management program based on assumptions described in Chapter 3. These results provide the foundation for many of the policy analyses and comparisons in the Baseline Report, particularly the analyses of alternatives in Chapter 6.

This chapter includes five sections.

- **Section 4.1** reports overall Base Case results, including an overview of life-cycle costs and schedules.
- **Section 4.2** describes the Base Case estimate from a geographical perspective, including the distribution of life-cycle costs by state and site.
- **Section 4.3** focuses on costs for the major functional elements (waste management; environmental restoration; nuclear material and facility stabilization; science and technology development; landlord; and national program planning and management).
- **Section 4.4** analyzes the waste types and volumes that underlie the life-cycle cost estimate.
- **Section 4.5** examines costs for support activities such as program management, administrative services, and security.

4.1 OVERALL RESULTS

4.1.1 The Range of the Base Case

Based on the 1996 Base Case assumptions, the life-cycle cost to complete the Environmental Management program is projected to be between $189 billion and $265 billion, with a mid-range estimate of $227 billion. Life-cycle cost profiles are graphically depicted in Figure 4.1. All estimates are in constant 1996 dollars (see the box below).

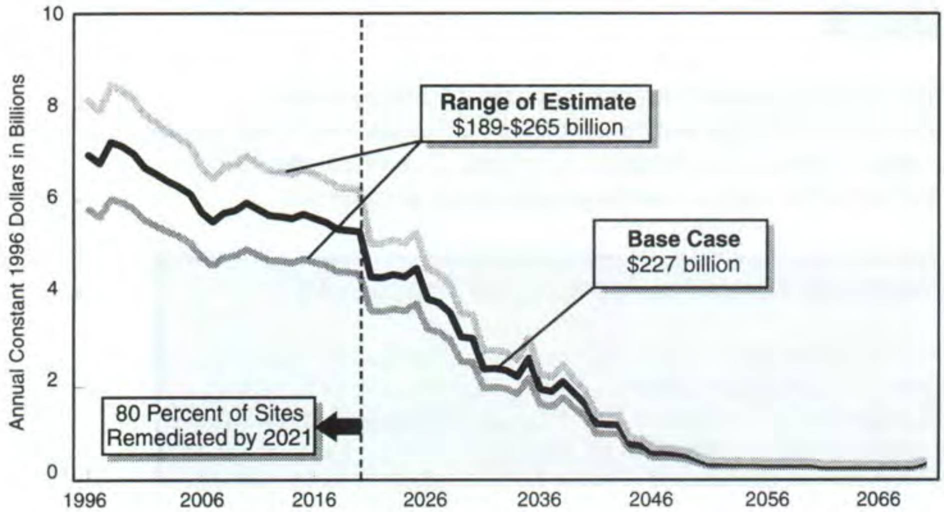


Figure 4.1. Base Case Life-Cycle Cost Estimate

The mid-range estimate - $227 billion - represents the sum of life-cycle costs for all site-specific activities and projects described in Volumes II and III of the Baseline Report. The upper range ($265 billion) and lower range ($189 billion) bound the mid-range estimate. Personnel at sites assigned one of three levels of confidence to their Base Case estimates (high, medium, or low). Then, a probabilistic analysis of these estimates was conducted to establish the range (see the "Confidence in Cost Estimates" box for more information).

CONSTANT VS. CURRENT DOLLARS

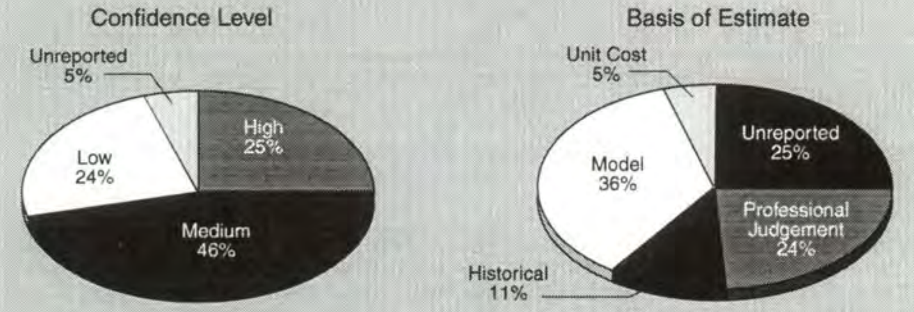
Constant dollars represent a dollar value adjusted for changes in prices. Dollars in the future are adjusted by removing inflation. Unless otherwise noted, all 1996 Baseline Report cost projections are in constant 1996 dollars as if costs were incurred this year.

Current dollars represent the dollar value of goods or services in terms of prices current at the time the goods or services are purchased (in other words, inflation is factored into the estimate).

A number of factors contribute to the uncertainty in the life-cycle estimate. The degree of project definition, the complexity of the project, and the application of new technology can significantly influence the confidence in the estimate. Other factors contributing to estimate uncertainty include errors in estimating unit costs and labor productivity, schedule delays, and even simple errors in arithmetic. Several of these factors, such as productivity and the use of new technologies, are discussed later in this chapter.

CONFIDENCE IN THE COST ESTIMATES

Cost estimators in the field assigned one of three levels of confidence to their Base Case project estimates: low, medium, and high. A **low confidence** rating means that the estimate could range from 100 percent higher to 100 percent lower than the Base Case estimate. A **medium confidence** rating indicates that the estimate could be 50 percent higher to 50 percent lower. A **high confidence** rating denotes a range of 25 percent higher to 25 percent lower. Percentages of the estimates that fall into each category are displayed below. Using these distributions, a statistical simulation was conducted to develop the uncertainty range in the life-cycle estimate. (Appendix C provides a more detailed discussion of this approach).



Level of Confidence and Basis of Life-Cycle Estimate (Dollar Weighted)

In addition to confidence levels, cost estimators reported the method (basis) upon which they developed their estimates. The basis of each site's estimates was reported as one of the following categories: based on best professional judgement, based on historical information or past experience, modeled, or based on unit costs. Percentages of the estimates that fall into each of these categories are displayed above. In general, there is a correlation between the confidence sites have in their estimates and the use of detailed or sophisticated cost estimating models.

The mid-range estimate of $227 billion is the projected cost for carrying out the currently planned tasks, including existing compliance agreement obligations (as of October 1995), for the active sites within the scope of the Environmental Management program. This case is used as the basis for analysis in this chapter and the basis for comparison of the alternative cases in Chapter 6. The mid-range case is referred to throughout this report as the "Base Case" estimate.

4.1.2 Productivity

For any long-range program, the amount by which the program improves productivity will have a significant effect on life-cycle cost. For example, if productivity, defined as the ratio of outputs-to-inputs, increases at an annual rate of one percent, the program will be approximately 50 percent more productive in 2040 than it was in 2000. Larger productivity improvement rates have even more dramatic effects over a longer time horizon. Therefore, any program that has an extended timeframe should be concerned about productivity improvement and should ask the question: How will productivity influence the long-term costs of the program? The Environmental Management program is such a program.

For this reason, the Environmental Management program asked site personnel to include an estimate of projected productivity savings in their life-cycle cost estimates. The site-derived productivity savings, which were approximately five to ten percent across the Environmental Management program, were included in the site estimates. Almost all of these productivity improvements are expected before 2000. These productivity improvement initiatives include performance-based contracting, re-engineering of operational processes, privatization, reducing overhead activities, streamlining site characterization processes, and introducing cost-efficient technologies.

Two additional productivity estimates were derived from the Base Case based on different assumptions regarding productivity improvement. For the purposes of this report, a long-term productivity goal of one percent after 2000 was established. The one percent assumption reflects the average productivity savings historically achieved by government agencies. The highest cost case assumes that productivity will not increase over current levels. That is, projected site productivity savings estimates were removed from the life-cycle estimates.

Based on these three productivity cases, the life-cycle cost for the program ranges from $195 billion to $241 billion. Figure 4.2 presents these three cases, depicting three different productivity-based life-cycle cost profiles for the Environmental Management program.

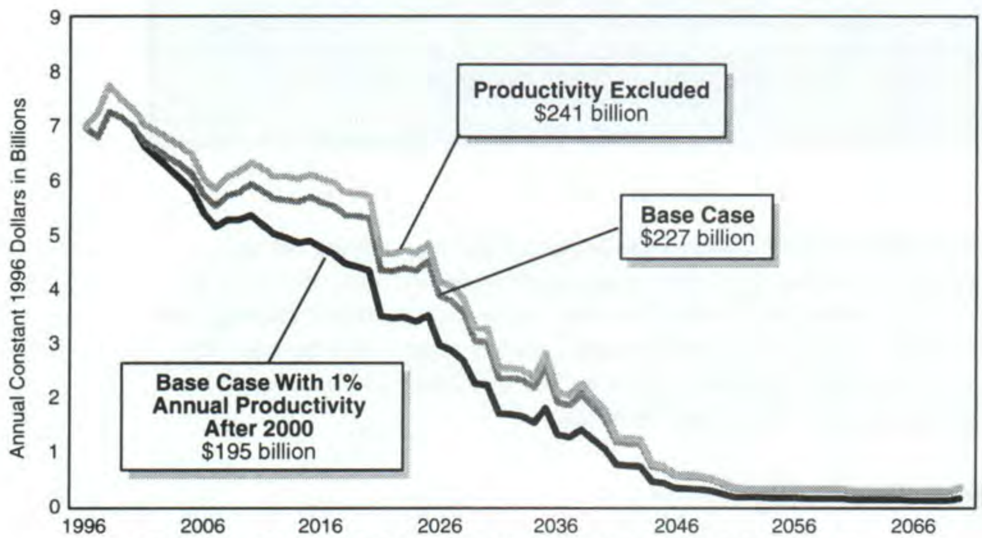


Figure 4.2. Annual Cost Estimate Based on Productivity Assumptions

Site-based productivity estimates produce a total life-cycle cost reduction of $14 billion, resulting in a total life-cycle cost for the program of $227 billion. This case is used as the base estimate for the confidence level range (discussed in Section 4.1.1).

It is also the basis for the results in the remainder of this chapter. With no productivity savings, completion of the Environmental Management program is estimated to cost $241 billion—$14 billion higher than the Base Case and $46 billion higher than the lowest case (reflecting one percent productivity savings beyond 2000). In the 1995 Baseline Report, productivity assumptions were incorporated in the Base Case estimate. These assumptions projected a potential short-term productivity goal of 23 percent by the year 2000 and a long-term goal of one percent productivity savings after 2000. This assumption decreased the total 1995 life-cycle cost from approximately $350 billion ($360 billion in constant 1996 dollars) to $230 billion ($237 billion in constant 1996 dollars). The 1995 approach, which is explained in Section 5.3, differs from the 1996 approach described above.

4.1.3 Reconciling the Base Case Cost Estimate with Budget Projections

The Base Case is not a budget estimate. In fact, with cost projections expected to exceed budget availability and priorities continuing to be defined, a clear articulation of the current baseline projection is useful. The projected budget target (as of October 1995), based on larger federal budget realities, is that funding for the Environmental Management program will be funded at approximately $5.5 billion in annual funding (in current dollars) by 2000. After accounting for expected inflation, this number equates to $4.9 billion in constant 1996 dollars. The difference between the assumed funding for the Base Case estimate and the funding target results in a projected budget shortfall. Figure 4.3 indicates that this shortfall amounts to $27 billion over a 25-year period.

This budget shortfall has been anticipated since 1993. During this period, the Department has successfully reconciled this shortfall through a number of management initiatives intended to deliver more results for less money. Specific priorities for the Environmental Management program include:

From 1993-1996

- *Improved Contractor Efficiency* - Reduced contractor employment by 17,000 individuals or 33 percent; initiated performance-based contracting systems at most of the large sites in the complex.

- *Renegotiated Compliance Agreements* - To date, renegotiated agreements have resulted in more than $1 billion in potential savings for the Hanford Site and Savannah River Site.

- *Involved Stakeholders and Workers* - At Fernald, Ohio, recommendations from the Citizen Task Force on disposal options and future land use at the site are expected to result in over $2 billion in savings.

From 1997-2000

- *Privatizing Operations* - Improving public sector efficiency with more private sector incentives.

- *Conducting Management 'Work Outs'* - Department of Energy, contractors, and regulators come together to develop common sense reforms.

- *Investing in Science* - Bridging basic science and applied research needs on our most intractable environmental problems.

We believe that these efforts will greatly assist in reconciling estimated Base Case costs to budget realities. Additional changes such as legislative amendments to Superfund will also contribute to helping the program operate more cost effectively. Clearly, however, it is critical to good management to anticipate budget problems through effective life-cycle analysis.

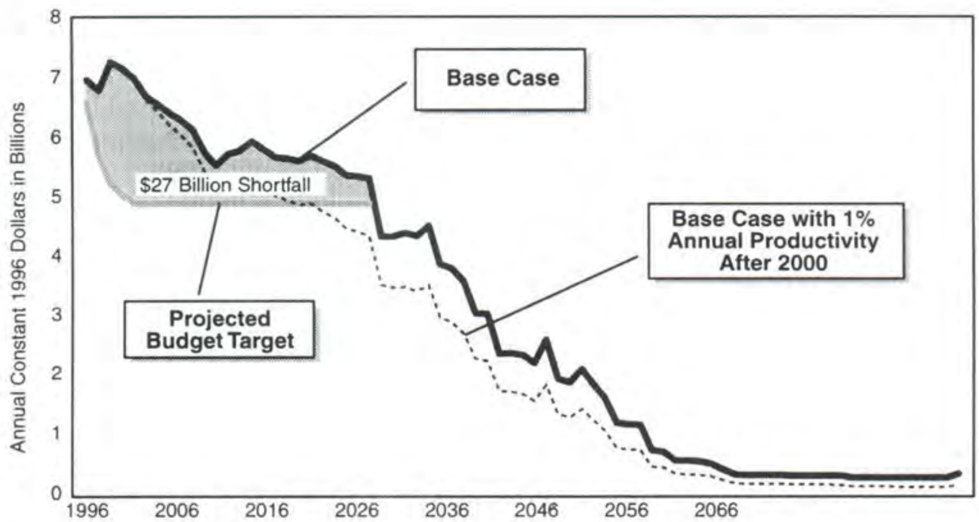


Figure 4.3. Long-Term Budget Shortfall

4.1.4 A Look at the Life-Cycle Base Case

The life-cycle activities for the Base Case will cost $227 billion and span a 75-year period (1996 to 2070), although most sites will be completed considerably sooner. By 2070, all environmental management sites requiring remediation will be completed (i.e., only long-term surveillance and monitoring activities and ongoing waste management activities at active sites will remain). Figure 4.4 presents the Base Case schedule for the completion of environmental remediation and decommissioning activities at the sites. As noted in Section 3.3.2, 102 sites require remediation. This figure illustrates that 80 percent of these sites will be remediated by 2021.

Annual costs at the program's completion in the year 2070 do not reach zero because of "post-closure" expenditures, referred to as post-closure long-term surveillance and monitoring activities. These activities focus on sampling, analyzing monitoring well data, maintaining protective covering or barriers, and providing for active institutional controls at near-surface and deep geologic disposal sites where long-lived radioactive wastes were left in place. Preliminary estimates indicate these long-term costs would range from $45-$65 million annually for several decades.

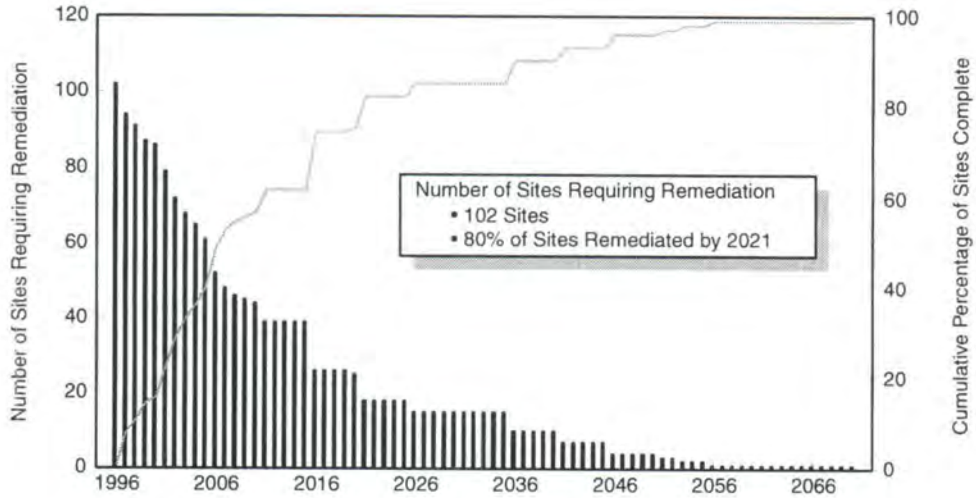


Figure 4.4. Base Case Schedule for Remediating Sites

The distribution of estimated Environmental Management program costs for major functional elements changes as the program (and the cleanup effort) moves closer to completion (see Figure 4.5). Given these estimates, the mix of activities comprising the Environmental Management program will change significantly over time. In the near term, the program is focusing on stabilizing nuclear materials and facilities. In 2000, for example, nuclear material and facility stabilization activities represent approximately 18 percent of the estimated site costs for waste management, environmental restoration, and nuclear material and facility stabilization. By 2020, these activities drop to six percent and by 2040 they are less than one percent of estimated cost because these activities are essentially complete. Also, during the next 40 years, the majority of environmental restoration activities are expected to be completed. Although environmental restoration costs as a percent of total costs actually increase from 2000 to 2020 when many large facilities are scheduled for decommissioning, they shrink to less than six percent of total estimated program costs by 2060. By this point, the environmental cleanup is essentially complete and all waste currently in inventory and generated by the Environmental Management program will have been disposed. By 2060, the primary responsibility of the program is expected to be managing waste generated by other Department of Energy programs (for example, the Energy Research Program and Defense Programs).

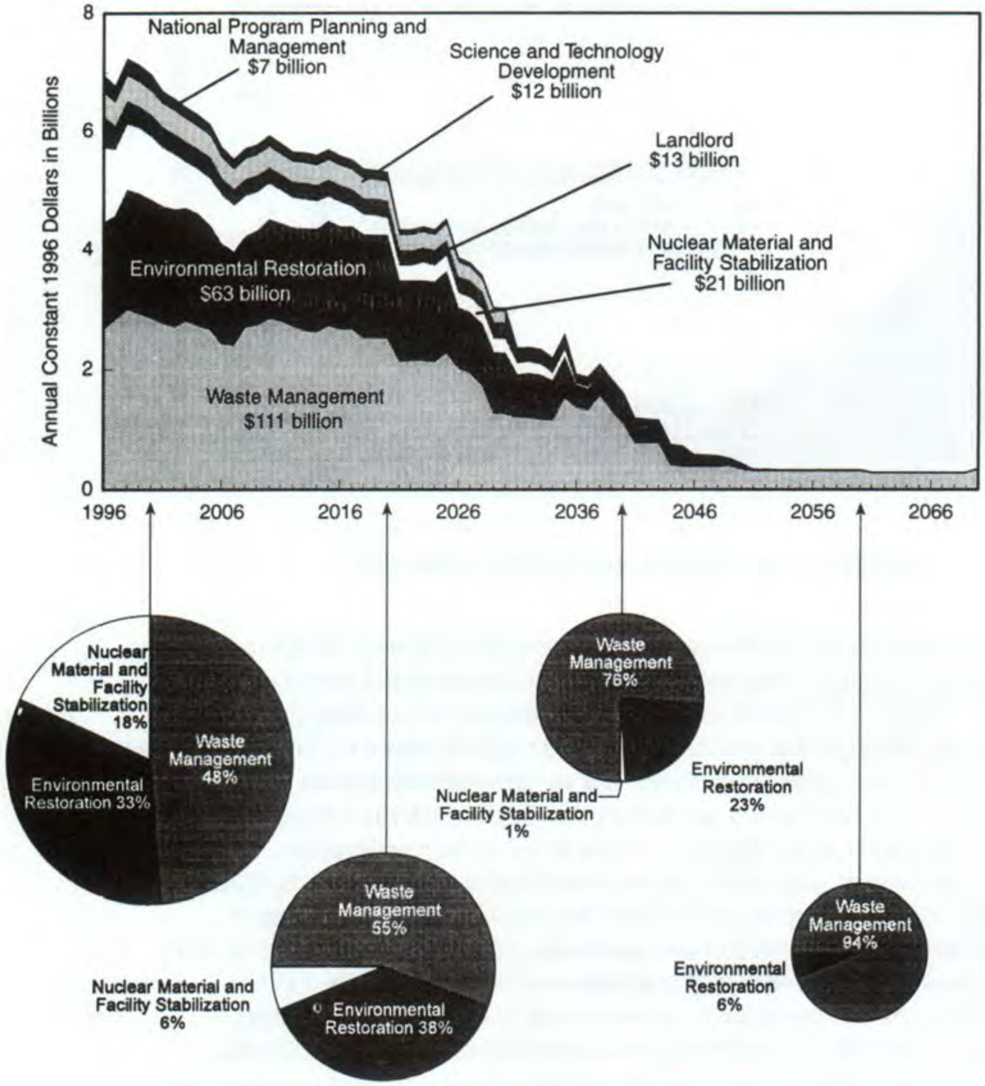


Figure 4.5. Cost Estimate for Major Functional Elements

At the program "end state" (in 2070), all mission-related activities are expected to be completed and most sites are available for alternative land uses. The expectation is that buildings are decommissioned, waste planned for offsite disposal is treated and will have been shipped to a permanent disposal site or commercial facility, and waste being disposed of onsite is capped in pits or trenches or securely enclosed in disposal cells. In 2070, Environmental Management program activities are focused on long-term surveillance and monitoring and waste management for Department of Energy programs still active at the sites. In other words, sites with ongoing missions ***outside*** of the Environmental Management program (for example, National Laboratories) will continue to incur ongoing waste management costs.

Many sites complete their Environmental Management mission-related activities before 2070. A closer examination of the estimated life-cycle cost profile in Figure 4.1 reveals a downward trend in annual costs. The estimate after 2050 is relatively level. Ninety percent of the total life-cycle cost is expected to be incurred by 2037 (see box).

A 75-YEAR LIFE-CYCLE PROGRAM?

While the life-cycle data indicate that Environmental Management mission-related activities are complete at all sites by 2070, many of the sites complete a substantial amount of work long before 2070. For example, 90 percent of the projected life-cycle costs for environmental management activities occurs by 2037. After this date, most of the costs are for managing wastes from on-going mission activities and for long-term surveillance and monitoring of remediated sites. These costs would extend far into the future, but are assumed to be complete in 2070 for the Baseline Report.

Despite the *general downward* cost trend described above, estimated costs suddenly increase or decrease for brief periods at several points. These upswings and downswings appear as anomalies to the overall trend, but reflect the progression of the program. For example, in 2020, completion of remediation and decommissioning activities at the Energy Technology Engineering Center, Fernald, Los Alamos National Laboratory, and Sandia National Laboratory-New Mexico contribute to a drop in estimated environmental restoration costs of more than $300 million. At the same time, treatment of high-level waste decreases (primarily at the Hanford Site), resulting in an additional cost decrease of almost $200 million. In 2025, a sudden increase in estimated cost occurs. It results from an upswing in high-level waste disposal costs following vitrification activities at the Savannah River Site. Estimated costs for high-level waste disposal are $200 million higher in 2025 than in 2024 and remain at the higher level until 2035 when high-level waste disposal costs increase again by an additional $400 million per year because of the expected beginning of shipments of vitrified high-level waste from the Hanford Site to a geologic repository for disposal.

PROJECTED LIFE-CYCLE COSTS BY CONGRESSIONAL APPROPRIATION

The Congressional Appropriations Subcommittee on Energy and Water appropriates funds for the Environmental Management program. These discretionary appropriations are divided into two accounts: defense and nondefense. *Environmental Management defense funding* represents $207 billion (or 91 percent) of total costs. Environmental management activities with a past defense mission (such as producing plutonium for nuclear warheads in production reactors at Savannah River Site) are appropriated under the defense account. On a life-cycle basis, nondefense activities represent $19 billion (or 9 percent) of the total projected life-cycle program cost. *Environmental management activities with a former nondefense mission* (such as the Fast Flux Test Facility at Hanford Site in Washington) are funded through nondefense appropriations.

4.2 A GEOGRAPHICAL VIEW OF THE ENVIRONMENTAL MANAGEMENT PROGRAM

The Department's Environmental Management program currently is operating in approximately 30 states and territories. By 2020, this number is expected to drop to 21 states. (See Figure 4.6 for the estimated annual spending level for environmental management activities in each state and a depiction of cleanup progress over time.) In

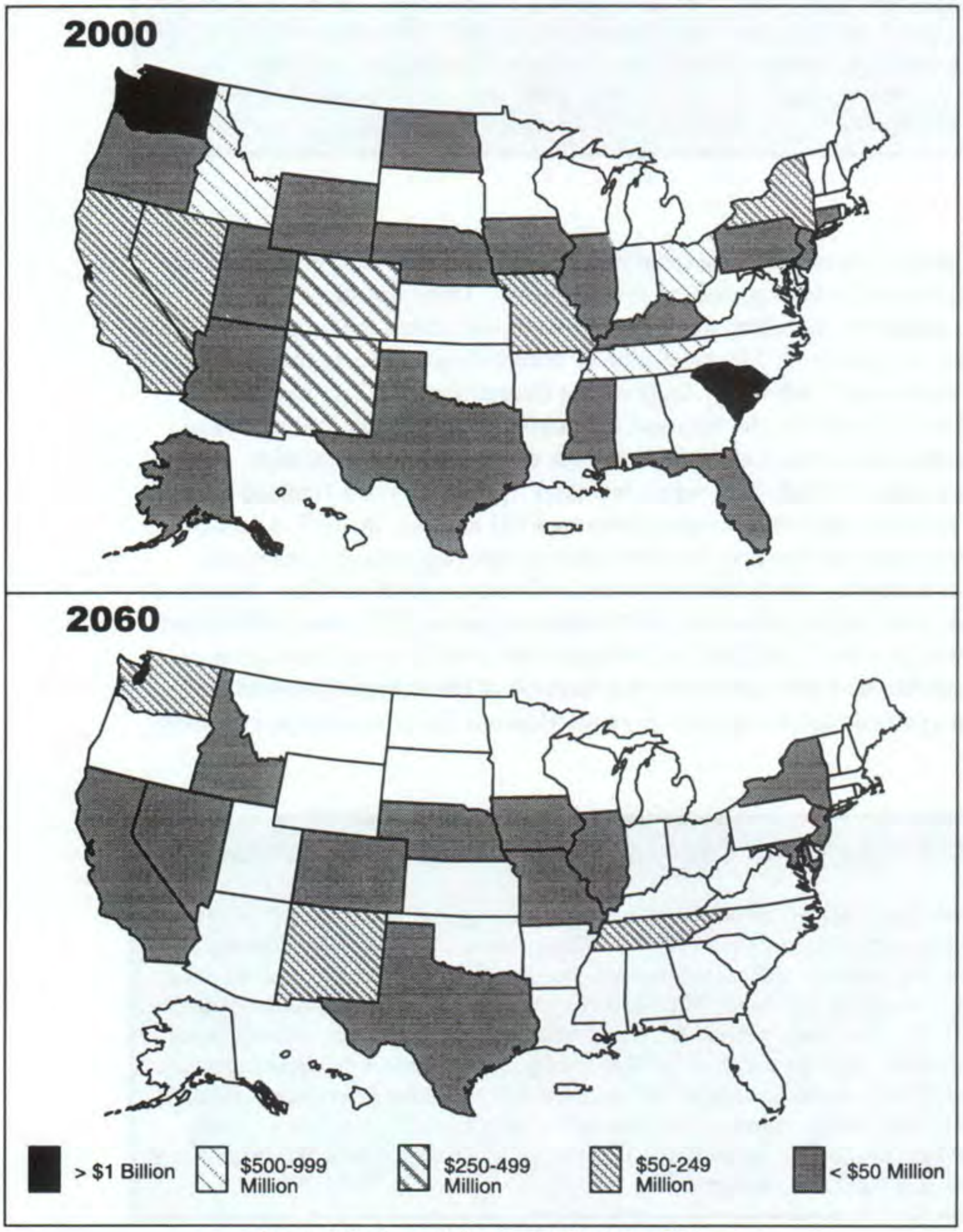


Figure 4.6. Annual Estimated Costs by State

2060, the total is expected to drop to 15 states, with almost all of the costs for long-term surveillance and monitoring and management of waste generated by programs with ongoing missions. Remediation is complete at all these sites by 2070.

Table 4.1 shows the Base Case cost estimate by state and site. These estimates reveal that the majority of costs will be spent at a small number of states and sites. Approximately three-quarters of the program's costs are concentrated in six states (Washington, Idaho, South Carolina, Tennessee, New Mexico, and Colorado), primarily at the five highest-cost sites (Hanford Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, Rocky Flats Environmental Technology Site, and Savannah River Site). For the purposes of this report, a site with life-cycle costs greater than $15 billion is defined as a high-cost site. Historically, the five highest-cost sites played the largest roles in nuclear weapons production and, therefore, require the largest amount of cleanup and waste management (see Table 4.2). Because these sites represent such a large portion of the program, the analysis of alternatives in Chapter 6 focuses solely on them.

Activities in two states, Washington (Hanford Site) and South Carolina (Savannah River Site), dominate the life-cycle cost estimates. They account for approximately $100 billion (or 44 percent) of projected life-cycle costs. The concentration of costs at the Hanford and Savannah River sites is particularly evident in Figure 4.7, which presents the total life-cycle cost by site and major crosscutting functions. In this figure, the highest-cost sites and crosscutting functions are presented separately while the smaller sites are grouped into an "Other Sites" category.

The expected end dates for the five highest-cost environmental management sites are listed in Table 4.3. Surveillance and monitoring activities will continue beyond these dates. All sites will be complete by 2070. These dates are expected to change based on variables such as project resequencing, program acceleration or delay (for example, to reduce long-term overhead costs or to wait for new technologies), regulatory changes, or significant budget reductions. However, these milestones are useful starting points for analyzing time lines, priorities, and the potential for program acceleration. (See the scheduling alternative case analysis in Chapter 6.)

Many of the other sites will be completed much sooner. Remediation is already under way at most Environmental Management sites. As described earlier, 80 percent of sites requiring remediation will be completely remediated by 2021. Only surveillance and monitoring and waste management at sites for programs with research or production missions remain after that point.

Table 4.1. Base Case Estimate by State and Site

Site	Base Case Life-Cycle Estimate (Constant 1996 $ in Millions)	Percentage of Total Base Case Life-Cycle Estimate
Alaska	6	<1%
Amchitka Island	6	<.01%
Arizona	212	<1%
Monument Valley	113	0.05%
Tuba City	99	0.04%
California	4,574	2.02%
Lawrence Livermore National Laboratory	2,408	1.06%
Oakland Operations Office	948	0.42%
Lawrence Berkeley Laboratory	533	0.23%
Energy Technology Engineering Center	351	0.15%
Stanford Linear Accelerator Center	161	0.07%
Sandia National Laboratories - Livermore	105	0.05%
General Electric Vallecitos Nuclear Center	23	0.01%
Laboratory for Energy-Related Health Research	22	0.01%
General Atomics	17	0.01%
Geothermal Test Facility	5	<.01%
Oxnard Facility	<1	<.01%
Colorado	18,203	8.02%
Rocky Flats Environmental Technology Site	17,319	7.63%
Grand Junction Projects Office	662	0.29%
Grand Junction	73	0.03%
Naturita Site	43	0.02%
Slick Rock	33	0.01%
Maybell Mill Site	22	0.01%
Rifle Sites	20	0.01%
Durango	12	0.01%
Gunnison Mill Site	12	0.01%
Rio Blanco/Rulison	7	<.01%
Connecticut	22	<1%
CE	22	0.01%
Florida	437	<1%
Pinellas Plant	437	0.19%
Idaho	18,980	8.36%
Idaho National Engineering Laboratory	18,622	8.21%
Argonne National Laboratory - West	357	0.16%
Lowman	<1	<.01%
Illinois	1,427	<1%
Argonne National Laboratory - East	847	0.37%
Chicago Operations Office	406	0.18%
Fermi National Accelerator Laboratory	165	0.07%
Site A/Plot M, Palos Forest Preservation	6	<.01%
Madison	2	<.01%
Iowa	26	8.04%
Ames	26	0.01%
Kentucky	4,857	2.14%
Paducah Gaseous Diffusion Plant	4,831	2.13%
Maxey Flats Disposal Site	26	0.01%
Maryland/District of Columbia	18,240	8.04%
Environmental Management Program Headquarters	18,218	8.03%
W.R. Grace & Company	22	0.01%
Massachusetts	13	<1%
Ventron	12	0.01%
Shpack Landfill/Ventron	<1	<.01%
Mississippi	8	<1%
Salmon Test Site	8	<.01%

Table 4.1. Base Case Estimate by State and Site (continued)

Site	Base Case Life-Cycle Estimate (Constant 1996 $ in Millions)	Percentage of Total Base Case Life-Cycle Estimate
Missouri	1,578	<1%
Weldon Spring Site Remedial Action Project	448	0.20%
Kansas City Plant	447	0.20%
St. Louis Downtown Site	266	0.12%
St. Louis Airport Site	244	0.11%
St. Louis Airport Site Vicinity Properties	97	0.04%
Latty Avenue Properties	76	0.03%
Nebraska	1	<1%
Hallam Nuclear Power Facility	1	<.01%
Nevada	3,652	1.61%
Nevada Test Site	3,644	1.61%
Central Nevada Test Area and Project Shoal Site	8	<.01%
New Jersey	713	<1%
Princeton Plasma Physics Lab	321	0.14%
Maywood Chemical Works	255	0.11%
Wayne Interim Storage Site	99	0.04%
Middlesex Sampling Plant	25	0.01%
DuPont & Company	8	<.01%
New Brunswick Site	6	<.01%
New Mexico	14,942	6.58%
Waste Isolation Pilot Project	8,391	3.70%
Los Alamos National Laboratory	4,081	1.80%
Sandia National Laboratories - Albuquerque	1,591	0.70%
Albuquerque Operations Office	802	0.35%
Inhalation Toxicology Research Institute	42	0.02%
Project Gasbuggy	15	0.01%
South Valley Site	12	0.01%
Shiprock	8	<.01%
Ambrosia Lake	1	<.01%
New York	4,927	2.17%
West Valley Demonstration Project	3,744	1.65%
Brookhaven National Laboratory	867	0.38%
Separations Process Research Unit	145	0.06%
Colonie Site	52	0.02%
Niagara Falls Storage Site	33	0.01%
Seaway Industrial Park	28	0.01%
Linde Air Products	28	0.01%
Ashland Oil #1	21	0.01%
Ashland Oil #2	8	<.01%
Bliss and Laughlin Steel	1	<.01%
North Dakota	24	<1%
Belfield	19	0.01%
Bowman	5	<.01%
Ohio	9,158	4.04%
Portsmouth Gaseous Diffusion Plant	3,960	1.74%
Fernald Environmental Management Project	3,017	1.33%
Mound Plant	1,357	0.60%
Ohio Operations Office	428	0.19%
Reactive Metals, Inc. (RMI Titanium Co.)	141	0.08%
Battelle - Columbus Laboratories	101	0.04%
Painesville	88	0.04%
Luckey	63	0.03%
B&T Metals	3	<.01%
Baker Brothers	<1	<.01%
Piqua Nuclear Power Facility	<1	<.01%
Oregon	6	<1%
Lakeview	6	<.01%

Table 4.1. Base Case Estimate by State and Site (continued)

Site	Base Case Life-Cycle Estimate (Constant 1996 $ in Millions)	Percentage of Total Base Case Life-Cycle Estimate
Pennsylvania	3	<1%
Canonsburg	3	<.01%
South Carolina	48,769	21.49%
Savannah River Site	48,769	21.49%
Tennessee	25,137	11.06%
Oak Ridge National Laboratory	9,352	4.12%
Oak Ridge K-25 Site	7,286	3.21%
Oak Ridge Y-12 Plant	6,168	2.72%
Oak Ridge Operations Office	2,038	0.90%
Oak Ridge Reservation Off-Site	267	0.12%
Oak Ridge Associated Universities	26	0.01%
Texas	689	<1%
Pantex Plant	683	0.30%
Falls City	6	<.01%
Utah	129	<1%
Monticello Mill Site & Vicinity	110	0.05%
Green River	8	<.01%
Salt Lake City	7	<.01%
Mexican Hat	3	<.01%
Washington	50,208	22.12%
Hanford Site	50,208	22.12%
Wyoming	11	<1%
Riverton	10	<.01%
Spook	1	<.01%
TOTAL	226,950	100.00%

Table 4.2. Historical Mission of the Five Highest-Cost Sites Drives Environmental Management Costs

Site	Total Life-Cycle Cost	Historical Mission / Environmental Management Functions
Hanford Site 145,000 Hectares (358,500 Acres)	$50.2 billion	• Uranium fuel fabrication and irradiation • High-level waste management
Idaho National Engineering Laboratory 230,000 Hectares (570,000 Acres)	$18.6 billion	• Reprocessing of spent nuclear fuel • High-level waste management
Oak Ridge Reservation 14,140 Hectares (35,000 Acres)	$25.1 billion	• Uranium enrichment / energy research • Weapons component production • Remediation activities
Rocky Flats Environmental Technology Site 2,510 Hectares (6,216 Acres)	$17.3 billion	• Plutonium weapons trigger fabrication • Stabilization of nuclear materials and facilities
Savannah River Site 80,000 Hectares (198,000 Acres)	$48.8 billion	• Uranium fuel fabrication and irradiation • High-level waste management

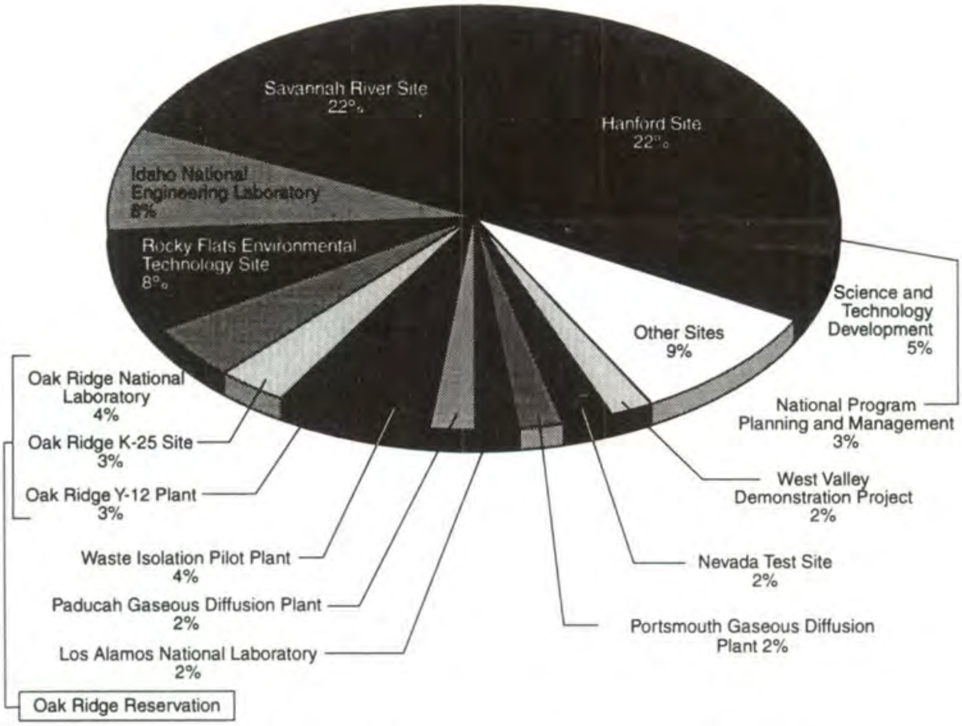


Figure 4.7. Distribution of Environmental Management Life-Cycle Estimate

Table 4.3. Estimated End Dates for the Five Highest-Cost Sites

Site	Projected Completion Date*	Life-Cycle Estimate 90% of Cost
Hanford Site	2052	2039
Idaho National Engineering Laboratory	2045	2035
Oak Ridge Reservation	2045	2044
Rocky Flats Environmental Technology Site	2055	2034
Savannah River Site	2040	2031

*See definition of site completion in Section 3.3.2.

Figure 4.8 focuses only on the highest-cost sites, providing total site cost estimates broken out by the functional elements of the Environmental Management program. At the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site, waste management consumes the largest portion of estimated program costs. At the Oak Ridge Reservation, environmental restoration activities are the highest proportion of estimated cost. At the Rocky Flats Environmental Technology Site, nuclear material and facility stabilization activities represent the largest proportion of estimated cost.

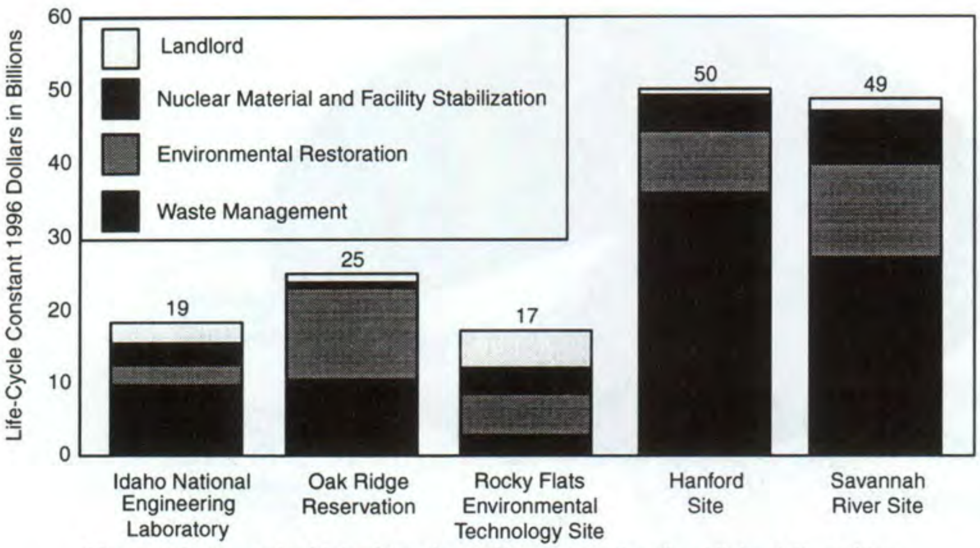


Figure 4.8. Costs by Major Functional Element for the Five Highest-Cost Sites

4.3 BASE CASE RESULTS BY MAJOR FUNCTIONAL ELEMENTS

The Base Case estimate for the six major elements of the Environmental Management program is shown in Figure 4.9. The highest percentage of the estimated life-cycle cost is for waste management activities, amounting to $111 billion (or 49 percent); followed by environmental restoration activities, $63 billion (or 28 percent); nuclear material and facility stabilization activities, $21 billion (or 9 percent); landlord activities, $13 billion (or 6 percent); science and technology development activities, $12 billion (or 5 percent); and national program planning and management activities, $7 billion (or 3 percent). Section 4.3 describes the results for these functional activities.

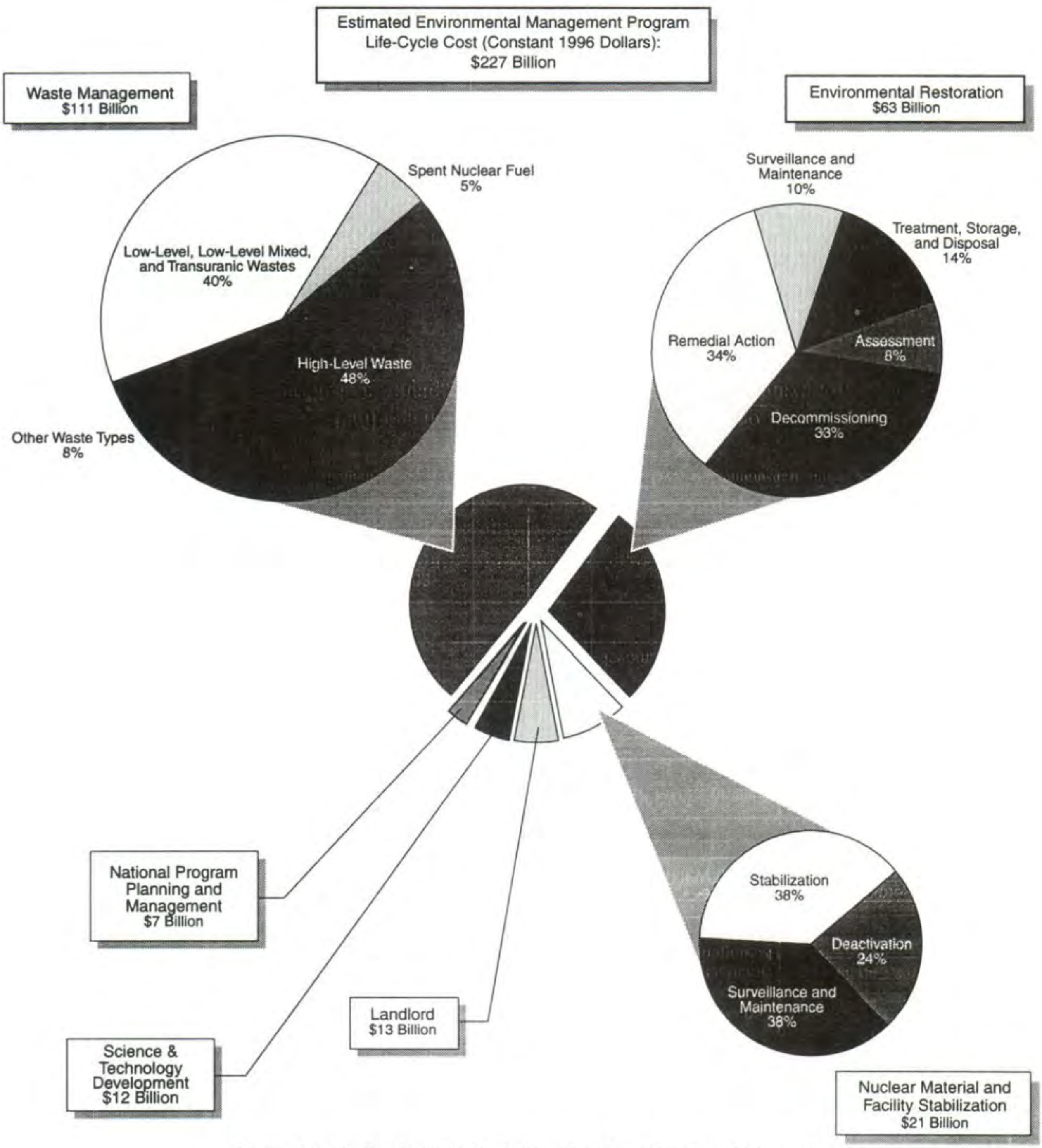


Figure 4.9. Estimated Life-Cycle Cost by Major Functional Element

4.3.1 Waste Management

The life-cycle cost estimate for the Waste Management program is $111 billion. This estimate covers a timeframe that extends to 2070, with most activities expected to be completed by 2045. Figure 4.10 and Figure 4.11 further disaggregate these waste management costs by type of waste addressed and waste management activity (see descriptions for the various waste types in Chapter 2).

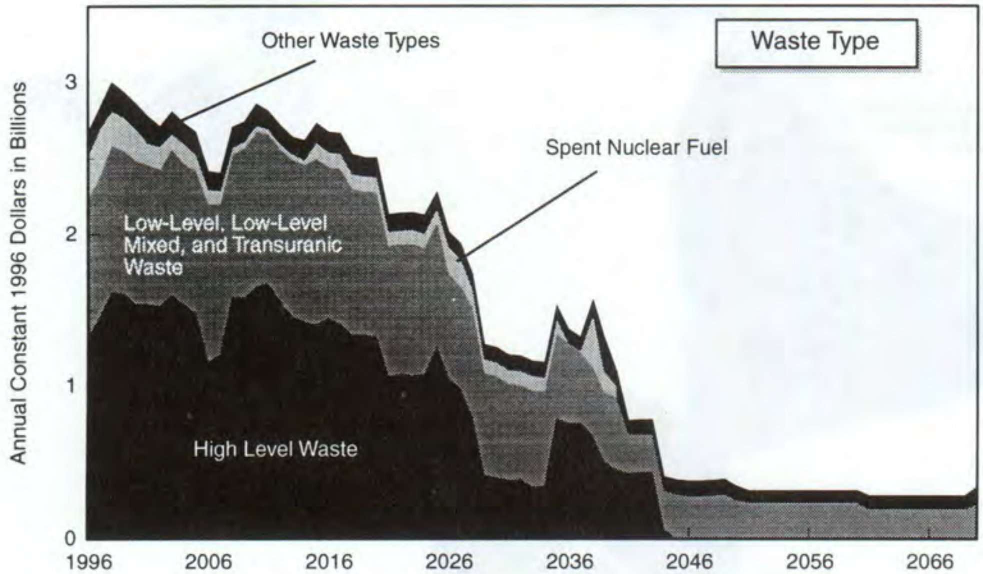


Figure 4.10. Estimated Waste Management Cost by Type of Waste Addressed

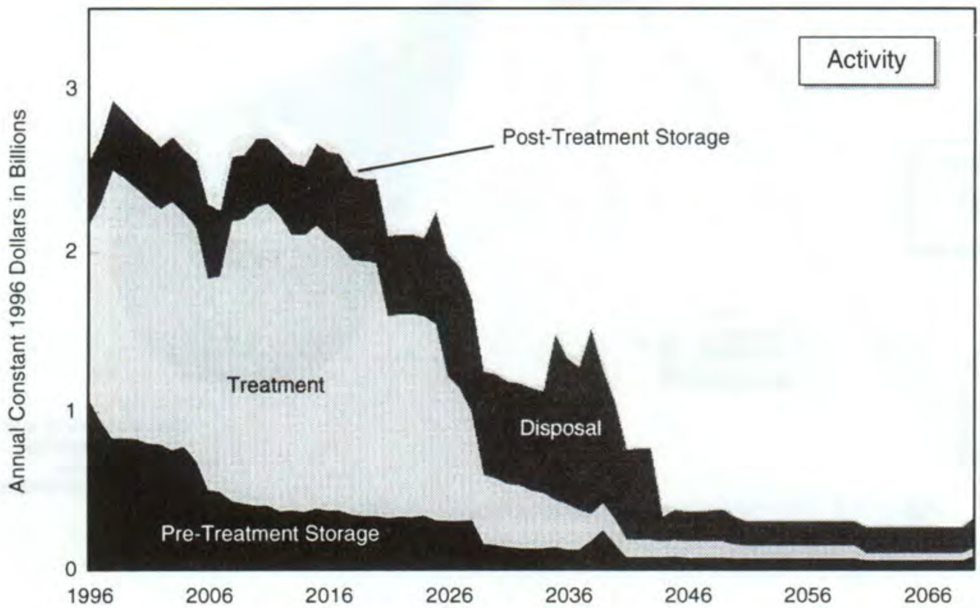


Figure 4.11. Estimated Waste Management Cost By Activity

A large portion of the life-cycle cost estimate for waste management activities is concentrated in a relatively small number of projects. Table 4.4 shows ten of the highest-cost waste management projects. These projects focus primarily on the treatment, storage, and disposal of high-level waste. This result is consistent with the fact that the largest portion of estimated Waste Management program costs ($53 billion or 48 percent) is associated with the management of high-level radioactive waste (see box).

Table 4.4. Ten of the Highest-Cost Waste Management Projects

Site	Project	Estimated Life-Cycle Cost (Billions)
Hanford Site	High-Level & Low-Level Vitrification	$15.5
Waste Isolation Pilot Plant	Waste Isolation Pilot Plant	8.3
Idaho National Engineering Laboratory	Chemical Processing Plant	4.8
Savannah River Site	Defense Waste Processing Facility	3.8
Hanford Site	Single- and Double-Shell Tanks	3.7
West Valley Demonstration Project	High-Level Waste Vitrification Facility	3.7
Savannah River Site	H Tank Farm	2.1
Savannah River Site	F Tank Farm	1.5
Savannah River Site	High-Level Waste In-Tank Precipitation	1.5
Hanford Site	T Plant	1.0

Figure 4.12 shows a breakdown of the cost estimate for high-level waste activities. The Department currently stores more than 300,000 cubic meters (393,000 cubic yards) of high-level waste – the largest volume in the Department's inventory – in 243 large underground tanks. High-level waste management activities include onsite storage, treatment, handling, transportation and disposal. The majority of these costs are for treatment, in particular for *vitrification,* which is the permanent immobilization of high-level waste in glass. The Defense Waste Processing Facility at the Savannah River Site, which recently started processing high-level waste, will operate for 32 years, with a life-cycle cost estimate of approximately $4 billion.

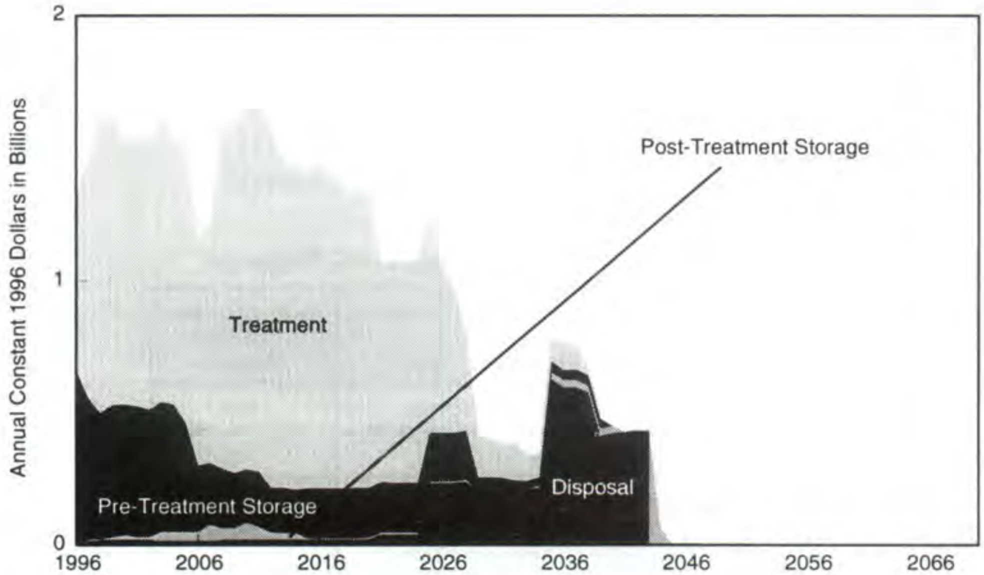


Figure 4.12. Estimated Cost for High-Level Waste Management Activities

WHY DOES IT COST SO MUCH TO MANAGE HIGH-LEVEL WASTE?

The large costs associated with managing high-level waste are due to many factors: large volume, intense radioactivity (which requires any plant that processes high-level waste to be shielded and operated by remote control), and technical difficulties associated with the management of this type of waste. These factors are magnified by problems associated with historical waste management practices. Due to inadequate record keeping, characterization of stored waste frequently requires extensive testing. Many older, single-shelled tanks were designed for a 25-year life span with the expectation that the waste would be transferred to a central repository for disposal. For example, by 1973, 15 high-level waste tanks at Hanford were known to have leaked into soil and ground water. Waste in these corroding tanks must be transferred to newer double-walled tanks using difficult remote-handling procedures. Additionally, large quantities of high-level waste currently in liquid form require treatment through new technologies (for example, vitrification), which results in a more stable and less voluminous form.

To implement these technologies, the Environmental Management program must overcome many technical challenges and will require billions of dollars to construct and operate new facilities. Some facilities, such as the Idaho National Engineering Laboratory New Waste Calcining Facility and the Savannah River Site vitrification facility (Defense Waste Processing Facility), are already operational. Others, such as the vitrification facilities at the Hanford Site and Idaho National Engineering Laboratory, are still in the planning phase.

Management of transuranic waste (see description in Chapter 2) represents the second highest percentage of estimated waste management cost ($16 billion or 14 percent). Figure 4.13 shows annual cost estimates for treating, storing, and disposing of this type of waste. At the Idaho National Engineering Laboratory, approximately 60,000 cubic meters (78,600 cubic yards) of transuranic waste were buried at the Radioactive

Waste Management Complex from 1952 to 1970. Since 1970, 40,000 cubic meters (52,400 cubic yards) of Department of Energy defense-generated waste have been placed there in retrievable storage in an earthen berm. These totals represent over 60 percent of the Department's transuranic waste inventory. Costs to manage this type of waste at the Idaho National Engineering Laboratory are estimated to be approximately $50 million per year.

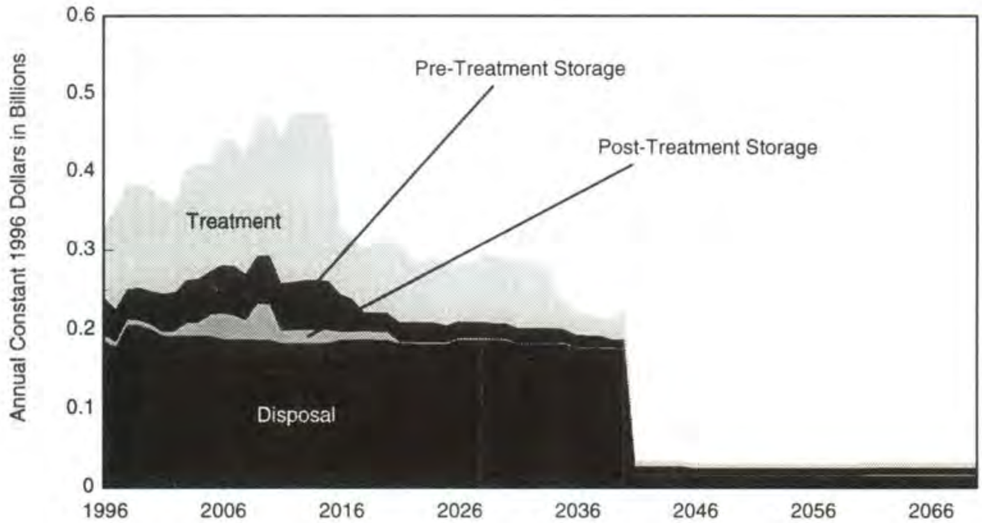


Figure 4.13. Estimated Cost for Transuranic Waste Management Activities

TRANSURANIC WASTE: WHAT DRIVES THE COST?

Throughout the nuclear weapons complex, the current transuranic waste inventory in storage totals more than 100,000 cubic meters – the equivalent of roughly 500,000 (55-gallon) drums. As in the case of high-level waste, costs for transuranic waste management are heavily influenced by past practices. Much of the Department's transuranic material was placed in temporary storage under the assumption that a permanent repository would soon be available. Some containers holding the waste have corroded, requiring repackaging and relocation. Since a repository is not yet available for final disposition of the waste (see discussion of the Waste Isolation Pilot Plant in Chapter 2), transuranic storage capacity needs to be expanded at some sites. However, past records regarding the content of transuranic waste packages are inadequate. More information is needed to determine how to prepare or treat the waste before disposal. In addition, because the Department of Energy's hazardous waste is subject to the requirements of the Resource Conservation and Recovery Act, the Department also must determine which transuranic waste contains hazardous contaminants and then upgrade storage facilities to meet applicable U.S. Environmental Protection Agency standards.

A portion of the transuranic waste management cost is driven by the type of radioactive elements contained in the waste. For example, transuranic waste stored at Idaho National Engineering Laboratory contains only alpha-emitting radioactive elements, so the waste package provides sufficient shielding to protect workers and the environment and can be contact-handled. Only a small portion of the transuranic waste at the Idaho National Engineering Laboratory contains sufficient penetrating radiation to require remote handling. The volume of transuranic waste at the Oak Ridge National Laboratory and the Savannah River Site is smaller than that at the Idaho National Engineering Laboratory, but it represents a large amount of radioactivity.

Estimated costs for managing the remaining types of waste (low-level waste, low-level mixed waste, hazardous waste, and sanitary waste) and spent nuclear fuel combine to account for approximately 37 percent of the total waste management cost estimate.

4.3.2 Environmental Restoration

The life-cycle cost estimate for environmental restoration activities is approximately $63 billion. This estimate represents 28 percent of the total program cost estimate. These activities are expected to span a timeframe that extends to 2070. Figure 4.14 depicts estimated annual environmental restoration costs for the major environmental restoration functions:

- Remedial Action (34 percent),
- Decommissioning (33 percent),
- Treatment, Storage, and Disposal (14 percent),
- Surveillance and Monitoring (10 percent), and
- Assessment (8 percent).

Examples of high-cost environmental restoration projects are listed in Table 4.5.

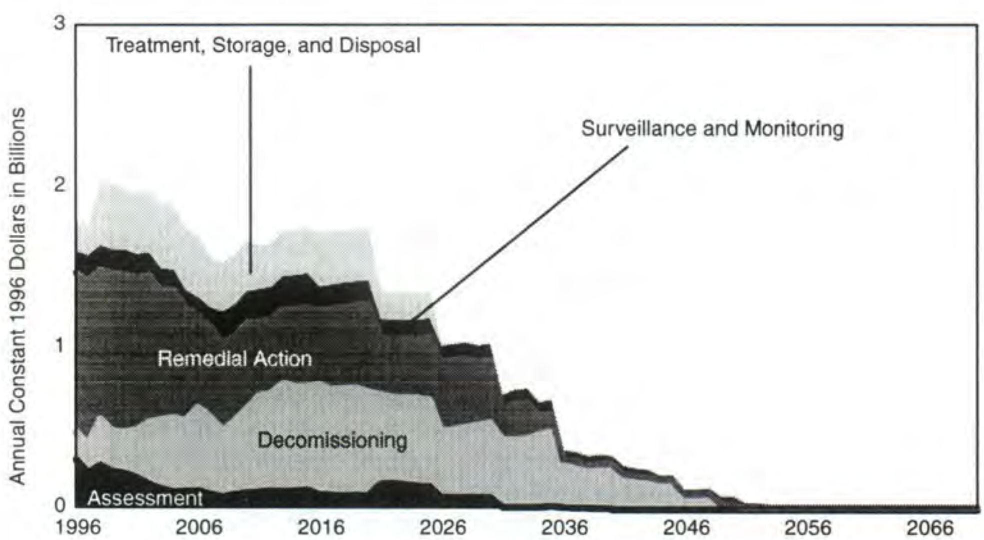


Figure 4.14. Estimated Annual Costs for Environmental Restoration Activities

Remedial actions represent the greatest proportion of estimated environmental restoration costs ($22 billion, or 28 percent). Most remedial actions are expected to be completed by 2016. Remedial action projects fall into three broad categories: those that involve remediating contaminated ground water (which represent 9 percent of estimated remedial action costs); those that involve remediating soils and buried waste (48 percent of estimated costs); and those that involve remediating multiple environmental media (43 percent of estimated costs).

EXPECTED COST SAVINGS FROM POLLUTION PREVENTION

Environmental Management established a Pollution Prevention program in 1991. The Department of Energy defines pollution prevention as activities that involve source reduction and recycling of all waste and pollutants. Pollution prevention refers to the use of materials, processes, and practices, including recycling activities, that reduce or eliminate the generation and release of pollutants, contaminants, hazardous substances, and waste into land, water, and air. This discussion addresses the potential reduction in life-cycle costs that can be attributed to pollution prevention activities.

Current funded pollution prevention projects focus primarily on routine waste from operations. They include a wide range of simple and complicated projects and are applicable at many facilities. For example, a \$5,000 investment in laundering rags can avoid nearly \$14,000 in yearly disposal costs. Dry-ice abrasion equipment is used in a more technology-intensive project that will clean surface radiation from lead-shielding bricks. A \$500,000 investment yields a one-time savings of \$1.2 million by avoiding disposal of a mixed radioactive waste.

To evaluate the potential cost savings from pollution prevention activities, information was collected from three sources. The first source was cost information from a demonstration program that was established for projects with a high return on investment over a short timeframe. Second, cost savings information was available from a number of other field projects under way that provide a significant payback over a longer period of time. Finally, the cost data were evaluated on past pollution prevention projects.

Using cost savings, total project costs, and various other data from these three sources, the life-cycle cost savings were estimated through 2005. Currently, the projected savings from these projects exceeds \$1.6 billion. Other specific projects for which life-cycle data are not available would increase this figure. Many of these projects can be replicated or adapted at multiple sites. Although there are insufficient data to extrapolate total projected pollution prevention savings in a meaningful, quantitative way, complex-wide savings could be in the tens of billions of dollars. In addition, the Department has established goals for reducing the volume of radioactive, low-level mixed, sanitary, and hazardous waste from routine operations 50 percent by the year 2000. Achieving these goals would reduce waste management costs by an estimated \$5 billion over the environmental management life-cycle. The Department will continue to pursue pollution prevention activities aggressively because they are consistent with the Department's core values for respecting the environment, and they result in a more efficient use of limited resources by reducing site operating costs.

Remedial actions also can be described as involving containment strategies (i.e., stabilizing or otherwise immobilizing contamination in place) or removal strategies (i.e., excavating contamination for treatment and/or disposal elsewhere). Sixteen percent of estimated remedial action costs are expectd to be spent on containment strategies involving barriers or solidification. In the case of ground-water remediation, these strategies include pumping and re-injecting contaminated ground-water upgradient to prevent the spread of plumes. The balance of estimated costs is expected to be spent on projects involving a combination of removal and containment strategies (See Figure 4.15).

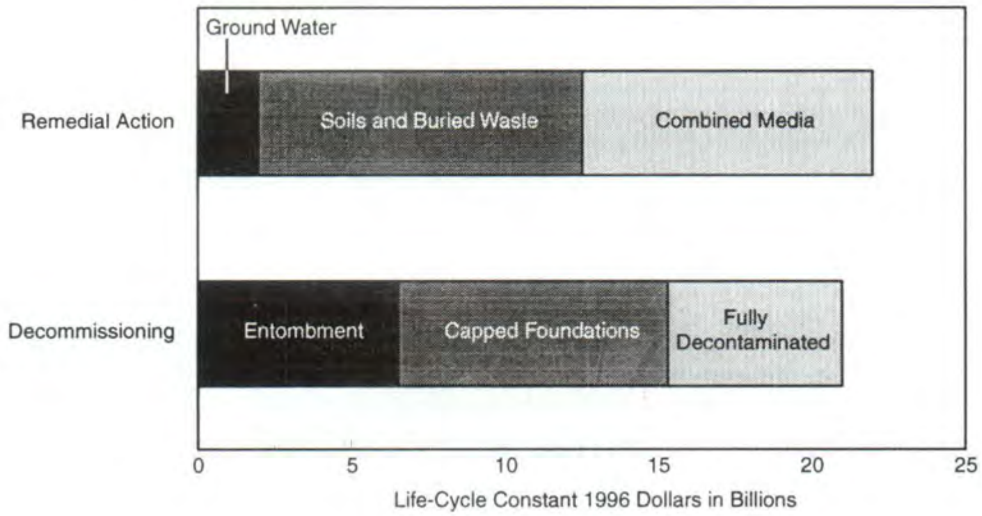


Figure 4.15. Life-Cycle Costs of Various Containment Strategies

Table 4.5 Selected High-Cost Environmental Restoration Projects

Site	Project/Type	Estimated Life-Cycle Cost (Millions)	Estimated Waste Volumes (Cubic Meters)*
REMEDIAL ACTION			
Hanford Site	100-NR Soils	$209	426,000
Idaho National Engineering Laboratory	Radioactive Waste Management Complex Buried Waste	1,385	349,000
Lawrence Livermore National Laboratory	Main Site- Ground Water	334	<100
DECOMMISSIONING			
Oak Ridge Y-12 Plant	Building 9201-4 Removal	256	17,000
Rocky Flats Environmental Technology Site	771 Plutonium Recovery Decontamination/ Containment	430	13,000
Savannah River Site	R Reactor Entombment/Removal	699	103,000
TREATMENT/STORAGE/DISPOSAL			
Portsmouth	Storage	80	N/A
Sandia National Laboratory/ New Mexico	Disposal Facility	25	N/A

* Cubic Meters of hazardous, transuranic, low-level, low-level mixed, and sanitary waste combined

Decommissioning focuses on the safe maintenance, demolition and final disposition of surplus facilities (for example, reactors, hot cells, processing plants, and storage tanks). Rubble and contaminated materials from demolition will either be removed or contained at the building site (for definitions see Section 3.3.4). Greater decontamination leads to a greater percentage of "clean" building materials, which leaves a lower percentage of contaminated materials to be disposed. Decommissioning activities represent the second highest proportion of estimated costs, $21 billion (or 33 percent).

The most contaminated and some of the largest structures are assumed to be entombed, including the former processing buildings (called canyons) at the Savannah River Site and the plutonium production reactors at the Hanford Site. Projects assuming entombment of structures account for 31 percent or $7 billion of estimated decommissioning costs. Facilities assumed to be decontaminated with some waste capped in the building foundations is 42 percent or $9 billion of estimated decommissioning costs. The balance of the facilities are assumed to be fully decontaminated with all materials disposed away from the building site and represents 27 percent or $5 billion of estimated decommissioning costs.

A 38-ACRE BUILDING?

Several of the highest-cost environmental restoration projects are associated with decommissioning the three gaseous diffusion plants. Gaseous diffusion, a process used to enrich uranium, involves a series of vast structures designed to drive gaseous uranium through miles of filters. The end product of this process is enriched uranium-235, which is used for nuclear weapons, submarine fuel, and nuclear power plants. Massive plants were built to execute this process at three locations: the K-25 Plant in Tennessee, the Paducah Plant in Kentucky, and the Portsmouth Plant in Ohio.

Various hazardous, nonhazardous, and radioactive waste resulting from past activities was generated and disposed of at each of the gaseous diffusion plant sites. These sites together encompass approximately 1,860 hectares (4,600 acres). The main building at the K-25 Plant in Tennessee is a half-mile long and covers 15 hectares (38 acres). The effort required to complete decommissioning is, therefore, extensive. These activities include the removal of hazards and contaminants in and around facilities, removal of all major building systems (piping and electrical systems), and demolition (or preparation for potential use) of all buildings and facilities – a total estimated life-cycle cost of approximately $9.2 billion.

The majority of decommissioning activities are expected to occur between 2012 and 2026. Most decommissioning follows facility deactivation activities, which are expected to occur most intensely before 2010. In addition, decommissioning activities are generally expected to occur not specifically identified in Federal Facility Compliance Agreements. Consequently, decommissioning activities have been scheduled to follow remedial actions at most sites.

Assessment activities represent $5 billion, or 8 percent of estimated environmental restoration costs. The assessment activities associated with remedial actions make up the majority (approximately two-thirds) of estimated assessment costs. The majority of assessment costs are for remedial actions because the contamination addressed by remedial actions is spread over greater areas and types of media (i.e., soils and ground water) than in contaminated facilities. In addition, some assessment activities result in the decision that no further action is required because contamination has been successfully addressed by a past action or contamination is low and at a safe level.

Waste treatment, storage, and disposal activities also are associated with remediating sites and represent approximately $9 billion, or 14 percent, of estimated environmental restoration costs. More than 90 percent of the activities identified as treatment, storage, or disposal are associated with sites where there are limited or no ongoing waste management operations, such as Portsmouth Gaseous Diffusion Plant in Kentucky. Activities at these sites are for a limited duration and are generally associated with large decommissioning projects.

When contamination exists in the environment, actions are necessary to maintain structures that contain it and monitor against possible migration. The $7 billion cost estimate for surveillance and monitoring is associated with such activities before, during, and after remedial action and decommissioning activities are complete. These costs are expected to diminish as restoration is accomplished, but they do not completely end because most sites assume some residual contamination.

Figure 4.16 presents another perspective on environmental restoration activities. Five sites dominate the life-cycle estimates of environmental restoration costs. These sites (Hanford Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, Rocky Flats Environmental Technology Site, and Savannah River Site) account for 67 percent of estimated environmental restoration costs and require the longest time to remediate. Another 13 large sites account for an additional 28 percent of total cost. The remainder of the sites are categorized in three groups: Formerly Utilized Sites Remedial Action Program (FUSRAP) sites, Uranium Mill Tailings Remedial Action (UMTRA) sites and all other sites. Cleanup of these sites will account for much of the near-term progress in the program. The FUSRAP sites account for 25 of the sites and two percent of the estimated total life-cycle costs. The UMTRA group comprises 20 sites and represents one percent of the total life-cycle cost. The other small sites account for less than one percent of the overall environmental restoration costs.

Figure 4.16. Environmental Restoration Annual Cost by Site Size and Type

4.3.3 Nuclear Material and Facility Stabilization

The life-cycle cost for nuclear material and facility stabilization activities is estimated to be $21 billion. This cost estimate includes nuclear material stabilization ($8 billion), facility deactivation ($5 billion), and surveillance and maintenance ($8 billion). Figure 4.17 provides a graphical depiction of the total life-cycle cost estimate for these activities. A small number of projects make up the majority of estimated nuclear material and facility stabilization costs (approximately 60 percent). (See Table 4.6).

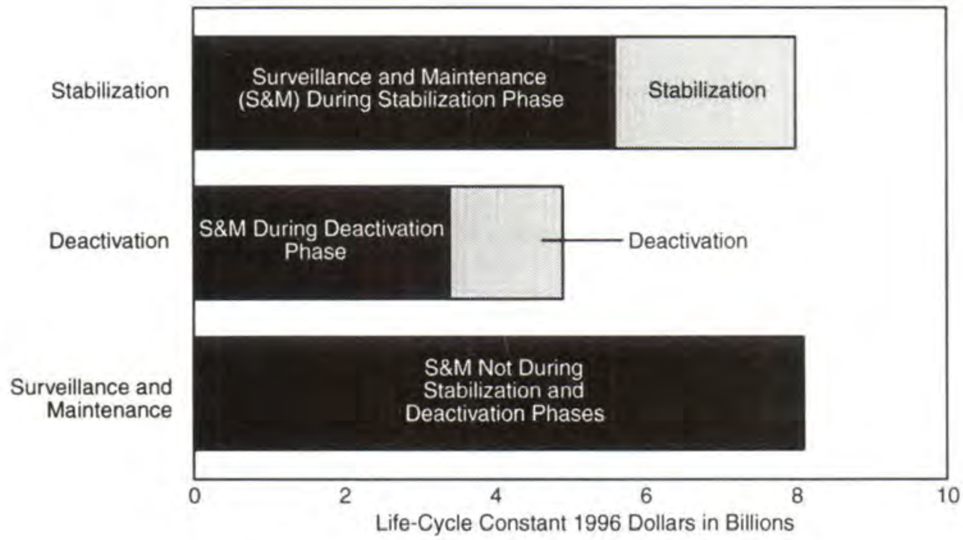


Figure 4.17. Nuclear Material and Facility Stabilization Cost By Activity

Nuclear material stabilization activities account for the largest proportion of estimated nuclear material and facility stabilization costs. Stabilization also includes storage costs at some sites (for example, storage of plutonium at the Rocky Flats Environmental Technology Site). As indicated in Figure 4.17, surveillance and maintenance activities occur throughout both the stabilization and deactivation phases of a project. In fact, during these phases, approximately 70 percent of the costs are for surveillance and maintenance activities. These costs represent the base capacity needed to support deactivation and stabilization efforts. Typically, these activities provide necessary material and facility safety "envelopes."

Surveillance and maintenance activities not conducted during facility stabilization or deactivation account for the second highest proportion of estimated nuclear material and facility stabilization costs. These surveillance and maintenance activities are incurred while a facility awaits stabilization, deactivation, or eventual decommissioning by the Environmental Management program. One of the unique problems included in nuclear material and facility stabilization activities is the stabilization, deactivation, and transition of buildings contaminated with special nuclear materials (see box). The unique set of actions and concerns associated with stabilizing special nuclear materials left in surplus facilities, such as plutonium, is responsible for the large estimated nuclear material and facility stabilization costs.

Table 4.6. Ten of the Highest-Cost Nuclear Material and Facility Stabilization Projects

Site	Project	Estimated Life-Cycle Cost (Billions)
Hanford Site	Plutonium Finishing Plant Facilities	$2.2
Savannah River Site	F Canyon	1.1
Savannah River Site	H Canyon	0.9
Savannah River Site	Actinide Packaging Facility	0.6
Rocky Flats Environmental Technology Site	371 Plutonium Recovery Building	1.1
Nevada Test Site	Area 15 Facilities	0.5
Rocky Flats Environmental Technology Site	707 Production Building	0.5
Rocky Flats Environmental Technology Site	771 Plutonium Recovery Facility	0.5
Rocky Flats Environmental Technology Site	559 Plutonium Analytical Laboratory	0.3
Rocky Flats Environmental Technology Site	776/777 Manufacturing/Assembly Facility	0.3

PLUTONIUM MATERIALS

In 1989, when the last weapons production facilities shut down, 23.6 metric tons (26 tons) of plutonium remained at the Rocky Flats Environmental Technology Site in Colorado, Savannah River Site in South Carolina, and Hanford Site in Washington State.

Plutonium can be very dangerous, even in small quantities. Plutonium metal may spontaneously ignite if exposed to air above certain temperatures or if multiple canisters are stored in close proximity. Plutonium must be handled with extreme caution, requiring workers to wear special anti-contamination clothing and undergo scanning for radiation contamination. Buildings with plutonium inventories also require extensive safety systems to protect against accidents and theft.

To transition the plutonium facilities into a safe and stable mode, each site must remove any corroded plutonium storage containers, drain tanks and pipes, and solidify all liquids removed. Because of the nature of plutonium, this stabilization and deactivation process is very costly. Hanford's Plutonium Finishing Plant, the largest plutonium facility, has over 4,000 kilograms (8,800 pounds) of plutonium in storage. The life-cycle cost for nuclear material and facility stabilization at this single facility is estimated at approximately $2.2 billion. This estimate includes storage of special nuclear material prior to final disposition.

4.3.4 Science and Technology Development

Science and technology development goals include reducing waste management life-cycle costs, reducing risks to people and the environment during and after cleanup, and solving cleanup problems that currently have no solution. Science and technology development activities represent $12 billion or 5 percent of the total life-cycle cost estimate. These activities are assumed to occur over the next 35 years. These funds are for basic science as well as applied technology development and demonstration projects. The Base Case estimate is based upon the use of existing technologies and assumes no cost savings from the use of emerging technologies.

Because projected budgets are potentially restrictive, achieving cost reduction through the application of new technology is of prime importance. In fact, potential cost savings are a key factor in allocating science and technology development funds. Potential savings also give regulators and stakeholders information useful for evaluating the value of a new technology for implementation. The Environmental Management program is currently supporting the development of approximately 170 technology systems. Of these, approximately 120 have cost savings as their primary objective.

For the 1996 Baseline Report, a special analysis of the cost savings from science and technology development activities was conducted. Thirty-seven of these 120 technology systems serve as the basis for estimating cost savings in the analysis of the 1996 Base Case. (See Appendix F for details on the cost savings methodology.) A three-step process is used to estimate potential cost savings from the successful application of the 37 emerging technology systems/subsystems. The process is predictive in nature because the 37 technologies have not had sufficient production application to build detailed historical cost and performance data bases. As a result, the cost savings projection uses conservative assumptions and practices to avoid overestimating the potential cost savings.

Projected cost savings from science and technology development activities, for the first decade's $3 billion investment (1990 - 1999), are estimated in the range of $15 to $20 billion over the life-cycle of the 1996 Base Case for the Environmental Management program. This estimate is considered conservative as discussed in Appendix F. No estimate of savings from later decades' investment in technology development was made. The range of potential savings is attributable to the associated range of "success coefficients" used by the cost engineers and system technologists in their calculations. Relative to cost profiles, these savings are estimated to have a slight impact on treatment and remediation costs before 1998, but the estimated savings will increase to a level equal to approximately 13 percent of projected treatment and remediation costs for the remainder of the environmental management life cycle. Because these estimated cost savings are related to projected treatment and remediation systems and their scheduled implementation, most of the savings will be realized from 2000 to 2030. Although the technology systems in this analysis are at various stages of development, the selected suite of 37 innovative technology systems will presumably be fully developed and implemented during the 1990 to 1999 timeframe.

4.3.5 Landlord

Landlord activities are associated with the provision of site-wide support: providing utilities, maintenance, infrastructure and general management for the entire installation. Overall, the Environmental Management program is landlord at nine Department of Energy installations. The life-cycle costs for these activities are estimated to be approximately $13 billion. The largest estimated landlord costs are at the Rocky Flats Environmental Technology Site (approximately $5 billion). Other large landlord costs occur at the Idaho National Engineering Laboratory (approximately $3 billion), the Savannah River Site (approximately $1.6 billion), and the K-25 Site in Oak Ridge (approximately $1.2 billion).

Environment, safety, and health activities represent the largest share of estimated landlord costs (34 percent) followed by facility maintenance activities (30 percent) and facility management and engineering activities (8 percent). Regulatory compliance, safeguards and security, and monitoring activities also make up a large portion of estimated landlord costs.

4.3.6 National Program Planning and Management

National program planning and management activities account for $7 billion of the estimated life-cycle cost of the Environmental Management program. National program planning and management activities can be organized into three broad areas: program direction, program management, and transportation and emergency management. Program direction primarily comprises the costs of salaries and benefits for federal employees at Headquarters. Program management includes the costs for technical and analytical support contractors. The transportation and emergency management activities support all Department of Energy organizations in planning and managing transportation issues.

4.4 VOLUMES OF WASTE AND SPENT NUCLEAR FUEL

The Environmental Management program manages waste from several sources: waste inventories currently in storage that were generated during weapons production and other activities, waste generated through remediation and decommissioning activities conducted by the Environmental Restoration and Nuclear Material and Facility Stabilization programs, waste generated by the Waste Management program during activities such as treatment or repackaging, and waste generated by other Department of Energy programs with ongoing missions (for example, waste generated by the Energy Research program). Figure 4.18 provides more details on the sources of the waste and spent nuclear fuel. Most waste currently being stored (or in inventory) is high-level waste. Nearly all spent nuclear fuel also is currently in storage. The majority of waste generated during remediation and decommissioning is classified as hazardous, low-level, low-level mixed, sanitary, or transuranic. Most of this waste is generated through the remediation and decommissioning of large quantities of contaminated media (including soil, ground water, and facilities).

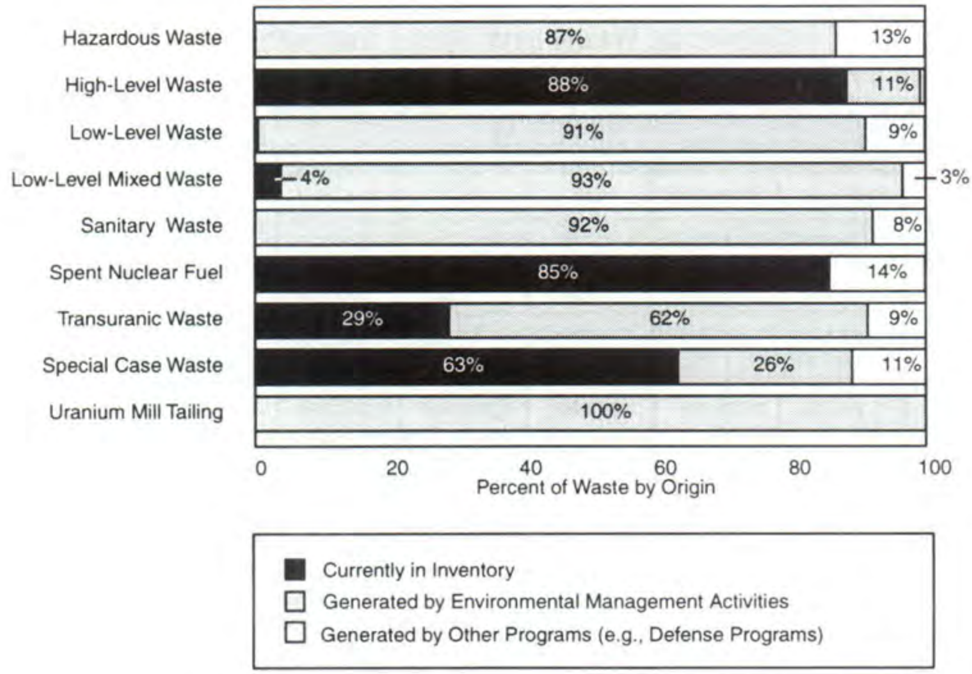


Figure 4.18. Source of Waste and Spent Nuclear Fuel Addressed by the Environmental Management Program

Several key variables affect the scope of the program's treatment, storage, and disposal operations: the type and amount of waste that requires management, the media that contains the waste; and the timing of the waste management needs. Timing is driven by variables such as waste generation rates, regulatory requirements (for example, limitations on onsite storage), and acceptance of waste from other Department of Energy programs or outside sources (for example, commercial nuclear power plants or foreign countries). These variables determine the program's treatment, storage, and disposal capacity needs. Waste management planning, therefore, depends on the estimates of incoming waste developed by waste generators and the amount of waste currently in storage.

Table 4.7 presents the volumes of waste and spent nuclear fuel requiring management. These volumes only include the initial volumes requiring management, excluding treatment residuals. For the waste managed by the Waste Management program, estimates are categorized into four areas: (1) waste currently in inventory; (2) waste generated by the Environmental Restoration and Nuclear Material and Facility Stabilization programs; (3) waste generated by the Waste Management program after 1996; and (4) waste generated by other Departmental programs (e.g., Defense Programs) and transferred to the Waste Management program for treatment, storage, or disposal.

Table 4.7 indicates that more than two thirds of the waste generated by environmental restoration activities is managed and disposed of within the scope of that program. This is the most cost-efficient arrangement because it eliminates multiple handlings of contaminated waste and specially-tailored treatment and disposal methods for waste generated from remedial actions and decommissioning.

Table 4.7. Initial Volumes of Waste and Spent Nuclear Fuel Managed by the Environmental Management Program

Management Responsibility	Waste Management (WM) Program					ER/NMFS
Generator	Inventory	ER/NMFS	WM	Other	Subtotal	
Hazardous Waste	2,400	287,000	43,000	290,000	623,000	1,550,000
High-Level Waste	346,000	38,000	5,500	2,900	393,000	–
Low-Level Mixed Waste	51,000	222,000	86,000	46,000	404,000	928,000
Low-Level Waste	69,000	2,230,000	649,000	1,390,000	4,340,000	11,300,000
Sanitary Waste	–	1,660,000	5,250,000	977,000	7,880,000	4,450,000
Spent Nuclear Fuel	2,600	–	20	400	3,000	–
Transuranic Waste	108,000	94,000	49,000	32,000	284,000	91,000
Special Case Waste	2,400	–	1,000	400	3,900	–
Uranium Mill Tailings	–	–	–	–	–	24,100,000
Other (K-65 Residues)	–	11,000	–	–	11,000	–

ER = Environmental Restoration
NMFS = Nuclear Material and Facility Stabilization
Notes: All volumes in cubic meters, except spent nuclear fuel, which is in Metric Tons of Heavy Metal. Totals may not add due to rounding.

Generally, permanent treatment facilities built within the scope of the Waste Management program are designed to treat process waste with high concentrations of contaminants in the form of liquids or sludges. Disposal cells are equipped to handle residues from those treatment facilities and meet stringent requirements to prevent migration or leaching of contaminants to the environment.

Figure 4.19 shows the types of contaminated media addressed by the Environmental Restoration program. These contaminated media are treated using temporary or portable treatment systems designed for these waste media. Contaminated soils and building materials generally do not require additional treatment prior to disposal.

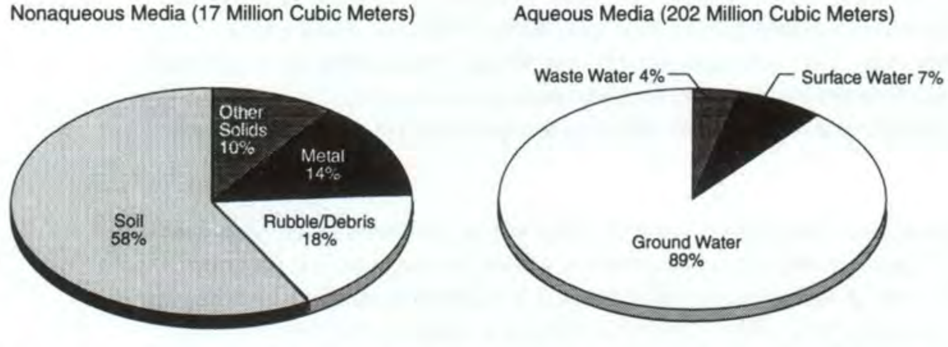


Figure 4.19. Contaminated Media Addressed by the Environmental Restoration Program

Packaging required for disposal is incorporated into the scope of the remediation and decommissioning activities to minimize rehandling. Hazardous waste is generally sent to commercial vendors for treatment and/or disposal. Large volumes of soil and building material are disposed of in onsite disposal cells specially designed and permitted for such waste.

Table 4.8 focuses on the volume estimates of contaminated media for environmental restoration activities, which, by their nature, include handling and treatment of contaminated materials. The table lists volumes for both nonaqueous (generally solids) and aqueous (generally water) media that are removed from the ground or decommissioned facilities for "ex situ" management versus volumes that are managed "in situ" without removal from contaminated media or facilities. The handling activities include exhuming contaminated soil and buried waste, soil washing, treatment of contaminated ground water, and decontamination and demolition of facilities.

Table 4.8. Volumes Managed by the Environmental Restoration Program
(Volumes in Thousands of Cubic Meters)

	Nonaqueous		Aqueous	
Waste Type	Ex Situ Volumes	In Situ Volumes	Ex Situ Volumes	In Situ Volumes
Low-Level Waste	11,300	20,700	300	3,400
Low-Level Mixed Waste	5,200	500	38,000	–
Transuranic Waste	100	–	–	–
Hazardous Waste	1,500	2,300	3,700	42,200
Uranium Mill Tailings	24,100	5,000	900	14,300
Sanitary Waste	1,500	–	196,600	1,300
Total	**39,400**	**33,200**	**201,900**	**99,200**

Notes: Includes volumes addressed within the Baseline reporting period (1996 - 2070). Does not include previous years. Totals may not add due to rounding.

Handling and treatment of environmental media will result in waste volumes that may need further specialized treatment and disposal. Handling strategies for aqueous media are dominated by pumping and treating of ground water. This process generates a small amount of waste in comparison to the treated water, which is reinjected. Handling strategies for nonaqueous media generally result in generating large volumes of waste. Some treated volumes are returned to the ground. If the medium is still somewhat contaminated, it may be contained with a barrier.

The in situ column reflects those volumes addressed without handling the aqueous and nonaqueous contaminated media. In these instances, engineered barriers are deployed to contain the contamination or in place treatment methods (e.g., bioremediation) are applied to eliminate contaminants. In some cases, encapsulation is used to preclude migration of contamination. Some of these volumes have been previously handled, such as those nonaqueous volumes mentioned above, but they are predominately left in place (in situ).

4.5 SUPPORT COSTS

The focus of the Baseline Report is on estimating the costs of mission-related activities necessary to complete the Environmental Management program, including the six major functional elements described earlier in this section. The Environmental Management program also directly funds activities in support of the environmental mission. These support costs make up approximately 20 percent of the life-cycle cost estimate. Excluding an analysis of these support costs (which are integral to the performance of the program) would lead to a significant underestimation of the program's total life-cycle estimate.

Direct support costs are approximately 26 percent of costs at Environmental Management sites in FY 1996. Figure 4.20 indicates that the majority of these support costs (approximately two-thirds) are for the management of the six functional elements of the program described above. Approximately 10 percent of the support costs funds environment, safety, and health activities. The remaining 20 percent funds financial and administrative activities; infrastructure, safeguards and security; stakeholder and regulation interations.

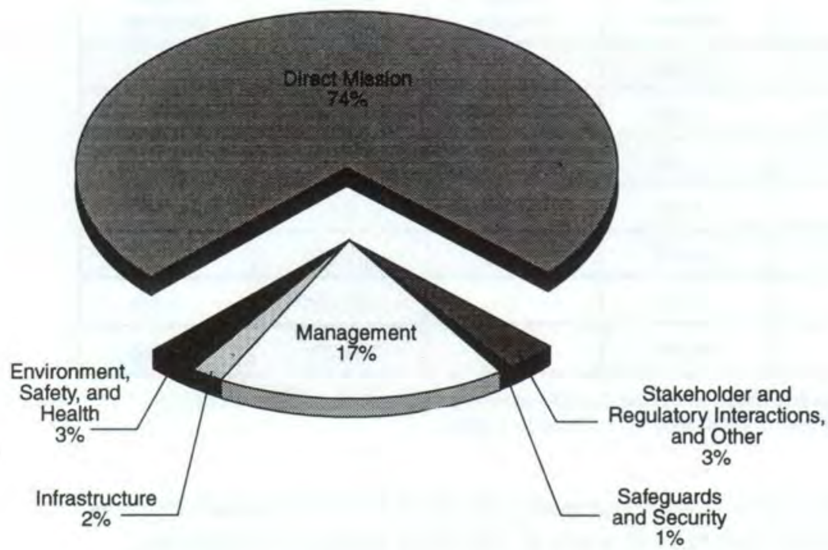


Figure 4.20. Fiscal Year 1996 Support Costs

Figure 4.21 illustrates a second finding on support costs: support costs have a relatively fixed component. As the level of mission-related activities at a site increases or decreases, a portion of support costs remains relatively constant. For example, program management costs for specific waste types or major projects are constant until the project or program reaches completion. This finding has significant ramifications for the life-cycle cost of the program. As annual budgets decrease, support costs also decrease, but at a slower rate. Support costs make up approximately 26 percent of total cost in FY 1996. By 2050, when most mission activities are complete, support costs account for the largest portion of the program's cost estimate.

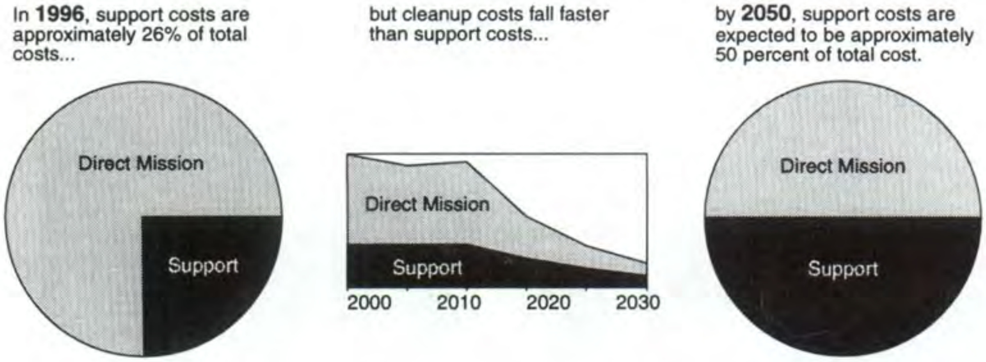
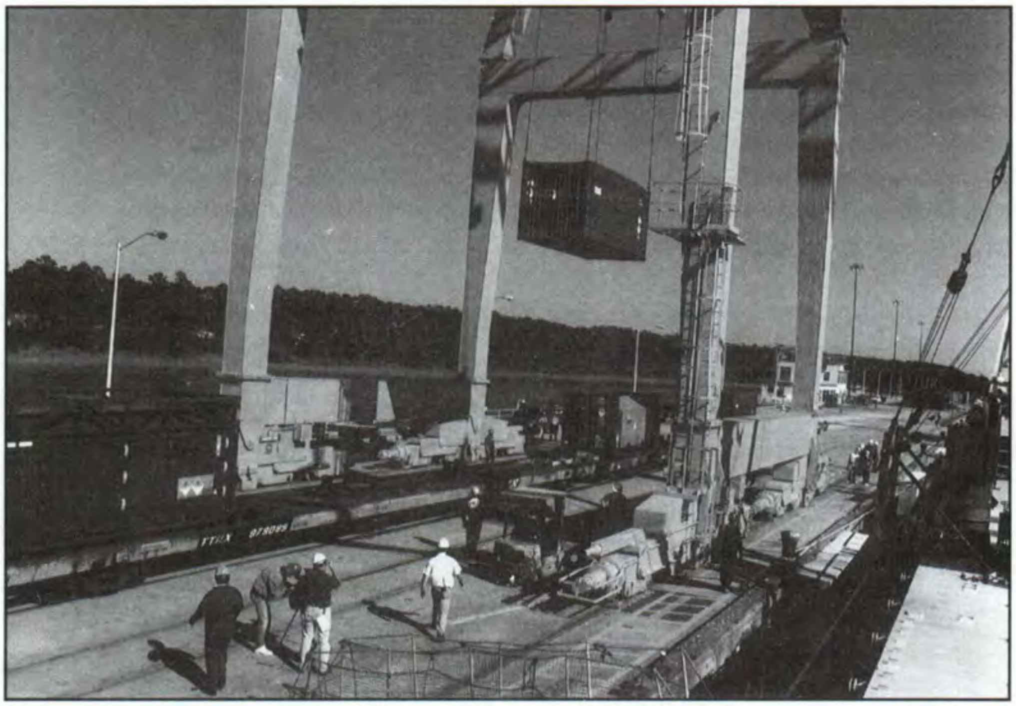


Figure 4.21. Support Costs Over Time

Because support costs are a large component of life-cycle cost, the Environmental Management program is currently implementing several cost reduction initiatives. For example, overhead cost reduction is central to the program's productivity improvement efforts. Several sites also have productivity improvement goals focused on reducing overhead costs.

"Atoms for Peace" Mobile Exhibit, United States Atomic Energy Commission, 1957. *The "Atoms for Peace" program, initiated under the Eisenhower Administration, assisted foreign countries with peaceful applications of nuclear energy in exchange for a commitment to forego nuclear weapons development. From the 1950s through the 1970s, as part of the "Atoms for Peace" program, the United States supplied highly enriched uranium to fuel foreign research reactors in 41 countries around the world.*



Spent nuclear fuel transportation package is offloaded from a ship onto a waiting rail car, Military Ocean Terminal, Sunny Point, North Carolina, 1995. *In support of national and international nonproliferation policies, highly enriched (weapons grade) uranium that was supplied to foreign countries is being returned to the United States in the form of spent nuclear fuel. Improved life-cycle planning is helping identify the long-term issues and strategies involved in the return of the spent fuel.*

6.0 ALTERNATIVE SCENARIOS

A number of significant assumptions regarding factors affecting costs underlie the Base Case estimate. Varying these assumptions can often influence the overall life-cycle cost estimate. To help inform national policymaking and local decisionmaking processes, the 1996 Baseline Report provides a more rigorous analysis of alternative program scenarios. By changing certain key assumptions we are able to examine the influence of each factor on the life-cycle cost and schedule of the Environmental Management program (see box). The analyses varied assumptions regarding the following factors expected to influence program costs:

- **Land Use** — What effect do future land-use decisions have on the overall scope, cost, and schedule of cleanup for Environmental Management sites? What factors limit consideration of land uses?

- **Program and Project Scheduling** — What are the cost consequences of delaying and accelerating programs and projects? What is the relationship between program pace, funding levels, and life-cycle cost?

- **A "Minimal Action" Scenario** — What is the minimum funding required for preventing risks to human health and the environment from increasing for 75 years without the constraints of current legal requirements?

The approach for estimating life-cycle costs for the alternative scenarios mirrors the basic methodology employed for the Base Case estimate. Site estimates and assumptions provided the basis for these analyses. The land-use analysis varies from the Base Case in that the analysis assumes different site end states suitable for various uses, and measures the cost and waste volume consequences of cleaning up to these alternative end states. The program and project scheduling analysis assumes the same actions and subsequent end states for programs and projects as described in the Base Case, but applies funding and scheduling constraints to better analyze the cost consequences of accelerating or delaying programs and projects. The minimal action scenario uses methods developed by site personnel to re-scope projects and activities to meet a set of minimal action assumptions and thus diverges dramatically from the Base Case. Although implementation of particular scenarios may require regulatory relief, no scenario specifically examines the impact of changing regulatory requirements.

SCENARIOS ARE NOT DECISIONS

Scenario analyses attempt to identify a set of possible futures, each of which is plausible, but not assured. These analyses are intended to foster and help inform local and national discussions regarding potential policy strategies for the Environmental Management program. Each scenario provides an explicit framework for further discussions and reaction. The analyses were developed using hypothetical assumptions that do not represent plans or decisions endorsed by the Department of Energy or the Environmental Management program.

The three analyses focus on the five sites in the Environmental Management program estimated to have the highest life-cycle costs — Hanford Site, Washington; Idaho National Engineering Laboratory, Idaho; Oak Ridge Reservation, Tennessee; Rocky Flats Environmental Technology Site, Colorado; and, Savannah River Site, South Carolina. Together, these sites account for approximately 70 percent of the Environmental Management total program cost estimate and comprise over one million acres of federal land. By focusing on the five highest-cost sites rather than on the other 145 sites in the program, the analysis is able to account for the majority of program costs and establishes a reliable basis for evaluating the impacts of alternative assumptions. Figure 6.1 shows the distribution of costs for the five sites in relation to the entire Environmental Management program.

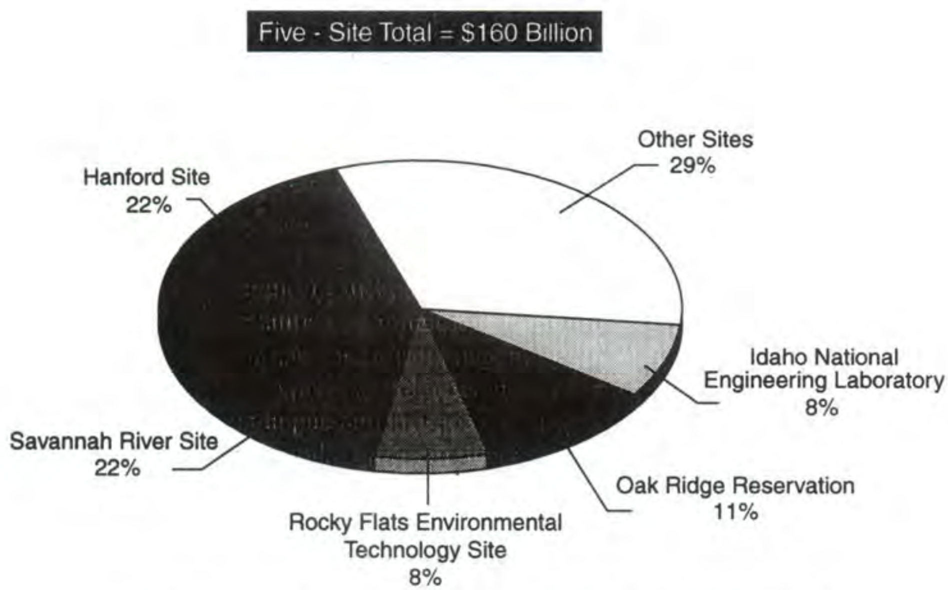


Figure 6.1. Distribution of Life-Cycle Costs for the Five Highest-Cost Sites

In developing the scenarios, the Department assumed that *inter*site funding could generally *not* occur. That is, one site could not accelerate work by "borrowing" funding from another site. It was assumed that *intra*site funding could take place. For example, funding for waste management activities could be used to fund stabilization and deactivation activities within a site. (The exception to this convention was for a single land-use case that addressed extreme clean-up).

6.1 LAND USE

One of the primary difficulties in estimating the total cost of the Environmental Management program is that future land use (i.e., the ultimate disposition of lands currently managed by the Department) generally has not been determined. The Department continues to work with local stakeholders and regulators to determine future uses of land and facilities. This process has identified initial future use preferences at a number of sites (*Charting the Course: The Future Use Report*, April 1996), but final decisions are still pending. Until these decisions are made, there will be considerable uncertainty regarding the nature and extent of required environmental restoration activities. This, in turn, adds uncertainty to estimates of total program cost. For example, analyses presented in the 1995 Baseline Environmental Management Report indicated that future-use decisions could change the total cost of the Environmental Management program by hundreds of billions of dollars. It was a broad analysis, without site-specific data. The land-use analysis presented here provides site-specific data and is a more limited evaluation of how a range of potential future land-use decisions could affect environmental restoration activities, and how these changes would affect the total cost of the Environmental Management program. A key feature of this analysis is the consideration of site-specific constraints on future land use.

SIGNIFICANT FINDING OF THE LAND-USE ANALYSIS

The Department conducted a land-use analysis to examine how future decisions will affect cost and end-state conditions. Four scenarios, preserving infrastructure for ongoing missions and ecologically sensitive areas, were developed ranging from *Iron Fence* to *Modified Green Fields*. An additional scenario, *Maximum Feasible Green Fields* eliminated Department missions from the end state and completed cleanup to the fullest extent of available technologies regardless of the impact on the ecology.

- **Consideration of site-specific constraints in preserving missions and habitats significantly restricts the range of land uses possible at sites; the resulting variation in estimated program cost was, at most, six percent from the Base Case.**

- **Implementation of a *Maximum Feasible Green Fields* scenario is expected to cost 77 percent more than the Base Case. This scenario yields an additional 65,450 hectares (162,000 acres) clean enough for Residential or Agricultural uses compared to the Base Case. Under this scenario, the Department's industrial infrastructure would be largely eliminated, and the more extensive remedial actions would result in considerable disturbance of ecologically sensitive areas.**

- **Assumptions regarding future missions did not consider long-term storage of special nuclear materials. This storage would significantly affect the number of acres that would be held as buffer zones to provide security and protect offsite populations.**

This section includes a description of the general assumptions for this analysis; a description of the five alternative scenarios developed for the land-use analysis; an overview of how the alternative scenarios were developed and analyzed; the results in terms of estimated cost, the schedule of remediation activities, and end states in acres of land attaining specific cleanup levels; and the implications of this analysis. Appendix C provides a more detailed discussion of the land use analysis methodology, and Appendix D presents site-specific results for each of the alternative scenarios.

6.1.1 General Assumptions for the Land-Use Analysis

The alternative scenarios evaluated in this section are based on changes to the Base Case assumptions for environmental management activities. The primary assumptions and bounds for this analysis are as follows:

- The primary focus of this analysis is the estimated cost for environmental restoration and associated support activities. Waste management activities and cost estimates are affected only to the extent that changes in environmental restoration activities result in changes in the volume of waste that is treated and/or disposed at waste management facilities. A number of Environmental Management program activities are *not* affected by this analysis, including (1) decommissioning of waste management facilities; (2) high-level waste and spent nuclear fuel management, and (3) nuclear material and facility transition activities.

- The alternative scenarios incorporate *land-use standards* developed for this analysis that provide a consistent basis for comparing land use assumptions and evaluating alternatives across sites. Land-use standards are provided for six land use categories: Disposal/Storage Areas, Open Space, Industrial, Recreational, Residential, and Agricultural. The land-use standards include both operational definitions as well as assumed technology strategies for each category.

- The alternative scenarios also incorporate *site-specific constraints* on future use (i.e., real-world limitations on the future uses that can be achieved). These constraints include ongoing program missions (including waste disposal/storage); legal commitments (e.g., Records of Decision); the presence of unique or sensitive ecological systems (e.g., endangered species habitat), and the limits of current technology (e.g., the inability to remove contaminants such as tritium from ground water).

- All alternative scenarios assume a level of annual funding for the Environmental Management program equal to that for the Base Case. If estimated costs increased above this amount (e.g., because of more extensive remedial actions), projects and activities were delayed until sufficient funding was available. The scenarios generally assumed no transfer of funds from one site to another.

6.1.2 Alternative Land-Use Scenarios

The Department used the underlying land-use assumptions in the Base Case as the point of reference to evaluate the effect of the following five alternative land-use scenarios on the estimated life-cycle costs of the Environmental Management program: Maximum Feasible Green Fields, Modified Green Fields, Recreational, Industrial, and Iron Fence. These five scenarios were chosen to represent varying land use outcomes (and differing levels of environmental restoration activity). The Maximum Feasible Green Fields and Iron Fence scenarios represent the two endpoints of the land-use continuum attained at the five highest-cost sites. The Recreational scenario represents an intermediate land-use end state without access restrictions, while the Industrial scenario represents an intermediate land-use end state with access restrictions. The Modified Green Fields scenario illustrates how an aggressive clean up strategy might be tempered when considering continued Departmental missions at these five large sites.

Maximum Feasible Green Fields — To illustrate a maximum cleanup scenario, the land-use analysis assumed that continued Department of Energy missions and stewardship facilitated by a continued government presence would end at some future time. This scenario removes site-specific constraints, except for technology challenges and assumes a limited number of disposal areas. To support the Residential or Agricultural land uses required by this scenario, the most aggressive cleanup goals are used in removing all contaminated media or materials at the five sites.

Modified Green Fields — This scenario, like the Maximum Feasible Green Fields scenario, has as its goal Residential or Agricultural standards, but it considers all applicable site-specific constraints. It represents the most stringent remediation strategy possible while continuing Departmental missions and presence at the site.

Recreational — Contaminated areas at each site are assumed to be remediated to a level that supports Recreational uses, while considering site-specific constraints. This scenario combines removal and containment remediation strategies.

Industrial — Contaminated areas at each site are assumed to be remediated to a level that supports Industrial uses, while considering site-specific constraints. This scenario places more emphasis on containment strategies than does the Recreational scenario because Industrial use encompasses more institutional controls.

Iron Fence — Contaminated areas at each site are assumed to be remediated to a level that supports the Disposal/Storage land uses (also termed Controlled Access). Generally, contamination will be monitored or contained in place. The Iron Fence scenario is intended as the alternative with the least cost. Therefore, in a small number of instances where removal actions are less costly than containment actions, this scenario selects the least-cost alternative.

6.1.3 How the Land-Use Scenarios Were Developed and Analyzed

Three variables were identified that significantly affect environmental restoration activities: (1) level of existing contamination, (2) future-use assumptions, and (3) site-specific constraints. Data for these variables were collected for the Base Case. The five highest-cost sites verified the Base Case data and defined the parameters for developing new cost and schedule data for the alternative scenarios described above. These variables, and how they were combined to develop the alternative land-use scenarios, are described briefly below.

6.1.3.1 FUTURE-USE ASSUMPTIONS

The starting point for any land-use analysis is an assumed future-use goal. These goals determine the types of activities that are assumed to occur in the future, the likely exposure pathways, and whether contaminated media may be remediated with in situ remediation strategies, such as capping in place. These, in turn, determine the type and extent of environmental restoration activities that are likely to be required. For example, containment of surface and subsurface contamination (e.g., capping and monitoring) is sufficient for an Industrial future-use goal because adequate controls are maintained (e.g., capped areas can be fenced off), the types of exposures are limited, and assumed exposure levels are relatively low. In contrast, a Residential future-use goal requires extensive removal of surface and subsurface contamination because the types of activities associated with this use (e.g., gardening, excavating foundations, playing in dirt) can breach containment structures, more types of exposures are possible, and assumed exposure levels are relatively higher.

Table 6.1. Land-Use Categories Defined for this Analysis

Land-Use Category	Operational Definition
Disposal/Storage Area	The Department maintains restricted access areas for secure storage or disposal of nuclear materials or waste. Barriers and security fences prevent access by unauthorized persons. Wildlife and plants are controlled or removed. This category also is known as "Controlled Access".
Industrial	Active industrial facility where ground water may be restricted.
Open Space	Posted areas are reserved generally as buffer or wildlife management zones. Native Americans or other authorized parties may be allowed permits for occasional surface area use. Access to or use of certain areas may be prevented by passive barriers (e.g., where soil is capped). Limited hunting or livestock grazing may be allowed.
Recreational	Unfenced areas where daytime use for recreational activities (e.g., hiking, biking, sports), hunting, and some overnight camping is allowed. Fishing may be limited to catch-and-release.
Residential	Unfenced areas where permanent Residential use predominates. There is no restriction on surface water, but ground-water use may be restricted.
Agricultural	Unfenced areas where subsistence or commercial agriculture predominates without restriction on surface or ground-water use.

This analysis required a consistent basis for comparing land-use assumptions and evaluating alternative scenarios across the five highest-cost sites. Therefore, a set of land-use standards was developed for six land-use categories that includes both operational definitions and assumed technology strategies for each category (Table 6.1).

The standards were used to describe uses and relative cleanup level of acreage consistently. For instance, land on which grazing is permitted has been referred to by individual sites as Agricultural use, but according to the standards, it is categorized as an Open Space use. If the land has not been contaminated, it would meet the cleanup levels for all uses and could be described as suitable for Agricultural use. (Appendix D presents Base Case application of standards for uses and cleanup levels.) These standards were developed solely for this analysis and are *not* intended to replace specific land-use definitions at any site nor usurp the authority of that site to tailor land-use to conditions present. Using these standards, the Base Case future-use assumptions were compared and, to the extent possible, reconciled with the future land-use preferences identified by the Future Use Working Groups.

6.1.3.2 SITE-SPECIFIC CONSTRAINTS

In general, any desired land-use goal is achievable with current environmental restoration technologies. Notable exceptions include instances where there is no effective removal technology (e.g., tritium in ground water) or where risks to remediation workers using conventional removal technologies are unacceptably high. These and other site-specific constraints place limits on the land-use goals that are *likely* to be achieved. For example, all of the five highest-cost sites have assumed that some Department of Energy missions (e.g., industrial activities, monitoring of waste disposal areas) will continue through the end of the Environmental Management program. In addition, the Department has entered into legal commitments that incorporate specified land-use goals. Finally, the presence of unique or sensitive ecological systems may limit future human uses of these areas. Because it is unrealistic to assume certain future uses in the face of these site-specific constraints (e.g., Residential use within a waste disposal area), the Department incorporated these constraints into this analysis.

6.1.3.3 LEVEL OF EXISTING CONTAMINATION

At the five highest-cost sites, the majority of the land area (approximately 400,000 hectares [one million acres] or 87 percent) is essentially uncontaminated and already meets the requirements for the Open Space, Residential, or Agricultural land-use categories. This includes approximately 80,000 hectares (200,000 acres) at Idaho National Engineering Laboratory that had unexploded ordnance (removal of unexploded ordnance is essentially complete) and approximately 60,000 hectares (150,000 acres) at the Savannah River Site where stream beds are contaminated. Both these areas meet the requirements of the Open Space land-use category. This analysis focuses on the remaining 63,000 hectares (155,000 acres) (13 percent). These areas are contaminated to varying degrees. In most cases some remedial action will be required, even to meet Disposal/Storage Area standards. In some areas, however, existing contamination is sufficiently low that remedial action may be required under some future use assumptions (e.g., Residential), but not others (e.g., Open Space). This information is incorporated into the analysis.

6.1.3.4 DEVELOPING THE LAND-USE SCENARIOS

Using the six standard land-use categories, a nominal future-use assumption was assigned to each land-use scenario. These uses ranged from Disposal/Storage Area for the Iron Fence scenario to Residential/Agricultural for the two Green Fields scenarios (Table 6.2).

For each land-use scenario, remedial strategies were assigned to all contaminated areas at the five highest-cost sites. Cost and waste volume data were calculated to remediate the site to the nominal land use category for that scenario, except where site-specific constraints or level of existing contamination indicated otherwise. For areas with no site-specific constraints, remedial actions were used where existing contamination did *not* already meet or exceed the nominal land-use standard. In the Industrial scenario, for example, areas were remediated unless existing contamination was low enough to meet Industrial or Recreational standards. As a consequence, the remedial strategy for a given area of contaminated soil might be containment (capping) under the Iron Fence, Industrial, and Recreational scenarios, but removal under the two Green Fields scenarios.

Table 6.2. Assumed Remedial Strategies for Alternative Land-Use Scenarios

<table>
<tr><th rowspan="2">Scenario</th><th rowspan="2">Future-Use Assumption</th><th colspan="2">Assumed Remedial Strategy for Contaminated Areas[1]</th></tr>
<tr><th>Areas With No Site-specific Constraints[2]</th><th>Areas With Site-specific Constraints[3]</th></tr>
<tr><td>Iron Fence</td><td>Disposal/Storage Area</td><td>If area currently meets any land use standards, no actions required; otherwise, remediate to meet disposal/storage area standards</td><td rowspan="4">Maintain Base Case remedial strategies:
• Do not vary areas with disposal/ storage missions
• Remediate areas with other ongoing missions to meet Industrial standards
• Avoid active removal for ecologically sensitive areas (remain mostly open space)
• Generally do not vary areas with existing Records of Decision</td></tr>
<tr><td>Industrial</td><td>Industrial</td><td>If area currently meets industrial or recreational standards, no actions required; otherwise remediate to meet industrial standards</td></tr>
<tr><td>Recreational</td><td>Recreational</td><td>If area currently meets recreational standards, no actions required; otherwise remediate to recreational standards</td></tr>
<tr><td>Modified Green Fields</td><td rowspan="2">Residential or Agricultural</td><td rowspan="2">Remediate all areas to meet residential or agricultural standards</td></tr>
<tr><td>Maximum Feasible Green Fields</td><td>Remediate most areas to meet Residential or Agricultural standards[3]</td></tr>
</table>

[1]No actions are required for uncontaminated areas because they already meet Residential or Agricultural standards

[2]For some areas, technical constraints limited remedial strategies under some scenarios but not others (e.g., some areas can be remediated to meet Open Space, Industrial, and Recreational standards but not Residential or Agricultural)

[3]All site-specific constraints are lifted except for technology limitations and certain disposal areas at the Hanford Site, Idaho National Engineering Laboratory, and Savannah River Site

For areas with site-specific constraints, the Base Case remedial strategy was generally left unchanged across all scenarios. For example, contaminated areas in portions of the sites with an assumed ongoing Industrial mission were assumed to be remediated to meet Industrial standards, whether the nominal future-use assumption was Disposal/Storage Area or Residential/Agricultural. The only exception was the Maximum Feasible Green Fields scenario, in which all site-specific constraints were lifted except for technology constraints and constraints regarding certain waste disposal areas at the Hanford Site, Idaho National Engineering Laboratory, and the Savannah River Site.

Parametric models were used to estimate environmental restoration costs and volumes of waste generated for each contaminated area under each alternative scenario. The Baseline Environmental Management Report Integration Tool (See Methodology in Appendix C) was then used to estimate waste management costs associated with the changing waste volumes, as well as changes in program duration under each alternative scenario.

6.1.4 Results

This section presents the results of the land-use analysis in terms of cost and schedule estimates and end-state conditions.

6.1.4.1 COST AND SCHEDULE ESTIMATES

Estimated costs for the Environmental Management program at the five highest-cost sites range from $150 billion for the Iron Fence scenario to $284 billion for the Maximum Feasible Green Fields scenario (Figure 6.2). These estimated costs are respectively six percent lower and 77 percent greater than the Base Case estimate of $160 billion for these five sites. When site-specific constraints are considered (i.e., Iron Fence through Modified Green Fields), there is little difference in estimated cost among the alternative scenarios. The estimate for the Modified Green Fields scenario ($166 billion) is only 10 percent greater than the estimate for the Iron Fence scenario and six percent greater than the Base Case estimate. The Base Case estimate is between that of the Industrial scenario ($155 billion) and the Recreational scenario ($162 billion). It is important to remember that these are generalized findings, and that actual land use will likely vary significantly among different sites.

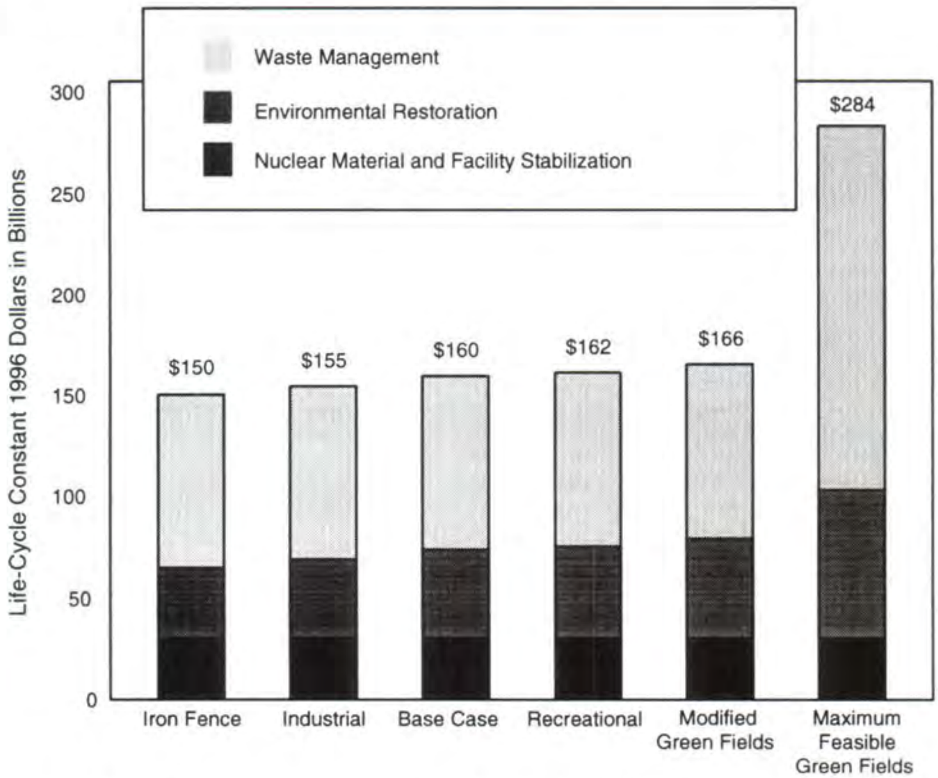


Figure 6.2. Costs for Environmental Restoration, Waste Management, and Nuclear Material and Facility Stabilization By Land-Use Case

When site-specific constraints are considered, environmental restoration activities account for most of the variation in estimated cost. Waste management cost estimates change slightly because of variation in estimated waste volumes, but few changes in overall waste management strategy are required, given that most waste management and nuclear material and facility stabilization activities were held constant across the scenarios. When site-specific constraints are lifted (i.e., for the Maximum Feasible Green Fields scenario), cost estimates increased more steeply for both environmental restoration and waste management activities. These large increases are due to the more extensive removal strategies used during environmental restoration activities as well as the greater volumes of waste expected to be generated by these activities. They also reflect a major change in waste management strategy at Oak Ridge Reservation and the Rocky Flats Environmental Technology Site. Under the other land-use scenarios (including the Base Case), the waste management strategy included onsite disposal of some waste at these sites. Under the Maximum Feasible Green Fields scenario, however, all waste was assumed to be shipped offsite for disposal.

The average duration of the Environmental Management program at the five highest-cost sites is estimated to change as the scope of environmental restoration activities changes under the alternative scenarios (Table 6.3). The reduced scope of activities under the Industrial and Iron Fence scenarios reduced the average program duration estimate from 75 years (Base Case) to 73 years (Industrial) and 72 years (Iron Fence). When site-specific constraints were considered, the small increase in the scope of environmental restoration activities under the Recreational and Modified Green Fields scenarios did not increase estimated program duration. Under the Maximum Feasible Green Fields scenario, however, average program duration increased to 78 years.

Table 6.3. Schedule Impacts of Alternate Land-Use Cases

	Iron Fence	Industrial	Base Case	Recreational	Modified Green Fields	Maximum Feasible Green Fields
Average Program Duration (years)	72	73	75	75	75	78

These program duration estimates do *not* include long-term surveillance and monitoring required to safeguard residual contamination at sites that is expected to decay naturally or is contained within engineered structures. Such activities may be required for decades. Although it was not possible to quantify the duration of surveillance and monitoring, it is likely that it would be longer for scenarios that emphasized containment over removal strategies (i.e., Iron Fence and Industrial) than for the Green Fields scenarios.

6.1.4.2 END STATE CONDITIONS

Table 6.4 illustrates the differences in end-state conditions among the Base Case and each alternative land-use scenario. Using the land-use standards discussed above, the acreage of the five highest-cost sites has been depicted according to the most stringent standard met by the assumed end-state condition, yielding a measure of cleanup level and referred to as maximum allowable use.

As noted earlier, the majority of the land area at the five highest-cost sites (approximately 400,000 hectares [one million acres]) is relatively uncontaminated and currently meets the requirements for Open Space, Residential or Agricultural land-use categories. Of these, the smaller number of acres meeting the Agricultural land-use standard is due to the large number of acres for which use of ground water is prohibited (in this analysis, ground water use is required to meet the Agricultural land use standard but not the Residential land-use standard). In addition, a relatively limited number of acres meet the standards for Storage/Disposal or Industrial uses across all cases. For the currently contaminated land areas, most of the variation in land use assumptions involves shifting from an emphasis on open space in the Iron Fence scenario to residential in the Modified Green Fields. Recreational use, although a small percentage of overall use, is most frequent in the Recreational and Modified Green Fields scenarios. When site-specific constraints are lifted (i.e., in the Maximum Green Fields scenario), all land areas except Storage/Disposal Areas are assumed to be remediated to meet a Residential or Agricultural standard.

Table 6.4. Acreages of Maximum Allowable Use*

Land-Use Standards	Iron Fence	Industrial	Base Case	Recreational	Modified Green Fields	Maximum Feasible Green Fields
Agricultural	132,500	132,500	132,500	132,500	132,500	133,000
Residential	653,000	844,000	861,000	844,000	863,000	1,022,500
Recreational	17,500	19,500	3,000	67,500	153,000	0
Open Space	341,000	147,500	147,500	103,500	0	0
Industrial	10,000	14,000	14,000	10,000	9,500	5,000
Disposal/ Storage	13,500	10,000	9,500	10,000	9,500	7,000
Total	1,167,500	1,167,500	1,167,500	1,167,500	1,167,500	1,167,500

* Acre numbers have been rounded for presentation

The Maximum Feasible Green Fields scenario yields an additional 65,500 hectares (162,000 acres) of Residential and Agricultural use over that achieved in the Base Case, at an increased cost of approximately $124 billion.

6.1.5 Implications of the Results

The land-use analysis demonstrates that when site-specific constraints are considered, land-use options are limited, and thus land-use decisions are likely to have only a small effect on environmental restoration costs. In the absence of such constraints, however, a greater range of land-use options is available, and therefore land-use decisions may have a greater effect on costs. This result is vividly illustrated by comparing the Maximum Feasible Green Fields and Modified Green Fields scenarios. Both assume the same aggressive clean up strategies but yet yield dramatically different results. The reason is that when site-specific constraints other than technology limits are lifted, cost estimates increase by $124 billion. This additional cost highlights the critical importance of site-specific constraints in land-use planning.

Many of the site-specific constraints examined in this analysis are manifestations of federal and local policies or priorities. For example, legal commitments and local laws limit future-use options for approximately 295,000 hectares (730,000 acres) (63 percent) of the uncontaminated land at the five highest-cost sites. In addition, the presence of endangered species and ecologically unique habitats may limit future use for approximately 57,000 hectares (140,000 acres) (12 percent) of uncontaminated land and some contaminated land at these sites. It will be necessary to consider these constraints, along with stakeholder and regulator preferences, to make ultimate decisions regarding future use. Near-term resolution of these issues is important, because the decisionmaking processes that govern environmental restoration activities will continue in the absence of coherent integrated site planning. Land-use options may become limited after deployment of certain remedial strategies, or remedies designed to meet Residential standards may be applied inappropriately, resulting in higher than necessary costs.

The siting of Disposal/Storage Areas and continuing Department missions have implications beyond the acres directly around these structures. The implications of these future missions on land-use alternatives underscores the importance clarifying overall goals and developing an integrated, complex-wide, multimission facilities plan. In fact, the site missions considered in this analysis did not include long-term storage of plutonium and other nuclear materials at any of these large sites. Such storage could preclude releasing any land because of security and public safety concerns. Other missions will require safety analyses to determine their specific buffer requirements.

Technology challenges relating to ground water and surface water will continue to limit land use alternatives in the near term. Information relating to technology limits and costs of aggressive remediation strategies should be integral to all decisionmaking activities regarding land use and remedial strategies.

EFFECTS OF LAND-USE DECISIONS ON RISK

Future land-use decisions will have implications beyond the cost and duration of the Environmental Management program. Future land-use decisions can also influence the risks incurred by members of the public, workers involved in remediation, site personnel (not involved in remediation), and the environment. Because land-use decisions affect the remedial strategy and, hence, the remedial technologies selected to accomplish remediation, the choice of land use will affect the type of work performed by remedial workers, the volume of waste requiring subsequent management, and the types of accidents that could injure workers, expose them to radioactive or hazardous materials, or release such materials into the environment. All of these factors influence the risks to the public, remedial workers, and the environment.

A comprehensive evaluation of risks associated with the five land-use scenarios discussed above was beyond the scope of this analysis. However, to provide some indication of these effects, several sites evaluated how risks to human health and the environment might change with land-use goals. The sites used their own methods to assess changes in risk for selected projects. An example of these analyses is presented in the box on the following page. This evaluation is not based on an engineering study, but is a qualitative examination of potential risk consequences.

EFFECT OF LAND USE ON RISK — AN EXAMPLE FROM THE OAK RIDGE RESERVATION

The Oak Ridge Reservation evaluated the risk impacts of land-use decisions using five environmental restoration projects for which it was feasible to achieve alternative future uses ranging from Iron Fence to Green Fields. This evaluation assumed that protection of public health and onsite personnel is maintained during the activities required to achieve each of the alternative land-use scenarios, and the only potential risk implications evaluated that could be significant would be those to the involved remedial worker. Risks to waste management workers from waste generated during remediation were not evaluated.

The evaluation indicated that moving from a highly restrictive future land-use scenario (Iron Fence) to an unrestrictive future land-use scenario (Green Fields) would significantly increase risks to remedial workers. This potential increase in risk is primarily due to the greater number of worker-hours required to reach a less restrictive land use.

Typically, the longer the duration of the remediation, construction, or operation and maintenance activities, the greater the chance of injury from physical hazards (e.g., construction accidents) and the greater the exposure to radiological and chemical hazards. General construction accidents also are more likely as strategies move toward more removal activities because some tasks such as earth moving or demolition activities have greater inherent physical risks based upon the nature of the work and the equipment involved.

6.2 PROGRAM AND PROJECT SCHEDULING

Many observers have speculated that the pacing of the Environmental Management program has a significant impact on life-cycle cost. The 1995 Baseline Report confirmed the premise that life-cycle costs will increase if the program is extended and decrease if direct mission activities are completed more rapidly. Given the scale of the projects undertaken in the Environmental Management program, their cost, and the long-term commitment required, the relationship between cost and schedule is important. A clear understanding of how scheduling may influence cost will provide the basis for effective long-term planning and greater integration of the various components of the program. This section provides an analysis of the likely impact of changes in the schedule of direct mission activities on the life-cycle cost of the Environmental Management program in a series of alternative scheduling cases.

The following discussion on program and project scheduling is divided into six sections: General Assumptions; Description of the Alternative Cases; Analytical Approach; Results; Overall Implications of the Analysis; and Limitations of the Analysis. As with the other alternative scenarios, this analysis focuses on the five highest-cost sites in the Environmental Management program: Hanford Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, Rocky Flats Environmental Technology Site, and Savannah River Site.

SIGNIFICANT FINDINGS OF THE PROGRAM AND PROJECT SCHEDULING ANALYSIS

Key assumptions in the area of program and project scheduling were modified to develop three scenarios. These scenarios examined the life-cycle cost effects of reducing program funding, delaying high-level waste and spent nuclear fuel disposal, and accelerating facility stabilization and deactivation activities. Significant findings are:

- A $49 billion increase in life-cycle cost for the *Funding Reduction Scenario* is largely due to increased pre-treatment storage for high-level waste, increased surveillance and maintenance for plutonium-holding buildings and chemical separations facilities, and support costs. Support costs account for approximately forty-five percent of the life-cycle cost increase. Due to the fixed nature of support costs, as Environmental Management funding is reduced, there are fewer resources available to address direct mission activities. In the Funding Reduction scenario, direct mission activities are delayed, thereby postponing program completion and increasing support costs.

- Vitrified high-level waste and spent nuclear fuel will be stored for an additional 30 years in the *Delayed Waste Disposal Scenario* until shipments to a national geologic repository begin. Additional storage costs will increase life-cycle cost by less than one percent.

- The *Accelerating Stabilization and Deactivation Scenario* reduces the amount of annual surveillance and maintenance required to keep facilities in a safe, secure, and stable condition until final disposition is determined. Accelerating these activities reduces life-cycle cost by less than one percent.

6.2.1 General Assumptions for the Scheduling Analysis

The alternative schedules in this section are based on changes to the Base Case assumptions. The primary assumption driving schedules in the Base Case is that funding is available to fulfill negotiated compliance agreements and to meet legal requirements. The scheduling analysis does not assume that funding will be available to meet all of these requirements. End states, however, are assumed to be the same as in the Base Case. The assumptions varied in this analysis include:

- the level of funding available;
- commencement of shipments of Department of Energy high-level waste and spent nuclear fuel to a geologic depository; and
- the priority of programs and projects to be completed.

While continuing to address urgent risks and minimize costs, this analysis varies these assumptions in a series of scheduling scenarios. Each scenario changes one or more of the assumptions and demonstrates the likely impact on life-cycle cost. *(Note: all scenarios were developed independent of compliance agreements and potential fines and penalties.)*

6.2.2 Alternative Scheduling Scenarios

The Department developed three alternative scheduling scenarios for the analysis.

- **Funding Reduction** — The current Base Case projects annual funding requirements of $7.5 billion in FY 2000. This assumption complies with the FY 1995 National Defense Authorization Act mandate that requires the Department to provide cost estimates associated with complying with existing compliance agreements regardless of budget targets. Because this Base Case estimate clearly exceeds expected funding availability, it is prudent to analyze the long-term impacts of reduced funding using a scenario that constrains the overall program spending. This is exactly what is analyzed through the funding reduction case that constrains the Environmental Management program's annual budget to $4.9 billion ($5.5 billion in current dollars).
- **Accelerating Stabilization and Deactivation** — The Environmental Management program performs surveillance and maintenance on all of its facilities to maintain them in a safe, secure condition until final disposition has been achieved. Stabilization and deactivation of facilities can help to lower these non-discretionary costs through the removal of fissile and other dangerous materials. However, because of the additional cost required to perform stabilization or deactivation, sites are often forced to limit the pace at which these activities are performed and incur high-cost surveillance and maintenance activities. This case examines how life-cycle cost is affected if stabilization and deactivation of facilities was accelerated to reduce the amount of costly surveillance and maintenance required.
- **Delaying Waste Disposal** — Base Case costs are based on the availability, beginning in 2016, of a geologic repository for the disposal of Department of Energy high-level waste and spent nuclear fuel. This scenario analyzes the impact of a 30-year delay in waste shipments on the life-cycle cost of the Environmental Management program.

Projects were rescheduled and life-cycle costs were recalculated for each alternative scenario using a general analytical approach.

6.2.3 Analytical Approach

The program and project scheduling analysis relies upon data collected in the Base Case. Additional information was gathered from the sites to assist in the analysis.

Three scheduling variables, duration scope growth, physical scope growth, and support costs, were identified as posing a probable impact on life-cycle cost. The Department evaluated the impact of these variables on projects accounting for approximately 80 percent of the costs at each of the five highest-cost sites. This provided a manageable and representative sample of the activities in the Environmental Management program.

6.2.3.1 DURATION SCOPE GROWTH

Scope growth refers to the increase or decrease in the cost of a project due to a delay or acceleration in the current Base Case schedule. Duration scope growth refers to increases in cost due to additional years of nondiscretionary activities performed at the site, including surveillance, monitoring, and maintaining contaminated areas and facilities, and the storage of waste awaiting treatment or disposal. These activities must be performed each year that a project is in operation or awaiting clean up to keep a waste, an area, or a facility in a safe, secure state until a final action is implemented.

6.2.3.2 PHYSICAL SCOPE GROWTH

Typically, contaminated facilities deteriorate and contaminated land areas increase over time. Aging production and processing buildings, decaying storage facilities, and migrating contaminants in the soil contribute to the change in physical scope of the project. These changes are referred to as physical scope growth. Where delaying a project results in physical scope growth, project costs may increase. Conversely, accelerating a project that has physical scope growth potential may decrease project cost.

Projects were assessed by the sites according to how the scope of a project would change over time if that project were delayed, and conversely, how the scope might change if the project were accelerated. For environmental restoration and nuclear materials and facility stabilization activities, estimates of physical scope growth were provided for 5, 10, 20, and 50 year delays.

The Department used a different approach to determine physical scope growth for waste management activities. Using models, the Department estimated the change in costs under different treatment scenarios and then compared these costs to the Base Case. Each treatment scenario required a different strategy for the construction of storage and treatment facilities to house and treat waste. (See Appendix C for further details on this methodology.)

6.2.3.3 SUPPORT COSTS

As discussed in previous chapters, a portion of the Environmental Management program costs are not incurred for specific projects. Instead, they are incurred for activities that are not directly related to direct mission activities, but are essential to the safe and effective management of these activities. Accelerating the completion of the Environmental Management program activities should reduce the number of years for which these support costs are incurred and therefore reduce life-cycle costs. Conversely, delaying the completion of the Environmental Management program should increase the number of years for which support costs are paid and increase life-cycle cost.

For the scheduling analysis, models were used to estimate annual support costs. Based on the statistical relationship between support and direct mission costs in the Base Case at each site, new support costs were estimated for each alternative scenario.

6.2.4 Scheduling Results

Section 6.2.2 briefly described the three scheduling scenarios. The results of the analysis are presented below.

6.2.4.1 FUNDING REDUCTION

For this scenario, a reduced annual funding level of $4.9 billion (in 1996 constant dollars) was assumed, consistent with the Administration's outyear target of $5.5 billion (in current dollars) for FY 2000.

To meet the funding constraint, each site's funding limit was reduced proportionally in FY 1998, FY 1999, and FY 2000 and then held constant thereafter at the FY 2000 level. For the five large sites, this amounts to $3.5 billion in 2000. All activities and end states in this case were consistent with those assumed in the Base Case, since this

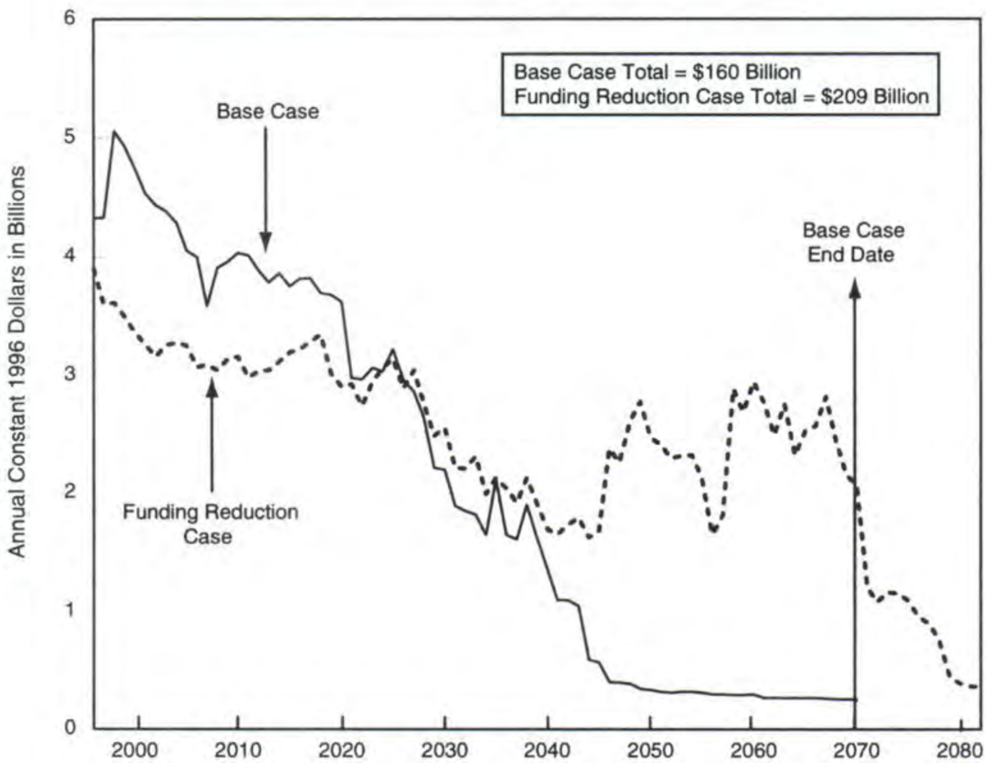


Figure 6.3. Annual Comparison of the Funding Reduction Case and the Base Case

analysis focuses on rescheduling, and not on re-scoping. Therefore, compliance agreements are met in substance, but not according to schedule.

Projects were rescheduled based on comparisons of the likely impact of scope growth on life-cycle cost. To stay beneath the funding level, projects assumed to have little or no scope growth were delayed, and projects assumed to have significant scope growth were accomplished as soon as possible. Because of technical constraints, relationships between large, interconnected projects, including those where changes in scope could cascade from one project to another, were maintained.

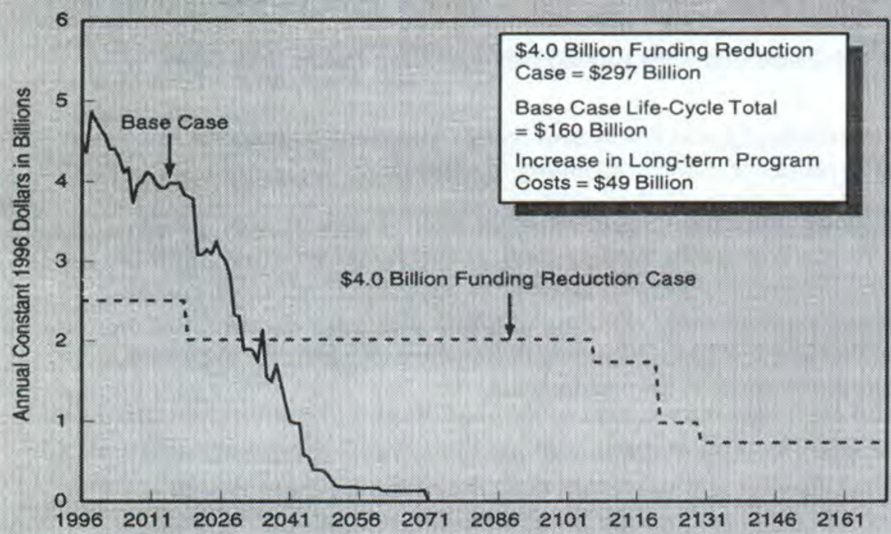
A reduction in near-term spending results in a 31 percent increase in life-cycle costs. Delayed treatment and disposal of waste results in increased storage costs, ground-water and surface-water contamination migrates as remediation is delayed, facilities decay, requiring maintenance and repairs, and sites have to pay additional support costs as the program end date stretches past the Base Case. As discussed in earlier chapters, support costs are relatively fixed. As funding levels are reduced, fewer dollars are available to conduct direct mission activities. Figure 6.3 provides an annual cost profile comparison between the Funding Reduction Case and the Base Case.

A $4.0 BILLION FUNDING REDUCTION CASE

The $4.9 billion Funding Reduction case described in this chapter estimates the expected life-cycle cost for the five largest sites under a currently targeted funding scenario. In reality, however, many different funding levels could be set, each of which would have a different impact on the total life-cycle cost of the Program. This sidebar describes additional analyses performed to better estimate the relationship between different funding levels and total life-cycle cost of the Environmental Management program.

Using simplified modeling techniques, the likely change in total life-cycle cost was estimated if the funding level were reduced to $4 billion annually. As in the $4.9 billion case, certain assumptions were made about the cost drivers in the program: support costs were assumed to be relatively fixed, and direct mission costs were expected to increase over time as a result of scope growth. Because of the fixed nature of support costs and the impact of scope growth as projects are delayed, an annual budget of $4 billion not only extends the program into the twenty-second century, but also significantly increases life-cycle cost. Under the $4 billion case, the total life-cycle cost for the five sites is $297 billion, an increase of 87 percent above the Base Case. Direct mission activities would be completed in approximately 2172, more than 100 years after the end date of the Base Case. The increase in life-cycle cost is largely due to support costs incurred during the additional years of operation.

As the funding level is reduced, support costs become a larger proportion of the total budget. Thus, direct mission activities will take significantly longer to complete, incurring additional support costs, nondiscretionary surveillance and maintenance costs, and a significant amount of scope growth as facilities deteriorate and contaminants spread. In many ways, this is a conservative estimate. In addition to the support costs required to maintain sites in a safe working state, other nondiscretionary costs are also incurred irrespective of the level of clean-up activity. If funding falls to a level where resources are only available to pay for support costs and nondiscretionary requirements, direct mission activities cannot be performed.



6.2.4.2 ACCELERATING STABILIZATION AND DEACTIVATION

Surveillance and maintenance activities ensure that adequate material and facility safety and security requirements are met. These costs represent a "mortgage" associated with managing potential hazards resulting from the presence of radioactive and hazardous materials in the facility. Stabilization and deactivation activities are conducted to mitigate these hazards. Once these hazards have been mitigated, surveillance and maintenance costs for maintaining the facilities are reduced significantly.

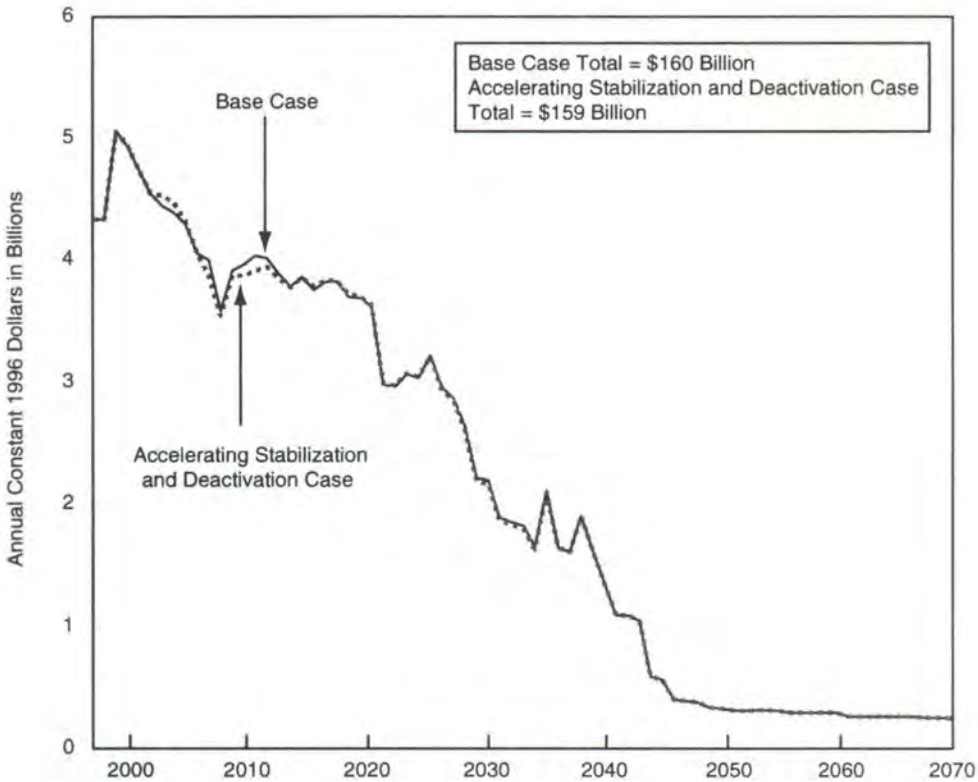


Figure 6.4. Annual Comparison of the Accelerating Stabilization and Deactivation Case and the Base Case

Further acceleration of stabilization and deactivation has minimal life-cycle cost impact. By completing projects earlier in the life cycle, total costs decrease because fewer surveillance and maintenance activities are required.

This scenario was analyzed to determine if total life-cycle cost reductions could be achieved by accelerating stabilization and deactivation activities. For the analysis, stabilization and deactivation activities in the Base Case were accelerated to begin in the near-term, ultimately reducing costly surveillance and maintenance activities by one or two years. The results of the analysis demonstrate that approximately $500 million in life-cycle cost can be saved by accelerating stabilization and deactivation activities. The results imply that most stabilization and deactivation activities have already been scheduled prudently in the Base Case to realize cost savings in the out-year costs for facilities. Figure 6.4 provides an annual cost profile comparison between the Accelerating Stabilization and Deactivation Case and the Base Case.

6.2.4.3 DELAYING WASTE DISPOSAL

The Environmental Management program currently assumes that it will permanently dispose of high-level waste and spent nuclear fuel at a national geologic repository. In the Base Case, sites assume that shipments from the Environmental Management program to a national geologic repository begin in 2016. For this analysis, the Department assumes that sites send waste to a geologic repository beginning in the year 2046, a 30-year delay.

Only three of the five sites currently have high-level waste and spent nuclear fuel assumed to be disposed of at a national geologic repository: the Hanford Site; the Idaho National Engineering Laboratory; and the Savannah River Site. *(Note: The Department of Energy's Office of Civilian Radioactive Waste Management manages and funds the development of a national geologic repository. The costs incurred by a 30-year delay in this analysis represent only those direct costs to the Environmental Management program and reflect Department of Energy defense and nondefense waste only. This analysis does not account for any costs incurred by the Civilian Radioactive Waste Management program. Furthermore, the results are not intended to be extrapolated or applied to the commercial nuclear industry or to costs associated with the disposal of commercial nuclear waste.)*

For this scenario, high-level waste and spent fuel are still being treated to the same end state assumed in the Base Case. High-level waste vitrification will continue as scheduled in the Base Case. However, the vitrified glass logs will be stored for an extended period until the repository can accept them. Increases in life-cycle cost are due to additional years of waste storage, and in some cases, the construction of new storage facilities.

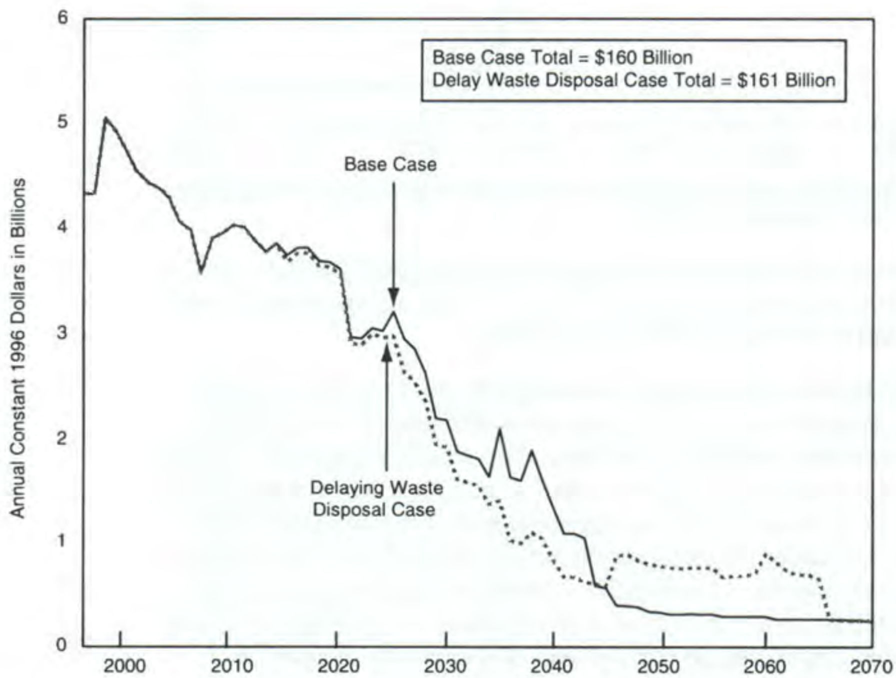


Figure 6.5. Annual Comparison of the Delaying Waste Disposal Case and the Base Case

The results of this case reveal that delaying waste disposal shipments to a national geologic repository has an impact of less than $1 billion (about a one percent increase) on the life-cycle cost of the Environmental Management program. Figure 6.5 provides an annual cost profile comparison between the Delay Waste Disposal Case and the Base Case.

Delaying shipments to a national geologic repository increases life-cycle cost by approximately one percent. Delaying the disposal of high-level waste and spent nuclear fuel increases life-cycle cost because storage facilities must accommodate the waste for a longer period of time. In some cases, if onsite storage is inadequate, sites must construct new storage facilities.

6.2.5 Overall Implications of Program and Project Scheduling Analysis

The scheduling analysis indicates that there will be a significant increase in total life-cycle cost of the Environmental Management program if annual funding levels are reduced to $4.9 billion. The increase is due not only to support costs that must be paid as long as there are mission activities at the site but also to scope growth of direct mission activities. Stabilization and deactivation activities would have to be postponed and additional years of costly surveillance and maintenance would be realized. In addition, treatment of high-level waste would have to be performed at a much slower rate, thereby increasing pre-treatment storage costs (i.e., single-shell tanks that currently are storing high-level waste would have to be replaced). Any near-term savings from a reduced Environmental Management program budget are offset by large increases in life-cycle cost.

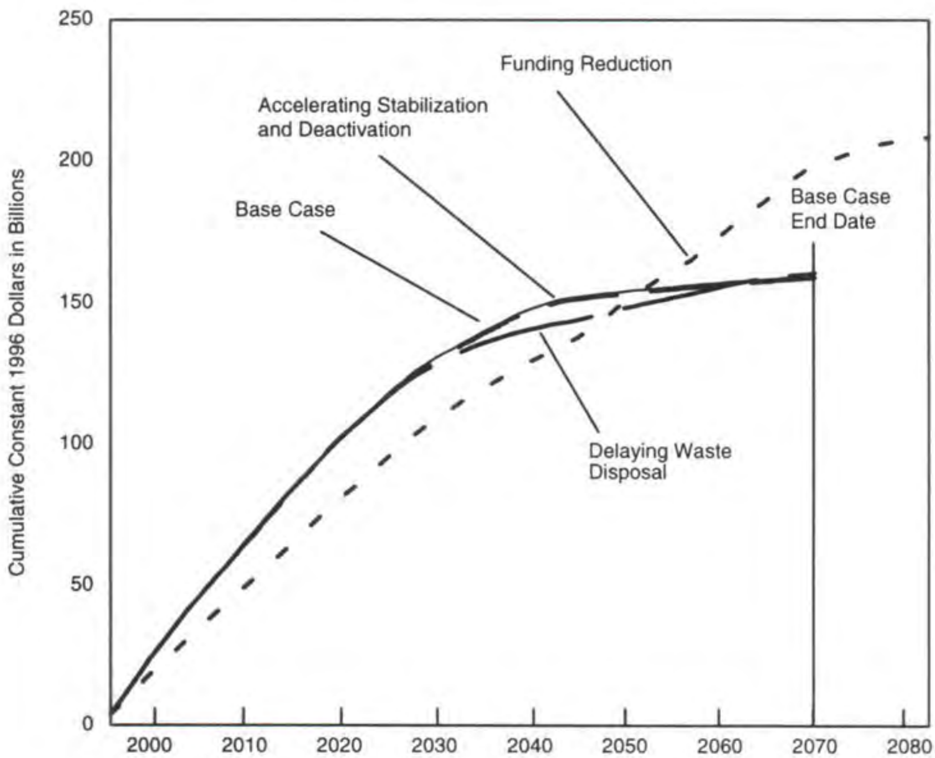


Figure 6.6. Comparison of Alternative Scheduling Scenarios (Cumulative Costs)

The results demonstrate that the Accelerating Stabilization and Deactivation and Delaying Waste Disposal cases have a minimal impact on the total life-cycle cost of the program. By accelerating stabilization and deactivation activities, more funds are spent earlier in the life-cycle, but less is spent in later years, resulting in only $300 million savings in direct mission cost. Delaying disposal activities increases direct mission life-cycle cost by only $600 million because of additional direct storage costs. Because neither case extends the life-cycle of the program, support costs do not vary significantly from the Base Case. Both cases support evidence that these activities are prudently scheduled in the Base Case. Figures 6.6 and 6.7 provide life-cycle cost comparisons of the Base Case and the three alternative scheduling scenarios.

Figure 6.7 provides a summary comparison of the scheduling cases, broken-out by direct mission and support costs. Support costs increase approximately $20 billion in the Funding Reduction Case, a 15 percent increase above the Base Case.

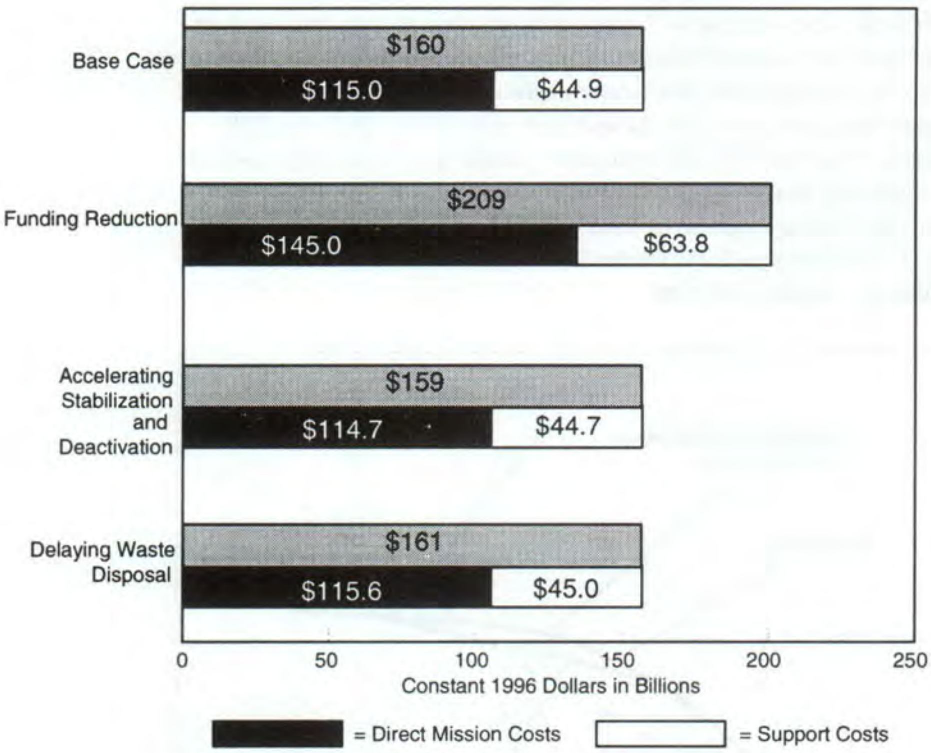


Figure 6.7. Comparison of Alternative Scheduling Scenarios (Direct Mission and Support Cost Totals)

EFFECTS OF PROJECT DELAYS ON RISK

Scope growth associated with project delays may have implications beyond the cost of the Environmental Management program. Scope growth also has the potential to affect risks to public health, workers, onsite personnel, and the environment. Additional years of nondiscretionary activities such as surveillance and maintenance or waste storage will increase the period of time that workers are exposed to the types of accidents that could injure them, expose them to radioactive or hazardous materials, or release such materials into the environment. Physical deterioration of facilities or storage units, or the spread of contamination in the environment, could increase both the likelihood of accidents and the amount and type of work required to complete direct mission activities.

A comprehensive evaluation of risks associated with project delays is beyond the scope of this analysis. However, to provide some indication of how risks to human health and the environment might change with project delays, several sites evaluated how risks to human health and the environment might change if selected projects were delayed for 5, 10, 20, or 50 years. An example of these analyses is presented in the box below. This evaluation is not based on an engineering study, but is a qualitative examination of potential risk consequences.

EFFECT OF PROJECT DELAY ON RISK — AN EXAMPLE FROM THE OAK RIDGE RESERVATION

The Oak Ridge Reservation considered the possible risk implications of delaying the decontamination and decommissioning of the K-25 Gaseous Diffusion Plant and associated process buildings. The process buildings are contaminated by uranium hexafluoride, technetium-99, asbestos, PCB's, inorganic acids, organic acids, metal fluorides, hexafluorides, oxyfluorides, and other chemicals. A qualitative evaluation of the risks associated with the workers, onsite personnel, offsite receptors, and ecological receptors was performed.*

Because of the location of the buildings, the Department predicts that delays of up to 50 years will not affect risks to onsite personnel, the public, or the environment. However, the current conditions of these facilities pose risks to the workers performing general surveillance and maintenance activities in the buildings and risks to the workers during the decommissioning activities. The results indicate that worker risk is mainly dominated by physical hazards (e.g., the roofs in some buildings are currently in need of repair).

Based on the conditions of the buildings, even a five-year delay in starting decontamination could increase the risk to workers. Risk would likely increase as a result of continuing building decay, which may cause washout events (due to damage in the steam lines or water lines), air exposures (due to breakdown in the air handling system), and roof collapse. A roof failure has already occurred at a facility awaiting decommissioning at K-25 and it is expected that a failure could occur in other buildings. A 50-year delay could result in an even greater increase in risk to workers both before and during the decommissioning is initiated since the gaseous diffusion plant and associated facilities would show even further signs of decay.

* This analysis assumed that techniques would remain the same, and the decontamination and decomissioning strategy in the Base Case would be the same strategy employed for each of the delay cases.

6.2.6 Limitations of the Analysis

This scheduling analysis is intended to be used for policy analysis purposes. Thus, it is meant to show at a policy level how and why aggregate life-cycle costs change as Base Case scheduling assumptions change. It is not meant to show how these changes affect costs at individual sites or to help sites schedule projects.

First, not all projects were rescheduled. Only those projects accounting for 80 percent of the costs in each program at each site were examined. By focusing on only a portion of the activities at a given site, the analysis potentially understates both savings from an acceleration case and cost increases from the funding reduction and delay disposal cases.

Second, support costs were modeled at each site to reflect changes in the annual cost due to rescheduling. Support costs were estimated using a statistical analysis of the relationship between Base Case annual direct and support costs.

Third, the scope growth factors provided by the sites are subject to uncertainty. Specific activities were rescheduled based on theoretical scope changes. How the costs for activities change over time is difficult to estimate, and an analysis based on those estimated scope changes would have the same level of uncertainty.

6.3 A "MINIMAL ACTION" SCENARIO

The current budget deficit and the growing need to reassess national priorities have led to a controversial yet pragmatic question: What is the minimum funding required for maintaining the Environmental Management program without increasing risk to human health or the environment, but without the constraints of current environmental regulations and compliance agreements? The interest in this "minimal action" scenario is driven by a number of diverse perspectives on the program. Some observers, especially supporters of the program, have speculated that the cost of a minimal action scenario is not significantly different from current program expenditures (especially in the short term). This view is based on the fact that a large amount of funding currently is required simply for the program to serve as the landlord at Environmental Management sites and to monitor the storage of highly radioactive waste and special nuclear materials.

Other observers, especially critics of the current regulatory system, believe that current requirements can be relaxed, generating a substantial cost savings without negative human health and environmental consequences. Finally, policymakers express interest in this minimal action case because it provides a lower boundary for the range of alternatives available to the program. With this information in hand, policymakers and stakeholders can better understand what tasks are truly necessary for short- and long-term risk and cost reduction.

The minimal action scenario differs substantially from the other alternate program cases in this chapter: it requires a complete re-examination of the mission of every activity in the program. An initial analysis of a minimal action case was conducted for the 1995 Baseline Report (see box). The 1996 Baseline Report expands on this analysis by: (1) focusing in more detail on the life-cycle cost implications of a minimal action scenario at the five highest-cost sites, (2) examining in more depth the site end-states and long-term risks associated with the case, and (3) making a more explicit comparison between the Base Case and the minimal action case.

Like many of the other analyses in this report, this case is a policy-level examination of the consequences of modifying key program assumptions. However, this analysis provides a broad perspective on the implications of a minimal action analysis. The information in this section is *not* based on a detailed engineering analysis. Each site developed its own methods of addressing this scenario; in many cases this involved a complete rescoping of projects and activities. The next steps for a more complete minimal action scenario is to extend the analysis to all Environmental Management sites and base the results on a more detailed engineering evaluation of the minimal action alternatives.

This section begins with a presentation on how the minimal action case was developed, highlighting the guiding principles and strategies used by the sites to develop their minimal action approach. This is followed by an overview of the assumptions used by the sites in developing their minimal action scenario. The results of the analysis are presented in three areas: 1) Minimal action 75-year cost estimate by site, functional area, and over time; 2) End states at each site (final physical condition), focusing on post-2070 land use, onsite waste inventories, and surveillance and monitoring activities; and, 3) Onsite and offsite risks (both human and environmental) during and beyond the minimal action case period. The section concludes with a discussion of the overall implications and limitations of the minimal action analysis.

SIGNIFICANT FINDINGS OF THE MINIMAL ACTION ANALYSIS

This analysis examines the consequences of re-structuring the Environmental Management Program to focus on two objectives: preventing human health and environmental risks from increasing and otherwise minimizing costs for 75 years. Meeting compliance agreements and regulatory requirements was not necessary as long as activities were consistent with these objectives.

- Major changes in the program would occur under this scenario. Remedial actions would be limited to problems with urgent risk implications, and most facility decommissioning would cease. Waste treatment would be minimized, with onsite storage or disposal replacing offsite shipments for disposal. Waste storage facilities would not be required to meet national waste regulations. All high-level waste, spent nuclear fuel, and special nuclear materials would remain onsite.

- Estimated costs *during* the 75-year period would decrease by more than 40 percent, with major declines in environmental restoration costs (70 percent lower) and waste management costs (40 percent lower). On the other hand, estimated annual costs for long-term surveillance and monitoring activities *after* the 75-year period would be nearly four times higher than in the Base Case.

- A minimal action strategy would leave waste inventories onsite and many buildings standing. These would require significant surveillance and monitoring efforts to continue far into the future. As waste management facilities and buildings deteriorate over time, risks to workers will increase, and additional costs for upgrades or repairs would be incurred. There also would be a greater chance that contamination could spread offsite to threaten public health and the environment.

1995 MINIMAL ACTION CASE

The 1995 Baseline Environmental Management Report Minimal Action case projected program costs through 2070 with the premise that available annual funding would be dramatically reduced beyond the year 2000.

Assumptions
- Treatment and disposal of all high-level waste and spent nuclear fuel
- Stabilization and surveillance and monitoring of surplus facilities
- "Safe" storage of all low-level, low-level mixed, and transuranic waste

Excluded from Scope of Analysis
- Environmental Restoration
- Deactivation and decontamination activities
- Treatment and disposal activities for low-level, low-level mixed, and transuranic waste
- Long-term risk information

Findings
- Twenty-seven percent reduction in 75-year cost estimates from 1995 Base Case

6.3.1 How the Minimal Action Case Was Developed and Analyzed

The objectives of this case are to develop an alternate scenario that does *not* increase life-cycle risks from current levels to humans and the environment while still reducing costs through 2070. The minimal action case examines 75-year costs and activities at the five largest sites within the Environmental Management program (Hanford Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, Rocky Flats Environmental Technology Site, and Savannah River Site). The sites used the following broad guiding principles to create their minimal action scenario:

- All activities should reflect the lowest possible cost options.
- Activities must *not* increase the public health, worker, or ecological risks associated with the Base Case through 2070.
- Activities must be consistent with safety goals but do not need to address compliance agreements or regulatory requirements.

These principles differ from the Base Case in that the Base Case is a compliance case, whereby costs, end states, and risks reflect

MINIMAL ACTION SCENARIO PERIOD OF ANALYSIS

Unlike the Base Case, Environmental Management activities in this minimal action scenario are not completed by the year 2070. For purposes of analysis, however, the period of 1996 through 2070 was chosen to provide a snapshot of the minimal action case. Use of this time period provided an easy comparison of activities, cost estimates, and end states between the Base Case and the minimal action case. Throughout this section, the 75-year period of analysis refers specifically to the time period of 1996 through 2070 and should not be interpreted as the complete life-cycle period of the minimal action case.

activities that address all current environmental regulations and compliance agreements.

In developing their minimal action scenario, the sites used the following strategies to develop a case that stabilizes and safely contains waste and surplus materials onsite *and* minimizes the costs of safeguarding these materials throughout the 75-year minimal action case time period (1996 through 2070):

- Urgent risk reduction - Eliminate immediate human health and environmental risks.
- Mortgage reduction - Minimize costs during the minimal action analysis period.
- Minimum action - Eliminate projects that do not pose risks during the minimal action analysis period.
- Regulatory relief - Activities do not need to meet compliance agreements or environmental regulations unless they affect urgent risks.
- Prudent management practices - Pursue more "complete" actions if cost-effective.
- Institutional controls - The Federal Government will maintain all control of federal lands.

Each of the five sites used the 1996 Base Case data as a foundation for developing site-specific assumptions and 75-year costs. From the Base Case, sites modified their project and activity schedules and scopes of work based on minimal action assumptions. After developing a set of minimal action projects and activities, each site evaluated cost differences, site "end states," and pre-2070/post-2070 onsite and offsite risks.

6.3.2 Cross-Site Assumptions

Based on the approach discussed above (address urgent risks while reducing costs and overall effort), each site developed its own site-specific minimal action scenario. In general, the sites adopted similar approaches when addressing specific activities (Table 6.5). The only exception was the treatment and stabilization of high-level waste.

For high-level waste, each site found a different minimal action approach to addressing onsite high-level waste inventories. Savannah River Site found that the best minimal action strategy is to stabilize high-level waste and store it onsite. The site recently completed construction of the Defense Waste Processing Facility (a facility used to stabilize high-level waste into glass through a process called "vitrification"). Under the Base Case, Savannah River Site plans to use the Defense Waste Processing Facility to vitrify the high-level waste and then ship the glass to an offsite geologic repository. Because the construction of this facility is already complete, the Savannah River Site plans to use the facility in the minimal action scenario, but at an accelerated rate. The Savannah River Site also will keep the vitrified high-level waste onsite, saving the expenses involved in preparing and shipping the waste to offsite disposal.

Table 6.5. Cross-Site Assumptions

Waste Type/ Program Area	Base Case Assumption	Minimal Action Case Assumption
High-Level Waste	To be disposed of in a geologic repository.	Onsite storage. Differing treatment and stabilization practices across sites.
Spent Nuclear Fuel	To be disposed of in a geologic repository.	Onsite storage in concrete or stainless steel "dry storage" casks.
Low-Level, Low-Level Mixed, and Transuranic Waste	Some treatment of low-level and low-level mixed waste; dispose of offsite. Treat transuranic waste and ship to Waste Isolation Pilot Plant.	Storage and disposal onsite with minimal treatment.
Environmental Restoration	Remediate (cleanup) all areas required by environmental regulations/compliance agreements. Buildings will be demolished.	Remediate only areas with urgent environmental or human risk implications. Buildings will be remain in place.
Nuclear Material and Facility Stabilization	Nuclear material stabilized. Deactivation activities to minimize surveillance and maintenance.	Same as Base Case.
Support	All costs to support mission activities.	Re-estimation based on minimal action activities. Landlord and support activities extended through 2070 at all sites.

The Hanford Site stores high-level waste in 149 single-shell tanks and 28 double-shell tanks. Approximately 200 million liters (53 million gallons) of high-level, low-level, and transuranic waste have been stored in these underground storage tanks since 1944. While no waste has leaked from the double-shell tanks, 67 of the older single-shell tanks have leaked approximately four million liters (1.1 million gallons) of this waste into the surrounding soil.

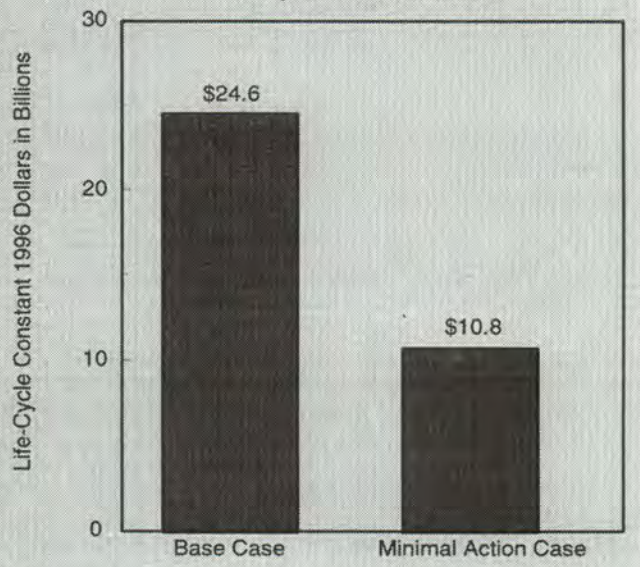
The Hanford Site found that the best minimal action approach is consolidating the high-level waste from the double-shell tanks, and leaving single-shell tank high-level waste in existing tanks. All high-level waste from the double-shell tanks will be separated from low-level liquid waste and consolidated into two tanks. The emptied double-shelled tanks will be capped. To avoid increasing risk for the 75-year period of analysis, the Hanford Site will begin replacing double-shell tanks around 2030. The high-level waste in the single-shell tanks will be stabilized and remain in the tanks. Throughout the minimal action period, the domes (roofs) of the single-shell tanks will be protected from structural collapse. The waste in the single-shell tanks will remain in these tanks indefinitely at some increased risk due to continued tank deterioration and leakage.

HANFORD SITE — EVALUATING STRATEGIES FOR HIGH-LEVEL WASTE

The Hanford Site has 149 single-shell tanks and 28 double-shell tanks. These tanks contain both solid and liquid high-level waste, primarily from spent fuel reprocessing plants. Under the Base Case, all waste will be removed from these tanks, treated so that it can be separated into two fractions (high-level waste and low-level waste), and then vitrified. The low-level waste will then be disposed of onsite and the high-level waste canisters will be stored onsite until they can be shipped to a geological repository for disposal.

In developing their minimal action case, Hanford planned to stabilize and leave single-shell tanks in place. At first, Hanford considered also leaving the double-shell tank waste in storage and replacing these tanks every 50 years. However, it was determined to be lower cost to process the double-shell tank waste into two fractions so that the low-level waste fraction could be disposed onsite and the remaining smaller high-level waste fraction could be stored in two double-shell tanks. This would require only two double-shell tanks to be replaced every 50 years versus 28 double-shell tanks, resulting in the lowest 75-year cost estimate. Continued storage of the waste in the 149 single-shell tanks would include adding structural support to prevent dome collapse. The waste in the single-shell tanks would continue to be stored through the minimal action case period at some increased risk due to continued tank deterioration and leakage. The increased risk to the public of future leakage from the stabilized single-shell tanks is reduced in the minimal action case by the continued maintenance of existing site boundaries and restricted access to the ground water under the site.

Tank Waste Remediation System
(75-year Cost Estimate)



Idaho National Engineering Laboratory stores its high-level waste in aboveground storage tanks. For high-level waste stabilization, however, Idaho found the lowest risk, least-cost option in calcining the waste at the New Waste Calcining Facility. (Calcining converts liquid high-level waste into a granular solid. This process makes the waste less corrosive and dramatically reduces volume.) Under the Base Case, Idaho plans to further stabilize the calcined high-level waste through vitrification and ship it to an offsite geologic repository. Because the high-level waste is already in a sufficiently stable form to minimize risks over the 75-year period, Idaho's minimal action approach is to store the calcined waste in onsite bins.

In comparing the Base Case and minimal action case assumptions, the scope of activities in terms of nuclear material and facility stabilization does not change. The specific goal of the nuclear material and facility stabilization program—to ready these materials and facilities for a "cheap to keep" mode—leads to relatively inexpensive long-term surveillance and monitoring. This goal is consistent with the guiding principles of the minimal action approach. Therefore, the activities involved in nuclear material and facility stabilization will continue in the minimal action case.

6.3.3 Minimal Action Case Results

The results of minimal action analysis are presented in the following four categories: 75-year cost estimates by function area and over time, end states, and risk implications. Figure 6.8 compares the 75-year cost estimate for the Base Case and minimal action case for each of the five highest-cost sites. As a result of the minimal action case analysis, the 75-year cost estimate for all five sites was reduced to approximately 56 percent of the Base Case cost estimate for the same period.

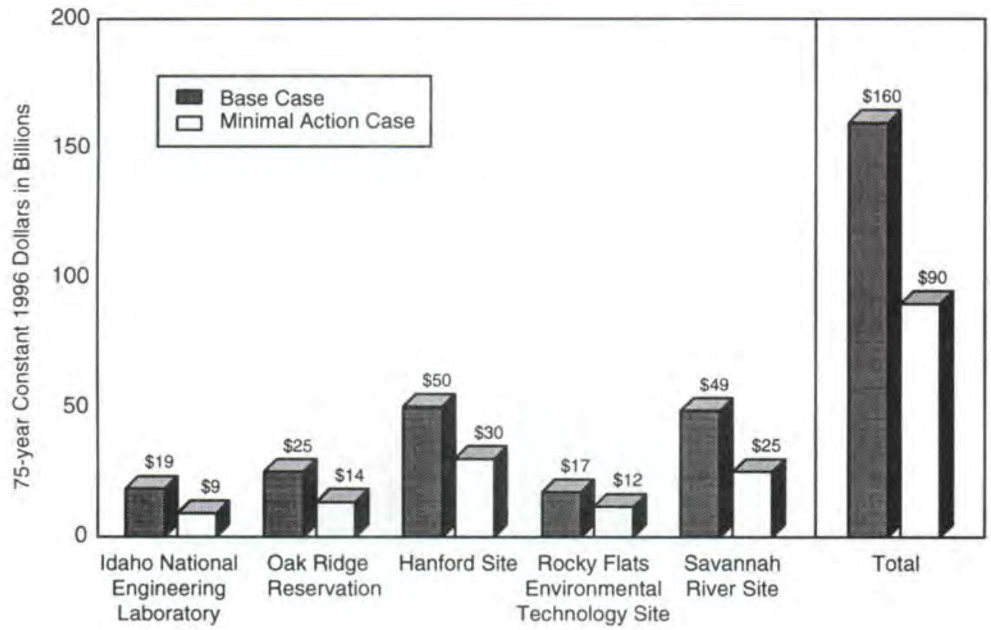


Figure 6.8. Minimal Action Results for the Five Highest-Cost Sites

6.3.3.1 75-YEAR COST ESTIMATE ACROSS FUNCTIONAL AREAS

As mentioned above, the assumptions used in the minimal action case were strong drivers of the results of this case. Specifically, the shift in assumptions between the Base Case and the minimal action case is clearly apparent when 75-year costs are compared at the functional level (Figure 6.9). The minimal action case life-cycle cost estimate represents a 44 percent reduction from the total Base Case 75-year cost estimate. The elimination of offsite shipping and disposal activities at the Idaho, Hanford, and Savannah River Sites reduced the high-level waste cost estimate by 45 percent from the Base Case, matching the overall cost estimate reduction. This decrease, however, is not as equally distributed across the remaining functional areas.

The change in strategy regarding the treatment and disposal of low-level, low-level mixed, and transuranic waste affects the 75-year cost estimate, with a 61 percent reduction from the Base Case. The treatment and storage of low-level and low-level mixed waste are controlled by numerous environmental regulations and compliance agreements. These regulations/agreements control the type of treatment, storage, and disposal method for each waste type. In the minimal action approach, however, the sites are not required to comply with these specific regulations or agreements. Hence, the sites found that they could still minimize onsite and offsite human and environmental risks for 75 years with the use of less expensive treatment activities and onsite storage and disposal facilities.

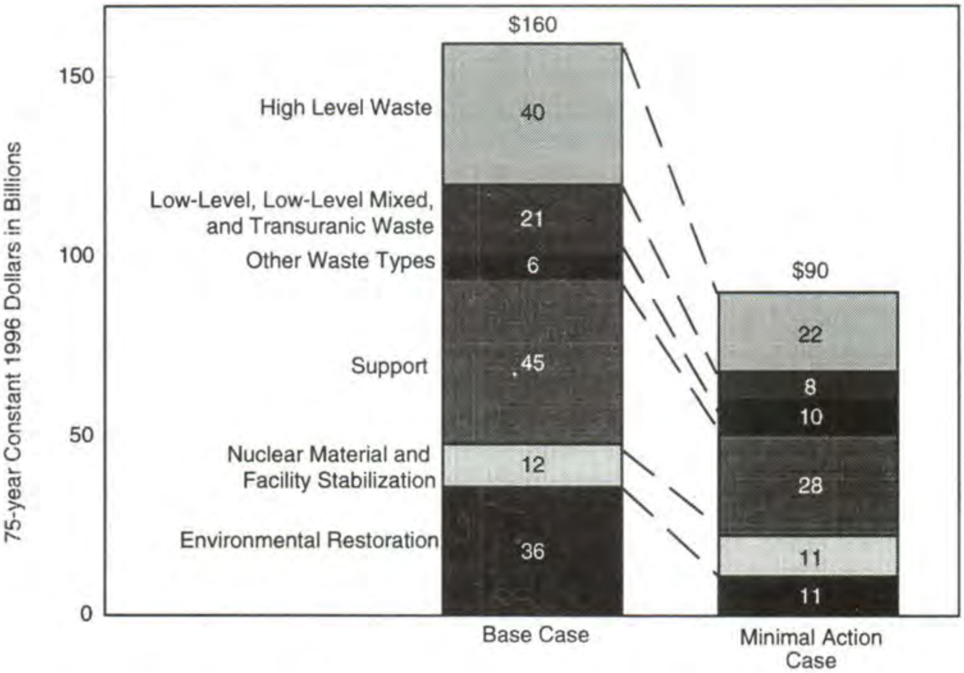


Figure 6.9. 75-Year Cost Estimate by Functional Area for Five Highest-Cost Sites

Under the Base Case, transuranic waste is destined for the Waste Isolation Pilot Plant, a geologic repository. For a site to ship to the plant, all transuranic waste must undergo extensive characterization and packaging efforts. Under the minimal action approach, each site found that it could keep 75-year risks at the same level as the Base Case and lower costs by storing the transuranic waste onsite with periodical repacking.

The greatest decrease between the two cases is represented in the 75-year cost estimate for environmental restoration activities—a 70 percent reduction in minimal action costs from the Base Case. This dramatic cost reduction clearly illustrates the impact of reduced compliance-driven remediation activities. It also highlights how most Base Case environmental remediation and decommissioning activities primarily address long-term (post-2070) contamination risks.

SAVANNAH RIVER SITE — ADDRESSING THE HIGH MORTGAGE

The nuclear material and facility stabilization activities at the Savannah River Site are focused on reducing all nuclear material hazards and preparing former production facilities for shutdown mode. Both aspects of this program highlight the guiding principles of the minimal action scenario: not increasing risk for the 75-year period above Base Case levels while minimizing effort.

NUCLEAR MATERIAL AND FACILITY STABILIZATION

75-year Cost Estimate

Base Case: $3.6 billion
Minimal Action: $3.9 billion

The Savannah River Site was established in 1950 to produce special radioactive isotopes to support national weapons programs. Upon completion of the production activities, a large inventory of nuclear material in various stages of the production cycle remained onsite. These materials include acidic solutions in stainless steel tanks, radioactive isotopes packaged in storage cans and drums, and nuclear reactor components stored in both dry and water-filled basins. To address the potential onsite and offsite risks and reduce the costs of managing these nuclear materials, the Savannah River Site will convert these materials into stable forms at their separations facilities.

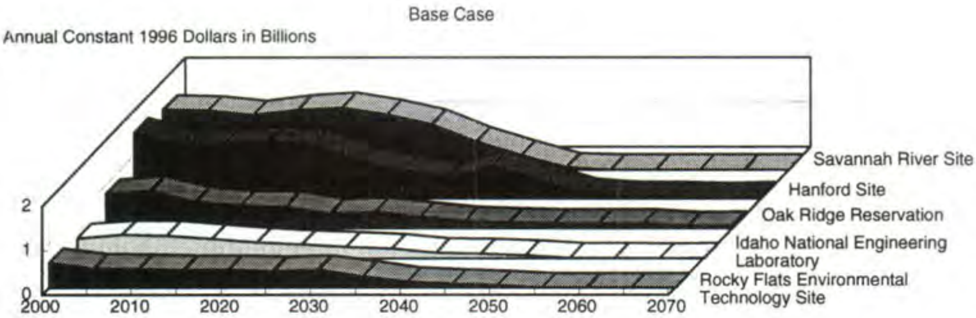
Upon completion of the removal of these nuclear materials, the site also is responsible for stabilizing and deactivating more than 1,000 buildings by coating or removing contaminated areas, removing all utility systems, and preparing these buildings and facilities for low-cost surveillance and monitoring activities. This aspect of nuclear material and facility stabilization activities reduces all life-cycle period onsite and offsite risks posed by surplus nuclear production buildings while minimizing the long-term costs of building maintenance.

The small increase in costs for nuclear material and facility stabilization activities at the Savannah River Site reflects the cost increase for long-term onsite storage of special nuclear material.

6.3.3.2 LIFE-CYCLE COST ESTIMATE OVER TIME

When presented over time, the minimal action case clearly illustrates the change in scope of activities at each site (Figure 6.10). In contrast to the Base Case, funding level estimates in the minimal action case are higher in the early years and then drop quickly, but are maintained at a fairly constant level after approximately 2030.

One of the 75-year schedule drivers is the different approach to waste management between the two cases. In the Base Case, the sites assume that high-level waste, spent nuclear fuel, and transuranic waste will be shipped to offsite disposal facilities by 2045. In the minimal action case, however, sites found that the least-cost strategy is to retain high-level waste, spent nuclear fuel, and transuranic waste in onsite storage facilities. This change in strategy refocuses cost efforts away from a short-term, high investment treatment and disposal strategy towards a strategy of long-term storage and continual surveillance and monitoring.



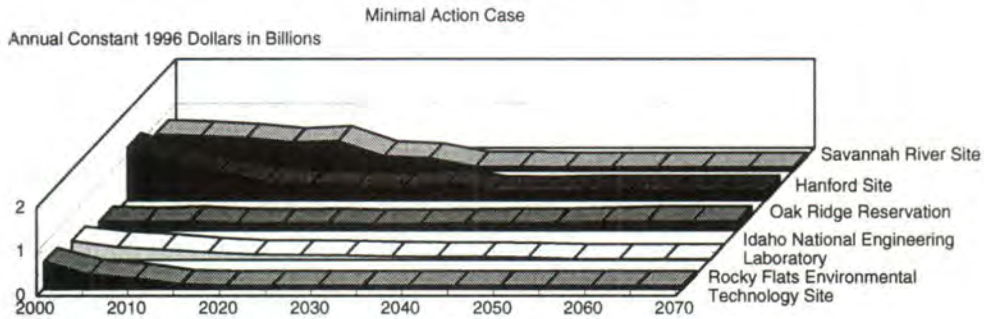


Figure 6.10. Base Case and Minimal Action Case Annual Costs

Another driver in the shift in the cost estimate over time between the two cases is the comparison of building deactivation and demolition activities. In the Base Case, most sites stabilize, decontaminate, and demolish all major buildings onsite and release a large amount of land for unrestricted use. Under the minimal action case, buildings are stabilized and left standing. Long-term surveillance and monitoring activities are required thereafter.

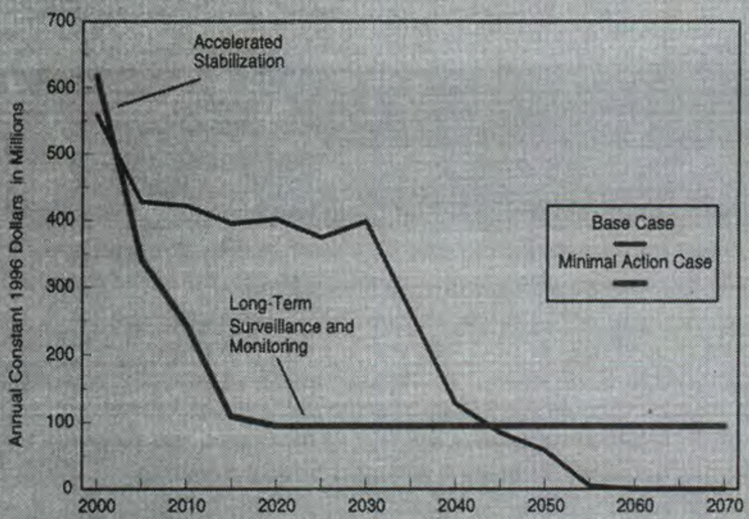
The shift in activity scope between the Base Case and the minimal action case is especially apparent in the area of support cost estimates. These cost estimates represent activities that are necessary for the continuation of each site's mission, but they are not mission-related activities. (See Chapter 3 for a more detailed description of Base Case support costs.) During the early stages of the 75-year period of analysis (1996-2025), minimal action support cost estimates range from 45 to 55 percent of Base Case cost. Between 2025 and 2050, however, the minimal action support cost estimates approach the same levels as the Base Case. By 2070, the minimal action support costs are actually *three and a half times higher* than the Base Case costs.

While the minimal action scenarios developed by each site decrease overall cost over the 75-year period, the minimal action scope of activities requires sites to continue operation beyond 2070. This is specifically apparent with Savannah River Site and Rocky Flats Environmental Technology Site, two sites that have nearly completed all activities by 2055 under the Base Case. These changes in minimal action and Base Case cost estimates reflect the minimal action case's shift to long-term surveillance and monitoring activities (and corresponding support activities) at the sites.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE — SHIFTS IN SPENDING OVER TIME

To minimize urgent risks and reduce the cost of activities over the long term, Rocky Flats found that a minimal action approach at their site involved a fundamental shift in activity scheduling.

Much like Savannah River, Rocky Flats is seeking a "cheap to keep" mode for all of its buildings and facilities. For their minimal action approach, Rocky Flats found that accelerating the process of stabilizing facilities will allow the site to shift more quickly to a lower-cost surveillance and monitoring phase.



Because of this acceleration, site costs are actually higher between 1996 and 2000. The increased stabilization activities increase the minimal action case by $188 million over the Base Case for 1996 to 2000. These activities lead to a shift to lower-cost surveillance and monitoring activities by 2015.

Although this initial minimal action investment is higher than the Base Case, Rocky Flats manages to decrease overall 75-year costs from $17.3 billion (Base Case) to $11.8 billion (minimal action case).

6.3.3.3 END STATES

As a result of storing waste onsite and eliminating most building demolition activities, each site's minimal action end state is quite different from the Base Case. These differences can be found in three major areas: land use, onsite waste inventories, and surveillance and monitoring activities.

Land Use: A large portion of land controlled by each site can be considered a buffer area used for both security and environmental safety reasons. As a result, a large portion of the land in both the Base Case and the minimal action case does not require any cleanup or remedial activities. Future land use in the minimal action scenario reveals little difference from the Base Case. For example, under the Base Case, Rocky Flats Environmental Technology Site plans to release 2,300 hectares (5,680 acres) as *unrestricted* Open Space and 40 hectares (100 acres) as *restricted* Open Space. The minimal action approach decreases the unrestricted Open Space land by only 235 hectares (580 acres). The difference: in the minimal action case, approximately 175 buildings and facilities remain standing and monitored by Rocky Flats.

Onsite Waste Inventories: As discussed above, all high-level waste, spent nuclear fuel, and transuranic waste remain onsite in the minimal action case. During the period of this analysis (1996-2070), in accordance with the minimal action principles, each site must perform activities aimed at maintaining onsite and offsite risks at the same level as the Base Case. However, after 2070 in the minimal action case, this waste remains onsite and will require continual storage and repacking activities that are not included in the Base Case or minimal action case 75-year cost estimations. To understand the magnitude of these waste inventories, the Hanford Site, for example, will have an estimated total of 165,000 metric tons (182,000 tons) of waste (high-level and transuranic) stored onsite at the end of the minimal action period. In the Base Case, all of this waste is shipped to offsite disposal facilities.

Surveillance and Monitoring Activities: Two factors — the long-term storage of high-level waste, spent nuclear fuel, and transuranic waste and the elimination of building demolition — require continuing surveillance and monitoring activities not addressed in the Base Case. In the minimal action case, the annual cost of surveillance and monitoring costs after 2070 is estimated at $135 million (for all five sites). Under the Base Case, these five sites estimate between $35-$50 million per year of surveillance and monitoring costs beyond 2070.

OAK RIDGE RESERVATION -- FOCUS ON THE MINIMAL ACTION END STATE

For its minimal action approach, Oak Ridge Reservation employs a strategy of stabilizing existing buildings with continual surveillance and monitoring activities to maintain them in a safe, shutdown condition. Its minimal action strategy also includes maintaining waste inventories onsite and minimizing remediation of non-urgent contamination. The impact of these activities on the end state of the Reservation differs greatly from the Base Case.

In the Base Case, few buildings remain onsite; most are demolished prior to 2070. Waste will be treated and shipped to offsite disposal facilities by 2070 and there will be no existing waste inventories requiring repackaging or surveillance activities.

The minimal action scenario presents a very different picture for Oak Ridge Reservation. With no demolition activities planned in the minimal action case, 150 buildings remain onsite at the end of 2070. Some of these buildings contain the waste volumes not shipped offsite, while others are vacant structures. All land containing waste and vacant buildings requires constant surveillance and monitoring activities to minimize structural or contamination risks. Waste remaining onsite also requires periodic repacking to eliminate any risks of deteriorating storage tanks and drums.

RISK IMPLICATIONS OF THE MINIMAL ACTION CASE

Estimating future risks involves a great deal of uncertainty. Even over the time period of the minimal action analysis, it is difficult to predict accurately any potential risks to humans and/or the environment. However, to obtain a better understanding of the consequences of performing minimal actions, each site was asked to estimate the potential risks to onsite and offsite populations from the minimal action scenario. Given the uncertainty of estimating risk, each site attempted to highlight potential

IDAHO NATIONAL ENGINEERING LABORATORY REMEDIATION AND RISK

The overriding objective of the minimal action scenario is to prevent the increase in risk to onsite and offsite populations (beyond Base Case levels) while attempting to reduce cost and effort. Nowhere is this more apparent than in the minimal action remediation strategies developed by Idaho National Engineering Laboratory.

Urgent Need

Test Area North is the site of a former nuclear research reactor that was designed to perform experiments simulating reactor accidents. Since 1975, both hazardous and radioactive contaminants have been migrating into the surrounding area ground water. Through three removal activities, 34 million cubic meters (44.5 million cubic yards) of contaminated ground water is being removed from the Test Area North (completion in 2001). Upon removal, the ground water will be treated; the resulting waste will be disposed at onsite (low-level waste) and offsite (hazardous waste) facilities.

The remediation activities for Test Area North are exactly the same in the minimal action and Base Cases. In developing their minimal action scenario, Idaho determined that the remediation of the Test Area North is necessary to address urgent environmental and human risks. If the contaminated ground water is not extracted, offsite populations will be at risk prior to 2070.

No Increased Risk During Minimal Action Period

In developing their minimal action approach, Idaho identified a Base Case project that does not affect risk during the minimal action case period: the environmental restoration activities at the Radioactive Waste Management Complex. The Complex was established in 1952 as a controlled area for the disposal of solid radioactive waste. Monitoring of the site has shown contamination in the soil below the Complex. The current Base Case strategy is to remove and treat the contaminated soil and ship any remaining waste to an offsite disposal facility. Estimated cost: $1.4 billion for the 75-year period of analysis.

To prevent an increase in risk to offsite populations during the minimal action case period, it is *not* necessary to undergo the removal, treatment, and disposal of soil beneath the Radioactive Waste Management Complex. In developing their minimal action approach, Idaho determined that risk during the minimal action case period will not increase if the remedy involves capping the contaminated area and installing monitoring equipment. The risk level continues to be low throughout the minimal action case period, as a system of long-term surveillance and monitoring is employed at the capped site. In doing so, the cost of addressing risk at the Radioactive Waste Management Complex under a minimal action scenario is only $152 million.

areas of concern in both the near term (the time immediately following the end of the minimal action case period) and the long term (more than 100 years after the end of the minimal action case period). The risks identified are those affecting onsite workers and offsite populations.

During the minimal action period, as outlined in the guiding principles, each site must address all urgent risks. In doing so, each site has included urgently needed remediation and treatment projects in the development of its minimal action scenario. Because of these actions, there is no expected increase in risk to humans or the environment above Base Case levels in the minimal action case through the end of 2070.

Risk issues become different from the Base Case at the end of the minimal action case period. During the minimal action case period (1996-2070), buildings are not demolished, waste remains onsite, and only urgently needed remediation activities are carried out. In the near term, there is the possibility that these buildings will begin to deteriorate, posing an occupational risk to onsite workers. The waste inventories that remain in onsite storage and disposal facilities may experience corrosion and structural deterioration. The deterioration of these facilities poses a potential environmental risk to the surrounding soils and ground water and a health risk to workers in the immediate areas. Finally, the elimination of most remediation activities during the minimal action case period creates the potential for the spread of soil and ground-water contamination, affecting risk to both onsite and offsite populations.

Over the long term (from roughly 100 years after the end of the minimal action case period), the risks identified in the near term are expected to intensify. If buildings have not already collapsed during the near term, there is an increased risk of collapse in the long term. Contaminated soils and ground water from both deteriorating waste storage areas and nonremediated sites may continue to spread, posing greater risk to offsite populations. Over the long term in the minimal action scenario, there is an increased chance that a catastrophic event could occur, dramatically affecting risk to both onsite and offsite populations. Investments such as replacing storage facilities and remediating high-risk areas dramatically reduce the risk of such an accident.

6.3.4 Overall Implications of a Minimal Action Case

The minimal action case reduces Base Case life-cycle costs by 44 percent over the 75-year period. This savings is accomplished through the elimination of compliance-driven remediation activities, minimization of building demolition, and change in waste disposal strategies. The question posed by this cost reduction is: What are the benefits from additional Base Case expenditures that are *not* addressed in the minimal action case scenario?

The greatest benefit of the higher Base Case costs can be found in a comparison of end states. Unlike the Base Case, a minimal action case leaves waste inventories onsite. This not only requires continual surveillance and monitoring activities, but also increases long-term risk to onsite and offsite receptors from the remaining contamination. Under a minimal action case, buildings left standing require long-term surveillance and monitoring, which may pose a potential risk to workers as these facilities continue to deteriorate. While reducing costs during the 75-year period (1996-2070), a minimal action case may actually produce *greater* costs beyond 2070. These costs would be incurred through continual surveillance and monitoring activities and the need to address potential onsite and offsite risks.

The reduced-cost minimal action case provides benefits in the potential uses of saved funds. Specifically, any savings gained from a minimal action case approach could be used to develop new technologies to address any post-2070 remediation activities or other end-state risks. Increased funding of new technologies also could be directed at long-term waste storage and disposal strategies, which could alleviate the need for sites to continue repacking stored waste.

6.3.5 Limitations of the Analysis

When it is applied to a "real world" situation, the minimal action case has several limitations, the greatest of which are the elimination of regulatory and compliance requirements and the impacts on stakeholder expectations. Specifically, the assumptions used for the minimal action analysis allow the sites to bypass regulations and stakeholder requirements. Under current compliance agreements, many sites have established guidelines and regulations governing waste management, environmental restoration, and facility deactivation and decommissioning activities. Federal environmental regulations (such as the Resource Conservation and Recovery Act) include specific requirements on the types of storage facilities that must be built and used at each site. The actual costs and scope of work found in a minimal-action-like scenario would be dramatically different.

Another limitation in a "real world" atmosphere is that, although the minimal action period cost estimate is only 56 percent of the Base Case, sites still require 68 percent of the Base Case cost estimate to meet minimal action goals in the immediate period of 1996 through 2000. In the case of Rocky Flats Environmental Technology Site, the minimal action case actually requires a 10 percent *increase* above the Base Case costs for the first five years. The increase is needed to address immediate remediation activities and long-term storage facility construction costs. For Rocky Flats Environmental Technology Site, specifically, a long-term cost-reducing minimal action strategy requires an increase in near-term funding.

Under this analysis, however, the following is true: there are limitations to the "minimal cost" aspect of the minimal action case when costs are assessed beyond the 75-year period. The minimal action case leaves waste onsite and eliminates most building demolition. Both of these situations prolong the requirement for long-term surveillance and monitoring activities and, therefore, extend the long-term site costs. Without addressing onsite waste inventories (either through onsite or offsite permanent disposal methods) and completely demolishing all facilities, the total costs and human health/environmental risks of a minimal action case will be *greater* than the Base Case at a point beyond 2070.

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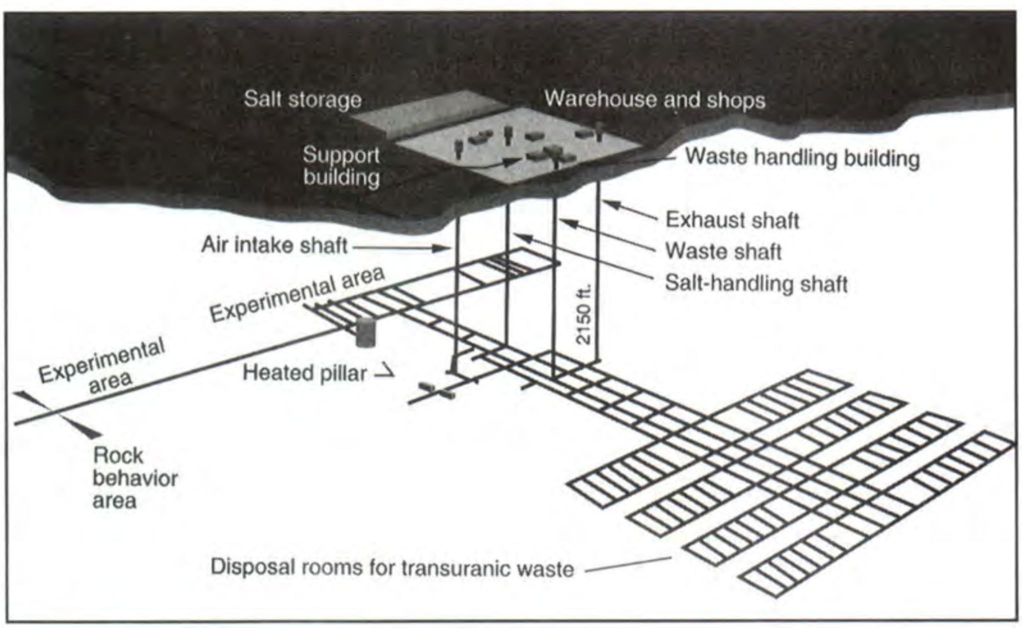
Plutonium Button and Rubber Glove, Rocky Flats Plant, Colorado, 1974. *Virtually everything involved in plutonium processing, such as this rubber glove, becomes contaminated and must be contained and monitored indefinitely. This waste is called "transuranic" waste, which includes any material containing significant quantities of plutonium, americium, or other elements whose atomic weights exceed those of uranium. Transuranic waste can include everything from chemicals used in plutonium metallurgy to used air filters, gloves (see photo), clothing, tools, piping, and contaminated soils.*



Waste Isolation Pilot Plant Schematic. *This simplified layout shows the surface facilities, the four shafts, the underground areas in which experiments are conducted, and the underground rooms in which transuranic waste will be disposed of if disposal is approved. The WIPP is intended for use in disposing of plutonium contaminated materials, such as the glove (above photo), but is not intended for use in disposing of bulk plutonium, such as the button in the above photograph. A life-cycle cost analysis for plutonium production requires consideration of the cost, strategies, and issues involved with all elements (including "externalities) of that production -- including the final disposition of both plutonium and transuranic waste.*

5.0 COMPARISON OF RESULTS TO THE 1995 BASELINE ENVIRONMENTAL MANAGEMENT REPORT

The 1996 Base Case estimate is similar to the 1995 Base Case in some respects, and quite different in other respects. The total 1995 Base Case estimate, including productivity estimates, was $237 (constant 1996 dollars). This total appears quite similar to the 1996 Base Case of $227 billion. There are important differences, however, that reflect changes in analytical methods and in the Environmental Management program as a whole.

First, the projected cost savings due to productivity improvements greatly affect the estimates. The 1995 total Base Case estimate was reduced from the sum of estimates provided by field offices ($360 billion in 1996 constant dollars) to reflect a projection of the amount of overall improvement in productivity expected. The 1996 Base Case does not include this type of alteration of cost projections provided by field offices, and, therefore, does not include an explicit productivity estimate. Instead, productivity is assumed to be included in estimates provided by field offices. The 1996 Base Case is essentially an integrated sum of estimates provided by field offices.

To reflect efforts underway to reduce costs, the Environmental Management headquarters office applied substantial improvements in productivity up through the year 2000 to the 1995 Base Case cost estimates provided by field offices. This "top down" change in cost estimates reflected a goal of achieving an approximately 20 percent increase in productivity and efficiency. Beyond the year 2000, the Department assumed a sustained productivity improvement rate of one percent compounded annually. Using these assumptions for projecting costs, the 1995 total life-cycle cost estimate was $237 billion (in constant 1996 dollars). It is worthwhile to note, however, that the site cost estimates reported in Volume II of the 1995 Baseline Report did not include productivity projections, and total cumulatively to $360 billion (in 1996 dollars). If comparable "top down" changes were made to the 1996 Base Case cost estimate provided by the sites in the 1995 Base Case estimate, then an additional one percent compounded annually would be applied to the 1996 Base Case estimate of $227 billion after the year 2000. Imposing this additional productivity change to the cost estimate provided by field offices would result in a 1996 Base Case of approximately $195 billion in constant 1996 dollars.

Another difference between the 1995 and 1996 Base Case estimates is how the range of estimated costs was calculated. In the 1995 report, the range of $200-$350 was developed using different productivity assumptions (e.g., $200 billion life-cycle cost estimate represented a 2 percent improvement in productivity compounded annually after the year 2000 for the life of the program). Alternatively, the 1996 cost range of $189 billion to $265 billion is based on site confidence in the cost estimates as reported by site personnel (i.e., there is 100 percent confidence that total life-cycle costs are less than $265 billion, and 100 percent confidence that total life-cycle costs are above $189 billion).

Because total estimates submitted by the sites in 1996 ($227 billion) are directly comparable to the total estimates submitted by the sites in 1995 ($360 billion), the 1996 Base Case of $227 billion is compared to the 1995 cost estimate of $360 billion. The 1996 cost estimate is thus approximately one-third lower than the 1995 estimate. This chapter describes this difference and the technical reasons behind it.

MAJOR DIFFERENCES BETWEEN THE 1995 AND 1996 ESTIMATES

- The 1996 Base Case is $133 billion (37 percent) lower than the 1995 Base Case.
- The duration of the 1996 Base Case is shorter than the duration of the 1995 case. Remediation at 80 percent of sites is expected to be complete by 2021 in the 1996 estimate as opposed to 2035 in the 1995 estimate.
- 1996 Base Case waste volume projections are lower than the comparable 1995 projections.
- The 1996 Base Case reflects less costly environmental management strategies (to achieve essentially the same risk reduction goals), particularly for facility decommissioning and waste management, than the 1995 Base Case.

This remainder of this chapter is organized into four sections:

- **Section 5.1** discusses the need for and chief benefits of developing a new Base Case and discusses general reasons for differences;
- **Section 5.2** describes the four major reasons for the differences examined in this chapter;
- **Section 5.3** outlines the major activities that result in cost reductions and relates those activities to the four major reasons for the differences discussed in Section 5.2; and
- **Section 5.4** describes the cost differences at the five major sites by examining the reasons for cost reductions at each site.

5.1 THE BENEFITS OF A NEW BASE CASE

The 1996 Base Case analysis is significantly more useful than the 1995 analysis for several reasons, all of which result from the "bottom-up" estimating approach described in Chapter 3. (Estimates for the 1996 Baseline Report were developed by field-based analysts to a much greater extent than was the case in 1995.) First, the data are generally more reliable at a more detailed level. By moving the estimating process closer to the knowledge base in the field, the Department has built the report on a better quality data base. As a result, the analyses of state, site, and project costs are considerably more rigorous and accurate than those in the 1995 estimate.

Second, the analysis of cost estimates principally by field personnel, (approximately half of the 1995 cost estimates were developed by Headquarters personnel), has brought about a number of collateral benefits that should help improve program management capabilities, thereby helping to reduce costs. As a result of this process of compiling the cost estimates, the Department now has a cadre of experienced life-cycle cost analysts. Field personnel have been encouraged and empowered to define meaningful long-range assumptions and outline long-term strategies for their sites. This capability provides a better basis for integrated site planning and facilitates better communication with regulators and other stakeholders, as well as between sites and program areas.

The Department also encouraged site personnel to develop their Base Case estimates with input from integrated multidisciplinary project teams, to identify interdependencies between programs, and to work together to resolve conflicting assumptions. The integration effort enhanced the quality and usefulness of the final product. This improved estimation methodology explains some of the differences between the estimates.

The transfer of greater responsibility from Headquarters to the field brought about a series of specific improvements to the cost estimate. It allowed the Baseline Report better access to the most recent cleanup plans, strategies, and cost data; allowed the use of site-specific cost estimating tools and experts rather than generic models; and provided a valuable "reality check" on the cost estimates. Working more closely with field personnel produced a more detailed cost estimate that reflects current strategies more accurately. Table 5.1 provides examples of specific changes to the cost estimate that resulted in these benefits.

Table 5.1. Examples of Changes in the Approach Used to Develop the Cost Estimate in 1995 Versus 1996

Program Element	1995	1996
Waste Management	• Headquarters personnel modeled costs for managing transuranic waste, low-level waste, and low-level mixed waste based upon input from sites. • Headquarters personnel estimated costs for managing hazardous waste based upon an analysis of FY 1996 budget documents. • National Spent Nuclear Fuel Program personnel modeled the costs for managing spent nuclear fuel based upon input from sites. • Waste management configuration for low-level mixed waste was consistent with Draft Site Treatment Plans submitted in 1994. • Costs for managing waste generated by non-Environmental Management programs ended upon completion of Environmental Restoration program or 2030—whichever was first.	• Site personnel estimated costs for managing transuranic waste, low-level waste, and low-level mixed waste costs based upon current plans. • Site personnel estimated costs for managing hazardous waste based upon best available data at the site and from commercial vendors. • Site personnel estimated costs for managing spent nuclear fuel using scenarios consistent with the Spent Nuclear Fuel Final Environmental Impact Statement preferred alternative. • Waste management configuration for low-level mixed waste was consistent with Proposed Site Treatment Plans submitted in April 1995. • Costs for managing waste generated by non-Environmental Management programs ended in 2070 unless non-Environmental Management programs were assumed to end at an earlier date.
Environmental Restoration	• The Base Case was built from existing environmental restoration baselines.	• The Base Case was built from more recent environmental restoration baselines that better reflect current baseline assumptions.
Nuclear Material and Facility Stabilization	• Headquarters personnel modeled costs for deactivating and stabilizing all facilities identified as surplus by the Surplus Facilities Inventory and Assessment (SFIA) using a 10-5-2 scheduling scenario: — 10 years pre-stabilization surveillance and maintenance (S&M) — 5 years stabilization/deactivation — 2 years post-stabilization S&M	• At the four largest nuclear material and facility stabilization sites, site personnel estimated the cost for deactivating and stabilizing all facilities identified as surplus by the SFIA. Site personnel also modified the SFIA list of facilities to reflect current plans. • For other sites, Headquarters personnel modeled deactivation and stabilization costs for all facilities identified as surplus by the SFIA using a 7-3-3-2-2 scheduling scenario: — 7 years pre-stabilization S&M — 3 years stabilization — 3 years post-stabilization S&M — 2 years deactivation — 2 years post-deactivation S&M
National Program Planning and Management	• Headquarters personnel modeled all costs for Environmental Management Headquarters and Operations Offices.	• Headquarters personnel modeled all costs for Environmental Management Headquarters. Operations Office personnel estimated Operations Office costs.

5.2 1995 VERSUS 1996 ESTIMATE - REASONS FOR DIFFERENCES

Two major factors underlie the differences between the 1995 and 1996 estimates. Today, the Environmental Management program has better knowledge of the scope of the program and a better understanding of how to achieve this scope cost-effectively. A detailed analysis indicates that more accurate information has resulted in a different life-cycle cost estimate for four reasons: change in scope of the estimate, change in technical assumptions for addressing environmental problems, change in anticipated productivity improvements, and change in the analytical models used to estimate cost. Table 5.2 provides definitions and examples for each reason.

Table 5.2. Example of Differences in the Estimates

Reason	Definition	Representative Example
Change in Scope	Change in the nature or magnitude of environmental problems being addressed.	• Since preparing cost estimates for the 1995 report, Hanford Site waste management personnel have gained a clearer understanding of the volume of waste that will be generated by environmental restoration activities. This understanding translated into lower volumes in the 1996 estimate than the 1995 projections.
Change in Technical Assumptions for Addressing Environmental Problems	**Change in technical approach, strategy, or schedule for addressing an environmental problem.**	• **In late 1995, the Department of Energy signed an agreement with the State of Idaho that accelerates the cleanup of the Idaho National Engineering Laboratory. The acceleration reduces storage and surveillance and maintenance costs that depend on the pace of the cleanup.** • **At the Oak Ridge Reservation, the 1996 report reflects commercial management of waste. By contrast, Oak Ridge Reservation personnel assumed government management of this waste in 1995. Oak Ridge Reservation personnel anticipate that commercial waste management will be less costly than government waste management.**
Change in Anticipated Productivity Improvements	Change in amount of work that can be performed by a given input.	• The Savannah River Site is undergoing several restructuring efforts—including business re-engineering, consolidation, and fixed-price subcontracting—that are leading to productivity increases. • The Pantex Plant is increasing productivity through waste minimization efforts.
Change in Estimating Models	**Use of different unit cost estimates, cost estimating algorithms, or models.**	• **In the 1995 report, Headquarters personnel modeled all nuclear material and facility stabilization direct mission costs using the 10-5-2 scheduling scenario outlined in Table 5.1. In 1996, personnel at large sites estimated these costs based upon realistic scenarios.**

Figure 5.1 indicates that there is not always a clear delineation between the reasons for cost differences. Some cost differences are caused solely by one factor. For example, a decrease in spent nuclear fuel disposal costs from the 1995 estimate to the 1996 estimate is due to a change in the cost estimating model–site models used in 1996 rather than the national model used in 1995. Other cost differences cannot be classified so simply. For example, success in waste minimization can be described as a reduction in scope and an improvement in productivity.

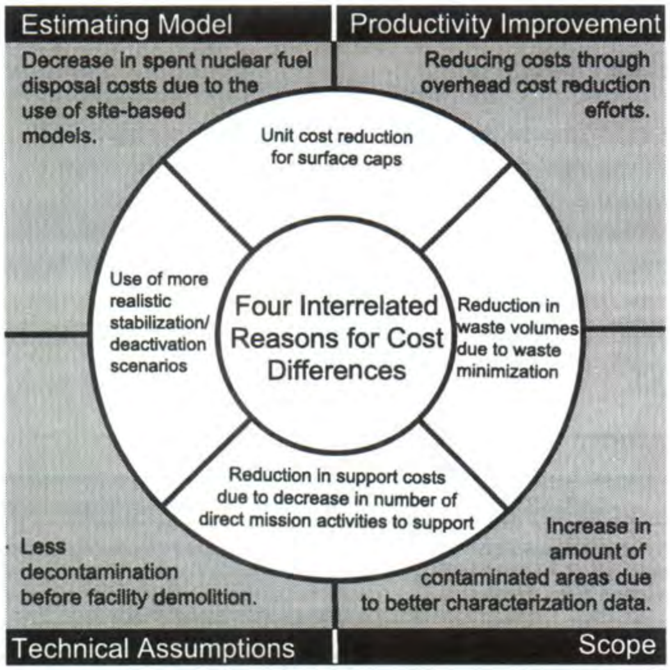


Figure 5.1. Four Interrelated Reasons for Cost Differences

Although these reasons overlap, the classifications provide a useful framework for understanding why the 1995 and 1996 life-cycle estimates are different. Figure 5.2 graphically illustrates the reasons for the differences between the two estimates. As shown, the differences can largely be attributed to two factors. The scope of the

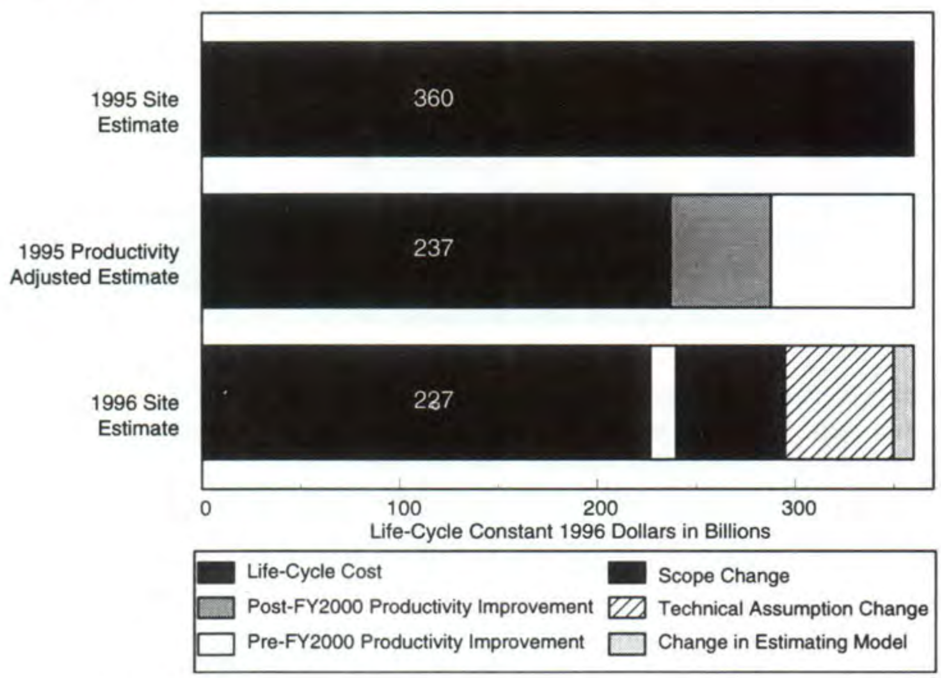


Figure 5.2. Comparison of 1995 and 1996 Baseline Report Cost Estimates

estimate is smaller in the 1996 estimate than in 1995, primarily because of reductions in waste volumes generated by the Environmental Management program and better waste volume estimates. Also, technical assumptions for addressing environmental problems have changed. In general, the 1996 estimate reflects less costly technical approaches to facility decommissioning and waste management. The remainder of this chapter presents a more detailed analysis of the differences between the 1995 and 1996 estimates.

PRODUCTIVITY IMPROVEMENT

The Environmental Management program is improving productivity. In 1995, site personnel submitted life-cycle cost estimates of $350 billion (or $360 billion in constant 1996 dollars). Through a comprehensive assessment of life-cycle productivity improvement, the Environmental Management program concluded that, by increasing productivity, these costs could be lowered by 23 percent in the next five years and by an additional one percent annually thereafter. The case highlighted in Volume I of the 1995 report reflects this goal for productivity improvement. As shown in Figure 5.2, these goals resulted in a Base Case of $237 billion in constant 1996 dollars. In 1996, sites submitted a Base Case costing $227 billion; the $360 billion estimate from 1995 was derived in a similar way (from site estimates with no productivity adjustments made at Headquarters). For this reason, the two estimates are comparable. This chapter compares them.

Although the differences in life-cycle cost estimates from 1995 to 1996 are not totally attributable to realizing the productivity improvements outlined in 1995, a significant portion of the difference results from productivity improvements, or the broader concept of performing the program in a more intelligent way.

Figure 5.2 shows that site personnel attribute approximately 10 percent of the life-cycle cost difference from 1995 to 1996 directly to productivity improvements. In a broader sense, many other cost savings from the 1995 to the 1996 Baseline Report can be considered productivity improvements. These savings result from executing the same scope of work in a smarter, more efficient, and less costly manner. For example, personnel at the Oak Ridge K-25 Site have learned that they can save a large amount of money by using rubble from decommissioning as backfill of the below-grade structure. The result: completing a similar scope of work with the same risk profile at a lower cost.

Adopting explicit productivity improvements and incorporating smarter, more efficient solutions to the problems of implementing the Environmental Management program indicate that the sites have, in effect, assimilated last year's productivity improvement goals (which changed the Base Case estimates from the $350 billion provided by site personnel to $230 billion) into the life-cycle cost estimates in the 1996 Baseline Report. For this reason, the 1996 Baseline Report does not make an explicit productivity adjustment to the life-cycle Environmental Management cost estimate.

5.3 ACTIVITIES WITH LARGE COST REDUCTIONS

The majority of the cost reduction in the 1996 report occurs in five major activities at environmental management sites: decommissioning; low-level waste, low-level mixed waste, and transuranic waste management; management of spent nuclear fuel; remedial action; and program management/support. This section discusses the major reasons for the lower estimates for these activities in the 1996 Baseline Report. Table 5.3 provides an overview of the activities that experienced the largest decreases.

Table 5.3. Overview of Activities With Large Cost Estimate Differences [#]

Activity	1995 Estimate*	1996 Estimate	Difference
Decommissioning	$47.2 billion	$18.2 billion	$29.0 billion / 61%
Low-Level Waste, Low-Level Mixed Waste, and Transuranic Waste Management	$54.9 billion	$32.0 billion	$22.9 billion / 42%
Spent Nuclear Fuel Management	$11.8 billion	$4.1 billion	$7.7 billion / 65%
Remedial Action	$24.4 billion	$17.5 billion	$6.9 billion / 28%
Program Management/Support	$87.2 billion	$57.2 billion	$30.0 billion / 34%

* Inflated to constant 1996 dollars for comparison.

[#] Unlike Chapter 4, support cost is reported as an independent functional element in Chapter 5.

There was also a difference in national program planning and management costs. These costs dropped from $47 billion in the 1995 report to $19 billion in the 1996 report. A large portion of this cost reduction occurred because costs for federal employees and their contractor support were estimated by Headquarters personnel for the 1995 report and classified as national program planning and management, regardless of their location. In the 1996 report, only federal employees and contractor support located at Headquarters were classified as national program planning and management. Costs for federal employees and contractor support located in the field were estimated at the appropriate site. Also, national program planning and management and science and technology development costs are lower in the 1996 estimate because they were assumed to vary proportionally with site costs. Because site costs are lower in the 1996 report, national program planning and management and science and technology development costs also dropped. The remainder of the section examines differences in the five major areas presented in Table 5.3.

Decommissioning - Decommissioning cost estimates dropped from $47 billion in the 1995 report to $18 billion in the 1996 report—a $29 billion decrease primarily caused by a change in the technical approach to facility decommissioning. Site personnel plan to perform less decontamination before demolition because of a better understanding of the scope of decontamination that is necessary before facility demolition. This insight reduces costs dramatically. At many sites, personnel now plan to dispose of rubble from decommissioning in place rather than in disposal cells that would have to be constructed, thereby reducing cost estimates.

Low-Level Waste, Low-Level Mixed Waste, and Transuranic Waste Management - Cost estimates for managing low-level waste, low-level mixed waste, and transuranic waste dropped from $55 billion in the 1995 report to $32 billion in the 1996 report—a $23 billion decrease. Two factors account for this drop: changes in technical approach and scope. The 1996 Baseline Report bases cost estimates on two less costly approaches to addressing these waste types. In particular, the Department plans to use less costly commercial waste management facilities rather than more costly government facilities. It also plans to reuse existing government facilities instead of building new ones. In addition, the volume of waste being managed by the Waste Management program is lower in the 1996 report than it was in the 1995 report. This is due primarily to two factors: better waste volume estimates and aggressive waste minimization and recycling efforts undertaken by the Department.

Spent Nuclear Fuel Management - Cost estimates for managing spent nuclear fuel dropped from $12 billion in the 1995 report to $4 billion in the 1996 report—an $8 billion decrease. Two factors account for this drop: acceleration of spent nuclear fuel disposal at a national geologic repository and use of better estimation models. Acceleration yields cost reductions because it reduces the duration of spent nuclear fuel storage *before* eventual disposal. Also, site-based models used for the 1996 report estimated significantly lower costs for spent nuclear fuel disposal at a national geologic repository.

Remedial Action - Remedial action cost estimates dropped from $24 billion in the 1995 report to $17 billion in the 1996 report—a $7 billion decrease. Most of this reduction is due to negotiations with regulators and more accurate predictions of the results of future agreements. During the last year, the Department has negotiated several agreements with regulators to perform less costly remediation than the 1995 report anticipated. These agreements suggest that future negotiations will render similar agreements and less costly remediation strategies. The 1996 Baseline Report reflects this expectation that future remediation strategies will be less costly than those anticipated in the 1995 report.

WHAT HASN'T CHANGED

This chapter focuses on the major differences between the 1995 and 1996 Base Case estimates. However, the life-cycle estimates for several functional areas are almost identical:

- High-Level Waste Management
- Surveillance and Maintenance of Facilities
- Nuclear Material and Facility Stabilization Support/Landlord Costs

Program Management/Support - Program management and support cost estimates dropped from $87 billion in the 1995 report to $57 billion in the 1996 report—a $30 billion decrease. This reduction is due to the fact that the 1996 estimate reflects a smaller program and less direct mission costs. Efforts to reduce overhead costs at Environmental Management sites also contribute to the reduction.

5.4 COST ESTIMATE DIFFERENCES FOR THE HIGHEST-COST SITES

Figure 5.3 indicates that most of the $133 billion cost reduction from the 1995 Baseline Report estimate is for the five highest-cost sites. The rest of this section details the cost reduction for each site.

5.4.1 Hanford Site Differences

Cost estimates at the Hanford Site dropped from $75 billion in the 1995 report to $50 billion in the 1996 report—a $25 billion decrease. Unlike several other sites, where there is one major explanation for the difference, several factors account for this difference. This section discusses the reasons for each major difference. Table 5.4 highlights the major activities with large cost differences between the two estimates.

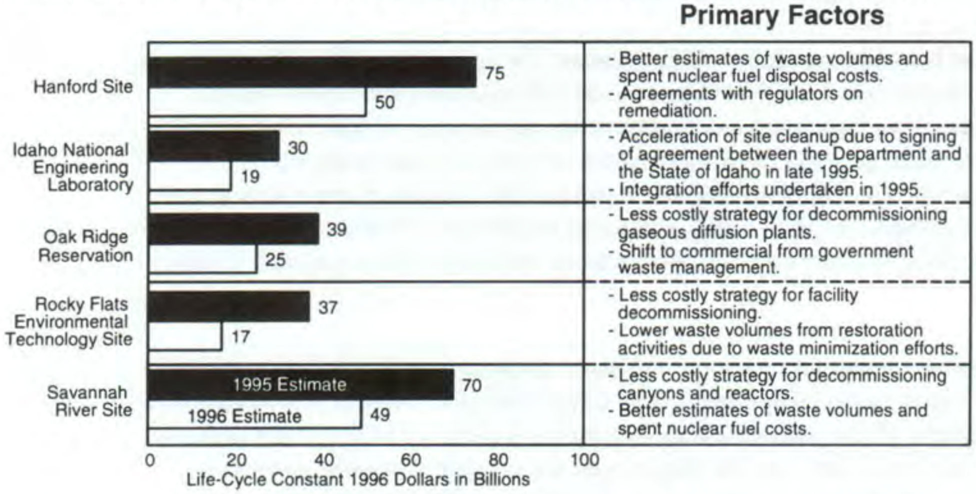


Figure 5.3. Comparison of 1995 and 1996 Cost Estimates for the Five Highest-Cost Sites

Table 5.4. Differences in 1995 and 1996 Cost Estimates at the Hanford Site

Activity	1995 Estimate*	1996 Estimate	Difference
Waste Management Support	$14.9 billion	$7.1 billion	$7.8 billion / 52%
Low-Level Waste Management	$5.7 billion	$0.8 billion	$4.9 billion / 86%
Remedial Action	$6.3 billion	$2.7 billion	$3.6 billion / 57%
Low-Level Mixed Waste Management	$4.3 billion	$2.4 billion	$1.9 billion / 44%
Spent Nuclear Fuel Management	$2.9 billion	$1.0 billion	$1.9 billion / 66%
Hazardous Waste Management	$1.9 billion	$0.0 billion	$1.9 billion / 100%
Transuranic Waste Management	$3.1 billion	$1.3 billion	$1.8 billion / 58%
Other Areas	$35.9 billion	$34.9 billion	$1.0 billion / 3%
Total	$75.0 billion	$50.2 billion	$24.8 billion / 33%

* Inflated to constant 1996 dollars for comparison.

Waste Management Support Costs - The Waste Management support cost estimate dropped from $15 billion in the 1995 report to $7 billion in 1996. The primary reason for this reduction: the 1996 estimate reflects a smaller program and fewer direct mission costs. Support cost estimates are lower because fewer mission activities require less support. Efforts under way at the Hanford Site to reduce support costs also contribute to the lower support and program management cost estimates.

Low-Level and Low-Level Mixed Waste Management - Low-level and low-level mixed waste management cost estimates at the Hanford Site dropped from $10 billion in the 1995 report to $3 billion in 1996. The primary reason is lower estimates for waste volumes due to better waste generation data than was available in 1995.

Remedial Action - Remedial action cost estimates dropped from $6 billion in the 1995 report to $3 billion in 1996. The primary reason for this reduction: recent agreements between the Department of Energy and regulators. These agreements reduce the amount of soil along the Columbia River (100 and 300 Areas) that the Department is required to remediate. Furthermore, approximately 50 percent of the analytical samples originally anticipated to be performed during the course of remediation have been eliminated, reducing remediation unit costs for the soil volumes that must be excavated.

Several other less important factors also contributed to a reduction in the estimated cost of remediation. The cost per square meter for applying surface caps has been reduced significantly, reflecting technical evaluations that resulted in revised remedial designs. This results in significant cost reductions when applied to the more than 5.7 million square meters (62 million square feet) of surface to be capped within the 200 Area. Also, the first phases of the Environmental Restoration Disposal Facility will be available earlier than previously planned, reducing disposal charges paid to the Waste Management program in the early years.

Spent Nuclear Fuel Management - Spent nuclear fuel management cost estimates at the Hanford Site dropped from $3 billion in the 1995 report to $1 billion in 1996. The primary reason for this reduction: a better estimate for the cost of disposing of spent nuclear fuel at a national geologic repository. In 1996, the Hanford Site personnel developed a bottom-up estimate for the spent nuclear fuel program, which has undergone detailed reviews with an emphasis on reducing costs. The 1995 estimate was part of a five-site generalized analysis developed by the Headquarters National Spent Nuclear Fuel program.

Hazardous Waste Management - Cost estimates for managing hazardous waste dropped from $2 billion to $49 million. This difference is also due to the use of better data. The 1995 estimate was based on a Headquarters analysis of budget and waste volume data; the 1996 estimate was developed by Hanford personnel. Based on high-level data, the waste volume estimate in 1995 was approximately 1.8 million cubic meters (2.4 million cubic yards). The 1996 waste volume estimate has been greatly reduced to approximately 33,000 cubic meters (43,230 cubic yards), translating into lower cost estimates for hazardous waste management.

Transuranic Waste Management - Cost estimates for managing transuranic waste dropped from $3 billion in the 1995 report to $1 billion in 1996 because of a shift in the technical approach for managing transuranic waste. The 1995 report assumed the construction of a new facility for managing remote-handled transuranic waste. The 1996 estimate assumes treatment of remote-handled transuranic waste in an existing canyon facility (T-Plant), resulting in lower costs than those required to construct a new facility. Also, transuranic waste volumes are significantly lower in the 1996 report than in the 1995 report because the Department has expanded its knowledge of waste generation.

5.4.2 Savannah River Site Differences

Cost estimates at the Savannah River Site dropped from $70 billion in the 1995 report to $49 billion in 1996, resulting in a $21 billion decrease. Table 5.5 indicates that the majority of the cost differences between the two reports can be found in the low-level mixed waste management, spent nuclear fuel management, decommissioning, and support cost estimates. As is the case with the Hanford Site, there are several major reasons for the differences.

Table 5.5. Differences in 1995 and 1996 Cost Estimates at the Savannah River Site

Activity	1995 Estimate*	1996 Estimate	Difference
Decommissioning	$12.4 billion	$6.6 billion	$5.8 billion / 47%
Waste Management Support	$11.3 billion	$4.9 billion	$6.4 billion / 57%
Low-Level Mixed Waste Management	$6.6 billion	$2.4 billion	$4.2 billion / 64%
Nuclear Material and Facility Stabilization Support	$8.6 billion	$5.2 billion	$3.4 billion / 40%
Spent Nuclear Fuel Management	$4.1 billion	$1.7 billion	$2.4 billion / 59%
Other Areas	$27.2 billion	$28.0 billion	($.8 billion) / (3%)
Total	$70.2 billion	$48.8 billion	$21.4 billion / 30%

* Inflated to constant 1996 dollars for comparison.

Decommissioning - Decommissioning cost estimates dropped from $12 billion in the 1995 report to $7 billion in 1996. This decrease is primarily due to the anticipation of a less costly technical approach to decommissioning reactors and canyons in 1996.

Support Costs - Support cost estimates for waste management and nuclear material and facility stabilization dropped from $20 billion in the 1995 report to $10 billion in 1996 because the 1996 estimate reflects a smaller program and fewer direct mission costs. In 1995, Headquarters personnel developed support cost estimates using high-level budget documents; in 1996, Savannah River Site analysts developed estimates of support costs.

Low-Level Mixed Waste Management - Cost estimates for managing low-level mixed waste dropped from $7 billion in the 1995 report to $2 billion in 1996. Improved waste volume data provided lower waste volume estimates that translated into reduced cost estimates for low-level mixed waste in 1996.

Spent Nuclear Fuel Management - Cost estimates for managing spent nuclear fuel dropped from $4 billion in the 1995 report to $2 billion in 1996 because of more accurate estimates. In 1995, personnel from the National Spent Nuclear Fuel Program estimated costs, and in 1996, Savannah River Site personnel developed the estimate. The site's estimates for disposal fees for a national geologic repository are substantially smaller than those provided by the national program.

5.4.3 Oak Ridge Reservation Differences

Cost estimates for the Oak Ridge Reservation dropped from $39 billion in the 1995 report to $25 billion in 1996. Table 5.6 indicates that the majority of this cost difference is due to changes in the Oak Ridge Reservation's technical approach to waste management and decommissioning. For waste management, the 1996 report emphasizes commercial treatment and disposal rather than constructing and upgrading existing facilities. This is a less costly waste management strategy. Also, the Department plans to generate less waste during environmental restoration activities which further reduces waste management costs. For these reasons, cost estimates for managing transuranic waste and low-level mixed waste decreased from $7 billion in the 1995 report to $3 billion in 1996.

Table 5.6. Differences in 1995 and 1996 Cost Estimates at the Oak Ridge Reservation

Activity	1995 Estimate *	1996 Estimate	Difference
Decommissioning	$9.1 billion	$3.0 billion	$6.1 billion / 67%
Environmental Restoration Program Management	$3.6 billion	$1.7 billion	$1.9 billion / 53%
Assessment	$4.2 billion	$1.8 billion	$2.4 billion / 57%
Transuranic Waste Management	$2.6 billion	$0.8 billion	$1.8 billion / 69%
Low-Level Mixed Waste Management	$4.0 billion	$2.8 billion	$1.2 billion / 30%
Other Areas	$15.9 billion	$15.0 billion	$0.8 billion / 5%
Total	$39.4 billion	$25.1 billion	$14.2 billion / 36%

* Inflated to constant 1996 dollars for comparison.

The majority of the cost difference at the Oak Ridge Reservation ($6 billion) is for decommissioning, in particular, decommissioning the K-25 Gaseous Diffusion Plant. This drop is due primarily to a change in technical assumption. Based upon a reevaluation of decommissioning scenarios, the Department anticipates the following decommissioning strategy:

- Recycle all process equipment and radioactive metals from the plants;
- Demolish the above-grade structures,
- Leave below-grade structures in place,
- Backfill with demolition rubble, and
- Cap the below-grade structure.

Although it is less costly than last year's strategy of disposing waste in onsite disposal facilities, the demolition fill will not be placed in a manner that will provide an adequate foundation for future development. If the plant is left standing for reuse, as is currently being pursued, the estimates will be further reduced.

PADUCAH AND PORTSMOUTH GASEOUS DIFFUSION PLANTS

The Department anticipates using the decommissioning strategy described above for the Portsmouth and Paducah Gaseous Diffusion Plants as well as the K-25 Gaseous Diffusion Plant. The result is similar cost savings at the Portsmouth and Paducah sites. Specifically, combined decommissioning costs for the Oak Ridge Reservation, Portsmouth Site, and Paducah Site decreased from $19 billion in the 1995 report to $5 billion in the 1996 report. If these plants are left standing for reuse as is currently being pursued, the estimates will be further reduced.

5.4.4 Rocky Flats Environmental Technology Site Differences

Cost estimates for the Rocky Flats Environmental Technology Site decreased from $37 billion in the 1995 report to $17 billion in 1996. Although the scope of the environmental problem at this site is approximately the same in both reports, the cleanup will be less costly, primarily because of changes in the technical approach to the problem. (Because cost estimates in this report reflect projections as of October 1995, the Rocky Flats Environmental Technology Site's environmental management strategy has changed since their Baseline Report cost submittal. Changes such as this are expected. Awareness and communication of change is a primary motivation for the Baseline Report.) Table 5.7 shows that the cost differences at this site are predominantly in two major areas: decommissioning and the management of low-level waste, low-level mixed waste, and transuranic waste. The $11 billion cost difference in decommissioning and related program management is due to the decrease in the amount of decontamination anticipated before demolition.

Table 5.7. Differences in 1995 and 1996 Cost Estimates at the Rocky Flats Environmental Technology Site

Activity	1995 Estimate*	1996 Estimate	Difference
Decommissioning	$11.2 billion	$3.6 billion	$7.6 billion / 68%
Environmental Restoration Program Treatment, Storage, and Disposal	$3.2 billion	$0.0 billion	$3.2 billion / 100%
Environmental Restoration Program Management	$4.1 billion	$1.1 billion	$3.0 billion / 73%
Low-Level Mixed Waste Management	$3.2 billion	$0.7 billion	$2.5 billion / 78%
Low-Level Waste Management	$2.3 billion	$0.5 billion	$1.8 billion / 78%
Other Areas	$13.0 billion	$11.4 billion	$1.6 billion / 12%
Total	$37.0 billion	$17.3 billion	$19.7 billion / 53%

* Inflated to constant 1996 dollars for comparison.

Lower waste management cost estimates occur primarily because of changes in scope and technical assumptions:

- **Waste generation from environmental restoration and nuclear material and facility stabilization activities is expected to decrease by 25 percent compared to 1995 –** Low-level and low-level mixed waste streams from nuclear material and facility stabilization activities were reduced through the planned expedited deactivation of buildings. Estimated volumes of low-level and low-level mixed waste streams from environmental restoration activities were reduced by assuming a risk-based remediation approach and recycling metals from decommissioning. The risk-based remediation approach focuses remediation on the buffer zone and accessible areas. Site personnel also expect transuranic waste volumes generated from decommissioning to be dramatically reduced.

- **Shift from offsite disposal strategy to a mixture of offsite and onsite disposal –** Onsite disposal of low-level waste and low-level mixed waste is less expensive than offsite disposal.

5.4.5 Idaho National Engineering Laboratory Differences

Cost estimates for the Idaho National Engineering Laboratory decreased from $30 billion in the 1995 report to $19 billion in 1996. A change in schedule accounts for the major difference between the estimates. Specifically, a settlement agreement signed by the Department of Energy and the State of Idaho requires program acceleration, thereby reducing costs. The agreement requires the Department of Energy to remove all spent nuclear fuel from the State by 2035 (15 years earlier than previously planned); to prepare all high-level waste for disposal by 2035 (15 years earlier than previous estimates); and to begin transuranic waste shipments to the Waste Isolation Pilot Plant by April 30, 1999. This cost reduction is due to the acceleration, which reduces the duration of storage and the period of time for which facilities must be maintained. It also shortens the period of time over which support costs are incurred.

Table 5.8 indicates that the majority of the cost difference at the Idaho National Engineering Laboratory is for spent nuclear fuel management ($3 billion) and high-level waste management ($3 billion). This decrease is due to the acceleration, which reduces the duration of storage and the period of time for which facilities must be maintained. In addition to reduced storage and facility maintenance costs, accelerated management of these waste types also reduces the support cost estimates and low-level mixed waste cost estimates. As discussed earlier, support cost estimates decrease ($1 billion) because direct mission activities are conducted over a shorter period of time. They also are reduced in magnitude. Low-level mixed waste cost estimates are lower because the acceleration of the high-level waste treatment facilities, which generates low-level mixed waste as a byproduct, forces the acceleration of the low-level mixed waste program.

Table 5.8. Differences in 1995 and 1996 Cost Estimates at the Idaho National Engineering Laboratory

Activity	1995 Estimate*	1996 Estimate	Difference
Spent Nuclear Fuel Management	$4.7 billion	$1.4 billion	$3.3 billion / 70%
High-Level Waste Management	$6.2 billion	$3.4 billion	$2.8 billion / 45%
Remedial Action	$3.6 billion	$1.7 billion	$1.9 billion / 53%
Waste Management Support	$4.2 billion	$3.0 billion	$1.2 billion / 29%
Low-Level Mixed Waste Management	$1.2 billion	$0.2 billion	$1.0 billion / 83%
Nuclear Material and Facility Stabilization Support	$4.7 billion	$4.0 billion	$0.7 billion / 15%
Other Areas	$5.3 billion	$5.0 billion	$0.3 billion / 6%
Total	$29.9 billion	$18.6 billion	$11.3 billion / 38%

* Inflated to constant 1996 dollars for comparison.

The other major cost difference between the two estimates is in the remediation cost estimates, which dropped from $4 billion in the 1995 report to $2 billion in 1996. The reduction is due primarily to the 1996 Baseline Report assumption that fewer pits and trenches will need remediation than anticipated in 1995. This new assumption is based on the outcomes of past agreements with regulators.

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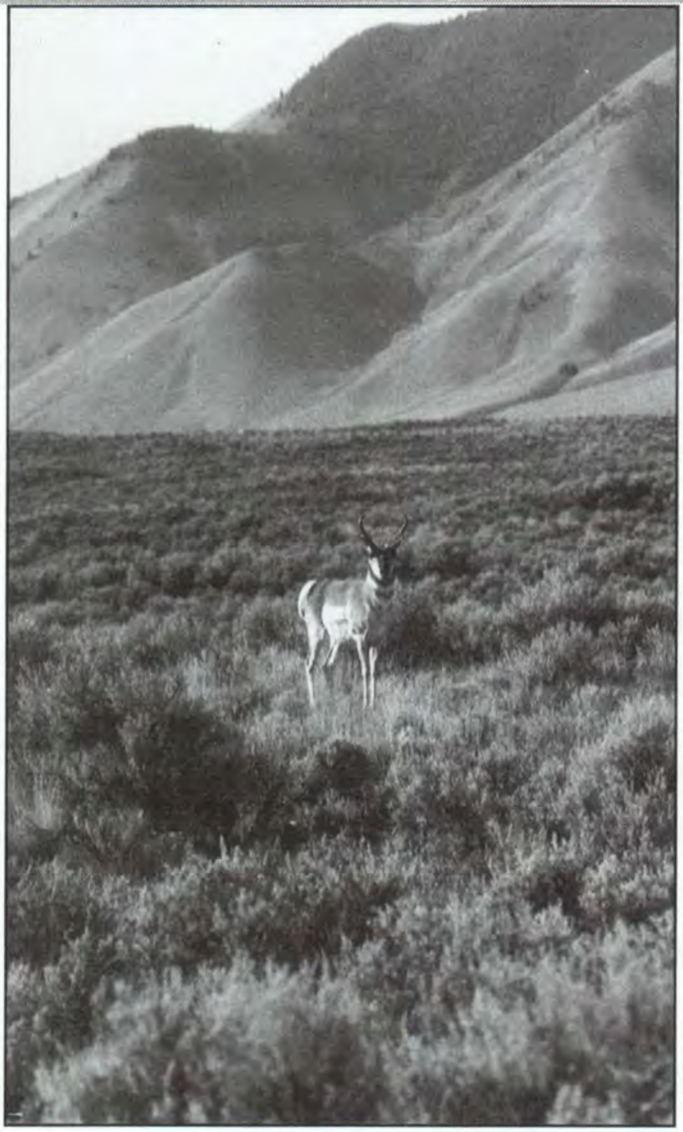

Pronghorn Antelope at the Idaho National Engineering Laboratory, 1993. *The paradox at many former nuclear weapons facilities is that, although localized, and sometimes hazardous, radioactive contamination exists, most of the land area is very rich ecologically because the habitat has been protected for safety and security reasons. As a result of decades of restrictions on most human activities, such as construction, mining, logging, fishing, or hunting, most of the land is already suitable for use as wildlife habitat, although it may pose unacceptable risks for residential use because of unexploded ordnance or other contamination. Life-cycle planning requires that long-term land use be considered in developing cleanup plans, so that funding is focussed on achieving an agreed-to end state.*

Future Site of the Portsmouth Gaseous Diffusion Plant, Portsmouth, Ohio, 1953. *Decisions concerning future land uses at Department of Energy sites, and the costs and other consequences of those decisions, will determine whether a site is partially or fully cleaned up to its pre-construction state. These decisions have an immense impact on life-cycle analyses.*

8.0 CONCLUSION

Like all recently formed organizations, the Environmental Management program spent its first several years building a foundation: defining its mission, gauging its scope, identifying key issues and priorities, and assembling an infrastructure to support successful planning and management. Since 1989, the program has introduced many planning initiatives focused on gathering programmatic data and providing a basis for strategic planning and program analysis. However, most of these initiatives failed to evaluate the Environmental Management program from a life-cycle perspective.

The program has matured significantly in seven years. The Department has now identified the program's basic scope and where the greatest risks lie. In addition, the baseline process has established a capability for projecting future costs and schedules, analyzing changes in assumptions and potential scenarios, and accounting for the interconnections between its distinct sites and programs. This analytical foundation for sound program management is summarized in the 1996 Baseline Report. Using the foundation that the Baseline Report now provides, program managers and policymakers can make more informed decisions regarding the direction of the Environmental Management program and of the elements that affect the program.

The purpose of the Baseline Report is to articulate clearly two elements of the Department of Energy's Environmental Management program: projected life-cycle costs and schedules. The Baseline Report describes the program, with Base Case results, from a variety of perspectives: for the overall program, by functional element, according to geographical distribution and by functional activity or phase). Because of the many uncertainties inherent in estimating environmental management costs and schedules, the overall results are presented with a cost *range* rather than a single figure. The program's life-cycle cost range is based on Base Case estimates developed by site personnel for the mid-range estimate, with upper and lower bounds based on high and low confidence levels. This range spans from $189 billion to $265 billion. Also included in the overall results is a second range showing the impact of productivity savings on the Base Case. The productivity savings range, which spans from $195 billion to $241 billion, makes it clear that productivity improvements can have a substantial impact on the program's life-cycle cost.

Included in the Base Case results are two Base Case analyses: pollution prevention and science and technology development. These analyses assess the cost savings derived from pollution prevention and technology development activities over time.

Also included in the Baseline Report are three alternative scenario analyses: land-use, program and project scheduling, and minimal action. These analyses compare the impacts of various cases on the Base Case. They focus on the impacts of each case on several dimensions of the program including estimated life-cycle cost, schedule and end state. The scenario analyses include five land-use cases, three program and project scheduling cases, and one minimal action case. Comparison of these nine cases reveals that, *in the absence of current constraints*, changes to key program variables (such as land-use decisions) can have a significant effect on the estimated 75-year cost of the program and on the projected program end state.

Significant impacts resulted from two of the nine alternative cases: the Maximum Feasible Green Fields land use case and the Minimal Action case. In both cases, however, current constraints (for example, regulatory requirements) were adjusted or removed. The majority of the cases (seven) resulted in minimal changes to the Base Case. These cases were developed with current constraints intact. Thus, the analysis provided the important finding that projected costs and end states can be affected through policy decisions, but, in many cases, existing constraints make it difficult for significant changes to occur.

The Environmental Management program now has improved information available to analyze policy decisions and set a future course. The program is in a critical transition period; it faces near- and mid-term decisions that will have important long-term ramifications. Some of these decisions can be made now and adjusted later (if new information calls for a different course); others will require long-term commitment to a specific path. For example, the program is still considering which technologies to pursue over the next decade and which facilities to build for the treatment, storage and disposal of waste. These decisions require a long-term commitment and a near-term financial investment.

An important conclusion of the Baseline Report is that, by understanding the impacts of various policy decisions, decisionmakers and stakeholders can direct the program in a manner that minimizes life-cycle costs, reduces program schedules, optimizes program end states, and achieves maximum reduction of risks. However, a great deal remains to be done to ensure that issues highlighted in this Baseline Report are framed effectively; data and methodologies supporting subsequent analyses are continually improved; and interested stakeholders have a voice in the debate. Specific steps include the following:

- **Improve Life-Cycle Cost and Schedule Estimates:** The 1996 Baseline Report is the program's second attempt to develop a comprehensive life-cycle cost estimate. This report improves upon the estimates and analyses developed last year based on a new methodology (that is, a bottom-up approach that emphasizes field-developed estimates); better information in areas such as program scope and outyear costs; and improved integration across programs and sites. Because the program is constantly changing, however, these estimates will need to be adjusted and improved. In addition, the program must continue to address uncertainties and information gaps, with ongoing data gathering, refined models and updated assumptions.

- **Use the Baseline Report to Address Ongoing Issues, Analyze Program Options, Provide Input to Strategic Decisions, and Develop Ties to Program Budgets**: Although the results of the analyses included in the 1996 Baseline Report are not definitive, they provide examples of analyses that can be conducted. Many other alternate case and sensitivity analyses would benefit the program (for example, impacts of various regulatory changes, effects of increased privatization, and effects of greater waste minimization). These analyses can be used to help inform strategic planning decisions, better focus the program's near-term planning and budgeting, and support legislative and regulatory reform.

- **Promote Informed, Broad-based Citizen Involvement in the Debate on the Program's Future:** One of the "next steps" included in the 1995 Baseline Report was to include more stakeholders in the debate and proactively seek citizen's views (in subsequent Baseline Report cost estimates). The 1996 Baseline Report achieved the goal of greater stakeholder participation. However, the task of using the information to cultivate more informed debate on the program's future still lies ahead.

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APPENDIX A.1

1995 BASELINE ENVIRONMENTAL MANAGEMENT REPORT REQUIREMENTS[1]

(a) Annual Environmental Restoration Reports—

(1) The Secretary of Energy shall (in the years and at the times specified in paragraph (2)) submit to the Congress a report on the activities and projects necessary to carry out the environmental restoration of all Department of Energy defense nuclear facilities.

(2) Reports under paragraph (1) shall be submitted as follows:

(A) The initial report shall be submitted not later than March 1, 1995.

(B) A report after the initial report shall be submitted in each year after 1995 during which the Secretary of Energy conducts, or plans to conduct, environmental restoration activities and projects, not later than 30 days after the date on which the President submits to the Congress the budget for the fiscal year beginning in that year.

(b) Annual Waste Management Reports—

(1) The Secretary of Energy shall (in the years and at the times specified in paragraph (2)) submit to the Congress a report on all activities and projects for waste management, transition of operational facilities to safe shutdown status, and technology research and development related to such activities and projects that are necessary for Department of Energy defense nuclear facilities.

(2) Reports required under paragraph (1) shall be submitted as follows:

(A) The initial report shall be submitted not later than June 1, 1995.

(B) A report after the initial report shall be submitted in each year after 1995, not later than 30 days after the date on which the President submits to the Congress the budget for the fiscal year beginning in that year.

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[1] *National Defense Authorization Act for FY 1994*, Section 3153, "Baseline Environmental Management Reports," Public Law 103-160, November 30, 1993; 103d Congress, First Session; *codified at* 42 U.S. Code 7274k.

(c) Contents of Reports—A report required under subsection (a) or (b) shall be based on compliance with all applicable provisions of law, permits, regulations, orders, and agreements, and shall—

(1) Provide the estimated total cost of, and the complete schedule for, the activities and projects covered by the report; and

(2) With respect to each such activity and project, contain—

(A) A description of the activity or project;

(B) A description of the problem addressed by the activity or project;

(C) The proposed remediation of the problem, if the remediation is known or decided;

(D) The estimated cost to complete the activity or project, including, where appropriate, the cost for every five-year increment; and

(E) The estimated date for completion of the activity or project, including, where appropriate, progress milestones for every five-year increment.

(d) Annual Status and Variance Reports—

(1)

(A) The Secretary of Energy shall (in the years and at the time specified in subparagraph (B)) submit to the Congress a status and variance report on environmental restoration and waste management activities and projects at Department of Energy defense nuclear facilities.

(B) A report under subparagraph (A) shall be submitted in 1995 and in each year thereafter during which the Secretary of Energy conducts environmental restoration and waste management activities, not later than 30 days after the date on which the President submits to the Congress the budget for the fiscal year beginning in that year.

(2) Each status and variance report under paragraph (1) shall contain the following:

(A) Information on each such activity and project for which funds were appropriated for the fiscal year immediately before the fiscal year during which the report is submitted, including the following:

(i) Information on whether or not the activity or project has been completed, and information on the estimated date of completion for activities or projects that have not been completed.

(ii) The total amount of funds expended for the activity or project during such prior fiscal year, including the amount of funds expended from amounts made available as the result of supplemental appropriations or a transfer of funds, and an estimate of the total amount of funds required to complete the activity or project.

(iii) Information on whether the President requested an amount of funds for the activity or project in the budget for the fiscal year during which the report is submitted, and whether such funds were appropriated or transferred.

(iv) An explanation of the reasons for any projected cost variance between actual and estimated expenditures of more than 15 percent or $10 million, or any schedule delay of more than six months, for the activity or project.

(B) For the fiscal year during which the report is submitted, a disaggregation of the funds appropriated for Department of Energy defense environmental restoration and waste management into the activities and projects (including discrete parts of multiyear activities and projects) that the Secretary of Energy expects to accomplish during that fiscal year.

(C) For the fiscal year for which the budget is submitted, a disaggregation of the Department of Energy defense environmental restoration and waste management budget request into the activities and projects (including discrete parts of multiyear activities and projects) that the Secretary of Energy expects to accomplish during that fiscal year.

(e) Compliance Tracking—In preparing a report under this section, the Secretary of Energy shall provide, with respect to each activity and project identified in the report, information which is sufficient to track the Department of Energy's compliance with relevant federal and state regulatory milestones.

APPENDIX A.2

1996 BASELINE ENVIRONMENTAL MANAGEMENT REPORT REQUIREMENTS[1]

(a) Annual Environmental Restoration Reports—

(1) The Secretary of Energy shall (in the years and at the times specified in paragraph (2)) submit to the Congress a report on the activities and projects necessary to carry out the environmental restoration of all Department of Energy defense nuclear facilities.

(2) Reports under paragraph (1) shall be submitted as follows:

(A) The initial report shall be submitted not later than March 1, 1995.

(B) A report after the initial report shall be submitted in each year after 1995 during which the Secretary of Energy conducts, or plans to conduct, environmental restoration activities and projects, not later than 30 days after the date on which the President submits to the Congress the budget for the fiscal year beginning in that year.

(b) Annual Waste Management Reports—

(1) The Secretary of Energy shall (in the years and at the times specified in paragraph (2)) submit to the Congress a report on all activities and projects for waste management, including pollution prevention and transition of operational facilities to safe shutdown status, that are necessary for Department of Energy defense nuclear facilities.

(2) Reports required under paragraph (1) shall be submitted as follows:

(A) The initial report shall be submitted not later than June 1, 1995.

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[1] *National Defense Authorization Act for Fiscal Year 1994*, Section 3153, "Baseline Environmental Management Reports" Public Law 103-160, November 30, 1993; 103d Congress, First Session; *amended by National Defense Authorization Act for FY 1995*, Sec. 3160. "Elimination of Requirement for Five-Year Plan for Defense Nuclear Facilities" Public Law 103-337, October 5, 1994; 103d Congress, Second Session, *codified at* 42 U.S. Code 7274k.

(B) A report after the initial report shall be submitted in each year after 1995, not later than 30 days after the date on which the President submits to the Congress the budget for the fiscal year beginning in that year.

(c) Contents of Reports—A report required under subsection (a) or (b) shall be based on compliance with all applicable provisions of law, permits, regulations, orders, and agreements, and shall—

(1) Provide the estimated total cost of, and the complete schedule for, the activities and projects covered by the report;

(2) With respect to each such activity and project, contain—

(A) A description of the activity or project;

(B) A description of the problem addressed by the activity or project;

(C) The proposed remediation of the problem, if the remediation is known or decided;

(D) The estimated cost to complete the activity or project, including, where appropriate, the cost for every five-year increment;

(E) The estimated date for completion of the activity or project, including, where appropriate, progress milestones for every five-year increment; and

(F) A description of the personnel and facilities required to complete the activity or project; and

(3) Contain a description of the research and development necessary to develop the technology to conduct the activities and projects covered by the report.

(d) Annual Status and Variance Reports—

(1)

(A) The Secretary of Energy shall (in the years and at the time specified in subparagraph (B)) submit to the Congress a status and variance report on environmental restoration and waste management activities and projects at Department of Energy defense nuclear facilities.

(B) A report under subparagraph (A) shall be submitted in 1995 and in each year thereafter during which the Secretary of Energy conducts environmental restoration and waste management activities, not later than 30 days after the date on which the President submits to the

Congress the budget for the fiscal year beginning in that year.

(2) Each status and variance report under paragraph (1) shall contain the following:

(A) Information on each such activity and project for which funds were appropriated for the fiscal year immediately before the fiscal year during which the report is submitted, including the following:

(i) Information on whether or not the activity or project has been completed, and information on the estimated date of completion for activities or projects that have not been completed.

(ii) The total amount of funds expended for the activity or project during such prior fiscal year, including the amount of funds expended from amounts made available as the result of supplemental appropriations or a transfer of funds, and an estimate of the total amount of funds required to complete the activity or project.

(iii) Information on whether the President requested an amount of funds for the activity or project in the budget for the fiscal year during which the report is submitted, and whether such funds were appropriated or transferred.

(iv) An explanation of the reasons for any projected cost variance between actual and estimated expenditures of more than 15 percent or $10 million, or any schedule delay of more than six months, for the activity or project.

(B) For the fiscal year during which the report is submitted, a disaggregation of the funds appropriated for Department of Energy defense environmental restoration and waste management into the activities and projects (including discrete parts of multiyear activities and projects) that the Secretary of Energy expects to accomplish during that fiscal year.

(C) For the fiscal year for which the budget is submitted, a disaggregation of the Department of Energy defense environmental restoration and waste management budget request into the activities and projects (including discrete parts of multiyear activities and projects) that the Secretary of Energy expects to accomplish during that fiscal year.

(e) Compliance Tracking—In preparing a report under this section, the Secretary of Energy shall provide, with respect to each activity and project identified in the report, information which is sufficient to track the Department of Energy's compliance with relevant federal and state regulatory milestones.

(f) Public Participation in Development of Information—

(1) The Secretary of Energy shall consult with the Administrator of the Environmental Protection Agency, the Attorney General, Governors and Attorneys General of affected states, appropriate representatives of affected Indian Tribes, and interested members of the public in the development of information necessary to complete the reports required by subsections (a), (b), and (d).

(2) Consultation under paragraph (1) shall not interfere with the timely submission to Congress of the budget for a fiscal year.

(3) The Secretary may award grants to, and enter into cooperative agreements with, affected states and affected Indian Tribes to facilitate the participation of such entities in the development of information under this subsection. The Secretary may also take appropriate action to facilitate the participation of interested members of the public in such development under this subsection.

1996 BASELINE ENVIRONMENTAL MANAGEMENT REPORT PUBLIC PARTICIPATION IN PLANNING REQUIREMENTS [2]

(e) Public Participation in Planning.— The Secretary of Energy shall consult with the Administrator of the Environmental Protection Agency, the Attorney General, Governors and Attorneys General of affected states, appropriate representatives of affected Indian Tribes, and interested members of the public in any planning conducted by the Secretary for environmental restoration and waste management at Department of Energy defense nuclear facilities.

[2] *National Defense Authorization Act for Fiscal Year 1995*, Sec. 3160(e) "Elimination of Requirement for Five-Year Plan for Defense Nuclear Facilities" Public Law 103-337, October 5, 1994.

APPENDIX B

THE ENVIRONMENTAL LEGACY

INTRODUCTION

During World War II and the Cold War, the manufacture of nuclear weapons progressed through a wide series of research, testing, and production at laboratories, chemical plants, nuclear reactors, machine shops, and test sites throughout the United States. The resulting environmental legacy includes radioactive and hazardous waste contamination, numerous contaminated buildings, and unneeded materials at many installations across the nation. The risks to human health and the environment from these activities vary from negligible to substantial.

Although the primary responsibility of the Environmental Management program is to address the risks posed by past nuclear weapons production activities, the program must also attend to contaminants resulting from activities outside the nuclear weapons production complex. The program must, for example, address hazardous and/or radioactive waste from nonweapons sources, including energy research, basic science, and the Three Mile Island nuclear power plant accident. The program also manages newly generated radioactive waste from ongoing programs throughout the Department of Energy, as well as spent nuclear fuel generated by the U.S. Naval Nuclear Propulsion Program and foreign research reactors.

The Department of Energy is preparing an Environmental Impact Statement to determine whether to adopt and implement a policy concerning management of additional spent fuel from domestic and foreign research reactors that contain uranium enriched in the United States. This effort is in support of the United States' nuclear nonproliferation policy. A Record of Decision concerning the foreign research reactor fuel is anticipated in April 1996.

In the future, the Environmental Management program will manage waste from weapons dismantlement and related maintenance activities. This appendix describes the environmental legacy of nuclear weapons production in the United States.

THE CAUSES OF THE ENVIRONMENTAL LEGACY

Perhaps the most important characteristic of the environmental legacy of nuclear weapons production is its dynamic nature. The environmental cost of 40 years of weapons production represents nearly 80 percent of the Environmental Management program's responsibilities. The balance results from activities similar to, but outside the realm of, nuclear weapons production. The scope of the environmental legacy has grown over many years. Today, contamination is being removed from the land, remediated in place, or contained to prevent its further spread; old facilities are being decontaminated, dismantled, and demolished; stored waste is being disposed of even as new waste is being generated; uncontained contamination is spreading by natural dispersion; and radioactive materials and chemical contaminants are decaying or deteriorating as time passes.

SOURCES OF CONTAMINATION

The process of manufacturing nuclear weapons relied on the production of three materials: highly enriched uranium, plutonium, and tritium. Production of these materials took place at an array of facilities throughout the United States. Nuclear weapons production at facilities such as the Plutonium Uranium Reduction Extraction Plant at Hanford Site, Washington; Building 771 at the Rocky Flats Environmental Technology Site near Denver, Colorado; and the F and H Canyons at the Savannah River Site in South Carolina resulted in the largest sources of contamination.

Figure B.1 shows the scope of the Environmental Management program. The following is a brief description of each step in the nuclear weapons manufacturing process, and the resulting contamination:

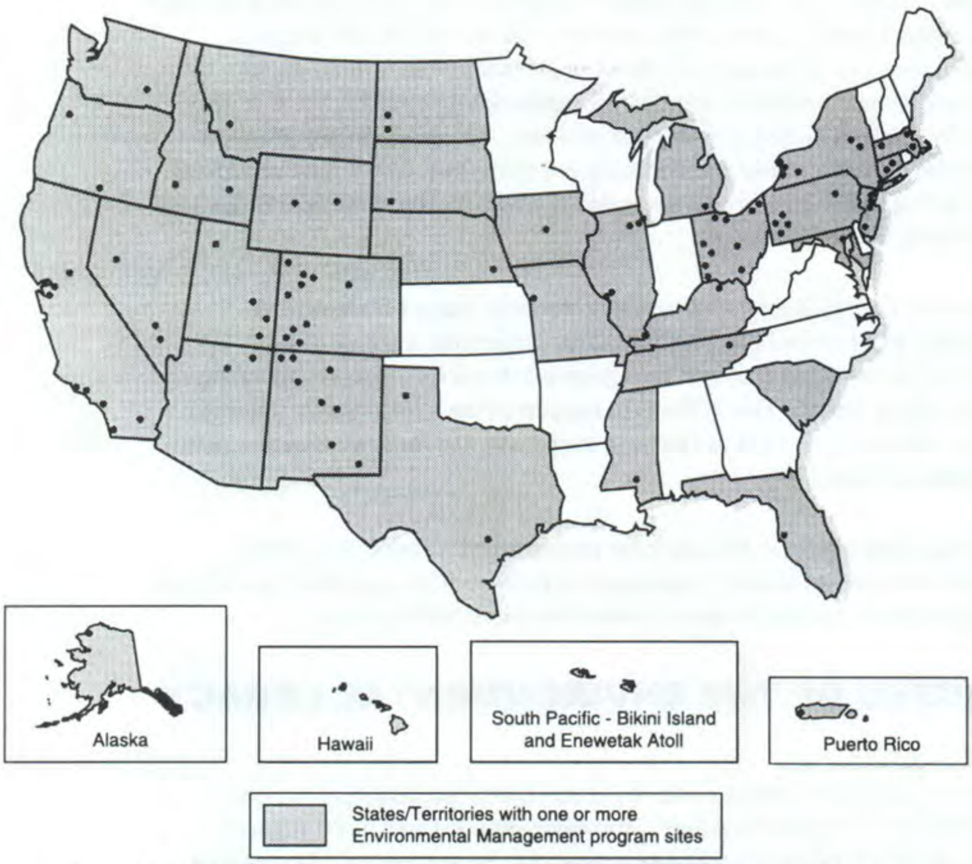


Figure B.1. The U.S. Department of Energy Environmental Management Program: Responsibilities from Coast-to-Coast and Beyond

Uranium Mining and Milling: Approximately 54.4 metric tons (60 million tons) of uranium ore were mined and milled in the United States for nuclear weapons production, primarily in western states. Most of this activity was carried out in the 1950s and 1960s. The environmental legacy of these operations includes large volumes of a sand-like byproduct known as "mill tailings," which contain toxic heavy metals and radioactive radium and thorium. The radioactivity present is a small fraction of the total radioactive material managed by the Environmental Management program. However, because of wind-blown waste and the use of some tailings in construction and landscaping projects, the contamination from these tailings affected thousands of individual sites.

Uranium Enrichment: At uranium enrichment plants in Ohio, Kentucky, and Tennessee, the mined and milled uranium-238 was enriched and separated to produce weapons-grade uranium-235 in the form of uranium hexafluoride gas. The environmental legacy of the enrichment process includes depleted uranium, large volumes of radioactive and hazardous waste, and facilities contaminated with radioactive materials, solvents, polychlorinated biphenyls, heavy metals, and other toxic substances.

Fuel and Target Fabrication: The uranium hexafluoride gas produced at the enrichment plants was converted into metal (uranium targets) at fuel and target fabrication facilities in the States of South Carolina and Washington. The environmental legacy of this step in the production of nuclear weapons includes unintended releases of uranium dust, landfills contaminated with hazardous chemicals, and facilities contaminated with radioactive and hazardous materials.

Reactor Irradiation: The uranium targets from fuel and fabrication plants were irradiated in 14 production reactors in the States of South Carolina and Washington to produce plutonium. This step produced radioactive spent fuel and radioactive contamination of reactor and storage facilities near large rivers.

Chemical Separation: The fission products and uranium and plutonium from spent fuel were reprocessed at chemical separation facilities in the States of Washington, Idaho, and South Carolina. This step in the production process generated approximately 385 million liters (100 million gallons) of highly radioactive and hazardous chemical waste. Some of this waste was discharged directly into the ground or stored in underground storage tanks. Some of the waste in underground storage subsequently leaked. This waste represents the vast majority of the radioactivity for which the Environmental Management program has responsibility. Many of the radioactive elements in this waste are long-lived and will pose risks to human health and the environment for tens of thousands of years. Contaminated facilities also have resulted from chemical separation.

Fabrication of Weapons Components: Plutonium was machined into warhead components at facilities in the States of Colorado, Washington, and Tennessee. Laboratories associated with the production complex also used plutonium to make and test weapons prototypes. This part of the production process resulted in transuranic waste and contaminated facilities.

Fabrication of Nonnuclear Weapons Components: Nonnuclear components required for weapons assembly were manufactured at plants in Texas, Missouri, Ohio, and Florida. Soil contamination from high-explosive waste, fuel and oil leaks, and solvents resulted from this part of the process.

Weapons Assembly, Disassembly, and Maintenance: Final assembly of nuclear warheads in Texas and Iowa resulted in radioactive and hazardous chemical contamination of facilities. In the years ahead, dismantling nuclear weapons at the Department's weapons assembly facilities will generate radioactive and chemical waste that must be safely managed. In addition, throughout the Cold War the government contracted with private firms to perform research and manufacturing, usually related to nuclear weapons production. As a result, radioactive contamination occurred at 46 sites in 14 states. These sites are collectively referred to as "formerly utilized sites."

Research, Development, and Testing: Between 1945 and 1992, over 1,000 nuclear devices were exploded in atmospheric, underwater, and underground tests. Most of the nuclear weapons tests were conducted in Nevada, but tests were also carried out in the Pacific and South Atlantic Oceans, Alaska, and New Mexico. Nuclear explosion tests were also conducted in Colorado, New Mexico, Mississippi, and Alaska for nonweapons purposes. The environmental legacy of these tests includes hundreds of highly radioactive underground craters as well as soil and debris contaminated with low-level radioactive waste. Nonnuclear weapons components were also tested, leaving a legacy of contamination from high-explosive materials and other chemicals.

APPENDIX D
LAND-USE ANALYSIS SITE-SPECIFIC RESULTS

Chapter 6 presents the land-use sensitivity analysis for the five highest-cost sites: Hanford Site, Idaho National Engineering Laboratory, Oak Ridge Reservation, Rocky Flats Environmental Technology Site, and Savannah River Site. The tables in Chapter 6 depict results that are summaries of the individual site results. The lower-level site results that support those summarized results are presented here for interested readers.

- Site Maps, Acreage, and Findings Summaries - Included in this appendix are two versions of each site's Base Case map showing end-state conditions. One map employs land-use standards to depict how clean sites will be (Maximum Allowable Use) and a contrasting version shows the site's assumed uses (Likely Use). Tables provide acreage by land-use standard and cost totals for the alternative scenarios and the Base Case. In addition, significant findings are included for each site.

- Site-Specific Constraints - Following the maps and summary information is a discussion of constraints at sites which limit the Department's consideration of future uses. A summary of contraints at sites is also included.

The methodology to conduct this analysis is detailed in Appendix C. Discussions of complex-wide implications are discussed in Chapters 6 and 7.

FRAMING THE RESULTS

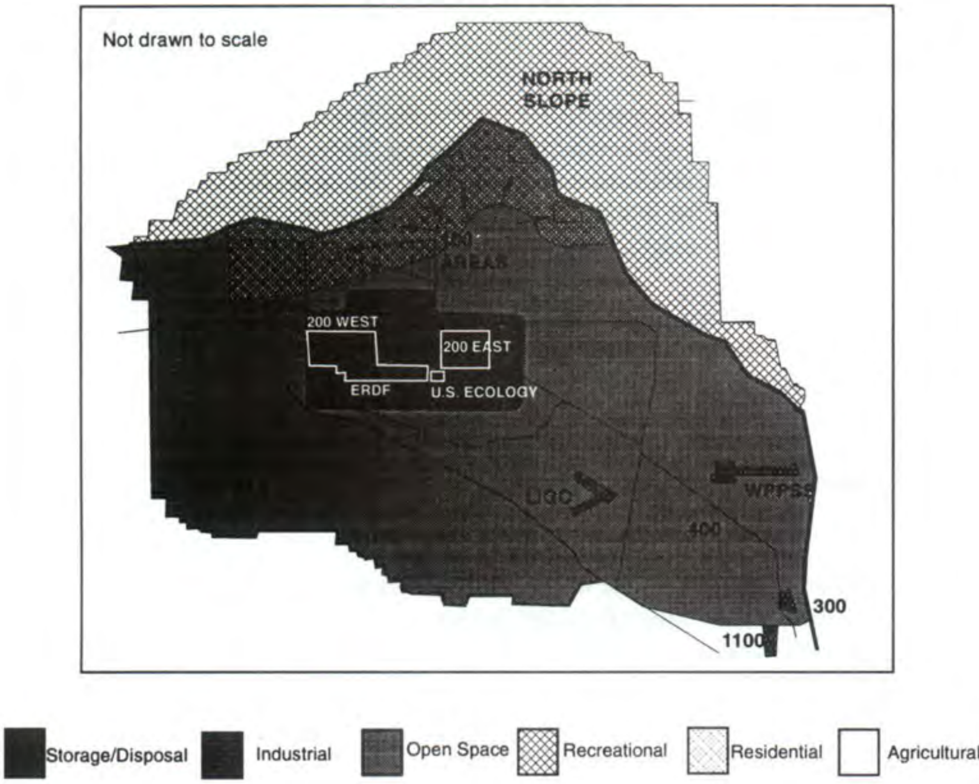
The land-use analysis was undertaken to produce information for national-level policy discussions. Most sites have conducted extensive studies of land-use alternatives for their individual sites, which have involved site stakeholders and regulators. This policy-level analysis cannot substitute for the community-level analysis needed to make decisions. The factors that affect land-use decisions have been summarized, and the relative prioritization of those factors, developed by site communities, has been captured here.

The site-specific results are presented only as background information to the analysis in Chapter 6. Although care was taken to capture site-specific conditions correctly, some inaccuracies may have resulted from summarizing and generalizing the data necessary for the national analysis.

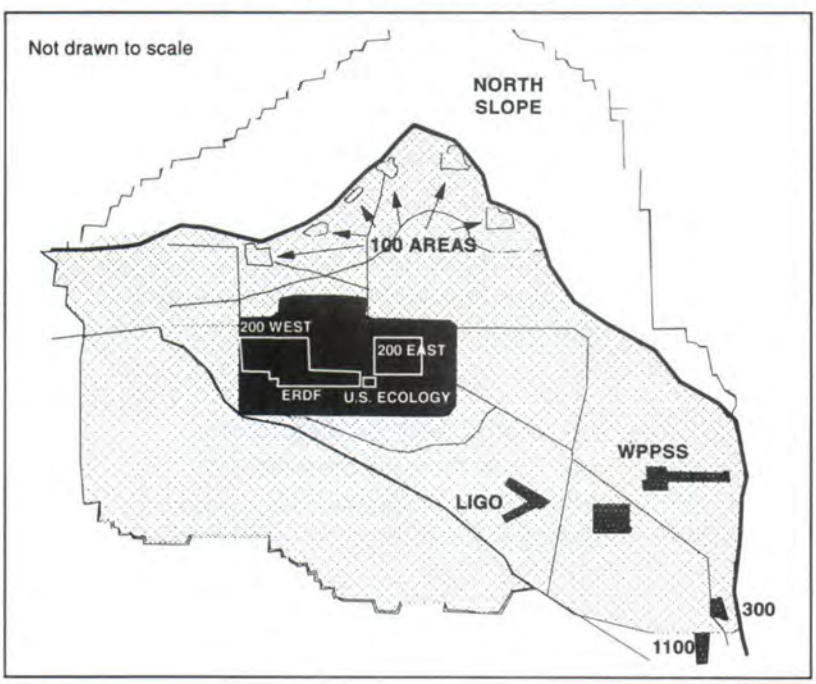
Those seeking information concerning individual site land-use alternatives and analyses should consult the future-use points of contact at the individual sites. A listing of those representatives and source documents relating to site future use are provided at the end of this appendix. Appendix H is a listing of site reading rooms that provide access to such reports and documents.

HANFORD SITE

Base Case Likely Use



Base Case Maximum Allowable Use



Hanford

LAND-USE SUMMARY

The majority of land on the Hanford Site currently meets Residential use standards and, of the remaining land, the Department actively uses only 3,300 hectares (8,150 acres) for industrial and storage/disposal activities. The storage of plutonium onsite is a major determinant of future land use because of buffer area and emergency planning requirements. In addition, the disposal and waste management activities in the 200 Area require an appropriate buffer area. As a result, the anticipated land use at the site is different from the maximum allowable use.

The site's Base Case cleanup strategies are aggressive in the 100 Area, assuming the complete dismantlement of the six reactors, removal of the reactor cores, and extensive excavation of contaminated soils. In contrast, the 200 Area remains Controlled Access for storage/disposal and waste management activities in all alternative cases. These two factors limit the range of variability in alternative land-use scenarios and their cleanup costs.

Alternative Land-Use Case Acreages*

Land-Use Standard	Base Case		Iron Fence	Industrial	Recreational	Modified Green Fields	Maximum Feasible Green Fields
	Likely Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use
Storage & Disposal	6,000	6,000	6,640	6,640	6,640	6,000	6,000
Open Space	278,000	0	0	0	0	0	0
Industrial	2,400	2,500	2,500	2,500	2,500	2,400	2,300
Recreational	72,000	0	16,360	16,360	16,360	0	0
Residential	0	261,000	244,000	244,000	244,000	261,100	261,200
Agricultural	0	89,000	89,000	89,000	89,000	89,000	89,000
COST	$50.2 billion		$47.7 billion	$49.1 billion	$49.2 billion	$51.0 billion	$51.7 billion

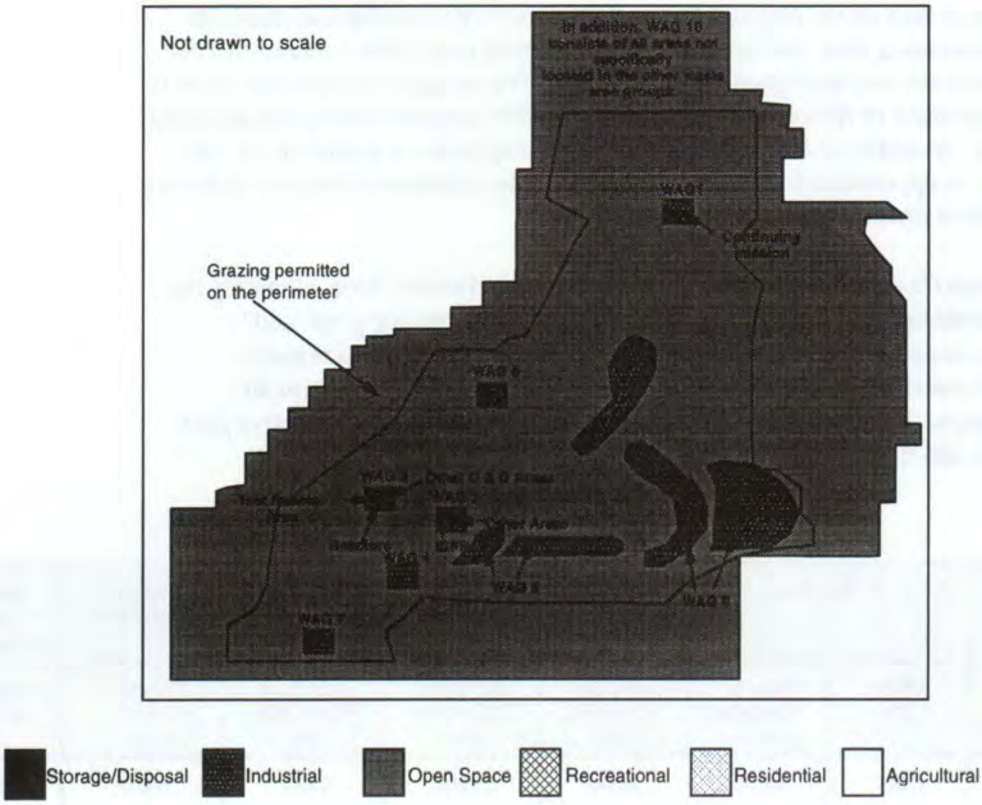
***Acre numbers have been rounded for presentation**

MAXIMUM FEASIBLE GREEN FIELDS

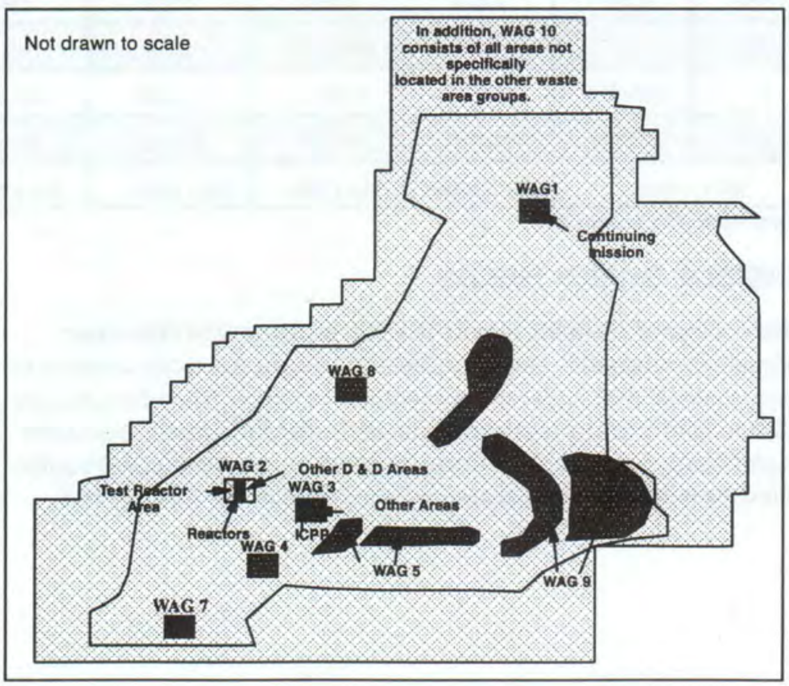
In this most aggressive cleanup scenario, almost 101,000 hectares (250,000 acres) could meet Residential use standards. However, since the disposal activities remain in the 200 Area, the associated buffer requirements continue to apply. Therefore, despite a significant increase in land meeting residential standards, the anticipated uses in this case do not vary significantly from the Base Case. In addition, the Maximum Feasible Green Fields case results in the loss of industrial infrastructure in the 300 and 400 areas.

IDAHO NATIONAL ENGINEERING LABORATORY

Base Case Likely Use



Base Case Maximum Allowable Use



Idaho National Engineering Laboratory

LAND-USE SUMMARY

The Idaho National Engineering Laboratory is the largest and most remote of the five sites included in the analysis. Under the Base Case, 99 percent of the land area meets the land-use standard for Residential use, as only small areas of the site were used for production or storage/disposal activities. The contaminated areas and facilities present only limited opportunities for alternative land uses. In addition, the site's Base Case decommissioning assumptions are aggressive, assuming "clean closure" and removal of all contaminated material. As a result, the Base Case costs approximate the Modified and Maximum Feasible Green Fields costs. The only major change in land use occurs in the Iron Fence Case, in which a large area of approximately 77,600 hectares (192,000 acres) containing unexploded ordnance is not fully remediated.

Alternative Land-Use Case Acreages*

Land-Use Standard	Base Case		Iron Fence	Industrial	Recreational	Modified Green Fields	Maximum Feasible Green Fields
	Likely Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use
Storage & Disposal	184	184	184	184	156	156	156
Open Space	524,816	0	192,000	0	0	0	0
Industrial	45,000	540	540	540	540	485	171
Recreational	0	0	0	0	28	28	0
Residential	0	569,276	377,276	569,276	569,276	569,331	569,673
Agricultural	0	0	0	0	0	0	0
COST	$18.5 billion		$17.2 billion	$17.3 billion	$17.3 billion	$18.5 billion	$19.0 billion

* Acre numbers have been rounded for presentation.

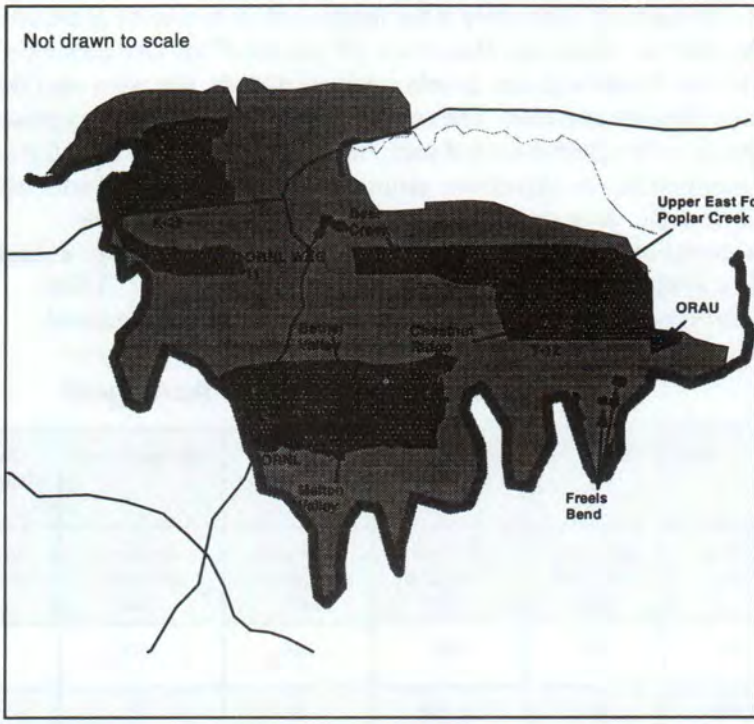
MAXIMUM FEASIBLE GREEN FIELDS

This most aggressive case for the Idaho National Engineering Laboratory results in only a small increase in cost from the Base Case. Some of the highest cost projects at the site (Idaho Chemical Processing Plant Tanks, Radioactive Waste Management Complex) have no other reasonable end state, and their costs remain constant across the alternative cases. Under this scenario, only an additional 160 hectares (400 acres) of land are added to the Residential use category.

While the site is essentially clean, its remote location and environmental setting limit any interest in reuse or redevelopment. In addition, State laws prohibiting new wells in the Snake River Plain Aquifer preclude any possibility of Residential or Agricultural use.

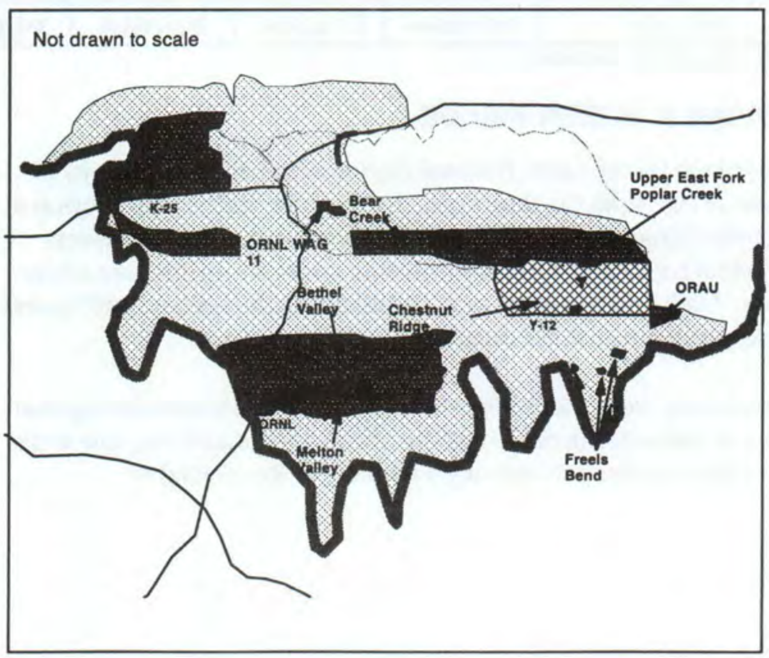
OAK RIDGE RESERVATION

Base Case Likely Use



Storage/Disposal | Industrial | Open Space | Recreational | Residential | Agricultural

Base Case Maximum Allowable Use



Oak Ridge Reservation

LAND-USE SUMMARY

The Oak Ridge Reservation is the smaller of the two sites located in environmental settings with high water tables. While the majority of the site is uncontaminated, the compact nature of the site and the three major production areas limit use of that land to Open Space. In addition, the Oak Ridge National Laboratory and the Y-12 Plant have established continuing missions that limit their variability in all cases except Maximum Feasible Green Fields. A significant portion of cost at the site is allocated to monitoring and addressing the migration of contamination from numerous areas of buried waste. These costs remain constant for all cases except for Maximum Feasible Green Fields.

Alternative Land-Use Case Acreages*

Land-Use Standard	Base Case		Iron Fence	Industrial	Recreational	Modified Green Fields	Maximum Feasible Green Fields
	Likely Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use
Storage & Disposal	2,541	2,541	2,541	2,541	2,541	2,541	0
Open Space	28,932	0	1,735	0	0	0	0
Industrial	3,527	3,527	3,527	3,527	1,969	1,969	0
Recreational	0	1,735	0	1,735	3,283	1,735	0
Residential	0	27,197	27,197	27,197	27,197	28,755	35,000
Agricultural	0	0	0	0	0	0	0
COST	$25.1 billion		$22.9 billion	$24.3 billion	$28.5 billion	$29.1 billion	$132.0 billion

* Acre numbers have been rounded for presentation.

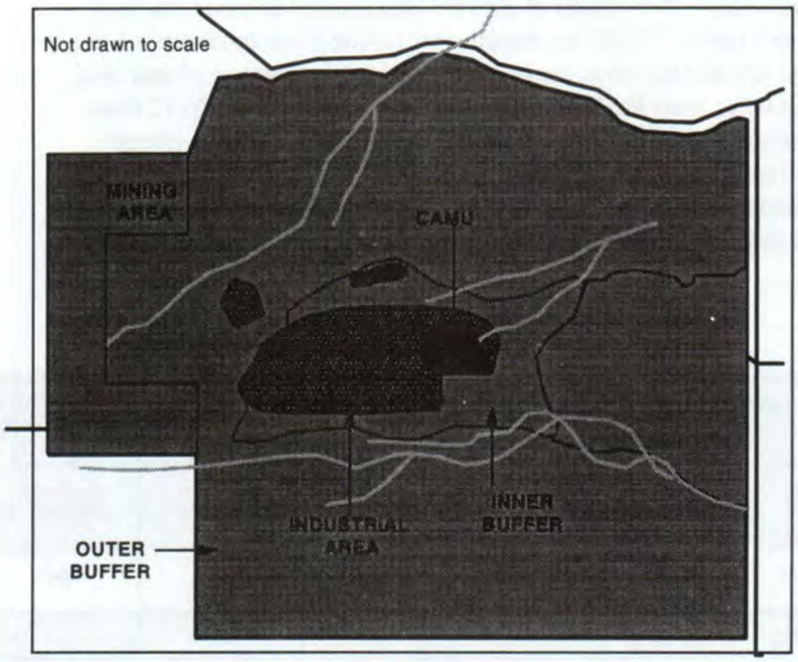
MAXIMUM FEASIBLE GREEN FIELDS

The Oak Ridge Maximum Feasible Green Fields scenario is the most aggressive cleanup proposed in the analysis. While the additional acreage meeting Residential land-use standards is not large, the task of excavating, treating and disposing large areas of buried waste at Oak Ridge National Laboratory, Y-12 Plant, and K-25 Plant, and large volumes of contaminated sediment from White Oak Lake result in a 520 percent increase in life-cycle cost. The majority of this cost increase is from treatment and disposal of previously buried waste. As in the other Maximum Feasible Green Fields scenarios, the existing industrial infrastructure is removed, and potentially sensitive habitat is disturbed.

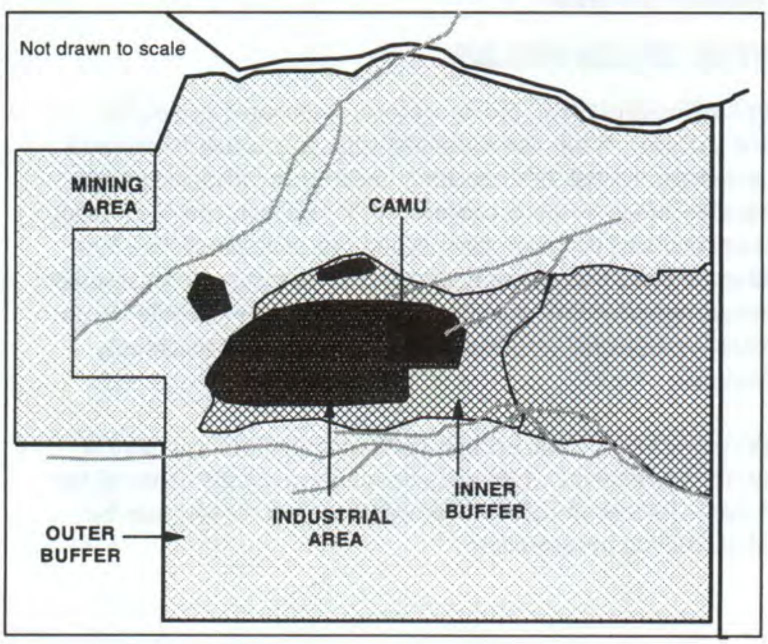
Under this scenario, the entire site is clean enough for Residential use and there is local interest in residential development of the site, especially along the banks of the Clinch River. Private sector interest in industrial development on the site may be limited by the removal of existing infrastructure.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Base Case Likely Use



Base Case Maximum Allowable Use



Rocky Flats

LAND-USE SUMMARY

The Rocky Flats Environmental Technology Site represents the smallest 2,500 hectares (6,216 acres) of the five sites discussed in this analysis. The majority of land is uncontaminated and meets Residential land-use standards, but is currently limited to use as a buffer area for the plutonium stored at the site. This buffer area contains large areas of sensitive tall grass prairie habitat as well as Preble's jumping field mouse habitat. The core area of the site is the focus of cleanup efforts and measures only 155 hectares (384 acres). Under all cases, except for Maximum Feasible Green Fields, this core area attains Industrial land-use standards to allow for potential environmental technology development activities.

Alternative Land-Use Case Acreages*

Land-Use Standard	Base Case		Iron Fence	Industrial	Recreational	Modified Green Fields	Maximum Feasible Green Fields
	Likely Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use
Storage & Disposal	68	68	68	68	68	68	0
Open Space	5,688	0	0	0	0	0	0
Industrial	460	460	460	460	460	460	0
Recreational	0	1,227	1,227	1,227	1,227	1,227	0
Residential	0	4,461	4,461	4,461	4,461	4,461	6,216
Agricultural	0	0	0	0	0	0	0
COST	$17.3 billion		$15.8 billion	$17.3 billion	$17.3 billion	$17.4 billion	$26.0 billion

* Acre numbers have been rounded for presentation.

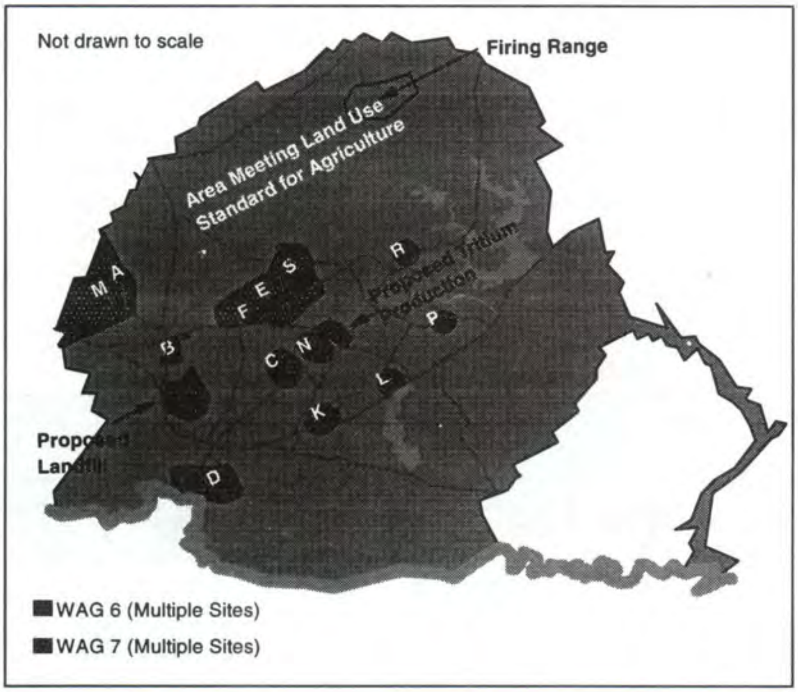
MAXIMUM FEASIBLE GREEN FIELDS

The Maximum Feasible Green Fields scenario for this site envisions the complete removal of all contaminated soil, building materials, and previously buried waste. Under this scenario, the entire site meets Residential use standards. The excavation of buried waste and the disposal of all remediation waste at an offsite location results in a significant (50 percent) increase in life-cycle cost. In addition, cleanup activities remove all existing industrial infrastructure and disturb/damage tall grass prairie and jumping mouse habitat.

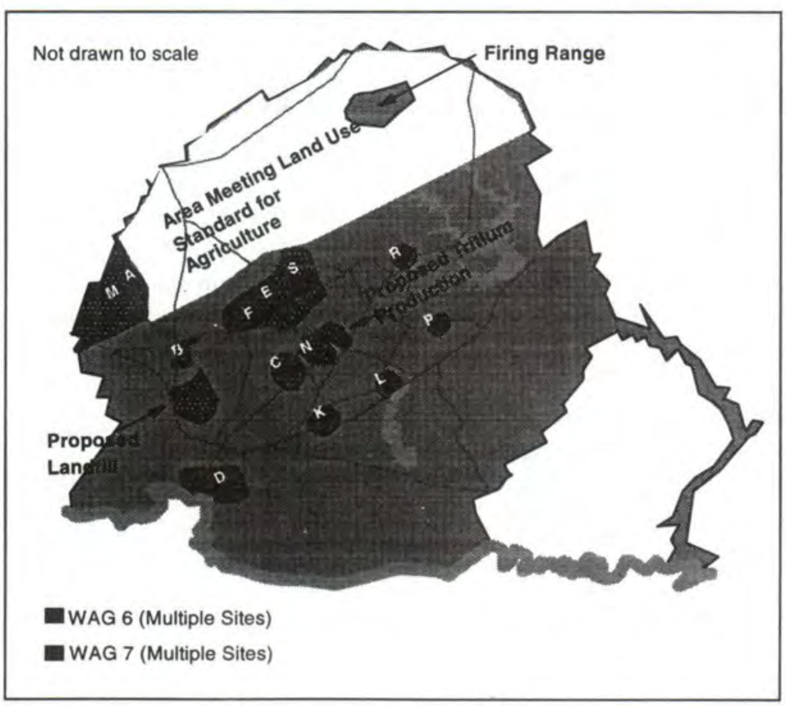
While land at the site would be clean enough to support Residential uses, the extensive private ownership of mineral rights may preclude full residential development. Some of the land might eventually be dedicated to residences, wildlife management areas, and mining activities.

SAVANNAH RIVER SITE

Base Case Likely Use



Base Case Maximum Allowable Use



Savannah River Site

LAND-USE SUMMARY

The Savannah River Site is the larger of the two sites (the other being Oak Ridge Reservation) located in humid environmental settings. The majority of the surface area at the site is uncontaminated. However, contaminated surface waters and sediment (streams south of production areas, L Lake, Par Pond) limit most of the remainder of the site to Open Space use. The area of the site north of the production areas is not affected by surface or ground-water contamination and therefore meets the land-use standard for Agricultural use.

The Base Case remediation strategy assumptions at this site are quite aggressive and, as a result, the Base Case costs at Savannah River Site approach those for the Recreational scenario. In addition, the end state of the five reactors and two chemical processing buildings is held constant, thereby limiting the variability of costs associated with alternative land-use cases.

Alternative Land-Use Case Acreages*

Land-Use Standard	Base Case		Iron Fence	Industrial	Recreational	Modified Green Fields	Maximum Feasible Green Fields
	Likely Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use	Maximum Allowable Use
Storage & Disposal	645	645	4,145	645	645	645	645
Open Space	190,755	147,255	147,255	147,255	103,255	0	0
Industrial	6,600	6,600	3,100	6,600	4,300	4,300	2,400
Recreational	0	0	0	0	46,300	149,555	0
Residential	0	0	0	0	0	0	150,955
Agricultural	0	43,500	43,500	43,500	43,500	43,500	44,000
COST	$48.8 billion		$46.8 billion	$46.9 billion	$49.4 billion	$49.7 billion	$54.8 billion

*** Acre numbers have been rounded for presentation.**

MAXIMUM FEASIBLE GREEN FIELDS

The Maximum Feasible Green Fields Case for the Savannah River Site is limited by the possible end state for the five reactors, the chemical processing buildings and the Storage/Disposal Areas in the E, F, and H Areas. All these areas remain Controlled Access for storage and disposal because more aggressive remediation or decommissioning strategies pose the possibility of spreading more contamination to ground and surface water. Excavation, treatment, and removal of contaminated sediments in streambeds and Carolina Bay wetlands brings the majority of the site to Residential standards, with the corresponding disturbance of those sensitive habitats. Industrial infrastructure is removed and the potential for private sector reuse is reduced. The interest for residential development is limited, and given the environmental setting, it is likely that most of land would be used for resource or wildlife management areas.

SITE-SPECIFIC CONSTRAINTS ON FUTURE LAND USE

The site-specific summaries presented above discussed land use primarily in terms of "maximum allowable use" (i.e., the standards that exist currently or could be achieved). While such uses can be achieved in theory, other factors such as legal commitments and ongoing mission needs may affect whether such uses are *likely* to be achieved. To illustrate how site-specific constraints may affect future use, the following table compares, for the Base Case, maximum allowable future land use with the most likely future land use at the five highest-cost sites.

Comparison of Maximum Allowable and Anticipated Land Use

Land-Use Category	Maximum Allowable Use (Acres*)	Likely Use (Acres*)
Agricultural	132,500	0
Residential	861,000	0
Recreational	3,000	72,000
Industrial	14,000	58,000
Open Space	147,500	1,028,000
Storage and Disposal	10,000	9,500
Total Acres	1,167,500	1,167,500

***Acre numbers have been rounded for presentation**

This comparison indicates that nearly 400,000 hectares (1 million acres) (85 percent of the total land area) at these sites currently meet or could be remediated to meet Residential or Agricultural use standards. However, none of these acres are likely to be used for agriculture or residences, given site-specific constraints. Instead, these areas are likely to be used for Open Space, Recreational, or Industrial purposes. At the Idaho National Engineering Laboratory, for example, all of the land with maximum allowable use designated as Residential is most likely to be used for Open Space or Industrial purposes.

The following paragraphs provide examples of how several key types of site-specfic constraints may affect future land use.

Legal Commitments — At some sites, future land-use and technology strategy has been determined through the regulatory process (e.g., a signed Record of Decision). A host of other legal commitments exist. Local laws can place restrictions on access to ground water (e.g., the Snake River Plain Aquifer in Idaho). All these legal mechanisms limit land uses considered for federally controlled sites or place land-use decisionmaking in the hands of other parties. Legal commitments limit future-use options for approximately 292,000 hectares (720,000 acres) (77 percent) of the uncontaminated land at the five highest-cost Environmental Management sites.

Technical Constraints — Some contamination problems (e.g., ground water contaminated with tritium) have no viable removal strategies compatible with

Agricultural or Residential land uses. Containment technologies and restrictions on ground-water use are the only means to manage such problems. Other contamination problems present unacceptably high risks to workers using conventional construction-type removal technologies and must be remediated by use of remote or robotic technologies. Technical constraints restrict future-use options for approximately 38,300 hectares (95,000 acres) (10 percent) of the uncontaminated land and 17,400 hectares (43,000 acres) (20 percent) of the contaminated land at the five highest-cost Environmental Management sites.

Safeguarding of Natural, Historical and Cultural Resources — The buffer areas at several Environmental Management sites support endangered species (e.g., red-cockaded woodpeckers at the Savannah River Site) or ecologically unique habitats (e.g., the tall grass prairie at the Rocky Flats Environmental Technology Site). Certain buildings are part of the nation's historical heritage due to their role in developing nuclear weapons and energy and have been designated National Historic Landmarks. These resources limit future use for approximately 56,500 hectares (140,000 acres) of uncontaminated land and some contaminated land at the five highest-cost sites.

Site Safety Considerations — Site safety considerations require that activities be limited to land for ongoing missions including research and storage/disposal of waste. In addition to land for housing these activities, in the past large areas of land have been set aside to provide buffer zones for those activities involving dangerous materials and weapons production. Future site missions, including long-term storage of nuclear weapons material, will determine whether those buffer zones can be contracted or must be maintained. Current projected land uses include only minimal buffers around disposal areas and do not include buffers for future research or storage missions. Approximately 2,600 hectares (6,500 acres) (3 percent) of contaminated land are restricted for storage, disposal and buffer purposes at the five highest-cost Environmental Management sites.

Practical Constraints — Given that permanent disposal of waste and continued research missions are planned for portions of four of the five sites analyzed, there are practical limitations to the future use of land adjacent to storage/disposal or research facilities. Spatial relationships are also significant. Parcels of clean land effectively surrounded by industrial or waste storage/disposal areas cannot be effectively used for many activities. Spatial and other practical constraints limit future-use options for approximately 20,000 hectares (50,000 acres) (5 percent) of uncontaminated land at the five sites analyzed.

Although a comprehensive listing would be too extensive here, a summary of the key factors constraining land use at the five highest-cost sites is included in the following table to provide a greater understanding of individual site constraints.

Key Constraints at Five Highest-Cost Sites

	Savannah River Site	Hanford Site	Idaho National Engineering Laboratory	Rocky Flats Environmental Technology Site	Oak Ridge Reservation
Permanent Disposal Areas	• Burial Grounds • Sanitary Landfill • Proposed Regional Landfill	• Environmental Restoration Disposal Facility • 200 Area	• Radioactive Waste Management Complex • Idaho Chemical Processing Plant	• Corrective Action Management Unit • Old Landfill • New Sanitary Landfill	• Burial Grounds at Oak Ridge National Laboratory, K-25, and Y-12
Entombed Facilities	• Process Areas • Reactors	• Process Areas • Fast Flux Test Facility			
Ongoing Mission	• B Area • New Tritium Facility	• Laser Interferometer Gravitational Wave Observatory • Pacific Northwest National Laboratory	• Army Tank Shielding Facility	• Environmental Technology Development	• Oak Ridge National Laboratory • Y-12 Defense Programs • Oak Ridge Associated Universities Energy Research
Private Reuse of Facilities/Land	• M Area		• Boron Capture Facility		• K-25 • Oak Ridge National Laboratory
Technology Limits	• Savannah River • Ground Water • Burial Grounds	• Columbia River • Ground Water • Burial Grounds	• Ground Water • Snake River Aquifer		• Clinch River
Historic Landmarks		• B Reactor	• Experimental Breeder Reactor		• Graphite Reactor • New Bethel and George Jones Baptist Churches
Sensitive Species/Habitat	• Carolina Bays • Red Cockaded Woodpecker • Bald Eagles			• Tall Grass Prairie • Jumping Field Mouse	• Wetlands • Bald Eagles
Legal/Agreements		• Arid Lands Ecology Reserve • North Slope	• New Wells Prohibited	• Mineral Rights	

Future Use Points of Contact and Reference List

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Tim Crawford (708) 252-2436

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John Kasprowicz (708) 252-2691

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Sue Peterman (513) 648-3179
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Rick D'Arienzo (510) 422-9247
Shaun Kesterson (510) 637-1702

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Juan Griego (505) 665-6439
Bill Pelzer (505) 667-7756

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Tim Sullivan (513) 865-3220

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Tim Killen (702) 295-1288

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Dave Kendal (423) 576-9359

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John Morgan (502) 441-5069

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Sharon Buell (806) 477-4041

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Deborah Garcia	**(505) 845-5460**
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APPENDIX E.1

PRODUCTIVITY IMPROVEMENT

The amount by which the Department can improve productivity over time will have a large effect on the life-cycle cost of the Environmental Management program. For example, if the Department improves productivity, defined as the ratio of outputs-to-inputs, at an annual rate of one percent from 2000 to 2050, the same scope of work can be accomplished in 2050 for approximately one-half the cost of completion in 2000. Larger productivity improvement rates would have an even more dramatic effect over the long-term. Therefore, the Department is concerned about productivity improvement for two major reasons. First, because productivity improvement can have a large effect on life-cycle cost, the accuracy of the Baseline Report cost estimate is dependent on addressing the issue of productivity improvement. Second, the Department is interested in improving productivity to actually reduce the life-cycle cost of the program. This appendix only addresses the first reason.

COST SAVINGS REALIZED THROUGH INCREASING PRODUCTIVITY

The Base Case life-cycle cost is $227 billion in constant 1996 dollars. This includes $14 billion in cost savings from anticipated productivity improvements. If the Department is able to improve productivity by an additional one percent annually from FY 2000 to program completion, the life-cycle cost will drop to $195 billion, an additional savings of $32 billion.

The Department approached the problem of forecasting productivity improvements for the Baseline Report in two ways. First, Headquarters asked field sites to develop cost estimates for the Baseline Report that reflect anticipated cost savings due to productivity improvement. The data submission from several sites reported cost savings due to productivity improvements in the short term, from FY 1996 through FY 2000. On average, site submissions indicated that they will be approximately five to ten percent more productive in FY 2000 than in FY 1996. The Base Case reported in Chapter 4 reflects these site-reported cost savings. The majority of these savings stem from site productivity improvement initiatives aimed at reducing overhead costs, reforming contracting procedures, improving project definition, reengineering business processes, streamlining cleanup activities, and preventing pollution. Only a small number of site submissions, however, indicated that productivity will increase after this period. A primary reason for this is the difficulty of estimating productivity improvements far in the future.

For this reason, the Department developed an additional case based upon the assumption that the Department would improve productivity in the long-term (post-FY 2000) at a rate consistent with the past performance of the federal government. Historical data from the federal government indicates that productivity has grown at approximately one percent annually over the long term.[1] Major reasons behind these annual productivity improvements include adopting improved technologies, using existing technologies more efficiently, and improving management structures. Increasing productivity at this rate will result in a life-cycle cost of approximately $195 billion, a savings of $32 billion from the Base Case.

[1]Bureau of Labor Statistics. Productivity Measures for Selected industries and Government Services. March 1994; American Productivity and Quality Center.

APPENDIX E.2

DISCOUNTING

The benefits received by the public or by an individual from government and private expenditures often are experienced at approximately the same time that the costs are incurred. This, however, is not always true. In the case of the Environmental Management program, 90 percent of costs will be incurred over the next 45 years; however, many of the benefits will be experienced far after this period. Therefore, in programs such as the Environmental Management program, the time at which benefits and costs are experienced becomes an important consideration.

For example, a dollar spent in ten years is worth less than a dollar spent today because today's dollar could be invested in a savings account or another investment and be worth more than a dollar in ten years. For this reason, policy analysts "discount" future costs and benefits so that all costs and benefits are evaluated at their worth in terms of today's dollars. Intuitively, "discounting" implies that future costs and benefits are worth less than costs and benefits received today. To determine how much less future costs and benefits are worth, analysts typically apply a discount rate. For example, a five percent discount rate implies that $1.05 received in one year is worth a dollar today.

CHOOSING A DISCOUNT RATE

A major issue in discounting future costs and benefits is selecting the appropriate discount rate. This choice often has a major effect on policy analysis results (as discussed in the next section). Analysts emphasize the use of two major variables to determine the proper discount rate. The first variable is the rate at which people are willing to sacrifice present consumption for future consumption. This is often called the time preference rate or the social rate of time preference. Second, public projects use resources that can be employed in private investment projects. Thus, if private investment projects yield 15 percent, diverting resources from private investment to public projects entails an opportunity cost of 15 percent or an opportunity cost rate of 15 percent. The return on private investment is often called the opportunity cost rate. The discount rate is usually approximated as one of these two rates. Using an appropriate discount rate, policy analysts can calculate the "present value" of streams of costs and benefits.

Based on analysis of the social rate of time preference and the opportunity cost rate, the U.S. Environmental Protection Agency and the Office of Management and Budget suggest using real discount rates (above inflation) of approximately three percent to seven percent.

EFFECT OF DISCOUNTING ON BASE CASE AND ALTERNATIVE CASE COST ESTIMATES

Table E.1 displays life-cycle costs in constant 1996 dollars and present value costs for the Base Case and nine alternative cases. The present value cost for each case was calculated separately using a three percent and a seven percent discount rate. Table E.1 also ranks the cases from least expensive (1) to most expensive (10). As is evident from this presentation, discounting results in a different relative ranking of the cases based upon cost. This is most evident in the funding reduction case. In constant 1996 dollars, the funding reduction case is the second most expensive case. In contrast, the present value cost of the funding reduction case is the second least costly alternative. The major reason for this difference is that the funding reduction case shifts costs farther into the future. Shifting costs farther into the future translates into a lower present value. To a lesser extent, costs for the delaying waste disposal case are higher than those for the Base Case in constant 1996 dollars, but have a lower present value cost than the Base Case. Discounting has little effect on the relative cost ranking of the other cases because the time profile of costs is similar for these cases.

Table E.1. Life-Cycle Costs for Base Case and Alternative Cases

Case	Constant 1996 Dollars	3% Discount Rate	7% Discount Rate
Base Case	$160 billion (5)	$96 billion (7)	$59 billion (6)
Accelerating Stabilization and Deactivation	$159 billion (4)	$94 billion (6)	$59 billion (6)
Delaying Waste Disposal	$161 billion (8)	$93 billion (4)	$58 billion (4)
Funding Reduction	$199 billion (9)	$89 billion (2)	$48 billion (2)
Iron Fence	$150 billion (2)	$90 billion (3)	$56 billion (3)
Industrial	$155 billion (3)	$93 billion (4)	$58 billion (4)
Recreational	$162 billion (6)	$96 billion (7)	$60 billion (8)
Modified Green Fields	$166 billion (7)	$99 billion (9)	$61 billion (9)
Maximum Feasible Green Fields	$272 billion (10)	$141 billion (10)	$80 billion (10)
Minimal Action	$90 billion (1)	$51 billion (1)	$33 billion (1)

APPENDIX F

SCIENCE AND TECHNOLOGY

BACKGROUND

The Environmental Management program has a mission to manage and direct focused, solution-oriented technology development. The program uses a systems approach to achieve its goals: reducing waste management life-cycle costs, reducing risks to people and the environment during and after cleanup, and solving cleanup problems that currently have no solution. The program has identified five major problem areas requiring technology development: mixed waste, tank waste, contaminated soils and ground water, landfills, and decommissioning facilities. The Office of Science and Technology formed teams for each of the five areas to concentrate technical efforts. In addition, the Office of Science and Technology formed three discipline-oriented, crosscutting technology programs that provide technology systems to the five focus areas.

Budgetary constraints make cost reduction critical. Potential cost savings are a key factor in allocating technology development funds to the focus areas and the crosscutting programs. Potential savings also give regulators and stakeholders information useful for evaluating the value of a new technology. The Office of Science and Technology is currently supporting the development of approximately 170 technology systems. Of these, approximately 120 have cost savings as a primary objective. Thirty-seven of these 120 technology systems serve as the basis for estimating cost savings in the analysis of the 1996 Base Case. Table F.1 displays the 37 technologies by focus and crosscutting program area.

COST SAVINGS REALIZED THROUGH TECHNOLOGY DEVELOPMENT

The projected savings in the Base Case life-cycle cost of $227 billion is $15 to $20 billion, assuming 37 emerging technologies demonstrated by the Technology Development program during 1990-1999 are implemented across the Department of Energy complex. The total investment for this decade in the entire Technology Development program, not just in the 37 technologies, is $3 billion. No savings estimates were made for later decades.

Table F.1. Technology Systems/Subsystems Used to Estimate Potential Cost Savings

Focus or Crosscutting Program Area	Technology
Plumes Contamination Focus Area	• Dynamic Underground Stripping • Horizontal Environmental Wells • In Situ Bioremediation • Recirculating Wells • Resonant Sonic Drilling • Passive Soil Vapor Extraction • Thermally Enhanced Vapor Extraction System • LASAGNA™ • In Situ Anaerobic Bioremediation • In-Well Vapor Stripping (NoVocs)™ • Automated Control System for Soil Vapor Extraction
Landfill Stabilization Focus Area	• Material Handling and Waste Conveyance System • Barriers for Subsurface Containment of Buried Waste • Alternative Landfill Cover Demonstration • Containment of Contaminants through Viscous Liquids • Cryocell Technology for Barriers • Innovative Grout (In Situ Stabilization) • Selected Retrieval
Decontamination and Decommissioning Focus Area	• Conversion of Asbestos-Containing Material into a Nonregulated Material • The Beneficial Reuse of Radioactively Contaminated Scrap Metal • Advanced Worker Protection System • Pipe Explorer™
Mixed Waste Focus Area	• Macroencapsulation of Mixed Waste • Stainless Steel High-Efficiency Particulate Air Filter • Plasma Hearth System • Combustion Melting Vitrification System
Tanks Focus Area	• Cesium Separation from Radioactive High-Level Waste by Crystalline Silico-Titanate Ion Exchange Resin • Cesium Separation from Radioactive High-Level Waste by Resorcinol-Formaldehyde Ion Exchange • Enhanced Sludge Washing of Radioactive High-Level Waste
Characterization, Sensors, and Monitoring Technologies Crosscutting Program	• Laser-Induced Florescence Imaging (LIFI) • Cone Penetrometer Technologies • Electrical Resistance Tomography Subsurface Imaging • Expedited Site Characterization (ESC) • Fiber Optic-Based Beta Scintillator Sensor
Efficient Separations and Processing Crosscutting Program	• High-Temperature Vacuum Distillation Separation of Plutonium Waste Salts
Robotics Crosscutting Program	• Contaminant Analysis Automation (CAA)

ASSUMPTIONS

The Office of Science and Technology made the following assumptions to develop projected cost savings which are attributable to technology development and summarized in the results section below:

(1) Projected technology development cost savings are based on replacing existing technologies assumed in the Base Case. Cost savings are proportional to the scope of the program. Thus, technology development cost savings for the highest land-use case in the sensitivity analysis will be greater than that for the Base Case.

(2) Technology development cost savings are based on projected cost savings from 37 of approximately 170 technology systems, of which 120 technology systems have identified cost reductions as their primary goal. The selected 37 technology systems/subsystems are at a more mature level of development than those not selected. In the private sector, about one in three technologies under advanced development — at the same relative stage of research demonstration as these selected 37 systems — is likely to be a commercial success. Therefore, selecting the most promising 37 out of 120 technology systems to estimate the aggregate potential cost savings should be a reasonable assumption. Consistently, the total investment for the development of over 170 innovative technology systems/subsystems during the period FY 1990 to FY 1999 has been estimated to be approximately $3 billion (1996 constant dollars).

(3) Projected cost savings affect only direct environmental management costs. Indirect and support costs are not affected.

(4) Savings from the 37 technologies accrue over the entire environmental management life-cycle. Potential savings from future substitutions of even more cost-effective (not yet developed) technology systems/subsystems are not included.

(5) Cost savings are calculated using conservative "success coefficients." These are technology-specific, judgment-based reductions to savings, which recognize that regulatory and technical uncertainties associated with new technologies will reduce the probability of their successful application in all cases.

(6) In all cases, the detailed calculations of the individual technology system cost study are individually subject to changes as cleanup plans and scenarios become finalized and articulated. In addition, full-scale demonstration will provide updated cost and performance data that will affect the individual technology system cost studies. However, the projected overall or aggregate level results remain valid because of the influence of conservative factors, such as the "success coefficients."

METHODOLOGY

Estimating potential cost savings from the successful application of the 37 emerging technology systems/subsystems is a three-step process. The process is necessarily predictive in nature because the 37 technologies have not had sufficient production application to build detailed historical cost and performance data bases. As a result, the cost savings projection estimate methodology uses conservative assumptions and practices to avoid overestimating the potential cost savings.

Development of Alternative Technology System Use Scenarios

The first step in the process is developing an implementation scenario for each of the 37 alternative technology systems. These scenarios will serve for comparison with existing technology systems that underlie environmental management costs in the Base Case. Ultimately, cost savings will be realized when the Department substitutes alternative technology systems that will realize cost reduction for existing baseline technology systems that are used to build up costs in the Base Case. Figure F.1 illustrates an example alternative technology system—in situ bioremediation; it would substitute for an ex situ air stripping pump-and-treat system for ground water contaminated with volatile organic compounds. For each potential substitution, the preliminary condition (for example, contaminated ground water) must be equivalent for both systems, and the end product of the alternative system must be equivalent to or better than the end product of the existing system.

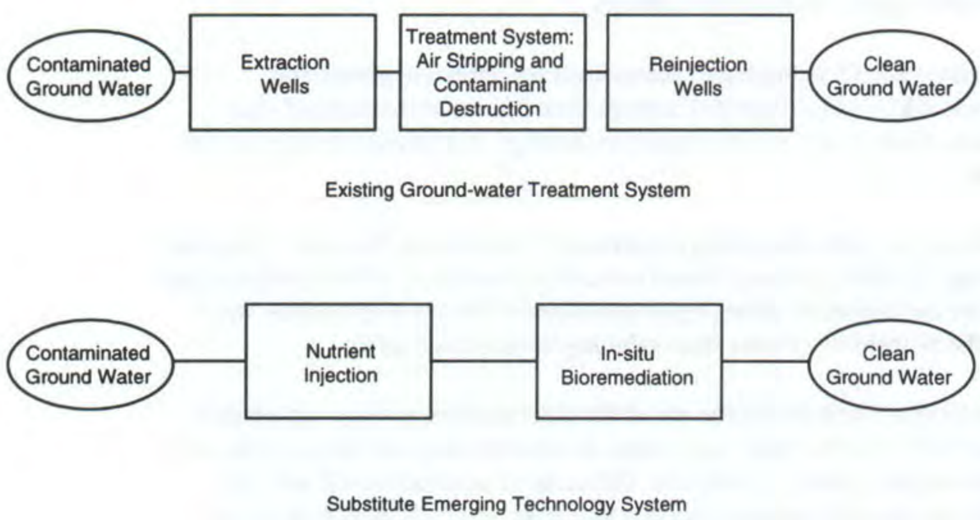

Figure F.1. Example of Comparable Technology System

For each pair of comparable application scenarios, life-cycle costs to construct, operate, and maintain an operating-scale system are estimated. Unit costs for each system are derived by dividing total life-cycle costs of each system by the volume of waste or contaminated media treated. Uncertainties in costs for emerging technologies result in estimates with confidence ranges usually between -30 and +50 percent. To preserve the conservative nature of the projected savings estimate, the upper end of the range is typically employed. Dividing the unit cost estimate for each alternative technology system by its existing technology system counterpart produces a life-cycle unit cost reduction factor for each of the 37 technology systems.

Application of Unit Cost Reduction Factors

Base Case life-cycle costs are composed of cost elements from each of the three major functional elements.

ENVIRONMENTAL MANAGEMENT PROGRAM	*TYPICAL COST ELEMENTS*
Waste Management	Treatment, storage, or disposal of a specific waste type
Environmental Restoration	Operable Unit
Nuclear Material and Facility Stabilization	Facility

To calculate projected potential savings for specific cost elements, the type and volume of waste or contaminated media involved and the existing technology system to be employed must be identified. Potential savings are only available to the subset of cost elements that employ an existing technology system for which there is an applicable alternative technology system/subsystem. Multiplying the direct unit cleanup costs for the existing technology by the unit cost reduction factor and the volume of waste or contaminated media to be treated in a cost element for which an alternative technology system exists results in a "raw" projected cost savings for that cost element.

There are instances where more than one of the 37 alternative treatment systems can substitute for an existing technology system in a cost element. For example, both in situ bioremediation and in-well vapor stripping could substitute for ex situ pump-and-treat air stripping of contaminated ground water. Site-specific conditions will usually dictate which substitution is optimal. Nevertheless, to preserve the conservative nature of the projected cost savings, the alternative technology system with the lowest unit cost reduction factor (least amount of estimated potential savings) is always substituted for each existing baseline technology system where multiple substitutions were possible.

Use of "Success Coefficients"

Raw projected cost savings for each applicable cost element are adjusted using conservative "success coefficients." These are technology-specific, judgment-based reductions to savings related to the recognition that regulatory and technical uncertainties associated with new technologies may reduce the probability of their successful application in all cases. There are three areas in which a success coefficient is applied: 1) technology applicability, because data are sometimes incomplete regarding waste characterization, planned action by the sites, and the emerging technology performance and cost, 2) stakeholder and regulator acceptance, and 3) site-specific institutional and schedule constraints. The Office of Science and Technology Development assigned a coefficient ranging in value from zero to one (most are in the range of 0.5 - 0.9) for each of the three factors above for each of the 37 technologies. To calculate projected cost savings for specific cost elements, raw projected cost savings are adjusted by each of the three success coefficients for a given emerging technology system.

RESULTS

Conservative projected cost savings from the Science and Technology Development program, for the first decade's $3 billion investment, are estimated in the range of $15 to $20 billion for the Base Case. The range of potential savings is attributable to the associated range of "success coefficients" used by the cost engineers and system technologists in their calculations. Relative to expenditure profiles, these savings are estimated to have a slight impact on the Base Case treatment and remediation expenditures before 1998, but the estimated savings will increase to a level equal to approximately 13 percent of projected treatment and remediation expenditures for the remainder of the environmental management life cycle. Because these estimated cost savings are related to existing treatment and remediation systems and their scheduled implementation, most of the savings will be realized from 2000 to 2030. Although the technology systems in this analysis are at various stages of development, the selected suite of 37 innovative technology systems will presumably be fully developed and implemented during the 1990 to 1999 timeframe.

APPENDIX G

POLLUTION PREVENTION

Section 3170 of Public Law 103-337, The National Defense Authorization Act for FY 1995, requires the Department of Energy to include a discussion on pollution prevention in the 1996 Baseline Environmental Management Report. This section of the Baseline Report responds to that legislative mandate by: (1) summarizing the Department of Energy's pollution prevention program, and (2) discussing the program's potential impact on reducing life-cycle costs of the Department of Energy's environmental management efforts.

POLLUTION PREVENTION PROGRAM OVERVIEW

The Office of Environmental Management established a Pollution Prevention program in 1991. The Department of Energy defines pollution prevention as the use of materials, processes, and practices, including recycling activities, that reduce or eliminate the generation and release of pollutants, contaminants, hazardous substances, and waste into land, water, and air. This section describes the Pollution Prevention program's objectives, goals, status, and future directions.

Program Objectives and Goals

The overall program objective is to minimize pollutant generation and release by implementing cost-effective technologies, practices, and policies. Partnerships among government agencies and private industry are used to achieve this objective. The Department of Energy has committed to meeting the following waste reduction goals[1] by 2000:

- Reduce the generation of radioactive, low-level mixed, and hazardous waste from routine operations by 50 percent.
- Reduce the generation of sanitary waste from routine operations by 33 percent.
- Divert 33 percent of sanitary waste from all operations for recycling.

Achieving these goals will result in significantly decreased waste-related expense that could represent an accumulated savings of over $1 billion by 2010 and of $5 billion over the environmental management life cycle. These goals should be attainable based on benchmarks from similar organizations involved with radioactive waste management. For example, the commercial nuclear power industry and the United States Navy reduced generation of low-level waste by 75 percent in six years

[1]The percentage reductions for these goals were established using 1993 waste generation rates as a baseline.

following passage of the Low-Level Waste Policy Amendments Act of 1985. Part of this reduction occurred as a result of improved volume reduction treatment processes; however, the principal reduction resulted from limitations on waste quantities allowed for disposal and from surcharges on waste generators. The Department of Energy is currently applying this industry approach by holding its waste generators accountable for both the quantity of newly generated waste and the direct cost(s) of managing the waste until final disposition. Beginning in FY 1996, selected Department of Energy sites will participate in a pilot program that will charge waste generators for the cost of disposing of their waste.

The United States Navy has documented a series of case studies in which hazardous waste generation rates were reduced significantly, sometimes up to 80 to 90 percent. Based on these results, the Department of Energy's goal of a 50 percent reduction should be achievable.

Program Status and Direction

The Department's commitment to pollution prevention is described in its 1996 Pollution Prevention Program Plan. The Department has institutionalized the program by establishing a Pollution Prevention Executive Board, an Office of Pollution Prevention within the Environmental Management program, and pollution prevention coordinators at its field sites. An important element of the program is the "high return on investment" program that funds specific pollution prevention projects that have the largest "payback" potential.

Cost Reductions from Specific Pollution Prevention Projects

The Department has sufficient information for three specific categories of pollution prevention projects to report waste volume reductions and corresponding cost savings. These are: (1) high return on investment projects, (2) waste minimization/pollution prevention projects, and (3) past pollution prevention projects.

In 1994, the Department sponsored pilot demonstrations of 13 high return on investment projects. Based on the success of these projects, an increase in funding was approved in FY 1996 for 22 projects in the high return on investment program. The Department is currently considering supplemental funding of nine additional projects.

Cost savings, total project costs, and various other data are kept for each high return on investment project. These data are used to forecast life-cycle savings through 2010, which is the useful life of most high return on investment projects. In addition, the Office of Pollution Prevention funded 26 projects (referred to in the table below as field projects) that did not meet the criteria for the high return on investment program but provided significant payback over a longer time period. Past pollution prevention projects have also resulted in cost savings. Table G.1 summarizes projected life-cycle savings over ten years through 2005 for high return on investment projects (assuming the Board approves supplemental funding), field projects, and selected past pollution prevention projects for which cost savings data are available. Because the high return on investment program is still in the early stages, most of the savings illustrated are projected rather than actual savings.

Table G.1. Projected Life-Cycle Savings

Project Category	No. Of Projects	Projected Costs	Projected Savings (Constant 1996 Dollars)
High Return on Investment Pilot Demonstration[2]	13	$ 2,700,000	$36,700,000
High Return on Investment FY96[2]	31	8,300,000	143,500,000
High Return on Investment FY 1996 Supplemental	9	2,100,000	101,000,000
Field Projects	26	2,700,000	256,000,000
Selected Past Projects	24	Implementation Costs Not Available	1,077,000,000
TOTAL	103		$1,614,200,000

Pollution Prevention Examples

Current return on investment projects focus primarily on routine waste from Department operations. They include a wide range of simple and complicated projects and are applicable at many Department facilities. For example, a $5,000 investment in laundering rags can avoid nearly $14,000 in yearly disposal costs. Dry-ice abrasion equipment is used in a more technology-intensive project that will clean surface radiation from lead-shielding bricks. A $500,000 investment yields a one-time savings of $1.2 million by avoiding disposal of a mixed radioactive waste.

Historically, the Environmental Management program has overseen pollution prevention projects implemented throughout the Department. Although pollution prevention data were not required for reporting purposes, many sites kept track of their accomplishments. Some of these projects involved waste streams other than routine waste such as environmental restoration waste. For example, in 1994, modified procedures for soil borings avoided 150 metric tons (165 tons) of contaminated soil drill cuttings, saving $4.5 million in waste disposal costs. At Weldon Springs, the use of slightly contaminated soil as capping and stabilization materials in remediation projects elsewhere on the site prevented the soil from becoming a waste and saved about $15 million. At the Hanford Site, two liquid

[2]Approved by the Pollution Prevention Executive Board.

effluents that had been discharged to evaporation ponds were eliminated by changing equipment and modifying existing systems to save over $26 million.

Summary of Pollution Prevention Results

Currently, the projected savings from specific projects for which data are available exceeds $1.6 billion. Other specific projects for which life-cycle data are not available would increase this figure. Many of these projects can be replicated or adapted at multiple sites throughout the Department. Although there are insufficient data to extrapolate total projected pollution prevention savings in a meaningful, quantitative way, it is not unlikely that complex-wide savings could be in the tens of billions of dollars. In addition, the Department has established goals for reducing the volume of radioactive, low-level mixed, sanitary, and hazardous waste from routine operations by 50 percent by the year 2000. Achieving these goals will reduce waste management costs by an estimated $5 billion over the environmental management life cycle. Regardless of total savings, actual results and projections from specific projects are unequivocal in demonstrating that pollution prevention activities save far more than they cost. Therefore, the Department will continue to pursue pollution prevention activities aggressively because they are consistent with the Department's core values for respecting the environment, and they result in a more efficient use of limited resources by reducing site operating costs.

APPENDIX H

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