

RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING IN THE UNITED STATES OF AMERICA

1. NATIONAL FRAMEWORK FOR MANAGEMENT AND REGULATION OF RADIOACTIVE WASTE AND DECOMMISSIONING

1.1 National Framework

1.1.1 Overview of National Policy

The United States' policy is to manage and dispose of radioactive waste to ensure the health and safety of the public, security of the radioactive material, and long-term containment and isolation from the environment.

The national policy on decommissioning is to ensure that licensed sites that contain residual radioactive materials are decommissioned or remediated in a safe, timely, and effective manner so that they can be returned to beneficial use.

U.S. policy is to involve the public in its key decision-making processes for radioactive waste management and decommissioning.

1.1.2 Overview of Relevant Institutions

Missions of Relevant Agencies

The primary Federal agencies with responsibilities related to radioactive waste disposal, decommissioning, and uranium recovery are the United States Department of Energy (DOE), the United States Nuclear Regulatory Commission (NRC), and the United States Environmental Protection Agency (EPA). Individual states also have related responsibilities.

DOE missions include advancing the national, economic, and energy security of the United States; promoting scientific and technological innovation in support of that mission; and ensuring the environmental cleanup of the national nuclear weapons complex. As part of that mission, DOE ensures safe and secure management and disposition of nuclear materials and radioactive waste to protect national security.

The NRC mission is to license and regulate the Nation's civilian use of byproduct, source, and special nuclear materials to ensure adequate protection of public health and safety, promote the common defense and security, and protect the environment.

The EPA mission is to improve and preserve the quality of the environment by implementing and enforcing environmental laws, setting environmental guidelines, monitoring pollution, performing research and promoting pollution prevention.

The roles of the DOE, NRC, and EPA in relation to the management and regulation of spent nuclear fuel (SNF) and high level waste (HLW) disposal, transuranic (TRU) waste disposal, LLW, uranium recovery, and decommissioning are described below.

SNF and HLW Disposal:

U.S. legislation established roles for the following three federal agencies regarding the disposal of SNF and HLW from civilian nuclear power plants as follows:

- DOE is responsible for managing and ultimately disposing of SNF and HLW ;
- NRC is responsible for implementing the EPA generally applicable radiation protection standards in its regulations, and for licensing disposal facilities for SNF and HLW; and
- EPA is responsible for promulgating generally applicable radiation protection standards necessary to protect the public from potential releases of radioactive material from disposal facilities.

TRU Waste Disposal:

U.S. legislation authorized the DOE to dispose of TRU waste that results from atomic energy defense activities at the Waste Isolation Pilot Plant (WIPP) in New Mexico. TRU waste has been disposed of at WIPP since 1999. DOE, EPA, and the State of New Mexico have management and regulatory roles at WIPP. DOE is responsible for the management of nuclear operations at the plant under the Atomic Energy Act of 1954. EPA also has a significant regulatory and oversight role. In 1992, the WIPP Land Withdrawal Act directed EPA to issue criteria for certification compliance of the WIPP facility with its final disposal regulations. The EPA must periodically recertify that WIPP meets its standards; the first review of compliance was completed in March 2006, and the second review of compliance was completed in November 2010. Under authority delegated by EPA, the State of New Mexico regulates the hazardous waste constituents in the TRU waste disposed of at WIPP.

LLW:

U.S. legislation has established roles for three federal agencies and the States for the management, disposal, and regulation of low-level radioactive waste as follows:

- DOE is responsible for and performs most of the low-level radioactive waste management activities for DOE-owned and generated waste located, for the most part, on DOE-owned sites. Much of this LLW was generated in connection with DOE's nuclear energy technology development and nuclear weapons programs. In addition to managing waste onsite, DOE also operates its own disposal facilities. DOE retains authority under the Atomic Energy Act of 1954 over LLW activities conducted by DOE or on its behalf, and such activities are not subject to NRC regulation, except as otherwise provided by law. DOE is also responsible for the disposal of greater-than-Class C (GTCC) LLW generated by NRC and Agreement State licensees.
- NRC is responsible for regulating the safety of private sector and non-DOE governmental activities, including all aspects of LLW management and disposal. NRC issues regulations; licenses nuclear power plants, enrichment plants, and the possession and use of nuclear materials and waste; inspects nuclear facilities; and enforces its regulations. Some NRC regulatory authority, including that associated with low-level radioactive waste management and disposal, can be relinquished to the 50 States of the U.S., the U.S. territories, Puerto Rico, and the District of Columbia, under the Agreement State

Program. NRC conducts a review of Agreement State LLW activities through a formal program known as the Integrated Materials Performance Evaluation Program (IMPEP);

- EPA is responsible for the regulation of the hazardous component of mixed waste, i.e., waste that contains both hazardous chemicals and low-level radioactive waste. This responsibility has been delegated by EPA to 48 States, the District of Columbia, and the territory of Guam; and
- Under the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLRWPA), each State is responsible for providing, either by itself or in cooperation with other States, for the disposal of Class A, B, and C LLW generated within the State (except for certain waste generated by the federal government).

Uranium Recovery:

U.S. legislation established roles for DOE, NRC, and EPA regarding licensing of uranium recovery facilities and the possession and disposition of the wastes from uranium recovery facilities as follows:

- DOE is responsible for remediating old uranium recovery facilities whose licenses had been terminated, including construction, operation, and closure of disposal facilities for waste, and is the long-term custodian for sites at which wastes from uranium recovery facilities are permanently disposed;
- NRC is responsible for licensing uranium recovery facilities (excluding uranium mines, which are regulated by the Office of Surface Mining, the U.S. Department of the Interior, and the individual States where the mines are located); and
- EPA is responsible for promulgating generally applicable standards necessary to protect the public and the environment from potential releases of radioactive material from uranium recovery facilities.

Decommissioning:

Three Federal agencies and individual States have responsibility for decommissioning in the United States as follows:

- DOE oversees the remediation of DOE facilities;
- NRC develops regulations for the decommissioning and remediation of residual radioactive materials at NRC licensed sites (or at sites that were or that could be licensed by NRC) and ensures adequate protection of the public and the environment through inspections and enforcement. NRC's regulations define decommissioning as removing a facility or site safely from service and reducing residual radioactivity to a level that permits: (1) release of the property for unrestricted use and termination of the license; or (2) release of the property under restricted conditions and the termination of the license;
- EPA sets general standards for radiation in the environment which NRC, DOE, and the States follow; and
- Individual States are responsible for ensuring adequate protection of public health and safety and the environment in the use of naturally-occurring radioactive materials and radiation-producing facilities. In decommissioning, States can assume responsibility for source, special nuclear and byproduct materials under the NRC's Agreement State Program.

1.2 National, Technical Regulatory Organisation(s)

1.2.1 Regulatory Function

DOE

Established in 1977, DOE is responsible for regulating the management of its own radioactive waste and SNF, except where otherwise mandated by law, e.g., where Congress has provided NRC with licensing and related regulatory authority over DOE activities or facilities.

NRC

The NRC is an independent regulatory agency established by the Congress in 1974 to ensure adequate protection of the public health and safety, to protect the environment, and to promote the common defense and security in the civilian use of nuclear materials in the U.S. NRC's scope of responsibilities includes regulation of: (1) commercial nuclear power; non-power research, test, and training reactors; (2) fuel cycle facilities; medical, academic, and industrial uses of nuclear materials; (3) the transport packaging, storage, and disposal of nuclear materials and waste; and (4) certain DOE facilities over which Congress has provided NRC licensing and related regulatory authority including facilities for the disposal of SNF and HLW.

To fulfill the agency's Congressionally-mandated mission, the NRC has established licensing procedures for regulating the use of by-product, source, and special nuclear materials. Specifically, the NRC goals for radioactive waste management are: (1) to ensure treatment, storage, and disposal of waste produced by civilian use of nuclear materials in ways that do not adversely affect current and future generations; and (2) to protect the environment in connection with civilian use of source, byproduct, or special nuclear materials through the implementation of the Atomic Energy Act (AEA) and the National Environmental Policy Act (NEPA).

EPA

The EPA was created in 1970, in response to the growing public demand for cleaner water, air, and land. The EPA is responsible for the implementation of Federal laws designed to protect the environment. Its mission includes establishing and enforcing environmental protection standards consistent with national goals. As part of that mission, EPA has issued standards that are now applied to facilities that manage or dispose of HLW, SNF, and TRU waste.

1.2.2 Organization and Resources

DOE

Within DOE, the Office of Health, Safety and Security (HSS) provides complex-wide independent oversight of SNF and radioactive waste management and decommissioning activities at DOE sites, other than facilities licensed by NRC. HSS ensures conformance of DOE activities with applicable laws and requirements for protecting the environment, and the safety and health of the public and workers at DOE facilities. HSS develops environmental, occupational safety and health, and medical policies, rules and implementation guidance for operation of DOE facilities. It conducts safety analyses and education and training programs. HSS also ensures that identified deficiencies and other important issues are tracked and corrective actions are taken. The Office of Environmental Management also chairs the Low-Level Waste Federal Review Group which is responsible for performance assessment review and issuance of disposal facility authorizations within DOE.

NRC

Within the NRC, the Office of Nuclear Material Safety and Safeguards (NMSS) directs all licensing and inspection activities of NRC associated with domestic nuclear fuel cycle facilities, transport of nuclear materials, independent interim SNF storage, and management and disposal of HLW. The Office of Federal and State Materials and Environmental Management Programs (FSME) directs all licensing and inspection activities of NRC associated with uses of nuclear materials, management and disposal of LLW, uranium recovery, and decontamination and decommissioning of facilities and sites.

FSME also establishes and maintains communication with States, local government, other federal agencies and Native-American Tribal governments, and administers the Agreement States Program, through which 37 States have signed formal agreements with the NRC allowing the State to assume, under State law, regulatory responsibility over certain byproduct, source, and small quantities of special nuclear material, consistent with the Commission's regulations. This Agreement State authority includes responsibility for licensing commercial low-level waste facilities within their borders. FSME also conducts periodic reviews of its Agreement States and Regional Offices.

The Office of Nuclear Regulatory Research (RES) is responsible for establishing the technical basis for regulations, and provides information and technical basis for developing acceptance criteria for licensing reviews. RES conducts research and performs analyses both in-house and through contractors to develop an independent basis for timely and realistic regulatory decisions, anticipates potential future safety problems and develops research programs to address these problems, and interprets research results to provide guidance for resolving licensing issues.

An important aspect of NRC's regulatory program is its inspection and enforcement activities. The NRC has four regional offices (Region I in King of Prussia, Pennsylvania; Region II in Atlanta, Georgia; Region III in Lisle, Illinois; and Region IV in Arlington, Texas) which conduct inspections of NRC-licensed facilities including nuclear waste facilities.

The NRC's Advisory Committee on Reactor Safeguards (ACRS) has statutory responsibilities as described in the Atomic Energy Act of 1954, as amended. The ACRS reviews and advises the Commission with regards to the licensing and operation of production and utilization facilities and related safety issues, including issues associated with nuclear materials and waste management and other matters referred to it by the Commission.

EPA

Within the EPA, the Office of Radiation and Indoor Air coordinates the Agency's activities that regulate the radiological aspects of HLW facilities under its jurisdiction. Environmental radiation protection standards regarding HLW, as previously described, have been developed by this office. Oversight of the operations, and periodic re-certification of compliance (every five years) for the Waste Isolation Pilot Plant for TRU waste disposal, is carried out by the Office of Radiation and Indoor Air with the assistance of EPA's Region VI office based in Dallas, Texas. Regulation of airborne radioactivity from DOE facilities, including those that manage SNF and HLW, is coordinated by this Office in cooperation with EPA's ten regional offices covering all 50 states.

EPA consults with the Radiation Advisory Committee of its Science Advisory Board, which Congress established in 1978 with a broad mandate to advise the Agency on technical matters and provide a mechanism for review of scientific and technical information being used or proposed as the basis for Agency regulations.

1.3 National Implementing Organisations

1.3.1 Scope of responsibility

DOE

The principal role of DOE is to help the nation meet energy, scientific, environmental, and national security goals. DOE is responsible for promoting America's energy security through reliable, clean, and affordable energy; ensuring America's nuclear security; strengthening U.S. scientific discovery, economic competitiveness; and protecting the environment by providing a responsible resolution to the environmental legacy of nuclear weapons production. One of the goals of DOE in regard to radioactive waste management is to mitigate risks and hazards associated with treatment and final disposition of nuclear materials, and deactivating and decommissioning and restoration of facilities and restoration of land areas no longer needed to support DOE's mission.

DOE is responsible for the management and disposition of SNF and HLW from commercial utilities. DOE is also responsible for management and disposition of DOE-owned SNF and HLW and other DOE-owned and -generated waste and materials. These are located, for the most part, on DOE-owned sites. SNF and HLW from decades of defense reactor operations are stored at DOE's Hanford Site, Washington, and at DOE's Savannah River Site, South Carolina. Canisters of HLW glass are produced and stored at DOE's Savannah River Site. DOE has completed vitrification of HLW at the West Valley Demonstration Project site, New York and the resulting canisters of HLW glass are stored at the site. Additionally, solid granular HLW calcine is stored in bin sets at the Idaho Site. (Naval reactor spent fuel is also currently stored at Idaho.) DOE is responsible for the ultimate disposition of this DOE SNF and HLW.

1.3.2 Organisation and resources

DOE

The Department of Energy is responsible for the management and disposal of radioactive waste it owns or generates. Pursuant to Standard Contracts entered into under the NWPA, DOE is also responsible for the disposal of SNF and HLW generated by commercial nuclear utilities and pursuant to the LLWRPAA, DOE is responsible for disposal of GTCC LLW that results from NRC or Agreement State licensed activities. As described in Section 3.2, activities previously performed by the DOE Office of Civilian Radioactive Waste Management (DOE-OCRWM) are being performed elsewhere in the Department. For example, the DOE Office of Nuclear Energy (NE) will lead used nuclear fuel activities previously performed by the DOE-OCRWM. In addition, NE's Used Nuclear Fuel Disposition Research and Development Office (UFD) will develop and execute a research and development (R&D) program that will address critical scientific and technical issues associated with the long-term management of used nuclear fuel.

Under the NWPA as amended in 1987, Congress created the U.S. Nuclear Waste Technical Review Board (NWTRB), an independent Federal agency, to review DOE scientific and technical activities for management and disposal of the nation's SNF and HLW.

The DOE Office of Environmental Management (DOE-EM) has responsibility for cleanup of the DOE weapons production and nuclear research sites across the U.S. DOE-EM has a complete waste treatment and management system for government-owned spent nuclear fuel and other radioactive waste. This includes numerous storage/interim storage and processing facilities (treatment and conditioning). Other waste management treatment and disposal systems support cleanup and closure of facilities no longer serving a DOE mission. In fulfilling its mission, EM is focused on:

- Constructing and operating facilities to treat radioactive liquid tank waste into a safe, stable form to enable ultimate disposition.
- Securing and storing nuclear material in a stable, safe configuration in secure locations to protect national security.
- Transporting and disposing of TRU and LLW in a safe and cost effective manner to reduce risk.
- Activating and decommissioning of excess contaminated facilities to reduce long-term liabilities/environmental risk(s) and maximizing resources for cleanup.
- Remediating soil and ground water contaminated with the radioactive and hazardous constituents.
- Fulfilling its commitments to reduce environmental/public risk and complete cleanup across all sites for the generations to come.

2. LEGAL FRAMEWORK

2.1 Primary Legislation and General Regulations

Legislation

Relevant laws authorizing DOE's, NRC's and EPA's radioactive waste and spent fuel programs include:

- Atomic Energy Act of 1954, as amended;
- National Environmental Policy Act (NEPA) of 1969, as amended;
- Energy Reorganization Act of 1974, as amended;
- DOE Organization Act;
- Uranium Mill Tailings Radiation Control Act of 1978, as amended;
- Low-Level Radioactive Waste Policy Act of 1980;
- Low-Level Radioactive Waste Policy Amendments Act of 1985;
- Nuclear Waste Policy Act of 1982;
- Nuclear Waste Policy Amendments Act of 1987;
- Energy Policy Act of 1992;
- Waste Isolation Pilot Plant Land Withdrawal Act of 1992;
- National Defense Authorization Act (NDAA) for Fiscal Year 2005; and
- Energy Policy Act of 2005 (EPact05).¹

In 1954, Congress passed legislation that for the first time permitted the wide use of atomic energy for peaceful purposes. The 1954 Atomic Energy Act (AEA) redefined the atomic energy program by ending the government monopoly on technical data and making the growth of a private commercial nuclear industry an urgent national goal. The AEA established the Atomic Energy Commission (AEC) with responsibility to regulate the commercial use of source, byproduct and special nuclear material including the regulation of civilian nuclear reactors. The Atomic Energy Act directed the AEC "[...] to encourage widespread participation in the development and utilization of atomic energy for peaceful purposes [...]". At the same time, it instructed the AEC to prepare regulations that would protect public health and safety from radiation hazards. Thus, the 1954 act assigned the AEC three major roles: (1) to continue its

¹ Each of these Laws is briefly described in Appendix 1.

weapons program, (2) to promote the private use of atomic energy for peaceful applications, and (3) to protect public health and safety from the hazards of commercial nuclear power.

In 1969, Congress passed the National Environmental Policy Act which established a national policy for the environment and provided for the establishment of the Council on Environmental Quality (CEQ) within the Executive Office of the President. Subsequently, the U.S. Environmental Protection Agency was created in 1970. At that time, EPA was given authority, pursuant to the AEA, for setting generally applicable standards for radioactivity in the environment. This authority has been used to establish standards for cleanup of uranium mill tailing sites, to establish environmental standards for the uranium fuel cycle, and to set environmental radiation protection standards for management and disposal of SNF, HLW, and TRU waste. Standards developed by EPA, under the AEA, are typically implemented and enforced by others. However, the Waste Isolation Pilot Plant Land Withdrawal Act of 1992 gives EPA authority to certify compliance with its public health and environmental radiation protection standards at DOE's Waste Isolation Pilot Plant² where defense-related TRU waste is now being disposed. The Energy Policy Act of 1992 charges EPA with developing site-specific standards for the Yucca Mountain site. In addition, under provisions of two major environmental statutes, the Clean Air Act (CAA) and the Safe Drinking Water Act (SDWA), EPA has the responsibility for regulating and enforcing the levels of radioactivity in air emissions and in drinking water. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPA can determine soil cleanup values and other residual radioactivity limits at contaminated sites that are covered by the Superfund Program. EPA also has authority to provide overall guidance to other federal agencies on radiation protection matters that affect public health.

In 1974, Congress passed the Energy Reorganization Act which abolished the AEC and transferred its functions to the U.S. Nuclear Regulatory Commission and Energy Research and Development Administration (ERDA). Congress subsequently abolished ERDA and transferred its functions to DOE. Additional legislation further defined the roles of the NRC and the DOE, and introduced a role for the States through the Low-Level Radioactive Waste Policy Act of 1980 (LLWPA) and the Low-Level Radioactive Waste Policy Amendments Act of 1985, which assigned to the States, rather than the federal government, responsibility for providing disposal capacity for commercial LLW.

The Atomic Energy Act of 1954, as amended, authorized NRC's licensing oversight of uranium recovery facilities. The Uranium Mill Tailings Radiation Control Act of 1978, as amended (UMTRCA), defined a new category of byproduct material for the tailings and wastes from uranium recovery facilities and identified the responsibilities of DOE, EPA, and NRC with regard to that byproduct material and the sites where it is located.

The Nuclear Waste Policy Act of 1982 (NWPA) established the U.S. government's responsibility and policy for managing SNF and HLW. The Nuclear Waste Policy Amendments Act of 1987 (NWPAA) specified the Yucca Mountain site as the only site to be characterized as a candidate repository and established a detailed approach for the disposal of SNF and HLW.

In 1992, Congress passed the Energy Policy Act (EnPA) mandating a new process for developing the HLW disposal regulations for the proposed repository at Yucca Mountain, Nevada. Congress, through EnPA, directed EPA to contract with the National Academy of Sciences (NAS) to evaluate the scientific basis for a Yucca Mountain standard, and further directed EPA to promulgate new site-specific public health and environmental standards based upon and consistent with the findings and recommendations of the NAS. The EnPA further directed NRC to revise its repository licensing criteria to be consistent with EPA's standards.

² For additional information on WIPP, the following EPA website should be consulted
<http://www.epa.gov/radiation/wipp>

Section 3116 of the National Defense Authorization Act (NDAA) for Fiscal Year 2005 provides DOE with a defined process by which waste at DOE's Savannah River and Idaho sites can be evaluated and disposed of based on the hazard it poses to human health and the environment, rather than its origin. The NDAA requires that (1) DOE consult with NRC on its non-HLW determinations and plans and (2) NRC, in consultation with the State, monitor disposal actions taken by DOE for the purpose of assessing compliance with NRC regulations in 10 CFR Part 61, Subpart C. If the NRC determines that any disposal actions taken by DOE are not in compliance, the NDAA requires NRC to inform DOE, the affected State, and congressional subcommittees. In addition, the NDAA provides for judicial review of any failure of the NRC to carry out its monitoring responsibilities.

On August 8, 2005, the President signed into law the Energy Policy Act of 2005 (EPAAct). It contains provisions relating to energy and development programs and includes specific provisions addressing, among other things, disposal of GTCC LLW (including certain sealed sources), naturally occurring radioactive materials (NORM), and accelerator-produced waste.

The applicable regulations for each of the three federal agencies principally responsible for radioactive waste management and disposal activities are contained in Title 10 (for NRC and DOE) and Title 40 (for EPA) of the *U.S. Code of Federal Regulations* (CFR), which is published annually. Regulations are developed through an open process, including the opportunity for public comment, and are published daily, in proposed or final forms, in the *Federal Register*.

2.2 Regulations Concerning Specific Activities or Facilities

A listing of specific regulations for each Agency is provided in Appendix 2.

2.3 Guidance on Implementation

The NRC issues guidance on how to implement its regulations in the form of *Regulatory Guides* and *Staff Positions*. *Regulatory Guides* are drafted by the NRC staff to establish a standard approach to licensing. They are not intended to be regulatory requirements, but they do reflect methods, procedures, or actions which would be considered acceptable by the staff for implementing specific parts of the Commission's regulations. *Staff Positions*³ are divided into two general types: so-called "generic" positions, dealing with issues which relate to licensing activities for nuclear facilities independent of the technology or site selected; and site-specific positions, which give site guidance or advice applicable to a specific site. In addition to the above guidance mechanisms, the NRC staff uses Standard Review Plans, which provide guidance to the NRC staff in reviewing licensee submittals. These plans are made public, so that licensees and applicants understand what is needed to comply with regulations. In this respect, the licensees and applicants have this third type of guidance to assist them in preparing their demonstration of compliance with the applicable regulations and standards.

Regarding international guidance, the NRC and EPA staff and its contractors have actively participated in Nuclear Energy Agency (OECD/NEA) and International Atomic Energy Agency (IAEA) activities dealing with disposal criteria, development of approaches for site characterization, and development of performance assessment methodologies. Important guidance for radiation protection programs is provided in International Commission on Radiological Protection (ICRP) technical guidelines. The ICRP standards are cited in NRC staff documents which focus on dose assessments. The NRC is currently addressing options for possible modification of applicable NRC standards and guidance for harmony with ICRP 103. EPA guidance for federal agencies on allowable exposure and calculation of dose and risk also consider ICRP recommendations.

³ Also include Staff Technical Positions and Branch Technical Positions

The EPA has issued guidance related to its oversight of the WIPP repository for defense-related TRU waste disposal. In February 1996, EPA published final criteria for the certification and re-certification of the WIPP's compliance with its generally applicable disposal standards. To assist in the implementation of these criteria and DOE's preparation of a Compliance Certification Application, EPA issued guidance in March 1996. Guidance regarding the management and storage of TRU waste at WIPP was made available on February 28, 1997. In June 2004, EPA finalized changes to its WIPP Compliance Criteria (40 CFR Part 194) to streamline the oversight and approval process for waste characterization activities at DOE's WIPP waste generator sites.

Joint guidance has been issued by the EPA and NRC on various aspects of mixed waste management, including mixed waste identification, storage, and disposal.

Extensive guidance has been issued by the EPA through its Superfund program for remediation of sites contaminated with radionuclides, including guidance on risk assessment and cleanup technologies. In 1995, EPA and DOE/EM issued joint policy/guidance for an agreed upon approach to decommission DOE's excess contaminated facilities, consistent with the requirements of CERCLA and encouraging a streamlined decision making process. As such, the policy establishes that decommissioning will preferentially (but not mandatorily) be conducted as non-time critical removal actions. This approach effectively integrates EPA oversight responsibilities, DOE lead agency responsibilities, as well as state and stakeholder participation.

DOE has also issued DOE Directives and guidance documents to address the conduct of deactivation and decommissioning, as embodied in DOE Order 430.1B *Real Property Asset Management* and associated guides for Facility Transition (DOE G 430.1-5), Surveillance and Maintenance (DOE G 430.1-2), Deactivation (DOE G 430.1-3), and Decommissioning (DOE G 430.1-4), and radioactive waste management and disposal (DOE Order 435.1).

DOE Order 435.1, "Radioactive Waste Management" and accompanying manual DOE M [435.1-1] are internal governing documents for radioactive waste management at DOE. The Order addresses protection of the worker, public health and safety, and the environment for all DOE onsite radioactive waste management, as well as environmental restoration activities resulting in off-site management and disposal of radioactive waste. DOE Order 435.1 applies to all DOE radioactive waste classes, including HLW, TRU waste, and LLW. The requirements span the life cycle of waste management facilities from planning through decommissioning and closure. The Order references other DOE requirements on radiation protection, environmental protection, and occupational safety.

DOE HQ Order 250.1, 1998, "Civilian Radioactive Waste Management Facilities – Exemption from Departmental Directives" stipulates that whenever applicable DOE requirements overlap or duplicate applicable requirements of the NRC related to radiation protection, nuclear safety (including quality assurance), and safeguards and security of nuclear material, NRC requirements alone will apply to the design, construction, operation and decommissioning of Yucca Mountain Project facilities.

3. WASTE MANAGEMENT STRATEGY AND CURRENT PRACTICE

3.1 Waste Classification and Quantities

Nuclear waste is a byproduct of the use of radioactive materials. HLW results from reprocessing SNF. SNF results primarily from fuel used by power reactors to produce electricity. TRU waste results primarily from atomic energy defense activities. LLW results primarily from reactor operations, and from medical, academic, industrial, and other commercial uses, and generally

contains relatively limited concentrations of radioactivity. Decommissioning waste results from the decontamination and removal of radioactive materials encountered at NRC-licensed facilities during site closure and restoration activities. Uranium mill tailing waste results from commercial uranium ore processing activities following mining and uranium extraction research and development projects, and uranium recovery waste results from *in situ* leach solution mining activities involving injection and recovery wells.

Spent nuclear fuel (SNF) and high-level waste (HLW): Currently 104 operating civilian nuclear power reactors provide about 20 percent of the electricity provided in the U.S. These reactors discharge an average of 2,100 metric tons of heavy metal (MTHM) annually, totaling approximately 65,000 MTHM at the end of 2010. Of these, about 49,000 MTHM are stored in water pools, with about 16,000 MTHM being stored in dry casks at the reactor sites. Assuming that all 104 currently operating reactors receive 20-year life extensions, it is projected that by completion of their life cycles, the total SNF inventory will be about 130,000 MTHM by 2055. In addition, there is a need to manage HLW, SNF, and excess plutonium generated from defense programs. All of the operating nuclear power reactors are storing SNF under NRC license in on-site spent fuel pools, or in independent spent fuel storage installations. In 1977, the U.S. government declared a moratorium on domestic reprocessing, which was later rescinded in 1981. In response to the initial moratorium, the utilities increased the amount of stored SNF in the reactor pools by using high-density storage racks. In 1990, the NRC amended its regulations to authorize licensees to store spent fuel in dry storage casks at reactor sites. Sixteen SNF cask designs have received certificates of compliance as a result of this regulation change, and are in use by about 48 facilities in the U.S.

Transuranic (TRU) waste: The WIPP LWA defines transuranic waste as waste containing concentrations in excess of 100 nanocuries of alpha-emitting transuranic isotopes per gram of wastes, with half-lives greater than 20 years, except for high-level radioactive waste; waste that the Secretary has determined, with concurrence of the EPA Administrator, does not need the degree of isolation required by the disposal regulations; or waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61. TRU waste, like HLW, contains significant long-lived radionuclides and can produce substantial external doses as well. TRU waste generally consists of protective clothing, tools, glassware, equipment, soils, and sludges that have become contaminated with transuranic radionuclides through operations or clean-up at defense-related facilities. As of August 2011, over 76,000 cubic meters of TRU waste had been disposed at WIPP. Before TRU waste may be disposed at WIPP, EPA requires that such waste be properly characterized. EPA verifies through inspections that each generator facility has appropriate technical procedures and quality controls for waste characterization. To date, EPA has approved seven of the “large quantity” TRU waste sites—and several “small quantity” sites—to dispose of waste at WIPP. Other sites will be inspected and approved as proper waste characterization controls are implemented.

Low-level waste (LLW): As of September 2007, a total of 16.7 million m³ of LLW and mixed LLW (MLLW) have been disposed of. Of this total, about 4.8 million m³ of LLW and MLLW has been disposed of at commercial disposal facilities (3 are currently operating, 1 is under construction, and 3 are closed). The remaining 11.9 million m³ is DOE-owned or generated LLW and MLLW that have been disposed of primarily at DOE sites, with a majority of the volumes resulting from cleanup activities. Currently DOE has disposal facilities for LLW and MLLW from site remediation and/or ongoing mission activities at Hanford Site, Idaho Site, Los Alamos National Laboratory, Nevada Test Site, Oak Ridge Reservation (Tennessee), and Savannah River Site. This volume also includes the waste in closed DOE disposal facilities at remediated sites at Fernald (Ohio), Weldon Spring (Missouri), and Monticello (Utah).

Commercial LLW disposal facilities must be licensed by either NRC, or an Agreement State, in accordance with NRC’s health and safety requirements. The facilities are to be designed,

constructed, and operated to meet safety standards. The operator of the facility must also extensively characterize the site on which the facility is located and analyze how the facility will perform for thousands of years into the future. NRC's requirements place restrictions on the types of waste that can be disposed of.

Uranium recovery: NRC activities under the Uranium Mill Tailings Radiation Control Act (UMTRCA) encompass the following: (1) oversight and programmatic direction for the uranium recovery program; (2) implementation of policies and programs; and (3) review of uranium recovery licensing and inspection programs for technical adequacy and consistency. The NRC staff also provides technical assistance to Agreement States on uranium recovery issues and implements an active interface program including ongoing consultation with federal, State, Native American Tribal Governments, and other entities to promote understanding of uranium programs and to resolve concerns in a timely manner.

Tailing waste is generated during the milling of certain ores to extract uranium and thorium. Over 240 million dry metric tons of tailings are managed at 67 sites. This waste has relatively low concentrations of radioactive materials with long half-lives. Tailings contain radium (which, through radioactive decay, becomes radon), thorium, and small residual amounts of uranium that were not extracted during the milling process. The Office of Surface Mining in the U.S. Department of Interior and individual states regulate mining. NRC regulates milling and the disposal of tailings in non-Agreement States, while State agencies regulate these activities in Agreement States when the agreement specifically includes tailings. Mill tailings consist of fine-grained, sand-like and silty materials, usually deposited in large piles next to the mill that processed the ore. Uranium mills are located principally in the western United States, where deposits of uranium ore are plentiful. NRC requires licensees to meet EPA standards for cleanup of uranium and thorium mill sites after the milling operations have permanently closed. This includes requirements for long-term stability of the mill tailings piles, radon emissions control, water quality protection and cleanup, and cleanup of lands and buildings.

3.2 Waste Management Strategy

SNF and HLW: In 2002, after more than 20 years of site characterization activities at Yucca Mountain, the site was approved by the U.S. President after a joint resolution was passed by Congress for development of a repository. DOE submitted the license application (LA) to the NRC on June 3, 2008, and it was docketed on September 8, 2008. The NRC was provided a 3 to 4 year review period before making its decision whether to grant a license to authorize construction of a repository.

In 2009, the Administration announced its intention to terminate the Yucca Mountain program. Alternative approaches for meeting the Federal responsibility to manage and ultimately dispose of spent nuclear fuel and high-level radioactive waste from both commercial and defense activities are being examined by the Blue Ribbon Commission on America's Nuclear Future.

LLW: The LLRWPA made States responsible for providing for the disposal of commercial Class A, B, and C LLW generated within their borders. The Act authorized States to enter into compacts that would allow several States to dispose of waste at a regional disposal facility. Most of the States have entered into compacts. At one time, a dozen new sites were being planned by the States, and a number of design and siting programs were implemented. The first new commercial disposal facility since the enactment of the LLRWPA is licensed by the State of Texas and is expected to be operational in January 2012. There are no other commercial LLW disposal facilities planned at this time.

One of the three operating LLW disposal sites for commercial LLW in the U.S., the Barnwell facility in South Carolina, restricted access to out-of-compact waste in mid-2008. This has caused

LLW generators in 36 States to store their Class B and C waste pending a new disposition option. A potential disposition option may be available with the opening of the new commercial facility in Texas. Generators from states other than Texas and Vermont, which already have access, may now seek approval from the Texas Compact to dispose of their out-of-compact class A, B, and C LLW at the WCS facility.

TRU waste: DOE disposes of TRU waste that results from atomic energy defense activities at WIPP. As of August 2011, EPA approved waste shipments from seven large and several smaller DOE sites, and completed more than 100 waste characterization inspections at DOE generator sites. In January 2007, EPA approved DOE to begin disposing of waste that is more highly radioactive, requiring remote (automated) handling. As of August 2011, over 76,000 m³ of TRU waste has been disposed at WIPP, including 2530 m³ of remote-handled TRU waste. The 10,000th shipment of TRU waste arrived at WIPP in September 2011.

Uranium recovery: NRC and DOE have a joint responsibility for implementing programs required by UMTRCA and consistent with standards set by EPA. UMTRCA established two programs to protect public health and the environment: Title I and Title II. The Title I program established a joint federal/State funded program for remedial action at abandoned mill tailings sites, with ultimate federal ownership under license from NRC. Under Title I NRC must evaluate DOE's designs and concur that DOE's actions meet standards set by EPA. For Title I, with the exception of the Moab site in Utah, which was transferred to the Title I program in 2001, only reviews for the groundwater remedial action program remain, as all surface remedial action was completed in fiscal year 1999. DOE has initiated remedial action at the Moab site, and is moving tailings to a new disposal facility at Crescent Junction, Utah. NRC and DOE have a memorandum of understanding (MOU) to minimize or eliminate unnecessary duplication of effort between the two agencies.

The NRC staff is responsible for planning and implementing the regulatory programs under UMTRCA. The Title I (of UMTRCA) program involves managing, coordinating, and conducting the safety and environmental reviews of pre-licensing and licensing activities, and the review and concurrence of documents related to the cleanup and licensing of abandoned uranium mill tailings sites. The Title II (of UMTRCA) program involves planning and directing the activities related to active, licensed uranium recovery facilities, including facility licensing and operation, as well as mill tailings management and decommissioning.

The Title II program deals with sites under license to the NRC or Agreement States. Under Title II NRC has the authority to control radiological and non-radiological hazards and ensure that NRC- and Agreement State-licensed sites meet all applicable standards and requirements during operations and before termination of the license. The staff reviews Title II licensee plans for operation, reclamation, decommissioning, and groundwater corrective action; license applications and renewals; license conditions changes; and annual surety updates. The staff also prepares environmental assessments for certain licensing actions. Long-term care of reclaimed tailings sites (by State or DOE) is licensed by the NRC under general licenses at 10 CFR Part 40.27 and 40.28.

3.3 Waste Management Issues at National Level

SNF and HLW: As mentioned previously, a repository at Yucca Mountain has been determined not to be a workable option; alternative approaches for meeting the Federal Government's responsibility to manage and ultimately dispose of SNF and HLW from both commercial and defense activities are being evaluated.

LLW: At the national level, the primary challenges are to obtain disposal options for generators for all LLW generated. As mentioned previously, since mid-2008, many U.S. generators no longer can dispose of their Class B/C LLW because the Barnwell facility closed to out-of-region

waste. A new LLW disposal facility in the State of Texas may provide a disposal path for Class B/C LLW from all states. Another challenge is for DOE to develop a disposal facility for greater-than-Class C (GTCC) low-level waste. DOE has initiated an environmental review of various alternatives for disposal of such waste. As required by EPACT 2005, DOE will submit a report to Congress and await Congressional action before making a final decision on disposal options for GTCC LLW.

3.4 Research and Development

3.4.1 Research infrastructure

NRC's research program in nuclear waste safety focuses on improving the regulatory framework in the area of assessing the performance of waste disposal, contaminated site cleanup, clearance, and decommissioning activities. At the NRC, the responsibility for generic waste-related research to support regulation resides in the Office of Nuclear Regulatory Research. Confirmatory HLW research is managed by the NRC's Office of Nuclear Material Safety and Safeguards and carried out at the NRC's Center for Nuclear Waste Regulatory Analyses.

Some current assessment techniques use overly simplistic or conservative assumptions to account for uncertainties and to ensure that dose estimates are over-estimated in order to adequately protect health and safety. Research is focused on improving supporting data, reducing uncertainties, and providing more realistic models of natural processes that control the movement of radionuclides in the environment. The results of this research will be applied most effectively at complex sites with large radionuclide inventories.

NRC research studies, both in-house and those involving outside contractors, provide information and analytical tools such as predictive models to assist in assessing the consequences to public health of intended (within applicable limits) and inadvertent releases to the environment of radioactive materials and the residual contamination that may be left after decommissioning. The ultimate objective is a capability for more realistic assessments of risk to the public from environmental releases.

3.4.2 Contents of R&D plans

The NRC research in this program is examining the mechanisms that control radionuclide movement through the environment with special attention given to groundwater systems and biotic pathways. Complex modeling techniques are evaluated for use in providing more realistic estimates of potential doses to the public for long-time periods into the future. Monitoring systems are studied to provide long-term methods for confirmation of site assessments. Physical and chemical processes and the uncertainties associated both with mathematical modeling and with the variability of natural systems are under study. Probabilistic techniques are applied to provide a risk perspective. Since concern with environmental contamination is common to many federal agencies, the NRC is cooperating on research and development in this area with a group of other federal agencies through the Interagency Steering Committee on Multimedia Environmental Models (see www.ISCMEM.org).

Examples of ongoing NRC waste research are:

- assessment of the performance of non-concrete engineered barriers to radionuclide release from waste facilities;
- study of exhumed disposal units to evaluate long term performance of covers;
- integrated groundwater monitoring strategies;

- incorporation of an integrated approach to uncertainty assessment in performance assessment models;
- enabling the use of reactive transport models in performance assessment (including participation in Phase 3 of the NEA Sorption Project);
- evaluation of the efficacy of uranium bio-remediation in subsurface media for potential application in decommissioning and uranium recovery;
- co-operation with other U.S. federal agencies to develop common integrated modeling strategies for assessing the performance of waste facilities;
- evaluating and determining data for food chain parameters in biosphere models;
- participation with the US Department of Energy in the “Partnership for the Development of Next Generation Simulation Tools to Evaluate Cementitious Barriers and Materials Used in Nuclear Applications;” and
- development of techniques to select the appropriate level of detail to be applied in modeling environmental systems (model abstraction).

The DOE’s Office of Environmental Management (EM) was established in 1989 to achieve the safe disposition of legacy wastes and facilities from defense nuclear applications. A large majority of these wastes and facilities are “one-of-a-kind” and unique to DOE. Many of the programs to treat these wastes have been “first-of-a-kind” and unprecedented in scope and complexity. This has meant that many of the technologies needed for the successful disposition of these wastes were not yet developed or required significant re-engineering to be adapted for EM’s needs. Throughout its existence, EM has required a strong technology component – focused on developing technologies to enhance safety, effectiveness, and efficiency – to accomplish its mission. The unique nature of many of the challenges requires a strong and responsive applied research and engineering program. To address this need, EM has established its Engineering & Technology Program.

The objective of the EM Engineering & Technology Program is to reduce the technical risk and uncertainty in the Department’s clean-up programs and projects. Risks are known technical issues that could prevent project success. Uncertainties are indefinite or unpredictable technical aspects of a project. To reduce those risks and uncertainties, the Program will provide technical solutions where none exist, improved solutions that enhance safety and operating efficiency, or technical alternatives that reduce programmatic risks (cost, schedule, or effectiveness). The Engineering and Technology Program currently consists of thirteen strategic initiatives to address these risks:

- Improved Waste Storage Technology
- Reliable & Efficient Waste Retrieval Technologies
- Enhanced Tank Closure Processes
- Next-Generation Pretreatment Solutions
- Enhanced Stabilization Technologies
- Improved Sampling and Characterization Strategies
- Advanced Predictive Capabilities
- Enhanced Remediation Methods
- Adapted Technologies for Site-Specific and Complex-Wide Decontamination and Decommissioning (D&D) Applications
- Improved SNF Storage, Stabilization and Disposal Preparation
- Enhanced Storage, Monitoring and Stabilization Systems
- Enhanced Long-Term Performance Evaluation and Monitoring
- Improved Packaging of SNF, TRU Waste and Nuclear Materials

3.5 Financing of Radioactive Waste Management

3.5.1 Framework and responsibilities

SNF and HLW:

Under the Nuclear Waste Policy Act, as amended, the commercial nuclear utilities pay a fee, currently assessed at 1/10 US-cent per kilowatt hour (KWh) of nuclear electricity generated and sold, which is deposited in the Nuclear Waste Fund to be used only for waste disposal.

LLW and TRU Waste: DOE, as a Federal agency, receives annual appropriations from Congress for its activities, including funding for DOE LLW and TRU waste management and disposal and decommissioning and cleanup of DOE's contaminated sites. DOE operates its own disposal sites, but also uses private sector disposal and processing facilities when appropriate. Non-DOE organizations are responsible for paying the costs associated with LLW management and disposal, including wastes generated during decommissioning. Many U.S. generators are private companies, and their LLW management costs are paid from the revenues generated by their business. Some non-DOE generators are Federal agencies, and receive funding through the Congressional appropriations process. Others are non-profits, universities, etc., and funding for LLW management is provided for in the overall budgets of these organizations.

Another category of funding is for commercial disposal sites. The licensees for such facilities are required to set aside funds during the operation of the facility so that money is available to carry out a post-closure institutional control program. U.S. regulations require that the State or Federal government implement that program, and take ownership of the site, and thus the funds would be dispersed by those organizations as well. Funds are accumulated by the disposal site operators from revenues generated by waste disposal for commercial generators.

Uranium Recovery: Owners of uranium recovery facilities must remediate their sites, at their expense, prior to termination of their license. Additionally, licensees are required to provide financial assurance that will provide sufficient funds for a third party to complete site remediation in the event that the licensee is unable to do so. In accordance with Criterion 9 of 10 CFR Part 40, Appendix A, NRC reviews the financial assurance annually.

3.5.2 Status of financing

Under the NWPA, nuclear utilities are required to enter into contracts with the Department for disposal of their waste and to pay fees currently equal to 1.0 mill per KWh of electricity generated and sold to cover the cost of disposal of the waste. These fees are deposited into the Nuclear Waste Fund. DOE is responsible for reviewing annually the amount of fees paid by the nuclear utilities, and determining whether sufficient funds are being collected to adequately finance the disposal program.

4. DECOMMISSIONING STRATEGY AND CURRENT PRACTICE

4.1 Decommissioning strategy

Under NRC regulations, decommissioning involves safely removing an NRC-licensed facility from service and reducing residual radioactivity to a level that permits the property to be released for unrestricted or restricted use. This action is taken by a licensee before termination of the license. In other cases, non-licensed facilities may also be required to decontaminate and decommission the site in order to meet NRC release limits. This activity comprises NRC's integrated regulation of the decontamination and decommissioning of facilities and sites associated with NRC-licensed activities, including associated research, rulemaking efforts, and

the coordination of decommissioning activities with all appropriate stakeholders and other regulators.

Unlike NRC that regulates the commercial nuclear industry, DOE is responsible for the deactivation and decommissioning of its own excess contaminated facilities, with EPA oversight and State and stakeholder participation. Similar to NRC's strategy, DOE aims to safely decommission its facilities to permit unrestricted or restricted release and/or use. Currently estimated at approximately 3,500 facilities, the DOE decommissioning scope is spread across 4 major and numerous smaller sites/geographic locations. Consistent with DOE's enduring management and control of some of its sites, in-situ decommissioning or entombment has been endorsed, and is being implemented as an acceptable decommissioning end state.

4.2 Status of decommissioning projects

Over the last 40 years, operations at licensed nuclear facilities have caused radiological contamination at a number of sites. This contamination must be reduced or stabilized in a timely and efficient manner to ensure protection of the public and the environment before the sites can be released and the license terminated.

Approximately 200 materials licenses are terminated each year. Most of these license terminations are routine, and the sites require little, if any, remediation to meet NRC's unrestricted release criteria. The decommissioning program focuses on termination of licenses that are not routine, because the sites involve more complex decommissioning activities. Currently, there are 13 nuclear power reactors, 10 research and test reactors, 14 complex decommissioning materials facilities, 1 fuel cycle facility (partial decommissioning), and 32 uranium recovery facilities that are undergoing non-routine decommissioning, or are in long-term safe storage, under NRC jurisdiction.

Through the Agreement State Program, 37 States have signed formal agreements with NRC, by which those States have assumed regulatory responsibility over certain byproduct, source, and small quantities of special nuclear material, including decommissioning of some complex materials sites. Agreement States do not have regulatory authority over operating or decommissioning nuclear power plants.

Since its creation in the early 1940s, DOE and its predecessor agencies have constructed, operated and excessed thousands of contaminated, often one of a kind/unique facilities including nuclear reactors, chemical separations plants, uranium enrichment facilities, research and analytical laboratories, and many various supporting facilities, utilities and infrastructure. The Office of Environmental Management has, since 1989 been responsible for the deactivation and decommissioning of DOE's excess contaminated facilities and during this time has established the programs and expertise to effectively undertake this unprecedented mission. As of 2009, DOE/EM has completed the deactivation and decommissioning of thousands of facilities including the associated environmental remediation and waste management activities leading to the closure (completion of remediation) of numerous major sites including Rocky Flats, Fernald Uranium Plant, Mound Radioisotopic Plant, Ashtabula Uranium Plant, and the Columbus Nuclear Research Facility. In addition, major individual excess contaminated facility deactivation and decommissioning projects have been completed at each of DOE's major sites and many smaller sites.

4.3 Decommissioning issues at national level

To fulfill the overall strategic objective in the decommissioning area, the NRC has committed itself to:

- Review licensing requests (e.g., amendments, renewals, decommissioning, and license termination plans) to confirm that they are consistent with regulatory requirements.
- Assess the key issues affecting the safe management of civilian low-level waste disposal to ensure that potential disruption in access to the three licensed disposal sites does not adversely affect licensees' ability to operate safely and decommission their plants safely.
- Develop, assess, and disseminate decommissioning lessons learned based on decommissioning practices and experience gained by licensees and regulators.
- Address the issue of adequate financial assurance funding for cleanup and remedial actions.

Decommissioning involves safely removing an NRC-licensed facility from service and reducing residual radioactivity to a level permitting the property to be released for unrestricted or restricted use. This action is taken by a licensee before terminating the license. Non-licensed facilities may also be required to decontaminate and decommission the site to meet NRC release limits.

The NRC has started an initiative to continually improve the licensing process for decommissioning sites and terminating NRC licenses in accordance with 10 CFR Part 20, Subpart E. This effort is referred to as the Integrated Decommissioning Improvement Plan. Its specific purposes include: describing a “continuous improvement” plan for decommissioning during FY 2004-2009; and integrating and tracking regulatory improvements from the License Termination Rule (LTR) Analysis, program management improvements from the Decommissioning Program Evaluation, and other staff improvements. Issues being addressed include:

- Restricted use/institutional controls, including engineered barriers and long-term monitoring;
- Developing a rule to ensure that future decommission sites have adequate financial assurance to complete decommissioning and that operational activities that could impact decommissioning are addressed in a timely manner during operation.

The overall challenge in the NRC’s decommissioning program is to ensure that decommissioning lessons learned are identified, memorialized and incorporated into current decommissioning projects as well as the operating procedures for future facilities. This aligns with international efforts to address decommissioning issues early in the design, construction and operation of authorized nuclear facilities.

4.4 Research and development

4.4.1 Research Infrastructure

NRC’s research program in decommissioning focuses on improving the regulatory framework in the area of assessing the performance of decommissioning activities. At the NRC, the responsibility for generic waste-related research to support regulation resides in the Office of Nuclear Regulatory Research. The objective of this research is to support decisions on the long term management of sites where radioactive material from licensed activities has contaminated soil and groundwater systems. These management decisions are based on assessments of the extent and potential impacts of this contamination and the evaluation of proposed management or remediation schemes. These concerns are not unique to decommissioning and the programs that

address them are listed under section 3.4 as one coherent program dealing with environmental contamination.

DOE's research programs in decommissioning are supported by efforts undertaken in the Office of Science, the National Laboratories and the Office of Environmental Management. Section 3.4.2 provides a more detailed discussion of EM's Technology Development Programs.

4.4.2 Contents of R&D plans

See programs listed in section 3.4.

4.5 Financing

4.5.1 Framework and responsibilities

There are extensive requirements for decommissioning financial assurance that apply to NRC and Agreement State licensees. These requirements help to ensure that funds will be available to decommissioning commercial facilities at the end of their useful life. The mechanisms for such funding include external sinking fund and sureties. The amounts in the funds vary, from none for licensees with very small amounts of radioactive materials, to tens of millions of dollars for large facilities with extensive decommissioning liabilities.

Since 1988, the NRC has required its licensees to provide financial assurance for decommissioning. For reactors, the regulations specify a minimum amount that must be set aside in a fund outside the licensee's control. The amount to be set aside varies according to reactor type, geographical location, and decommissioning methods. The required amount, for radiological decommissioning, which does not include spent fuel management or non-radiological costs, ranges from about \$ 350 million USD to \$550 million USD. The amount is adjusted annually, based on escalation factors for waste disposal costs, energy costs, and labor costs. The adjustment factors are issued in NUREG-1307, "Report on Waste Disposal Charges: Changes in Decommissioning Waste Disposal Costs at Low-Level Waste Burial Facilities." The money may be accumulated over time where the licensee is a regulated utility with electric rates set by a regulatory authority. The authority for setting electric rates is with the States, not the NRC. Due to deregulation of electric rates in some areas of the United States, some NRC reactor licensees may have rates set by a market auction process rather than a regulating authority. To the extent that a reactor licensee is subject to market forces for its electric rates, it must set aside decommissioning funds before starting operation, rather than accumulate the funds over time.

Licensees must report on the accumulation of reactor decommissioning funds every two years. When the facility is within five years of the end of its licensed life, the fund status report must be submitted annually. The licensee must plan to accumulate the required amount by the time that the license authority to operate expires. However, the license continues in effect until decommissioning is complete and the NRC terminates the license.

The decommissioning funds required by regulation do not include costs of spent fuel management. Those costs are provided for in a separate fund. No minimum amount is set by regulation; rather, the licensee makes its own estimate of spent fuel management costs. The licensee must then accumulate sufficient funds to cover the cost. Where the licensee has its electric rates set by a State regulatory authority, the cost of spent fuel management is often included in the rates.

4.5.2 Status of financing

The NRC maintains a record of financial assurance information of active licensees. In addition, the NRC is proceeding with developing a proposed rulemaking that would amend its regulations

to reduce the likelihood that any current operating facility will become a legacy site (e.g., a site with inadequate financial assurance for decontamination and decommissioning). For example, NRC is considering revision of 10 CFR 20.1406 to make it applicable to licensees as well as applicants. In addition, 10 CFR 20.1501(a) will be revised to include the term "residual radioactivity," a defined term in 10 CFR Part 20 which includes subsurface contamination within its scope. To better ascertain the extent of existing contamination within the subsurface media during facility operations, both 10 CFR 20.1406(c) and 20.1501(a) are being revised to include subsurface contamination within their scope.

The Department of Energy prepares, submits and receives annual funding allocations as determined by the United States Congress. In addition to this annual allocation, the American Recovery and Reinvestment Act of 2009 has provided an additional \$3 Billion aimed at accelerating the schedule for many deactivation and decommissioning projects.

ACRONYMS AND ABBREVIATIONS

ACNW&M:	Advisory Committee on Nuclear Waste and Materials
AEA:	Atomic Energy Act of 1954
AEC:	Atomic Energy Commission
ALARA:	As low as reasonably achievable
CAA:	Clean Air Act
CERCLA:	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ:	Council on Environmental Quality
CFR:	Code of Federal Regulations
DP:	Decommissioning Plan
D&D:	Decontamination and decommissioning
DOE	Department of Energy
EIS:	Environmental Impact Statement
EnPA:	Energy Policy Act of 1992
EPA:	Environmental Protection Agency
EPAct05:	Energy Policy Act of 2005
ERDA:	Energy Research and Development Administration
GTCC:	Greater than Class C low-level radioactive waste
HLW:	High-level radioactive waste
ICRP:	International Commission on Radiation Protection
IAEA:	International Atomic Energy Agency
IMPEP:	Nuclear Regulatory Commission's Integrated Materials Performance Evaluation Program
ISCMEM:	Interagency Steering Committee on Research and Development of Multimedia Environmental Models
LLW:	Low-level radioactive waste
LLRWPA:	Low-Level Radioactive Waste Policy Act of 1980
LLRWPA:	Low-Level Radioactive Waste Policy Amendments Act of 1985
LTP:	License Termination Plan
LTR:	License Termination Rule
LTSP:	Long-term surveillance plan
NAS:	National Academy of Sciences
NEPA:	National Environmental Policy Act of 1969
NDAA:	National Defense Authorization Act of 2004
NORM:	Naturally Occurring Radioactive Materials
NRC:	Nuclear Regulatory Commission
NWPA:	Nuclear Waste Policy Act of 1982
NWPAA:	Nuclear Waste Policy Amendments Act of 1987
NWTRB:	United States Nuclear Waste Technical Review Board
OCRWM:	Office of Civilian Radioactive Waste Management (DOE)
OECD/NEA:	Organization of Economic Co-operation and Development /Nuclear Energy Agency
RES:	Office of Nuclear Regulatory Research (NRC)
RESRAD:	A computer model designed to estimate radiation doses and risks from RESidual RADioactive materials.
SDWA:	Safe Drinking Water Act
SNF:	Spent nuclear fuel
SNL:	Sandia National Laboratory
TRU waste:	Transuranic waste
UMTRCA:	Uranium Mill Tailings Radiation Control Act of 1978, as amended
USGS:	United States Geological Survey
WIPP:	Waste Isolation Pilot Plant

**U.S. POLICY LAWS GOVERNING
RADIOACTIVE WASTE MANAGEMENT
and
DECOMMISSIONING**

- **Atomic Energy Act of 1954**, as amended, established the Atomic Energy Commission [the predecessor to the U.S. Nuclear Regulatory Commission (NRC) and U.S. Department of Energy (DOE)] with sole federal responsibility to regulate the commercial use of nuclear materials, by-products and sources including the regulation of civilian nuclear reactors.
- **National Environmental Policy Act (NEPA) of 1969**, as amended, requires federal agencies to consider environmental values and factors in agency planning and decision making. Full compliance with the letter and spirit of the National Environmental Policy Act, the U.S. national charter for protection of the environment, is an essential priority for U.S. Environmental Protection Agency (EPA), Council on Environmental Quality, DOE and NRC.
- **Energy Reorganization Act of 1974**, as amended, abolished the Atomic Energy Commission and transferred its functions to the NRC and Energy Research and Development Administration (ERDA) (the predecessor of DOE).
- **DOE Organization Act**, abolished ERDA and transferred its functions to DOE.
- **Uranium Mill Tailings and Radiation Control Act of 1978**, as amended, vested the EPA with overall responsibility for establishing environmental standards for active and inactive uranium production facilities, the NRC with responsibility for licensing and regulating uranium production and related activities, including decommissioning, and DOE with responsibility for long-term monitoring of the decommissioned sites. Uranium recovery and tailings disposal sites are divided into two categories: Title I dealing with DOE-remedial action programs of former mill tailings sites in which all or substantially all of the uranium was produced for sale to any federal agency prior to January 1971 under a contract with any federal agency; and Title II *dealing* with non-DOE mill tailings sites; and *in situ* leach uranium solution mining sites licensed by the NRC or an Agreement State according to NRC regulations.
- **The Low-Level Radioactive Waste Policy Amendments Act of 1985** made each State – rather than the federal government – responsible for disposal of Class A, B, and C low-level radioactive waste (LLW) generated within the State (except for certain waste generated by the federal government) and authorized States to form Regional Compacts (of States) for the safe disposal of such LLW and to decide whether to exclude waste generated outside a Compact. The Act also provided a system of milestones, incentives, and penalties to encourage States and Compacts to be responsible for their own LLW. The 1985 Amendments gave DOE the responsibility for disposal of Greater-Than-Class C (GTCC) LLW.
- **West Valley Demonstration Project Act of 1980** authorized DOE to conduct a technology demonstration project for solidifying HLW, disposing of waste created by the solidification, and decommissioning the facilities used in the process. The Act required DOE to enter into an agreement with the State of New York for carrying out the Project.

- **Nuclear Waste Policy Act of 1982 (NWPA)** established the federal responsibility and a federal policy for disposal of SNF and HLW to protect the public health and safety and the environment, and established the Nuclear Waste Fund composed of payments made by generators and owners to ensure that the costs of disposal of SNF and HLW will be borne by the generators.
- **Energy Policy Act (EnPA) of 1992** mandated a new and different process for developing the HLW disposal regulations for a repository at Yucca Mountain, Nevada. Congress, through EnPA, directed EPA to contract with the NAS to evaluate the scientific basis for a Yucca Mountain standard, and further directed EPA to promulgate new public health and safety standards based upon and consistent with the findings and recommendations of the NAS. The EnPA also directed the NRC staff to modify its technical requirements to conform to the new EPA standards.
- **Waste Isolation Pilot Plant Land Withdrawal Act (LWA) of 1992 (as amended)** withdraws land from the public domain for operation of the Waste Isolation Pilot Plant, a deep geologic repository for the disposal of TRU waste that results from atomic energy defense activities. The LWA defines operation limitations and the role of the U.S. Environmental Protection Agency and the U.S. Mine Safety and Health Administration. This law exempts transuranic mixed waste destined for disposal at WIPP from treatment requirements and land disposal prohibitions under the Solid Waste Disposal Act (more generally known as the Resource Conservation and Recovery Act). Provisions for economic assistance to the State of New Mexico are provided. This Act defines transportation and emergency preparedness requirements pertaining to WIPP, including NRC certification of WIPP shipping containers. Finally, this Act provides for EPA's continuing regulatory role at WIPP, including periodic re-certification that WIPP meets EPA's generally applicable environmental radiation standards as well as a variety of other Federal laws relating to public health and safety or environmental protection.
- **National Defense Authorization Act of 2005 (NDAA)** gives DOE authority to manage certain wastes, known as "incidental wastes," from reprocessing of spent nuclear fuel, at DOE sites in South Carolina and Idaho as low-level wastes provided the NDAA's criteria can be met. The NDAA also gave the NRC a consultation role in DOE's waste determinations and a monitoring role in waste disposal actions taken by DOE.
- **Energy Policy Act of 2005** contains provisions relating to energy and development programs and includes specific provisions addressing, among other things, disposal of GTCC waste (including certain sealed sources), NORM, and accelerator-produced waste. Among other provisions, Section 651(e) of the EPAct expanded the definition of byproduct material as defined in Section 11e of the Atomic Energy Act of 1954 (AEA), placing additional byproduct material under the NRC's jurisdiction, and required the NRC to provide a regulatory framework for licensing and regulating this additional byproduct material.

RADIOACTIVE WASTE MANAGEMENT REGULATIONS

U.S. Department of Energy

- 10 CFR Part 960, “General Guidelines for the Recommendation for Sites for Nuclear Waste Repositories” [Specifies DOE’s criteria for determining the suitability of siting a HLW repository in geologic media.]
- 10 CFR Part 961, “Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste”
- 10 CFR Part 765, “Reimbursement of Costs for Remedial Action at Active Uranium and Thorium Processing Sites”
- 10 CFR Part 766, “Uranium Enrichment Decontamination and Decommissioning Fund; Procedures for Special Assessment of Domestic Utilities”
- 10 CFR Part 820, “Procedural Rules for DOE Nuclear Facilities”
- 10 CFR Part 830, “Nuclear Safety Management”
- 10 CFR Part 835, “Occupational Radiation Protection”
- 10 CFR Part 851, “Worker Safety and Health”
- 10 CFR Part 1021, “National Environmental Policy Act Implementing Procedures”

U.S. Nuclear Regulatory Commission

- 10 CFR Part 20, “Standards for Protection Against Radiation”
- 10 CFR Part 21, “Reporting of Defects and Noncompliance”
- 10 CFR Part 30, “Rules of General Applicability to Domestic Licensing of By-Product Material”
- 10 CFR Part 40, “Domestic Licensing of Source Material” [Covers uranium mill tailings and *in situ* leach uranium recovery licensing.]
- 10 CFR Part 51, “Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions”
- 10 CFR Part 60, “Disposal of High-Level Radioactive Wastes in Geologic Repositories” [Covers generic criteria for siting, disposal and closure criteria for HLW disposal in a deep geologic repository. These criteria do not apply to the proposed repository at Yucca Mountain.]
- 10 CFR Part 61, “Licensing Requirements for Land Disposal of Radioactive Waste” [Covers LLW disposal criteria.]

- 10 CFR Part 62, “Criteria and Procedures for Emergency Access to Non-Federal and Regional Low-Level Waste Disposal Facilities”
- 10 CFR Part 63, “Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada” [Identifies site-specific licensing criteria for disposal of SNF and HLW in the proposed geologic repository at Yucca Mountain.]
- 10 CFR Part 70, “Domestic Licensing of Special Nuclear Material”
- 10 CFR Part 71, “Packaging and Transportation of Radioactive Material”
- 10 CFR Part 72, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste”
- 10 CFR Part 73, “Physical Protection of Plant and Materials”
- 10 CFR Part 74, “Material Control and Accounting of Special Nuclear Material”
- 10 CFR Part 75, “Safeguards on Nuclear Material – Implementation of US/IAEA Agreement”
- 10 CFR Part 76, Certification of Gaseous Diffusion Plants
- 10 CFR Part 110, “Export and Import of Nuclear Equipment and Material”

U.S. Environmental Protection Agency

- 40 CFR Part 191, “Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes”
- 40 CFR Part 192, “Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings”
- 40 CFR Part 194, “Criteria for the Certification and Re-Certification of the Waste Isolation Pilot Plant’s (WIPP) Compliance with the 40 CFR Part 191 Disposal Regulations”
- 40 CFR Part 197, “Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada”
- 40 CFR Part 266, “Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities”
- 40 CFR Part 61, “National Emission Standards for Hazardous Air Pollutants”
 - Subpart B, radon from underground uranium mines,
 - Subpart H, radionuclide emissions, other than radon, from DOE facilities,
 - Subpart I, radionuclide emissions from Federal facilities other than DOE or NRC licensed facilities,
 - Subpart K, radionuclide emissions from elemental phosphorus plants,
 - Subpart Q, radon from DOE facilities,
 - Subpart R, radon from phosphogypsum stacks,
 - Subpart T, radon from disposal of uranium mill tailings, and
 - Subpart W, radon from tailings at operating mills

- Title 40, Code of Federal Regulations relating to radiation protection include:
 - Part 141, “National Primary Drinking Water Regulations,”
 - Part 147, “State, Tribal, and EPA-Administered Underground Injection Control Programs,”
 - Part 148, “Hazardous Waste Injection Restrictions,”
 - Part 195, “Radon Proficiency Programs,”
 - Parts 220 and 133, “Ocean Dumping,”
 - Part 300, “National Oil and Hazardous Substances Pollution Contingency Plan,”
 - Part 302, “Designation, Reportable Quantities, and Notification,” and
 - Part 440, “Ore Mining and Dressing Point Source Category” (Uranium, Radium, and Vanadium Ores subcategory).