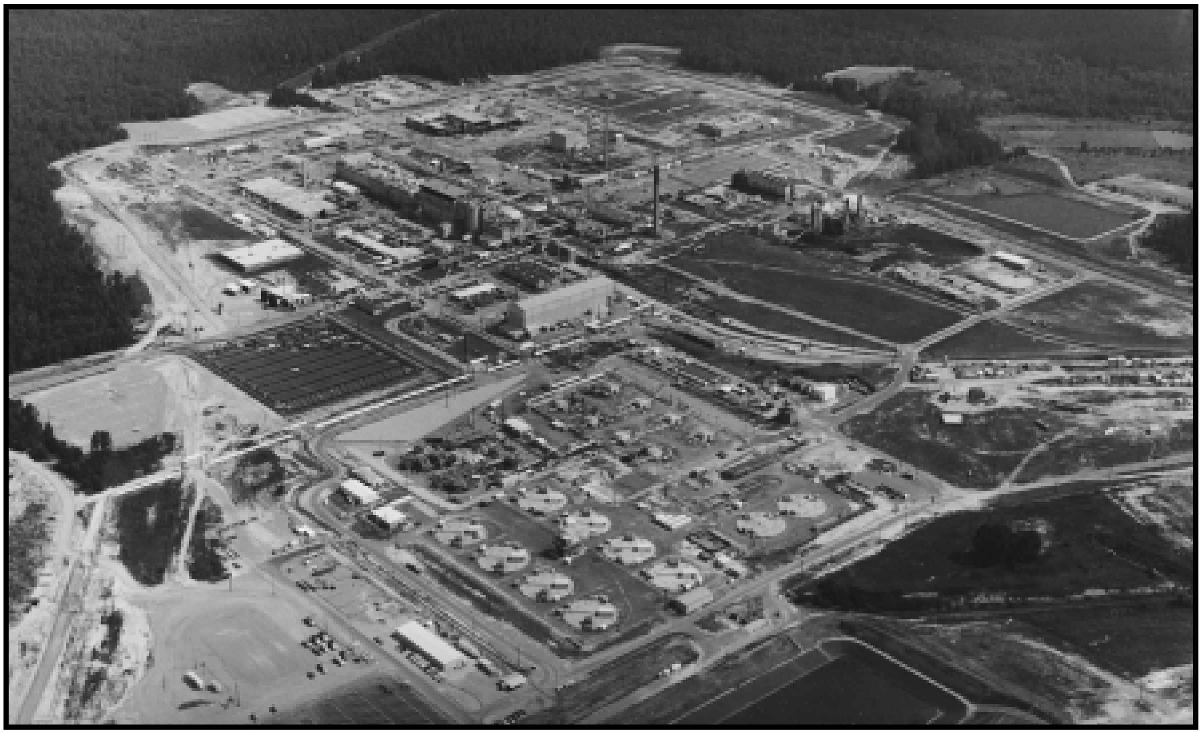
Landfill with RCRA Cap. Ten acres of black, high-density polyethylene cover a mixed waste landfill at the Oak Ridge Reservation. The cap is designed to prevent gases from escaping, reduce erosion, and keep rainwater from leaching contaminants into groundwater. Installed in 1989, the cap is designed to last from 15 to 20 years. Maintenance and monitoring will be required at least until 2019. *Solid Waste Storage Area 6, Oak Ridge Reservation, Tennessee, January 1994.*

Engineered units include radioactive, hazardous, and sanitary landfills; vaults; and tank farms with man-made containment systems. Engineered units at 70 sites are expected to require some level of stewardship activity. These include units such as the Environmental Restoration Disposal Facility (ERDF) and the high-level waste tanks at the Hanford Site. Engineered units generally contain large volumes of waste and contamination and include areas where the most highly contaminated wastes have been consolidated for permanent disposal or long-term retrievable storage. Engineered units will require active stewardship activities such as leachate collection, cap maintenance, erosion control, and access restriction. Data on the size and number of all the engineered units that will remain on DOE sites were not readily available for this analysis. Some sites, however, provided the precise number and size of engineered units that will remain onsite, with most sites containing only one or two units at closure.

Tuba City Disposal Cell, Arizona. A total of 1,100,00 cubic meters of contaminated materials was stabilized onsite in a 50-acre disposal cell. The disposal cell has a radon barrier cover and rock surface layer to control erosion. Long-term surveillance and monitoring activities at the disposal cell include annual surface inspections and a 10-year revegetation program. The Tuba City Site consisted of 42 acres. Nine acres were covered by the uranium mill tailings pile, 18 acres were former evaporation ponds, and the remaining acres were contaminated by wind-blown materials. DOE will continue routine groundwater compliance monitoring after groundwater remediation is complete in 2010. *Tuba City Uranium Mill Tailings Repository, Tuba City, Arizona, June 1998.*

Low-Level Waste Disposal Vault. This vault for low-level waste is located at the Savannah River Site. It is a reinforced concrete structure 25 feet tall, 600 feet long, and 200 feet wide. It houses 12 concrete cells that will be filled with solid grout ("saltstone") made by mixing a low-level waste solution with cement, fly ash, and slag. Radionuclides in the grout will include technetium-99, strontium-90, and cesium-137. Once all 12 cells are filled, the vault will be covered with earth and capped with clay. Active maintenance and monitoring will be required, along with passive institutional controls to prevent intrusion. *Z-Area Vault, Savannah River Site, South Carolina, January 1994.*

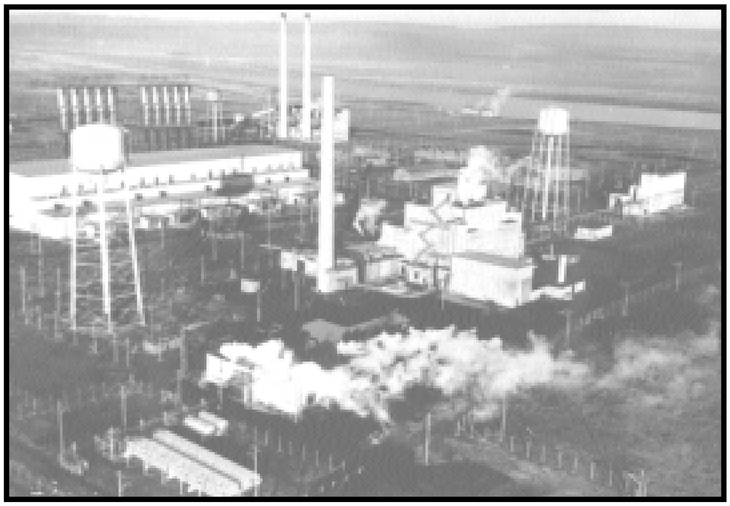


F-Area at the Savannah River Site. A number of facilities in this ½ square mile area will remain contaminated indefinitely because of a lack of cost-effective technologies available to remove the intense levels of radioactivity. The reprocessing "canyon" near the center of the photo is still operating, but, even after deactivation and decommissioning, it is unlikely to ever be decontaminated sufficiently to allow for unrestricted use. The underground storage tanks in the lower part of the photo will contain residual waste after most of the high-level waste has been removed for vitrification. Grout (similar to concrete) has been poured in the "emptied" tanks to immobilize the residual waste and prevent the buried tank shells from collapsing. *F Area, Savannah River Site, South Carolina, August 1983.*

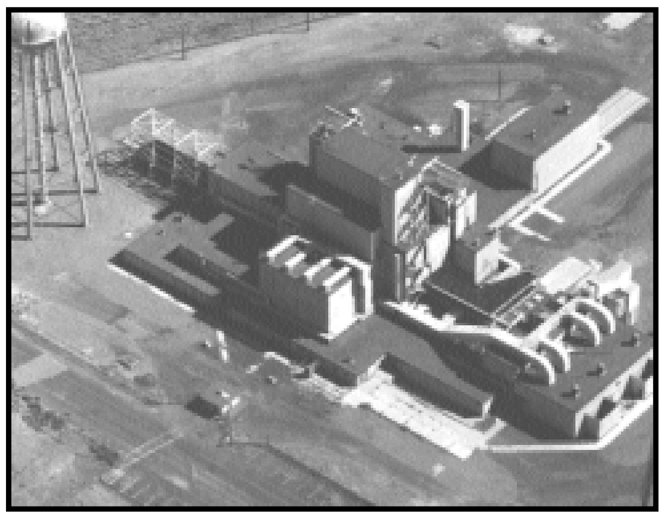
Facilities include entombed reactors, canyons and other buildings with residual contamination, as well as remaining infrastructure. Contaminated facilities will remain at as many as 32 sites. Many of the currently contaminated buildings across the complex will be fully demolished and will only require stewardship for an interim phase prior to decontamination and demolition.

Most contaminated facilities can be addressed by decontamination or demolition and disposal. Consequently, contaminated facilities typically pose less of a technical challenge for cleanup and stewardship than underground storage and disposal situations, such as high-level waste tanks. Nonetheless, certain contaminated facilities pose significant stewardship challenges, such as the nuclear production reactors and chemical separations facilities (reprocessing "canyons"). These facilities are very large, with extensive radionuclide contamination that is both intense and long-lived, and that could pose risks to workers conducting remediation activities. There are no specific plans as yet for the final disposition of the canyons. One option being considered is to demolish the buildings, bury them in place, and place an engineered cap on the area. Whatever the final disposition, these facilities will be in a long-term surveillance and maintenance mode until final decisions are made, and probably for very long periods of time thereafter. For example, the reactors at the Hanford Site will be placed in an interim safe storage mode for 75 years to allow the radioactive contamination to decay to safer levels, and the Department will then consider options for their final disposition. The photos in Exhibit 10 illustrate the changes in a reactor when it undergoes transition from production to interim safe storage. During the interim safe storage phase, DOE will be conducting technology demonstration projects to test at least 20 new technologies and approaches that may provide safer, less expensive, and more efficient ways to decommission aging nuclear facilities.

Exhibit 10: Interim Safe Storage of C Reactor at Hanford Site



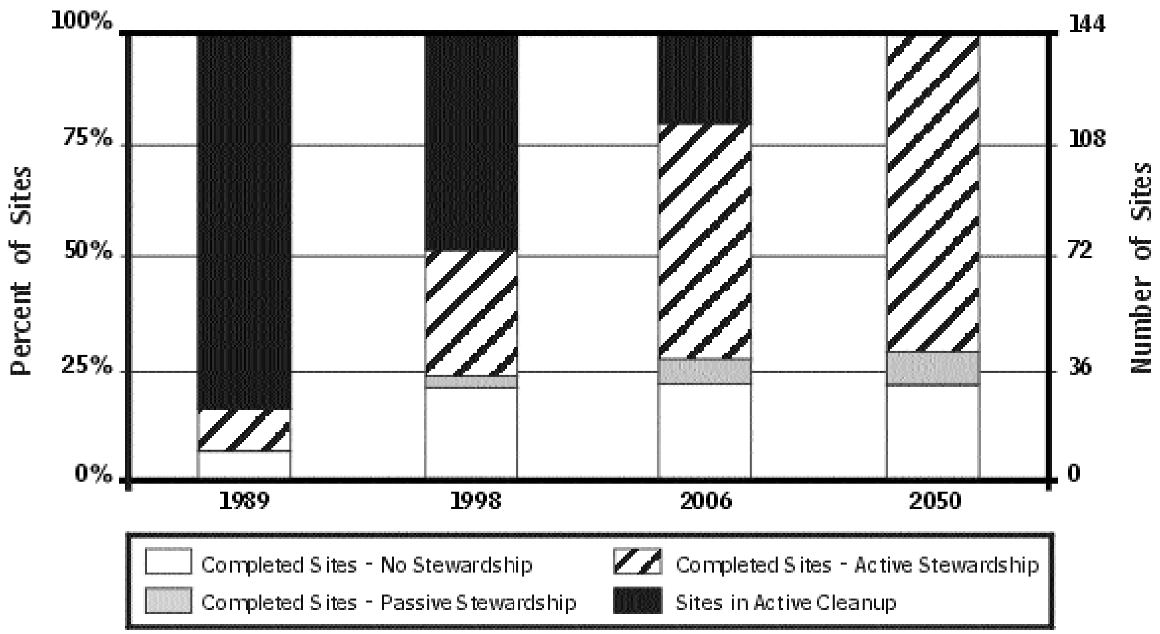
Hanford B/C Reactor Complex During Operation. Construction of the 100-B/C plutonium production reactor complex at Hanford began in August 1943 as part of the Manhattan Project. B Reactor (shown here), was the first of Hanford's nine production reactors to begin operating in September 1944, under the direction of Enrico Fermi. Work on C Reactor began in June 1951; it operated from November 1952 to April 1969. *Photo circa 1953. Source: U.S. Department of Energy-Richland Operations.*



C Reactor During Surveillance & Maintenance Phase. The reactor facility was abandoned in-place from 1969 until 1996, with only minimal surveys and structural maintenance work performed. Access was controlled, but the buildings gradually deteriorated and posed serious industrial safety and environmental risks. Assessments determined that aggressive cleanup action would be far less costly than structural repairs. *June 1996. Source: U.S. Department of Energy-Richland Operations.*

C Reactor in Interim Safe Storage. Decontamination and demolition of C Reactor secondary structures from 1996 to 1998 reduced the facility's "footprint" by 81%. All hazardous materials and nonessential equipment were removed. The reactor's core remains within its existing shielding walls, with the walls serving as a base for a new corrosion-resistant steel roof. This Safe Storage Enclosure, completed in September 1998, is designed to safely contain the reactor for up to 75 years while the radioactive contamination decays. *September 1998. Source: U.S. Department of Energy-Richland Operations*

Exhibit 11: Stewardship Activities Increase as Cleanup is Completed



Timing of Long-Term Stewardship Activities

DOE has already completed cleanup and is conducting long-term stewardship at 41 of the 109 sites expected to require stewardship. Long-term stewardship is also underway at portions of many other sites where cleanup activities and other missions (e.g., nuclear weapons maintenance) continue. Exhibit 11 illustrates that stewardship activities will increase as cleanup is completed.

- In 1989, 126 sites were undergoing active cleanup. Of the 18 completed sites, active stewardship was ongoing at nine sites, passive stewardship was occurring at one site, and no stewardship was required at eight sites.
- In 1998, fewer than half of the 144 sites were still undergoing active cleanup. Of the 74 completed sites, active stewardship was required at 39 sites, passive stewardship at two sites, and no stewardship at 33 sites.
- By 2006, only 21 of the sites (15 percent) are expected to be undergoing active cleanup. Of the 123 sites where cleanup is expected to be complete, active stewardship is anticipated at 84 sites, passive stewardship at four sites, and no stewardship at 35 sites.
- Active cleanup is expected to be completed at all sites by 2050. By then, active stewardship currently is anticipated at 103 sites, passive stewardship at six sites, and no stewardship at 35 sites.

The 21 sites expected to require active cleanup beyond 2006 generally are larger sites or sites with contamination requiring more complex remediation measures. All 21 sites will likely require extensive stewardship. Some stewardship activities already are taking place at portions of these sites where specific remediation goals have been met. For example, while cleanup at the Hanford Site as a whole is not expected to be complete until 2046, cleanup of portions of the site is already complete, and stewardship is underway. As other portions of these sites meet cleanup goals, stewardship will begin there as well.

Field of Wells at Savannah River Site A-M Area. The Integrated Demonstration site contains 150 monitoring wells, some quite shallow and some as deep as 200 feet. The wells keep track of the contamination left after the major cleanup project at the M Area, which included removing large amounts of waste, capping the old disposal area, and pumping and treating contaminated groundwater. The site also includes the world's first horizontal injection well used for environmental remediation. *M Area Settling Basin, Savannah River Site, South Carolina, January 1994.*

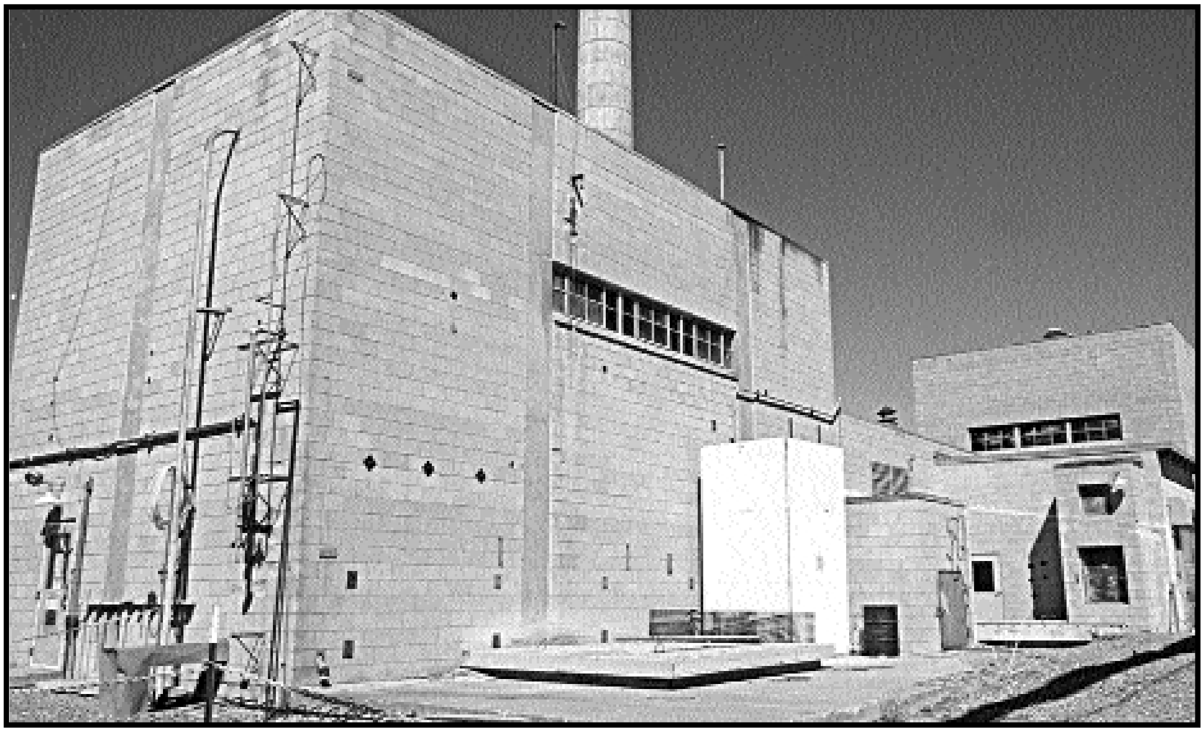
The duration of stewardship depends on the persistence of site hazards as well as the technologies available for remediation. The data submitted on the duration of stewardship activities were insufficient to determine a definitive end date for stewardship; however, several sites expected stewardship to be needed for 100 years or in perpetuity.

Land Use

As noted in Chapter 1 of this report (page 19), future land use, cleanup strategies, and long-term stewardship are interdependent. Therefore, information regarding future land use for DOE facilities is critical for developing effective cleanup strategies and long-term stewardship plans.

The *Paths to Closure* data that were used as the basis for this report provide very little information regarding future land use assumptions at DOE sites. Therefore, previous land use planning analyses (DOE 1996b, 1998b) were used to develop the future use assumptions provided in Appendix E.

Because these previous land use planning reports addressed a limited number of sites, DOE is seeking to improve its understanding of current and anticipated future land use to aid in site cleanup and stewardship planning. Moreover, DOE is working with its field office personnel to develop common definitions for land use categories (e.g. industrial vs. recreational), which will allow for inter-site planning and comparisons. Finally, site personnel are continuing to work with local governments and



Before: Waste Calcining Facility. This facility solidified high-level radioactive waste generated by the reprocessing of spent nuclear fuel. The photo, taken in 1990, shows the early stages of facility deactivation. *Idaho National Engineering and Environmental Laboratory, Idaho, 1990. Source: U.S. Department of Energy - Idaho Operations.*

After: Waste Calcining Facility. After the calcining plant's superstructure and contaminated equipment had been demolished, the remaining rubble pile was filled with grout to stabilize any residual contamination. *Idaho National Engineering and Environmental Laboratory, Idaho, May 1999. Source: U.S. Department of Energy - Idaho Operations.*

other stakeholders to develop plans for anticipated future land use that are consistent with required planning assumptions.

There are a number of reasons why decisions have not been made regarding post-cleanup alternative future use of many sites. First, many sites have, or are seeking, a non-EM mission (e.g., nuclear weapons materials management or scientific research), so active DOE control of the site is expected to continue indefinitely. Second, many fundamental cleanup decisions have not been made (e.g., cleanup strategy, amount of residual contamination, and disposition of excess property); until decisions have been made on these issues, definitive future use cannot be determined.

In some cases, before determining the future use of a site, DOE may prepare an environmental impact statement or environmental assessment pursuant to NEPA to analyze the potential environmental impacts of alternative uses. A number of DOE sites (e.g., Hanford, Nevada Test Site, and Los Alamos National Laboratory) have already been the subject of an environmental impact statement covering land use. Land use or resource management plans have also been developed for other sites (DOE 1998b).

Current Organizational Responsibilities

Current responsibility for long-term stewardship resides with a variety of DOE offices. For most sites, when cleanup is ongoing, but where cleanup of certain portions has been completed (e.g., Hanford and Savannah River Sites), long-term stewardship is part of the overall infrastructure maintenance responsibilities of the DOE operations office managing the site. For a number of sites where cleanup has been completed, personnel assigned to the Grand Junction Office (GJO) in Colorado perform a variety of long-term stewardship functions. The mission of DOE's GJO is to assume long-term custody of certain sites where cleanup is complete and to provide a common basis for their operation, security, surveillance, monitoring, maintenance, annual reporting, and emergency response. There are currently five types of sites assigned to the GJO program for long-term surveillance and maintenance:

(1) UMTRCA Title I sites, which are inactive uranium milling sites where NRC licenses terminated prior to November 1978;
(2) UMTRCA Title II sites, which are uranium milling sites licensed as of 1978;
(3) NWPA Section 151 sites that were privately owned and that contain radioactive wastes but not low-level mill tailings;
(4) Decontamination and decommissioning sites, including three entombed nuclear reactors (Hallam reactor, Nebraska; Piqua reactor, Ohio; and the Site A/Plot M burial site of Enrico Fermi's original "Chicago Pile" reactor, Illinois) and associated waste materials; and
(5) Other sites, including the former Pinellas Plant in Florida, transferred to GJO in 1997.

Long-term stewardship responsibilities for additional sites will likely be transferred to this program. For example, long-term stewardship responsibility for the Weldon Spring Site is expected to be transferred to GJO in 2002.

The Department's Nevada Operations Office is responsible for long-term stewardship at former nuclear explosion test sites in Alaska, Colorado, Nevada, New Mexico, and Mississippi (referred to as "Nevada Offsites").

Other offices perform stewardship functions following waste management activities. For example, Savannah River Site personnel are managing two underground storage tanks that had been filled with high-level waste and subsequently "closed" by removing and vitrifying most of the waste and filling the tank with grout. Also, DOE's West Valley (New York) personnel are developing long-term stewardship plans for the site following completion of waste management and other cleanup tasks.

Costs of Post-Cleanup Stewardship Activities Unknown

There are a number of long-term stewardship activities for which funding will likely be required. First, there are tasks required as part of direct site maintenance, including site monitoring, maintenance of the remedy, and regular (e.g., annual or five-year) review of the long-term stewardship plan to determine if changes are appropriate. Second, site security and overhead costs may include maintaining fences, gates, signs, roads, and utilities (e.g., electric, water and sewer) for security facilities in some cases. Third, a relatively small cost is required for record keeping, including archiving records, indexing, reproduction, title and deed recording, and distribution of records.

Compared to other activities (e.g., waste management, environmental restoration, fissile materials stabilization, and security) the Department currently spends relatively little money on long-term stewardship. As part of its cleanup program, the Department is seeking to lower the post-cleanup risks as much as possible and, as a result, the required costs for long-term stewardship site maintenance. There is little specific information available, however, on the Department's long-term stewardship funding requirements.

The primary reason for this lack of comprehensive and specific information is that the Department is conducting much of its current long-term stewardship responsibilities as part of the larger site infrastructure support and maintenance activities associated with operations.[4] Because these costs are combined with other site maintenance costs, such as site security, emergency response, and road repair, there is relatively little explicit information on long-term stewardship. Moreover, long-term stewardship costs are dwarfed by other site support costs incurred during active environmental management (i.e., environmental restoration, waste management, and nuclear materials and facilities stabilization) or other missions (e.g., Defense Programs or Nuclear Energy). The costs for long-term stewardship are more apparent when these other costs are eliminated through completions of the environmental management missions or cessation of the other missions, thereby eliminating the need for large site infrastructure support funding. Also, site personnel cannot project long-term stewardship costs until specific end states are determined for the active environmental management tasks.

Nonetheless, the Department has recently developed a significant amount of general long-term stewardship cost information, including cost elements (i.e., What is being funded?) and responsibility for costs (i.e., Who is funding it?), as well as some useful anecdotal cost information from specific projects.

The most explicit funding for long-term stewardship is provided through GJO. The FY 1999 budget for the Grand Junction long-term surveillance and monitoring program is $1.6 million, with life cycle costs for individual sites ranging from $4,000 to $2.5 million. These costs generally include collecting groundwater samples, repairing fences, conducting minor erosion control, restricting access, and conducting periodic surface inspections. These costs do not include potentially required major site repair if a breach in site containment were to occur. The costs also do not include active pumping and treatment of contaminated groundwater as part of a long-term remediation or containment system. In the near future, however, GJO will likely be responsible for such "pump and treat" systems at three former uranium mill tailings sites.

4. In a broader sense, long-term stewardship is an extension of the current funding for site infrastructure to maintain safe conditions (e.g., roof repair, repaving parking lots, radiation control). Clearly, one of the goals of cleanup, in addition to reducing risks, is to reduce the cost of maintaining safe site conditions, thereby reducing long-term stewardship costs.

The Department's Nevada Operations Office has managed long-term stewardship (mostly collecting groundwater and surface water samples near the underground test locations) at the "Nevada Offsites" for about 25-35 years. These activities are assumed to continue indefinitely. Annual costs currently range from $30,000 to $50,000 per site. The monitoring at these sites is performed by EPA but paid for by DOE. Experience with these sites suggests that such monitoring can be conducted at a modest cost, although its direct applicability to other DOE sites has not yet been determined.