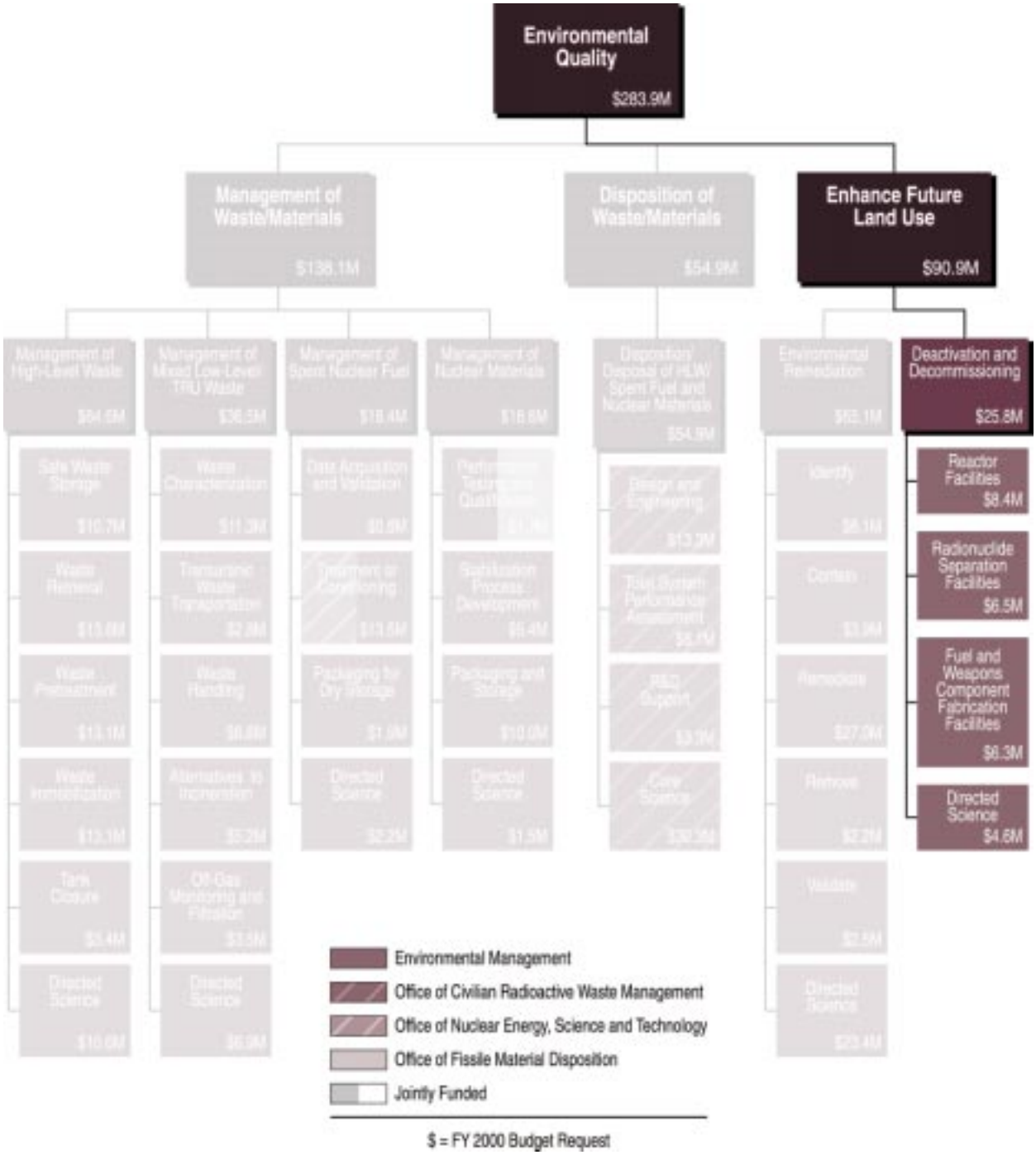
Chapter 9

Deactivation and Decommissioning



Chapter 9
Deactivation and Decommissioning

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Overview

Definition of Problem Area

DOE constructed over 20,000 facilities to support nuclear weapons production and other activities. Many of these facilities are contaminated with radioactive materials, hazardous chemicals, asbestos, and lead (including lead paint), have exceeded their design life and no longer serve a mission for the DOE. The potential for release of radioactive and hazardous materials to the environment and local communities and the risk of industrial safety accidents due to deterioration of these old facilities requires monitoring and maintenance. DOE plans to deactivate and decommission such facilities to reduce these risks and associated costs. Four major classes of facilities require Deactivation and Decommissioning: (1) Reactor Facilities, (2) Radionuclide Separation Facilities, (3) Fuel and Weapons Component Fabrication Facilities, and (4) Laboratory Facilities.

Facility D&D generally follows a sequence of activities which allows for safe *deactivation*, *decontamination*, and *decommissioning* of facilities while significantly reducing the risk to workers, the public, and the environment. The physical process for dispositioning the Department's surplus facilities includes:

> *Deactivation*. Activities to ensure surplus facilities are secure in a safe and stable condition, including removal of materials, shut down of facility systems, and removal or de-energizing equipment, pending their ultimate disposition.
>
> *Decontamination*. Removal of unwanted radioactive or hazardous contamination from facility equipment, surfaces, or structures.
>
> *Decommissioning*. Retirement of a nuclear facility, including removal of contaminated building materials and residue waste, waste treatment, and final disposition of the facilities, which may include complete destruction, free release for future use, or entombment in place.

These actions are founded on assessment phases which analyze present conditions, end state requirements, and options for achieving closure.

Figure 9-1 shows the EM D&D 5-year, 10-year and life-cycle costs at the operations office level. EM's D&D problem is grouped into 76 site projects with each project described in a Project Baseline Summary (PBS). Even within this complex-wide planning process, it should be noted that these 76 PBSs do not describe all of the buildings, and do not capture all of the outyear costs/mortgages for their cleanup and disposition. As shown in Table 9-1, D&D costs are sorted into five major categories: (1) pre-deactivation surveillance and maintenance, (2) deactivation, (3) decommissioning assessments, (4) pre-decommissioning surveillance and maintenance, and (5) decommissioning.

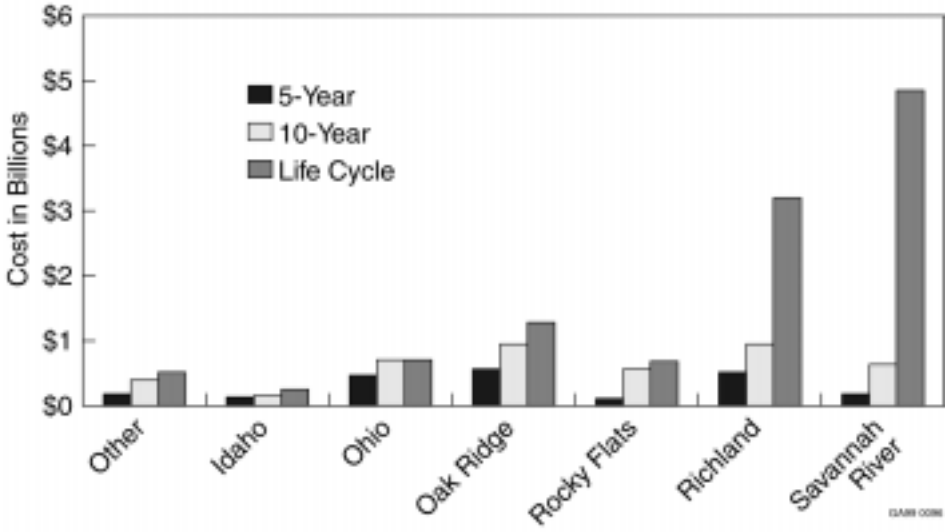

Figure 9-1. Five-year, ten-year, and life-cycle D&D costs.

Table 9-1. Life-cycle costs for DOE-EM facility D&D (dollars in millions).

	FY 1997–2006	**FY 2007–2070**	**Total through FY 2070**
Pre-Deactivation S&M	745	1,627	2,372
Facility Deactivation	771	575	1,346
Pre-Decommissioning S&M	297	3,186	3,483
Facility Assessments	155	83	238
Facility Decommissioning	2,167	1,669	3,836
Totals	**4,135**	**7,140**	**11,275**

EM typically performs decommissioning under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as a "non-time-critical removal action." In fact, there are few regulatory compliance agreements at DOE sites that specify D&D activities. Most sites Federal Facility Agreements deal with legacy waste and contaminated soil and groundwater problems, not with contaminated buildings. Exceptions are Fernald, Mound, Rocky Flats, and portions of Hanford, INEEL, Oak Ridge, and Savannah River. Fernald, Mound, and Rocky Flats are designated as closure sites under current planned funding scenarios; Mound is expected to close by the end of 2003, Fernald by the end of 2006, and Rocky Flats in the 2006-2010 period.

In *Accelerating Cleanup: Paths to Closure* the site problem holders for facility D&D activities have identified ninety-two technical and eight basic science needs that must be met to accomplish the current baselines. Life Cycle Asset Management (LCAM) has only recently been

instituted within DOE and the list of needs will surely grow as D&D proceeds. As more close out activities are identified and planned it is anticipated that the list of technology needs will expand and, despite efforts to anticipate every requirement, surprises are bound to occur.

The current set of major problem categories include:

- Remote characterization, decontamination and dismantlement technologies for tritium contaminated facilities and highly radioactive environments.
- Underwater characterization, video inspections, sample collection, radiological surveys, sizing, handling, packaging and decontamination problems associated with fuel storage pools and associated facilities.
- Remote characterization of chemical reprocessing facilities (canyons) to assess and describe possible end states and develop an appropriate disposition path.
- Methodologies capable of characterizing and detecting to release limits for treatment and recycle of contaminated scrap metal.
- Remote and/or robotic technologies for D&D activities on hot cells and gloveboxes, which are contaminated with high-levels of radioactivity and are often confined spaces.
- Technological problems in the D&D of graphite reactors in control and containment of aerosols and airborne contamination (graphite particles) during dismantlement operations and in identifying the quantity and location of radioactive contamination.
- Evaluation of the option of disposing of chemical reprocessing facilities (canyons) by removing all contaminants above the transuranic (TRU) threshold, filling the structure with low-level waste (LLW), and entombing the canyon as a permanent LLW disposal facility.

National Context/Drivers and Federal Role

DOE is only one of the two major owners of radiologically contaminated facilities facing D&D; commercial nuclear utilities are the other major owner. There are 442 commercial nuclear power plants worldwide, of which 100 are located in the U.S. Four of these facilities are currently slated for D&D and, due to deregulation of the electric power industry and the number of facilities approaching their expected operational life (35 to 40 years), many more are expected to undergo D&D in the next ten years. The current estimated D&D cost for one such nuclear power plant is $400 million (in current year dollars). From these data it is clear that the commercial nuclear sector must deal with an even greater total D&D cost than DOE. Major infrastructure changes will affect the commercial nuclear utilities. These changes are related to the aging of reactor facilities and the deregulation of the electric power industry. Collectively, these are expected to accelerate D&D activities in the commercial sector over the next 10 to 15 years. An opportunity exists, therefore, to leverage scarce DOE and nuclear utility resources to provide solutions to common technological problems. Toward this end the Department negotiated and signed a Memorandum of Understanding (MOU) with major commercial nuclear utility companies

agreeing to collaborative research, development and demonstration (RD&D) efforts. This MOU establishes a mechanism to facilitate the exchange of best business practices and lessons learned, and to plan/manage a leveraged RD&D program which meets the D&D technical needs of both DOE and the commercial nuclear utilities. The DOE expects to gradually transition a portion of its program to support this joint effort with the utilities.

Linkage to DOE Strategic Goals and Objectives

The D&D strategies and activities support and impact the Environmental Quality strategic objectives at the levels indicated in Figure 9-2.

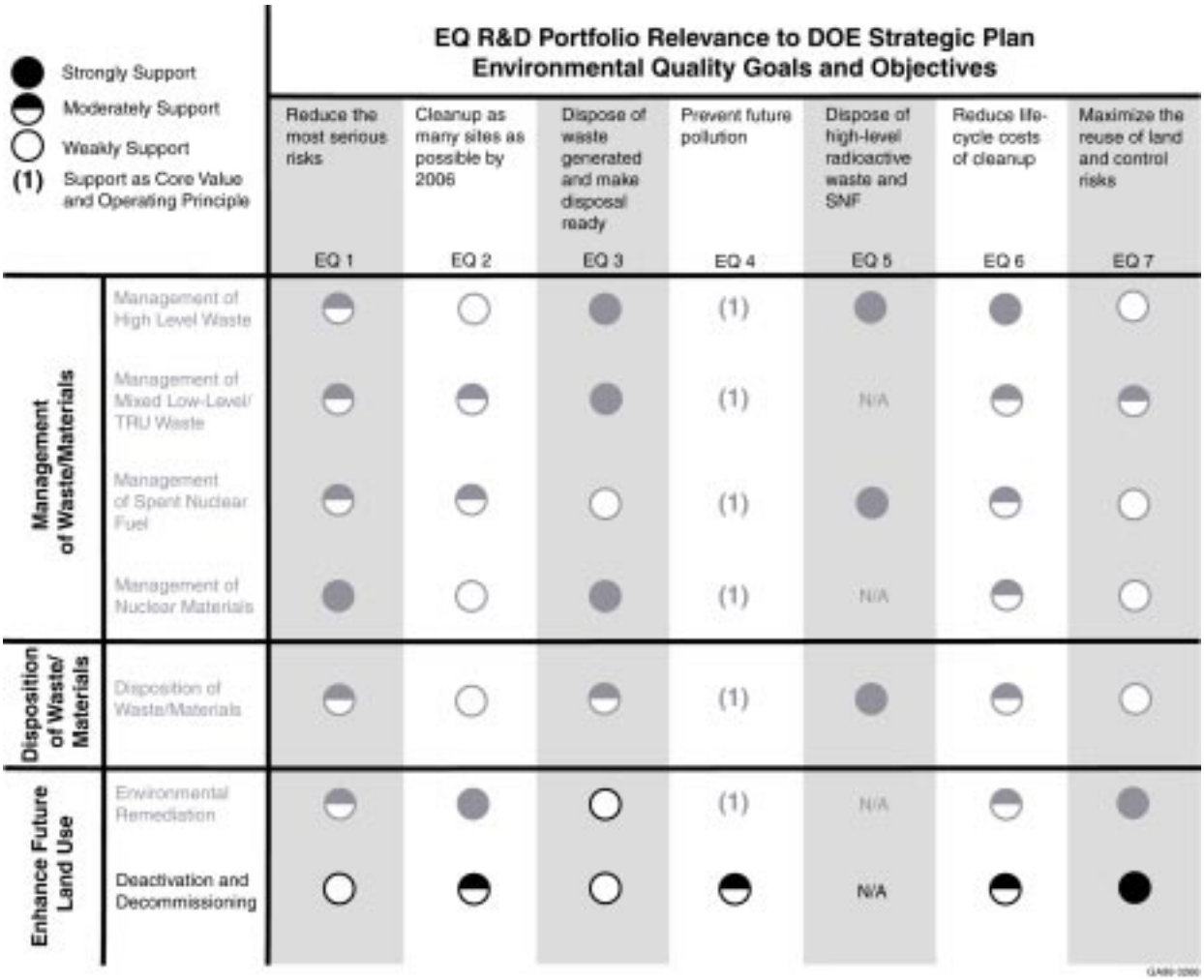

Figure 9-2. *Relevance of D&D R&D investments to Environmental Quality goals and objectives.*

The D&D mortgage from fiscal year (FY) 1997 through FY 2006 is $4.135 billion. It is estimated that this mortgage can be reduced by 25% using full-scale improved D&D technology. During the previous 58 demonstrations, cost reductions of 20% to 40% were achieved. The goal is to reduce the FY 2007 through FY 2070 mortgage by approximately 60%. This would reduce the projected $11.3 billion mortgage to $5.3 billion.

Considerable D&D expertise resides in the commercial nuclear sector within both the nuclear utilities and the commercial D&D contractor firms. EM has worked together with the commercial nuclear industry to exchange lessons learned and best practices and to develop a leveraged research, development and deployment program that meets D&D technical needs for both DOE and the commercial sector. EM's D&D technology program strategy is to quickly access and demonstrate/validate the many commercially available D&D technologies worldwide, which are not currently being used within the DOE Weapons Complex. More than 750 such technologies have been identified. More technologies are being added to the D&D technology inventory almost continuously as the worldwide technology search continues.

The D&D program addresses the four major EM Science and Technology (S&T) Program objectives identified in the EM Strategic Plan for Science and Technology through the following activities.

- Meet high priority needs
  - Ensure programmatic goals and strategies target end-user needs.
  - Ensure full and open communication between end users, technology developers, and technology producers.
  - Nurture private sector partnerships to develop common solutions and to address common problems.
  - Provide a balanced portfolio of near- and long-term investments.
- Reduce cost
  - Demonstrate technologies at full-scale as part of ongoing D&D activity.
  - Demonstrate improved and innovative technologies side-by-side with baseline technologies.
  - Collect all necessary data to fully assess the cost and performance of the improved or innovative technology against the baseline.
  - Conduct unbiased cost analyses and publish data for all demonstrated technologies.
  - Deploy successfully demonstrated technologies at multiple sites and for multiple applications.
- Reduce EM's technological risk
  - Consider risk-based criteria in the D&D portfolio investment analysis.
  - Conduct human factor evaluations to ensure worker safety and health considerations are taken into full account during development.

  - Conduct technology cost and performance assessments prior to full-scale demonstration.

  - Consider risk in the selection process.

  - Reduce risk and liability associated with first-time technology use through demonstration in a large scale D&D demonstration project.

  - Through successful demonstrations/deployments, offer favorable opportunities by transferring technology to multiple sites for further application.

- Accelerate technology deployment

  - Buy technologies (if available in the private sector), rather than make.

  - Demonstrate rather than develop.

  - Demonstrate in ongoing D&D line projects.

  - Develop only if not available.

  - Develop through supporting programs (Industry/University Programs, Crosscutting Programs and EM Science Program).

Problem Area Uncertainties

EM's D&D life cycle cost estimate at $11.3 billion is a known understatement. It represents about 33% of the total estimated cost ($31B) for all DOE D&D activities. EM's D&D problems are grouped into specific site projects with each such project describing the site history, D&D problem, and current and outyear funding scenarios. Even within the complex-wide planning process now underway, these projects do not describe all of the buildings, and do not capture all of the outyear costs/mortgages for cleanup and disposition. This has created a serious funding deficiency for D&D activities within the EM technology program due primarily to uncertainties with facility end state decisions and the low outyear costs/mortgages estimates for facility D&D. As a consequence, the life-cycle cost for completing D&D will be higher than currently recognized and the full potential benefits of science and technology investment are not currently seen.

In contrast to other EM problem areas (i.e., high-level waste, mixed waste and environmental remediation), considerable D&D expertise resides in the commercial nuclear sector, both within the nuclear utilities and the commercial contractor firms which perform their D&D. The present strategy of demonstrating improved and innovative commercially available technologies will continue into 2001, at which time the program, having depleted the current resource of available technologies, will require new technologies and will begin a gradual transition to emphasize technology development. Additionally the Department conducts a Directed Science effort within the EM Science Program in order to advance the D&D R&D activities focused on post-2006 D&D (90% of EM's D&D mortgage is post-2006). This post-2006 period is where most of the

technical uncertainty exists and is, consequently, also the period when the benefits of science and technology investment are likely to be greatest.

End states for most DOE buildings have not been defined and will not be fully defined for many years. As mentioned earlier, most D&D is conducted as a non-time-critical removal action and is, therefore, often subject to schedule delays. Where defined end states exist, they range from institutional controls to assorted states of brownfields to a few greenfields. End states for most facilities are being (or will be) negotiated with State and Federal regulators and local stakeholders. Until facility end state decisions are made, uncertainties in planning and funding D&D technology projects will persist. While these uncertainties make the precise definition of future needs impossible, they increase the probability that investments in science will pay off in applications that are not now recognized.

R&D Investment Trends and Rationale

In a recent report by the DOE Chief Financial Officer, the additional D&D mortgage for DOE-Defense Programs (DP), Nuclear Energy (NE), and Energy Resources (ER) is estimated to be $20 billion, cumulatively. EM will gradually accept responsibility from DP/NE/ER for the D&D of these buildings. As mentioned above, the estimated total D&D mortgage for DOE is at least $31 billion. This mortgage, though daunting, represents a significant opportunity for the development and widespread deployment of improved technologies to reduce the life cycle cost of facility decommissioning activities.

The current D&D R&D portfolio (Figure 9-3) has been developed to address problems identified for facilities in the EM arena. As new, potentially unique facilities are added, new problems and new science and technology needs which translate into opportunities for gainful investment may be expected to arise.

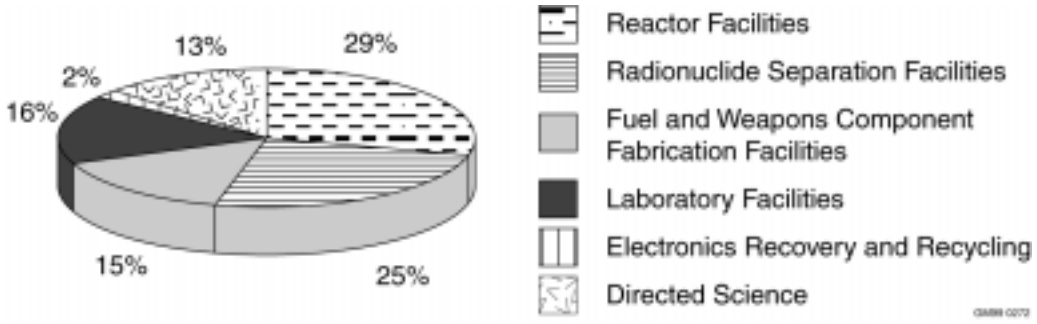

Figure 9-3. Cumulative investment in D&D areas over 3 years (FY 1998–FY 2000).

Key R&D Accomplishments

The EM D&D technology program has already achieved a number of successes, including:

- Satisfied 35 of the presently known 92 site needs with D&D technologies already demonstrated (including ten high priority needs).

- An additional 46 site needs (14 high priority) can be satisfied with DOE-EM identified technologies through modification and/or demonstration.

- Demonstrated 58 improved and innovative technologies at full-scale in the first three Large-Scale Demonstration and Deployment Projects (LSDDPs).

Of the 58 demonstrated technologies, 30 have been deployed subsequent to the LSDDP. These deployments can be broken down into the following D&D operational areas: (1) Characterization, (2) Decontamination, (3) Dismantlement, (4) Material Disposition, and (5) Worker Health and Safety.

Seven characterization technologies have been deployed a total of 34 times. Examples of deployed characterization technologies include:

- Deployment of the Surface Contamination Monitor and Survey Information Management System (SCM/SIMS) at Hanford, Rocky Flats, INEEL, Argonne, Bonus Research Reactor in Puerto Rico, and the Connecticut Yankee Nuclear Power Station. This automated surveying system records and displays real-time data for surfaces contaminated with alpha and beta/gamma radiation, and has been used to characterize over 600,000-sq. ft. of floor space at these sites. This system is appreciably faster than traditional baseline technologies for accurately surveying for both alpha and beta/gamma radiation. It helps accelerate D&D schedules.

- The GammaCam Radiation Imaging System, a 2-D gamma imaging system, has been deployed at the Chicago Pile 5 Research Reactor, Wolf Creek Nuclear Operating Corporation, Hanford's B Plant, Peach Bottom Atomic Power Station, Limerick Generating Station, and Arkansas Nuclear One Reactor. This technology provides high gamma-ray energy sensitivity and remote operation capabilities, which have helped eliminate worker exposure risks and accurately maps gamma radiation sources.

- The Laser Assisted Ranging and Data System (LARADS), a radiological mapping system, has been deployed at Hanford's C, F, and DR Reactors, the West Valley Demonstration Project, and Hanford's 221-1 B Plant. LARADS has been successfully used to map over 90,000-sq. ft. of floor and wall surfaces, providing a clear and concise representation of the measurement and location of contaminants that is acceptable for regulatory review and is cheaper than some of the current baseline methods.

Six decontamination technologies have been deployed seven times. Highlights of deployed decontamination technologies include:

- The Centrifugal Shot Blast System, an abrasive blasting technology for concrete and coating removal, has been deployed at a NRC Plutonium/Uranium facility at the Parks Township Site and at the Fernald Site. The Centrifugal Shot Blast System has a significantly faster production rate than some of the conventional baseline methods and has been used to decontaminate 2,500 sq. ft. of floor surfaces.

- The Concrete Grinder, a handheld concrete and coating removal system, has been deployed at the Hanford C Reactor. It is faster than conventional baseline technologies and thus helps accelerate project schedules. It is also lightweight and has reduced vibration, resulting in decreased operator fatigue. It provides a smooth finish, which allows for more reliable final surveys.

Eight dismantlement and material disposition technologies have been deployed twenty-three times. Highlights of deployed dismantlement and material disposition technologies include:

- The Oxygasoline Torch, a cutting torch technology, has been deployed at Fernald, Oak Ridge, Pantex Plant, sites in Russia and Kazhakstan, INEEL, and Hanford. The Oxygasoline Torch cuts faster, cleaner and cheaper on thick metal and under adverse conditions (rust) in comparison to the oxyacetylene torch, as well as providing significant cost savings.

- The Dual Arm Work Platform (DAWP) and the Rosie Mobile Work System were deployed for the decommissioning of the Chicago-Pile 5 Research Reactor at Argonne National Laboratory. The DAWP was used for a variety of D&D tasks including reactor control rod cutting and sizing, reactor vessel dismantlement, removal of contaminated lead panels, and dismantlement and removal of graphite bricks from the control rod penetrations. Rosie removed contaminated graphite blocks and safely off-loaded radioactive materials from the top of the CP-5 reactor without risking exposure to radiation by personnel.

In the worker health and safety category, nine technologies have been deployed sixteen times. Highlights of deployed health and safety technologies include:

- The Wireless Remote Monitoring System, a personnel and area monitoring system, was deployed at Hanford's C Reactor, Hanford's N Basin Project, Chernobyl's Unit 4 Shelter Project, and the Cooper Nuclear Power Station. The Wireless Remote Monitoring System provides real-time monitoring of worker dose levels, helping reduce the risk of worker exposure.

- The Personal Ice Cooling System (PICS) has been deployed at the Fernald site. PICS is a self-contained core body temperature control system that has been successfully used during high temperature D&D activities to increase worker productivity and comfort, and decrease cost compared to baseline heat stress management technology.

These 30 deployed technologies have resulted in 80 individual applications or deployments.

The above list includes several deployments in commercial plants, showing the mutual benefits of the DOE-Industry partnership in D&D technology development.

Key R&D Issues

Although DOE's investment in D&D R&D is expected to continue to return significant value in the form of technology deployments that are faster and cheaper, there are issues that will limit the long-term return. For example, the general lack of regulatory drivers for D&D action

schedules reduces the urgency of technology improvements. Thus, the more innovative improvements that could have major impacts in the post-2006 period receive very low priority.

The apparent short-term advantage that accrues from having a well-established commercial sector and, therefore, a substantial reservoir of readily deployable technologies may eventually prove to have a down side by delaying investment in less developed but potentially high-impact innovations. If accelerated schedules were to be mandated for D&D, there may not be time to bring these innovations to a deployable state. Moreover, the established commercial sector has a market interest in stating that current baseline technologies are sufficient.

Considering the magnitude of the total D&D mortgage identified above ($11 billion for EM, $31 billion for DOE and a greater amount for the commercial utilities), the current investment in science and technology is low ($26 million in FY 2000) particularly in light of the cost savings track record to date—20-40%. Despite this outstanding return, DOE's 1998-2000 investment trend is sharply downward. Unless DOE invests in D&D science and technology at a higher rate than is currently planned, potential savings of up to $1 billion before 2006 and $6 billion after 2006 in EM costs alone will not be realized. Additional costs for the DOE as a whole and for the commercial sector will be even greater.

Problem Area R&D Program

Budget: FY98-$39.5M, FY99-$33.9M, FY00-$25.8M

Program Description

The D&D R&D portfolio currently is invested in S&T resources and capabilities that range from directed research to technical assistance and which are coordinated with other EM programs to deliver integrated, technically defensible solutions for cleanup and environmental stewardship of DOE sites. EM's D&D technology program focuses on rapid deployment of improved and innovative solutions to lower cost and risk associated with D&D. EM's D&D investment in R&D supports the four major thrust areas of the EM Science and Technology program: (1) accelerate technology deployment, (2) reduce cost, (3) meet high priority needs, and (4) reduce EM's technological risk. To achieve this strategy, the D&D activities must quickly access, demonstrate, and validate the many commercially available D&D technologies available worldwide which are not currently being used within the DOE weapons complex. Over 750 such technologies have been identified, and more are being added to the D&D technology inventory as the worldwide technology search continues.

EM manages a series of LSDDPs designed to meet the technical needs and reduce the cost of facility D&D. In these LSDDPs, the science and technology program participates directly in site D&D projects (selected competitively) to demonstrate and validate a suite of potentially improved D&D technologies within these site projects. The first three LSDDPs, conducted in FY 1996 and FY 1997, were (1) CP-5 Research Reactor D&D at ANL-E, (2) Plant 1 Uranium Processing Facility D&D at Fernald, and (3) 105-C Production Reactor Interim Safe Storage at Hanford). These three initial LSDDPs resulted in 58 technology demonstrations, and 80 subsequent deployments of demonstrated technologies, both within DOE and the commercial nuclear utilities.

Four new LSDDPs were initiated in FY 1998 and several D&D technology demonstrations have been completed during FY 1998 and FY 1999. The four LSDDPs initiated in FY 1998 are: (1) TRU Waste Characterization, Decontamination, and Disposition at LANL, (2) Decontamination and Decommissioning of Fuel Storage Canals and Associated Underwater and Underground Facilities at INEEL, (3) Decontamination and Decommissioning of a Tritium Contaminated Facility at Mound, and (4) Deactivation of 321-M Fuel Fabrication Facility at Savannah River.

Additionally, DOE initiated a canyon disposition initiative at Hanford in March 1998. The remedial investigation/feasibility study (RI/FS) process utilizes the U-Plant (a chemical reprocessing canyon) and is working toward establishing an end state decision by the end of 2000. One potential option is to remove all TRU contaminants, fill the structure with waste, and entomb the canyon as a permanent disposal facility. This potential option could reduce the canyons D&D mortgage at Hanford by more than $1 billion, and is applicable to similar chemical reprocessing facilities at SRS, Oak Ridge and INEEL. Four new work packages have been created for 2000. These are described within work packages in the four Product Lines (Reactor Facilities; Radionuclide Separation Facilities; Fuel and Weapons Component Fabrication Facilities; and Laboratory Facilities).

To effectively manage its RD&D program, four product lines were created based upon the types of facilities for which DOE is responsible: (1) reactor facilities, (2) radionuclide separations facilities, (3) fuel and weapons component fabrication facilities, and (4) laboratory facilities.

Reactor Facilities

Budget: FY98-$10.3M, FY99-$10.2M, FY00-$8.4M

Description. There are 14 surplus production reactors across the DOE weapons complex, which represent a significant portion of the long-term D&D mortgage. There are also over 100 test and research reactors throughout DOE and U.S. universities, as well as many commercial nuclear reactors that are approaching their life expectancy. Improved technologies are required that facilitate lower cost and reduced risk for D&D of these reactors. In addition, highly contaminated fuel pool and associated facilities require improved technologies for characterization, decontamination and dismantlement.

R&D Challenges. Nuclear reactors around the world pose a multitude of challenges to D&D including auxiliary systems, piping, ventilation systems, fuel storage basins, biological shields, and reactor structure and core components. The D&D cost per commercial reactor has been estimated at $400-500 million.

R&D Activities. Improved technologies for characterization, decontamination and dismantlement that will lower overall cost to D&D these aging facilities as well as reduce risks to workers involved in D&D operations. These improved/innovative technologies will be demonstrated and deployed to help facilitate interim safe storage of DOE's production reactors to help reduce long term surveillance and maintenance costs. Improved technologies in the areas of debris/sludge removal from fuel storage pools, fuel storage pool water treatment, and decontamination of the storage pool surface will also be demonstrated.

Planned Accomplishments. The planned accomplishments are described below.

Fuel Pools and Associated Structures Deactivation and Decommissioning:

- 16-18 deactivation and decommissioning technologies will be demonstrated with validated cost and technical performance.
- 8 technologies will be deployed with 25% average cost savings.
- $25M mortgage reduction at INEEL will be achieved after broad deployment.
- Technologies will be deployed at Hanford K-Basins in FY2003-05 for major mortgage reduction.

Reactor D&D:

- Interim safe storage of the Hanford and Savannah River production reactors will reduce deactivation and storage cost from $24M to $16M each.

- Cost for decommissioning of DOE's research reactors will be reduced by at least 10%.

- Cost for decommissioning of commercial nuclear power plants and university research reactors will be reduced by at least 10%.

Radionuclide Separation Facilities

Budget: FY98-$10.9M, FY99-$7.1M, FY00-$6.5M

Description. Improved technologies are required to deactivate and decommission radionuclide separation facilities, including gaseous diffusion plants, fuel reprocessing canyons, chemical separation facilities, uranium recycling facilities, lithium enrichment facilities, and heavy water production facilities. D&D activities also lead to potential valuable resources, such as scrap metal and concrete. At present, most of these materials are disposed of as waste because of cheap burial costs. Decontamination of concrete and metals for recycle or free release may result in many project life cycle cost savings.

R&D Challenge. Radionuclide Separation Facilities are typically massive in size, are aging structures, and have high levels of contamination. These facilities have been used to process plutonium, uranium and various hazardous materials. Removal and disposition of radioactive and hazardous materials and equipment, deactivation of nonessential systems and utilities, and reconfiguration of systems to facilitate long-term surveillance and maintenance within these facilities with baseline technologies is very costly and poses high safety and health risks. Material generated during D&D activities is currently disposed of as low-level waste at typically high-life cycle costs. The ability to characterize and segregate contaminated and non-contaminated material will result in substantial life cycle cost savings.

R&D Activity. Technologies will be demonstrated and deployed which address characterization of specific contaminants, large-scale decontamination and dismantlement, waste disposition, worker health and safety, and remote operations. Technologies will also be demonstrated and deployed to accurately characterize and determine the type, quantity, and location of contamination to support development of a Record of Decision (ROD) to determine the final end-state of the U-Plant facility at Richland. Finally, improved technologies for rapid radioactive analysis and separation into contaminated and non-contaminated scrap material will be demonstrated and deployed for substantial life cycle cost savings.

Planned Accomplishments. The planned accomplishments are described below.

Canyon Disposition Initiative:

- Deploy 4-6 improved characterization systems (remote/robotic).

- CERCLA RI/FS completed and ROD established in FY 2000.

- Potential mortgage reduction of $1.1B at Hanford if the end state condition is an in-placed, entombed LLW disposal facility.

- Major mortgage reduction at SRS (F and H Canyons), INEEL (INTEC), and ORR (Y-12).

Processing Facilities Deactivation and Decommissioning:

- 8-12 deactivation and decommissioning technologies demonstrated with validated cost and technical performance.
- 5 deactivation and decommissioning technologies deployed.

Material Recycling and Release:

- 8-12 deactivation and decommissioning technologies demonstrated with validated cost and technical performance.
- 5 deactivation and decommissioning technologies deployed.
- Life-cycle costs documented for radioactive material decontamination/free release versus reuse as useful products for DOE.
- Some projects will use materials recycling and avoid disposal costs for waste materials.

Fuel and Weapons Component Fabrication Facilities

Budget: FY98-$2.7M, FY99-$5.8M, FY00-$6.3M

Description. Improved technologies are required to deactivate and decommission fuel and weapons component fabrication facilities including uranium milling and refining facilities, fuel and target fabrication facilities, weapons component fabrication facilities and weapons disassembly, dismantlement, modification and maintenance facilities.

R&D Challenges. Problems that will need to be addressed include: decontamination /dismantlement and metal/concrete waste disposal/recycling; characterization and removal of highly enriched uranium at fuel fabrication facilities; and characterization, decontamination and dismantlement of weapons component fabrication facilities that contain highly fissile materials, and numerous radioactive species, organics, and high explosive materials.

R&D Activities. Technology emphasis will be on real-time characterization, removal of tritium and highly enriched uranium from inaccessible areas, decontamination and remote dismantlement technologies that will significantly reduce the risk to workers, the public, and the environment.

Planned Accomplishments. The planned accomplishments are described below.

Tritium Contaminated Facilities Deactivation and Decommissioning:

- 20-25 deactivation and decommissioning technologies demonstrated with validated cost and technical performance.
- 10 deactivation and decommissioning technologies deployed with average 25% cost savings.
- Potential $25M mortgage reduction for Mound's Tritium Contaminated Facilities.

Fuel Fabrication Facility Deactivation:

- 8-10 deactivation technologies demonstrated with validated cost and technical performance.
- 4 deactivation technologies deployed with average 25% cost savings.
- Complete deactivation of 321-M building at SRS with substantial reduction in surveillance and maintenance and material control and accountability costs.
- Potential $20M mortgage reduction at SRS after broad deployment.

Weapons Component Fabrication Facilities Deactivation and Decommissioning:

- 8-12 deactivation and decommissioning technologies demonstrated with validated cost and technical performance.
- 4 deactivation and decommissioning technologies deployed with average 25% cost savings.

Laboratory Facilities

Budget: FY98-$9.8M, FY99-$6.0M, FY00-$0.0M

Description. Innovative and improved technologies are required to deactivate and decommission laboratory facilities including research, development and testing facilities, hot cells and gloveboxes.

R&D Challenges. Across the DOE weapons complex, there is a large number of surplus plutonium contaminated processing equipment including piping, ducts, tanks and gloveboxes characterized as TRU waste. To limit the amount classified as TRU, an improved waste management process that will characterize, sort, and segregate TRU and LLW is needed. Laboratory facilities including hot cells and gloveboxes are typically contaminated with high levels of radioactivity and often require remote/robotic applications to reduce worker exposure risk. Working space is often confined, which results in increased worker risks. Laboratory facilities are generally large structures with complex equipment and piping systems requiring repetitive robotic dismantlement and size/volume reduction techniques. These facilities usually have large areas of contamination on concrete and metal surfaces requiring characterization, decontamination and disposition of radioactive lead shielding, dust and debris removal, and remote cutting. Without this effort, baseline D&D approaches will be followed at most all DOE sites at typically very high costs.

R&D Activities. Laboratory facilities will address basic research, applied research, demonstrations and deployments of technologies and techniques for the D&D of laboratory facilities including hot cells and gloveboxes. D&D of these facilities, typically contaminated with high-levels of radioactivity, will require remote/robotic applications to reduce worker exposure risk. The R&D is to develop remote/robotic systems that can operate in the confined working space often found in these facilities.

Planned Accomplishments. The planned accomplishments are described below.

Transuranic Contaminated Materials and Waste Disposition:

- 10-12 deactivation and decommissioning technologies demonstrated with validated cost and technical performance.
- 5 deactivation and decommissioning technologies deployed with average 25% cost savings.
- Improved cutting tools deployed at Rocky Flats.
- Remotely operated robotic arm with tooling deployed in a Permacon enclosure at Rocky Flats in FY 2000.
- Central size reduction facility (enabling simultaneous D&D of multiple buildings) deployed at Rocky Flats in FY 2001.
- Potential $75-180M mortgage reduction at LANL and Rocky Flats after broad deployment.

Laboratory Facilities Deactivation and Decommissioning:

- 8-12 deactivation and decommissioning technologies demonstrated with validated cost and technical performance.
- 5 technologies deployed with average 25% cost savings.

Electronics Recovery and Recycling

Budget: FY98-$0.0M, FY99-$2.0M, FY00-$0.0M

This unique effort focuses on recycling glass, plastics, and metals contained in computers and other electronic equipment, including circuit boards, computer chips, etc. The electronics industry, major suppliers of components and raw material suppliers believe there are significant cost advantages to recovering and using recycled materials in the production process. The FY 1999 effort is intended to continue research and development for component recycling that were initiated under the National Electronics Recycling Project pilot project that was initiated in FY 1998 at Oak Ridge. All activities, especially information exchange, would be coordinated with the Oak Ridge efforts. Among the activities is the development of an Internet system for electronic commerce to serve as the

clearinghouse for arranging collection and appropriate direction of "like" products for cost-effective recycling.

Directed Science

Budget: FY98-$5.8M, FY99-$2.8M, FY00-$4.6M

Within the D&D investment portfolio, DOE funds research to advance science to solve environmental problems associated with placing equipment and structures in a desired end state. Desired end states include complete removal and remediation of the facility, release of the facility for unrestricted use, or release of the facility for restricted use. Nine subcategories of science needs have been identified in the area of deactivation and decommissioning:

- Reduction of wastes produced by remediation and decontamination.
- Characterization, monitoring, and certification of contaminated equipment facilities.
- Control of radioactive emissions, especially from waste processing activities.
- Improved methods for removing surface contamination, including metals, concrete, and non-porous surfaces.
- Containment technologies/techniques to prevent spread of contamination.
- Methods for size reduction in equipment.
- Technologies for removal of hazardous materials, including asbestos and lead.
- Remote handling and operations, including demolition.
- Decontamination techniques for process equipment and facilities.

Between 1998 and 2000, 22 directed research projects are being funded for a total amount of $13.5 million. The D&D basic research portfolio is concentrated in the scientific areas of analytical chemistry and instrumentation, biogeochemistry, engineering science, inorganic chemistry, materials science and separations chemistry.

Analytical Chemistry and Instrumentation: Focus is on waste characterization equipment and techniques. The objectives of this basic research project are to develop non-destructive methods for identifying the hazardous asbestos in real-time in the field using gamma spectroscopy. Another project aims to develop simple, inexpensive new chemical sensing materials which can be used as visual color test strips to sensitively and selectively report on the concentration and identity of environmental pollutants such as cations of lead, uranium, plutonium, strontium, cesium, and cobalt, as well as other species.

Biogeochemistry: Focus is on improved methods for removing surface contamination. Projects include biological and physical chemical parameters for effective decontamination of metal surfaces using environmentally benign aqueous-based

biopolymer solutions, and microbial processes with potential for decontaminating corroding metal surfaces.

Engineering Science: Focus is on robotics development and monitoring devices. Projects include work leading to a prototype dual-manipulator mobile work cell, which is supported and enhanced by computer vision, artificial intelligence, and virtual reality technology; avoiding the dangers associated with in-operation failure of robots to help DOE personnel reduce the risk of catastrophic in-site robot failures and thereby decrease the risk of damaging the containment facilities, loss of robot, and mission failures; and developing three-dimensional position-sensitive germanium detectors with the ultimate goal of improving image resolution without sacrificing spectroscopic resolution in gamma-ray imaging cameras.

Inorganic Chemistry: R&D in this area centers on solid/solution chemistry. Investments are being made for a robust process, Polymer Filtration®, which can address the various conditions that dilute waste streams present. Polymer Filtration® combines specially prepared water-soluble metal-binding polymers with commercially available ultrafiltration membranes to effect a selective separation of metal ions. It is anticipated that new materials such as this one will be able to address many DOE metal removal/recovery needs.

Materials Science: Focus is on surface chemistry and waste materials. Projects include a collaborative research program to characterize the novel chemistry and physics of the atmospheric-pressure plasma jet; study of the structure, composition, and mechanism of formation of radionuclide-containing surface films on metals relevant to the problem of decontaminating piping systems and waste storage tanks at DOE nuclear facilities; thermal effects between 100 and 1400 degrees on concrete engineering properties, chemical properties, and contamination behavior as a function of final temperature, heating rate and aggregate type; and optimizing a melt decontamination process through a basic understanding of the factors that govern partitioning of various radionuclides between metal, slag, and gas phases to (a) determine the nature of the association of radionuclides uranium, plutonium, cobalt, and strontium with stainless steel, plain carbon steel and copper surfaces commonly found at sites targeted for decommissioning, and (b) selectively remove the radionuclides using hydroxycarboxylic acids (citric acid and its analogs).

Separations Chemistry: Focus is on ligand design and ion exchange. Projects include use of innovative separation techniques for highly toxic radioisotopes such as plutonium and the experimental capability to handle these materials; use of colloid-enhanced ultrafiltration processes to remove and recover important radionuclide ions and associated contaminants from aqueous streams; and application of unique quantitative surface analytical capabilities to measure the depth-dependent radionuclide concentrations of test surfaces that represent the full range of materials and exposures found in nuclear facilities.

Budget Summary Table

(Dollars in thousands)

Program Activity	FY 1998 Appropriation	FY 1999 Request	FY 2000 Request
Reactor Facilities	$10,337	10,160	8,433
Radionuclide Separation Facilities	10,893	7,145	6,525
Fuel and Weapons Component Fabrication Facilities	2,652	5,782	6,254
Laboratory Facilities	9,784	5,951	0
Electronics Recovery and Recycling		2,000	
Directed Science	5,816	2,846	4,618
Total	**39,482**	**33,884**	**25,830**