

**Disposal Subcommittee  
Report to the Full Commission**

**Updated Report**

**Blue Ribbon Commission on America's Nuclear Future**

**Washington, DC**

**January 2012**

## PREAMBLE

The charter of the Blue Ribbon Commission on America’s Nuclear Future directs the Commission to “provide advice, evaluate alternatives, and make recommendations” for “a new plan” to manage the back end of the nuclear fuel cycle in the United States. The charter identifies several specific issues to be considered as part of the Commission’s work, including five that the Disposal Subcommittee addresses in this report:

- Options for permanent disposal of spent fuel and/or high-level nuclear waste, including deep geological disposal;
- Options to make legal and commercial arrangements for the management of spent nuclear fuel and nuclear waste in a manner that takes the current and potential future fuel cycles into account;
- Options for decision-making processes for management and disposal that are flexible, adaptive, and responsive;
- Options to ensure that decisions on management of spent nuclear fuel and nuclear waste are open and transparent, with broad participation; and
- The possible need for additional legislation or amendments to existing laws, including the Nuclear Waste Policy Act of 1982, as amended.

The Disposal Subcommittee began its inquiry by posing a more basic question: “How can the United States go about establishing one or more facilities for permanently disposing of high-level nuclear wastes in a manner and within a timeframe that is technically, socially, economically, and politically acceptable?”

In June 2011, the Subcommittee issued a draft report documenting its initial findings and presenting a set of specific recommendations for consideration by the full Commission. This updated report reflects additional information and comments received on the Subcommittee draft report and on the draft report of the full Commission between June and December 2011. This report also includes the results of the deliberations of the Commission’s *ad hoc* Subcommittee on the Commingling of Defense and Commercial Wastes, which was created in October 2011.

We want to be clear on one point at the outset: consistent with our charter and with the direction provided by the Secretary of Energy to guide our work we have *not* sought to identify or recommend specific locations (or even potential locations) for any component or facility of the U.S. nuclear waste management system. We also did not render an opinion on the suitability of the Yucca Mountain site or on the request to withdraw the license application for Yucca Mountain. Rather we have sought to learn from past efforts—successful and unsuccessful—to site nuclear waste disposal facilities and to develop specific guidance concerning an overarching strategy that we believe can dramatically improve the chances for success, regardless of where specific facilities in the nuclear waste management system are ultimately located.

Throughout, our inquiry and our deliberations have reflected an underlying conviction that this generation has an ethical responsibility to begin implementing a durable, integrated management strategy and practical solutions that will enable disposal of spent nuclear fuel and high-level radioactive wastes. If we do not—if more years and decades elapse while we do nothing—we will have made a decision of another kind: a decision to accept the continued accumulation of spent fuel at many dozens of sites around the nation. After the events of March 2011 in Japan, that prospect can no longer be viewed in the same light as it was before. Given that siting, licensing and constructing one or more disposal facilities will take time, the events at Fukushima underscore how important it is to ensure that safe and secure interim storage for spent fuel and high-level wastes is part of an integrated approach to nuclear waste management.

In sum, Americans have benefitted from the energy and deterrent capacity provided by nuclear technology for more than 50 years. We cannot and must not continue to defer responsibility for dealing with the resulting high-level wastes and spent fuel.

## EXECUTIVE SUMMARY

The Disposal Subcommittee of the Blue Ribbon Commission on America's Nuclear Future (BRC) addressed a wide-ranging set of issues, all bearing directly on the central question: "How can the United States go about establishing one or more disposal sites for high-level nuclear wastes in a manner and within a timeframe that is technically, socially, economically, and politically acceptable?"

To answer this core question and to develop specific recommendations and options for consideration by the full Commission, the Subcommittee and individual Commissioners held multiple meetings and deliberative sessions; visited Finland, France, Japan, Russia, Sweden, and the UK to learn first-hand about their disposal programs; and heard testimony from numerous experts and stakeholders both here and abroad. The Subcommittee also benefited from commissioned papers on several related topics; these papers may be found on the Commission web site at [www.brc.gov](http://www.brc.gov). All of these inputs, along with written comments received on the June 2011 draft of this report and comments and feedback on the full Commission's draft report to the Secretary of Energy (issued on July 29, 2011), have helped to inform the conclusions and recommendations that are summarized below and detailed at greater length in our full report.

***Recommendation #1: The United States should undertake an integrated nuclear waste management program that leads to the timely development of one or more permanent deep geological facilities for the safe disposal of spent fuel and high-level nuclear waste.***

The Subcommittee concludes that permanent disposal is needed under all reasonably foreseeable scenarios for nuclear waste with a low probability of re-use. This includes defense and commercial reprocessing wastes and many forms of spent fuel currently in the federal government's hands. The Subcommittee believes it is also very likely that permanent disposal will be needed for some portion of the existing commercial spent fuel inventory. The need for a disposal solution is, in our view, inescapable. It is also independent of policy debates concerning past or future applications of nuclear technology.

**The Subcommittee further concludes that geologic disposal in a mined repository is the most promising and technically accepted option available for safely isolating high-level nuclear wastes for very long periods of time.** This view is supported by decades of expert judgment and by a broad international consensus. All other countries with spent fuel and high-level waste disposal programs are pursuing geologic disposal. The United States has many geologic media that are technically suitable for a repository. Other concepts for geologic disposal have been proposed; these options may hold promise but will require further investigation.

***Nuclear materials that require long-term isolation exist and our nation has benefited from the activities that produced them. There is no ethical basis for leaving the entire burden of providing for their safe, long-term disposition to future generations. Thus, while Subcommittee members hold different views about the potential for future re-use of spent fuel, we all agree that it is time to begin developing and implementing integrated, workable solutions that include interim storage and permanent disposal of spent nuclear fuel and high-level radioactive wastes.***

After Fukushima, it is clear that past assessments of the safety and adequacy of current interim storage arrangements for spent nuclear fuel will need to be revisited. These issues were addressed by the Transportation and Storage Subcommittee of the BRC and are discussed extensively in its updated

report to the full Commission. We anticipate that new assessments will be undertaken by the relevant regulatory authorities in the months and years ahead and we do not presume to prejudge the conclusions that will be reached. Whatever those conclusions are, however, they can only underscore the Subcommittee's central conclusion that it is imperative to move forward within a reasonable timeframe to implement an integrated approach which would enable a safe permanent disposal solution for the inventories of high-level waste and spent nuclear fuel that already exist in the United States. After decades of broken promises and unmet deadlines in the nation's nuclear waste management program, tangible progress is needed—both to build confidence in our technical and institutional ability to responsibly manage the nuclear fuel cycle and because of the long lead-times needed to site, license, construct and begin to operate nuclear waste facilities of all kinds.

***Recommendation #2: A new, single-purpose organization is needed to develop and implement a focused, integrated program for the transportation, storage, and disposal<sup>1</sup> of nuclear waste in the United States.***

The U.S. Department of Energy (DOE) and its predecessor agencies, subject to annual appropriations and policy direction by Congress, have had primary responsibility for implementing U.S. nuclear waste policy for the last 60 years. Having examined this experience, the Subcommittee concludes that new institutional leadership for the nation's nuclear waste program is needed. A new organization offers the best opportunity to establish—from the outset—the track record of consultation, transparency, accountability, and scientific and technical credibility needed to re-establish trust with the public and key stakeholders.

We conclude that a federal corporation chartered by Congress offers the most promising model, although the Subcommittee believes that other organizational models could also be effective. Less important than the specific model chosen is that the new organization fosters a culture that consistently demonstrates the attributes noted above (i.e., transparency, accountability, etc.). In addition, the Subcommittee believes it will be crucial for new waste management organization to have: (1) a focused and well-defined mission, (2) the financial and institutional means to deliver on its commitments, and (3) sufficient independent authority—subject to appropriate financial, technical, and regulatory oversight—to provide institutional and programmatic stability over time.

However, the Subcommittee recognizes that it could take several years for this new entity to be authorized, funded, staffed and ready to proceed. In the meantime, DOE should continue making progress on this issue: for example, additional research is needed on different geologic media and engineered barrier systems, and there are other non-site-specific tasks that can and should be conducted in the interim, while the new organization is being set up. Likewise, the Environmental Protection Agency (EPA) and the Nuclear Regulatory Commission (NRC) should work on developing new site-independent geologic disposal safety standards.

***Recommendation #3: Assured access to the balance in the Nuclear Waste Fund (NWF) and to the revenues generated by annual nuclear waste fee payments from utility ratepayers is absolutely essential and must be provided to the new nuclear waste management organization.***

The current NWF and fee mechanism is not working as intended. No new policy or organization will succeed unless this changes. Specifically, revenues from the annual fee and the balance in the NWF must be made available to implement the nation's waste management program, as needed,

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<sup>1</sup> In this report we use the term "management" to refer to these three activities (i.e., transportation, storage and disposal).

independent of other budgetary pressures. This will require: (1) extricating the NWF from the web of budget rules that have created an unintended and dysfunctional competition between expenditures from the Fund and spending on other federal programs, and (2) removing funding decisions from the annual federal budgeting and appropriations process. Of course, greater budget independence must come with effective oversight mechanisms to ensure that resources—in this case the NWF funds—are being spent wisely to pursue only the objectives for which they are intended.

***Recommendation #4: A new approach is needed to site and develop nuclear waste facilities in the United States in the future. We believe that these processes are most likely to succeed if they are:***

- (1) Adaptive—in the sense that process itself is flexible and produces decisions that are responsive to new information and new technical, social, or political developments.***
- (2) Staged—in the sense that key decisions are revisited and modified as necessary along the way rather than being pre-determined in advance.***
- (3) Consent-based—in the sense that affected communities have an opportunity to decide whether to accept facility siting decisions and retain significant local control.***
- (4) Transparent—in the sense that all stakeholders have an opportunity to understand key decisions and engage in the process in a meaningful way.***
- (5) Standards- and science-based—in the sense that the public can have confidence that all facilities meet rigorous, objective, and consistently-applied standards of safety and environmental protection.***
- (6) Governed by partnership arrangements or legally-enforceable agreements with host states, tribes and local communities.***

This Subcommittee recommendation flows directly from an examination of the history of waste-management efforts in the United States and other countries. We drew several lessons from the decades-long effort to site a repository at Yucca Mountain in Nevada and from the ultimately successful completion of the Waste Isolation Pilot Plant (WIPP) facility in New Mexico. One lesson is that support for a facility (or at least acceptance)—both in directly affected communities and on the part of the host state—is a critical element of success. A second is that transparency and accountability, along with the flexibility to adapt to new information and to the concerns of key constituencies, are essential to sustain public trust in decision-making processes and institutions. We believe that a good gauge of consent would be the willingness of the host state (and other affected units of government, as appropriate) to enter into legally binding agreements with the facility operator, where these agreements enable states, tribes, or communities to have confidence that they can protect the interests of their citizens.

The approach to repository development laid out under the Nuclear Waste Policy Act Amendments of 1987 was highly prescriptive, subject to inflexible deadlines, and—as actually implemented—widely viewed as being driven too heavily by political considerations (as compared to independent technical and scientific judgments). By contrast, other countries—notably Canada, Finland, France, and Sweden—have adopted a phased, adaptive, and consent-based approach to facility siting and development. Finland and Sweden, in particular, have each successfully sited a deep geologic repository with the support of the host community.

Although there are notable political, cultural, and other differences between the United States and Finland and Sweden, their experience suggests that several process characteristics can greatly improve the odds of success: (1) a clear and understandable legal framework for moving forward with facility development; (2) financing for state, tribal, and local governments and citizen organizations that wish to be engaged in the process; (3) concerted efforts to promote public knowledge and awareness, both of nuclear waste issues generally and of plans for individual facilities specifically; and (4) openness and transparency in interactions among and within the implementing organization, the federal government, states, tribes, local governments, other stakeholder organizations, and the general public.

Implementing a phased, adaptive siting process with these characteristics will take time. However, attention to process must not come at the expense of progress. Without tying the waste management program to inflexible deadlines, it will nevertheless be important to articulate reasonable performance goals and milestones so that the new organization can be held accountable and so that stakeholders and the public can have confidence that the program is moving forward.

***Recommendation #5: The current division of regulatory responsibilities for long-term repository performance between the NRC and the EPA is appropriate and should continue. The two agencies should develop new, site-independent safety standards in a formally coordinated joint process that actively engages and solicits input from all the relevant constituencies.***

Many witnesses have recommended that the EPA and NRC regulatory systems be made fully consistent with each other. Some have also pointed out that it would be far better if such a rationalization or harmonization happened before any future disposal sites were identified, even for screening purposes, to avoid or at least minimize the perception that standards are being set to ensure that one or more (pre-selected) sites will meet them. This seems particularly important for individual protection requirements, which have been a clear point of contention in the past; however, it is likely to be relevant for many other issues as well.

The Commission also received and considered recommendations for a more fundamental redrawing of regulatory roles and responsibilities at the federal level (i.e., transferring all regulatory authority to the NRC or EPA). We concluded that while there are opportunities for improvement in the EPA/NRC regulatory process and in the working relationship between these agencies, the general division of roles and responsibilities that currently exists between EPA and NRC is appropriate and should be preserved.

***Recommendation #6: The roles, responsibilities, and authorities of local, state, and tribal governments (with respect to facility siting and other aspects of nuclear waste disposal) must be an element of the negotiation between the federal government<sup>2</sup> and the other affected units of government in establishing a disposal facility. In addition to legally-binding agreements, as discussed in Recommendation #4, all affected levels of government (local, state, tribal, etc.) must have, at a minimum, a meaningful consultative role in all other important decisions. Additionally, states and tribes should retain—or where appropriate, be delegated—direct authority over aspects of regulation, permitting, and operations where oversight below the federal level can be exercised effectively and in a way that is helpful in protecting the interests and gaining the confidence of affected communities and citizens.***

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<sup>2</sup> We are recommending the creation of a federally-chartered corporation that would act as the federal government's implementing arm for waste management in these negotiations. If, however, the responsibility is vested with an existing federal agency, the same recommendation would apply.

Federal–tribe and federal–state relations have been central to resolving the nation’s nuclear waste management challenges from the outset. Indeed, much of the difficulty of finding workable disposal solutions for spent fuel and high-level radioactive waste can be traced to the inherent tensions that exist in these relationships, especially when the legitimate interests and rights of different groups, represented at different levels of government, come into conflict.

The nature of these issues and the structure of our federal system mean that no single formula or approach offers a certain path to avoiding these conflicts in the future, or for successfully navigating them when they arise. A facility for the disposal of spent nuclear fuel and high-level waste will only be constructed and operated as a result of very complex negotiations between the federal government and state, tribal, and local governments. Therefore, the Subcommittee believes it would be unwise to attempt to identify or even suggest in advance a specific strategy for engaging with governmental authorities.

Experience suggests that the process characteristics discussed under Recommendation #4 can help promote collaboration rather than confrontation and thus improve prospects for successfully siting one or more disposal facilities. However, our nation’s long history of federal–tribe and federal–state conflicts also underscores the difficulty of building trust and confidence in a relationship where the distribution of prerogatives and power is perceived to be largely one-sided.

Given that the Atomic Energy Act of 1954 and subsequent regulations grant the federal government authority to regulate the possession and use of several categories of radioactive materials, including spent fuel and high-level nuclear wastes, the challenge is to affirm a role for states, tribes, and local governments that is at once positive, proactive, and substantively meaningful without increasing the potential for further conflict, confusion, and delay. In our discussions about how to strike this balance, the concept of “meaningful consultation” has emerged as an important term of art—one that can and has allowed for a more or less expansive view of state and tribal roles and responsibilities under different circumstances. In the case of WIPP, for example, the fact that the State of New Mexico gained permitting authority over the facility under the federal Resource Conservation and Recovery Act (RCRA) was a significant step in gaining state and local support for the project.

The Subcommittee believes that to engage in meaningful consultation on matters related to nuclear waste storage, transport, and disposal, and to exercise their proper regulatory roles and responsibilities in this context, local, state, and tribal governments need access to sound, independent scientific and technical expertise. Here again, the WIPP example is instructive. In that project, an Environmental Evaluation Group, formed of scientific and technical experts who were not associated with DOE or its contractors, was established for the express purpose of providing independent, outside advice to state and local officials concerning matters related to the WIPP facility. By all accounts, this group was instrumental in assuring New Mexico citizens and their representatives—not only in the immediate vicinity of WIPP but across the state—that their health and welfare interests were being protected and that their concerns were being heard and adequately addressed.

***Recommendation #7: The Nuclear Waste Technical Review Board (NWTRB) should be retained as a valuable source of independent technical advice and review.***

Decision makers at all levels of government require access to sound, independent technical advice and expertise. Since it was established under the Nuclear Waste Policy Act Amendments of 1987, the NWTRB has performed this role with distinction; it should therefore be retained as a valuable part of our larger institutional infrastructure for ensuring the responsible management of nuclear wastes.



Members should represent a carefully considered mix of scientists and engineers recognizing that the mix of needed disciplines will change as the new organization makes progress. Geoscientists should be balanced with engineers to ensure that all technical issues affecting the geologic disposal of nuclear waste are addressed. The NWTRB should retain the authority to identify the disciplines it needs as circumstances change, recognizing that at times it may need to reach out to experts in fields not previously represented on the NWTRB (e.g., economics, cost-benefit analysis, risk assessment/management, and others). As now, members should serve rotating terms and new members should be selected by the President from a candidate list prepared by the National Academy of Sciences. The NWTRB should report at least twice per year to the Board of Directors of the new organization and the Congress; as is now the case, these reports should be available to any interested party.

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## LIST OF ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
AMFM	Alternate Means of Financing and Managing
BEA	Budget Enforcement Act of 1990
BRC	Blue Ribbon Commission on America’s Nuclear Future
C&C	consultation and cooperation
CEO	chief executive officer
CFR	Code of Federal Regulations
CRA	Congressional Review Act
DHS	U.S. Department of Homeland Security
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DRR	Domestic Research Reactor
EDRAM	Environmentally Safe Disposal of Radioactive Materials
EEG	Environmental Evaluation Group
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration
ESF	Exploratory Studies Facility
EU	European Union
FERC	Federal Energy Regulatory Commission
FRR	Foreign Research Reactor
FY	fiscal year
GAO	Government Accountability Office
GRH	Gramm-Rudman-Hollings
IAEA	International Atomic Energy Agency
INL	Idaho National Laboratory

MRS	Monitored Retrievable Storage
MTHM	metric tons heavy metal
NARUC	National Association of Regulatory Utility Commissions
NAS	National Academy of Sciences
NEA	Nuclear Energy Agency
NEI	Nuclear Energy Institute
NGO	non-governmental organization
NRC	U.S. Nuclear Regulatory Commission
NWF	Nuclear Waste Fund
NWMO	Nuclear Waste Management Organization
NWPA	Nuclear Waste Policy Act
NWPAA	Nuclear Waste Policy Amendments Act
NWTRB	Nuclear Waste Technical Review Board
OCRWM	Office of Civilian Radioactive Waste Management (DOE)
OMB	Office of Management and Budget
OSHA	Occupational Safety and Health Administration
PAYGO	pay-as-you-go
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RD&D	research, development, and demonstration
SNF	spent nuclear fuel
SRS	Savannah River Site
STGWG	State and Tribal Government Working Group
TRU	transuranic
TVA	Tennessee Valley Authority
WIPP	Waste Isolation Pilot Plant

## 1. INTRODUCTION AND STRUCTURE OF REPORT

The Disposal Subcommittee of the Blue Ribbon Commission on America's Nuclear Future (BRC) was charged with developing recommendations for how the United States can go about establishing one or more disposal sites for high-level nuclear wastes<sup>3</sup> in a manner that is technically, politically, and socially acceptable. The Subcommittee began its investigation by asking a series of related questions:

1. Are one or more disposal facilities needed under all reasonably foreseeable scenarios?
2. If a permanent disposal system is needed, what are the alternative approaches for disposal?
3. What process(es) should be used to select new disposal sites, and what are the relative roles of federal, state, tribal, county, and local entities?
4. What are the essential elements of technically credible, workable, and publicly acceptable standards and regulations for disposal?
5. What are the essential elements for a technically credible, workable, and publicly acceptable institutional system and process for regulating the safety of disposal?

This report describes the Subcommittee's findings in each of these areas and provides background and context for the recommendations advanced in the Executive Summary above. We begin by describing the current inventory of spent<sup>4</sup> nuclear fuel and high-level waste in the United States. In section 3, we review the history of past efforts to implement a permanent disposal solution for these materials. Sections 4 through 8 then address the above questions. Section 9 presents our overall conclusions.

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<sup>3</sup> The term "high-level nuclear waste" does not have a fixed definition; however, for purposes of this report, it should be understood to encompass vitrified high-level radioactive waste, mostly from past national defense operations, and "used" or "spent" fuel from DOE and civilian nuclear power reactors. There are a few other types of wastes from both commercial and governmental sources (generally relatively small amounts) that are identified later in the report.

<sup>4</sup> Throughout this report, we generally use the term "spent" nuclear fuel. "Used fuel" is the term that appears in the Commission's charter, but "spent fuel" (sometimes abbreviated "SNF") is the term used in much of the literature on this topic and in many U.S. regulations and statutes concerning the back end of the nuclear fuel cycle. In addition, as stressed in the BRC's Final Report, the choice of one phrase over the other reflects a profound policy issue as to whether such fuel rods should be considered as a waste or a resource. The Commission did not reach a consensus on this question, so the use of the term "spent fuel" in this report should not be interpreted as reflecting a position on this question.



## 2. THE NATURE AND SCOPE OF THE NUCLEAR WASTE AND SPENT FUEL MANAGEMENT CHALLENGE IN THE UNITED STATES

More than five decades of civilian nuclear power production,<sup>5</sup> and an even longer history of nuclear weapons development, have produced substantial inventories of spent nuclear fuel (SNF) and high-level radioactive waste for which no comprehensive long-term disposition path has been established. These inventories exist and must be safely managed, regardless of the commercial nuclear industry's prospects going forward. At present, no facility for the permanent disposal of high-level radioactive waste or spent fuel is operating in the United States or anywhere else in the world, although Finland and Sweden have each successfully sited and are in the process of seeking licenses for deep geologic repositories for this purpose. In addition, the United States has an operating deep geologic repository for the sole purpose of disposing of defense transuranic (TRU) waste—this facility, called the Waste Isolation Pilot Plant (WIPP), is located in Carlsbad, New Mexico.

This section reviews the main categories of nuclear wastes produced by the back end of the nuclear fuel cycle, the quantities that currently exist and are projected to be generated over the next several decades, and the nature and duration of the radiological hazards posed by these materials.

### 2.1 Commercial Spent Nuclear Fuel

Irradiated nuclear fuel, commonly referred to as used or SNF, is a byproduct of the fission reactions that occur in nuclear reactors (in the case of commercial nuclear power plants, the energy from these reactions is used to produce steam for driving turbines that can generate electricity).

The current inventory of SNF from commercial reactor operations in the United States totals approximately 65,000 metric tons<sup>6</sup> (the standard quantity used is “metric tons heavy metal” or MTHM). This inventory is growing at a rate of roughly 2,000 to 2,400 MTHM each year as a result of ongoing commercial reactor operations. Estimates of future inventories depend heavily on assumptions about the rate of growth (or decline) in nuclear power production over the next several decades. In a briefing to the full Commission on March 25, 2010, a representative of the Department of Energy (DOE) Office of Nuclear Energy provided a range of projections for the growth in spent commercial fuel volumes up to the year 2050. At the high end, DOE projects that a significant expansion in domestic nuclear power production could result in a total inventory of 210,000 metric tons of spent fuel by 2050. On the low end, even if all nuclear power stations were shut down tomorrow, we would still be faced with an inventory of about 75,000 MTHM of spent fuel (equal to the current inventory of roughly 65,000 MTHM plus all of the fuel in the cores of the 104 commercial nuclear power reactors operating today).

With a few small exceptions,<sup>7</sup> SNF from the nation's commercial power industry exists in the form of uranium oxide pellets stacked in long, zirconium-alloy tubes (known as the “fuel cladding”).<sup>8</sup> The tubes are generally mounted in square metal frames to form a fuel assembly (figure 1); the reactor core of a typical nuclear power plant will hold anywhere from 100 to 1,000 such assemblies. Every 4 to 6 years, the fuel assemblies must be removed and replaced; at this point, they are considered “used” or “spent.”

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<sup>5</sup> The first commercial nuclear power plant in the United States, the 60-megawatt Shippingport plant in Pennsylvania, began operating in 1957.

<sup>6</sup> Adopted from “*U.S. Radioactive Waste Inventory and Characteristics Related to Potential Future Nuclear Energy Systems*,” prepared by Joe T. Carter, SRS, Robert H. Jones Jr., SRS, Alan J. Luptak, INL for the US DOE Used Fuel Disposition, May 211, FCRDOUSED-2011-000068, Rev 1.

<sup>7</sup> For example, graphite fuel at the Ft. St. Vrain 330 MW(e) high-temperature gas-cooled reactor.

<sup>8</sup> With the exception of small quantities (see table 2 for details), commercial fuel in the U.S. has not been reprocessed and remains in its original solid fuel form.



**Figure 1. Pressurized Water Reactor Fuel Assembly (Source: World Nuclear Association).**

The assumption in the early days of the U.S. commercial nuclear power industry was that spent fuel would be reprocessed in a matter of years—not decades—after an initial period of cooling.<sup>9</sup> Reprocessing to recover uranium and plutonium that could be re-used as reactor fuel would result in liquid waste streams suitable for vitrification, similar to the high-level waste streams generated by the nation’s defense program. The decision to forego commercial reprocessing<sup>10</sup>—a decision that was initially motivated by weapons proliferation concerns but that later came to also reflect cost considerations—combined with the federal government’s subsequent failure to develop a deep geologic repository in the timeframe mandated by the Nuclear Waste Policy Act (NWPA) of 1982, have left nuclear power plant operators with a growing inventory of spent fuel to manage on site. This means that all but a very small fraction of the nation’s existing commercial spent fuel inventory is currently being stored—either in water-filled pools or in dry casks—at some 65 reactor sites where the 104 currently operating reactors are located and at nine decommissioned reactor sites around the country.

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<sup>9</sup> Current practice is to immerse the spent fuel as soon as it is removed from the reactor core in water-filled pools on site; several years later, the fuel may be transferred to dry cask storage. Issues related to the storage of spent fuel have been addressed by the BRC’s Subcommittee on Transportation and Storage; a detailed discussion of them may be found in that Subcommittee’s revised report.

<sup>10</sup> Because there is no commercial reprocessing in the United States, the nuclear power industry does not currently have any high-level radioactive wastes of the type that DOE possesses (with the exception of small quantities stored at West Valley (see table 2 for details).

## 2.2 DOE-Owned Spent Nuclear Fuel

In addition to the SNF currently being stored at commercial nuclear power plant sites, DOE manages SNF at a number of government-owned, mostly defense-related facilities. The current inventory of DOE-managed SNF, however, represents only a small fraction of the nation's total spent fuel inventory: approximately 2,500 metric tons. In general, DOE has not taken commercial spent fuel for storage at its facilities except in special cases. For example, the fuel in the damaged Unit 2 reactor core from the 1979 Three Mile Island (TMI) accident was moved to the Idaho National Laboratory (INL) for study; in addition, DOE has assumed responsibility for storing spent fuel from the unique, gas-cooled Fort Saint Vrain reactor in Colorado (some of that spent fuel has been shipped to the INL for storage, while the rest is currently being stored on site). Inventories of government-generated spent fuel are growing slowly—a few metric tons per year—due to the operation of naval nuclear reactors as well as government- and university-operated research and test reactors.

Figure 2 shows the quantity and location of SNF and high-level waste at DOE sites. Both wet and dry methods of storage are in use at these sites, although at the Hanford site in Washington State—where by far the largest portion of DOE's current SNF inventory is being stored—all of the fuel has been moved to dry cask storage.

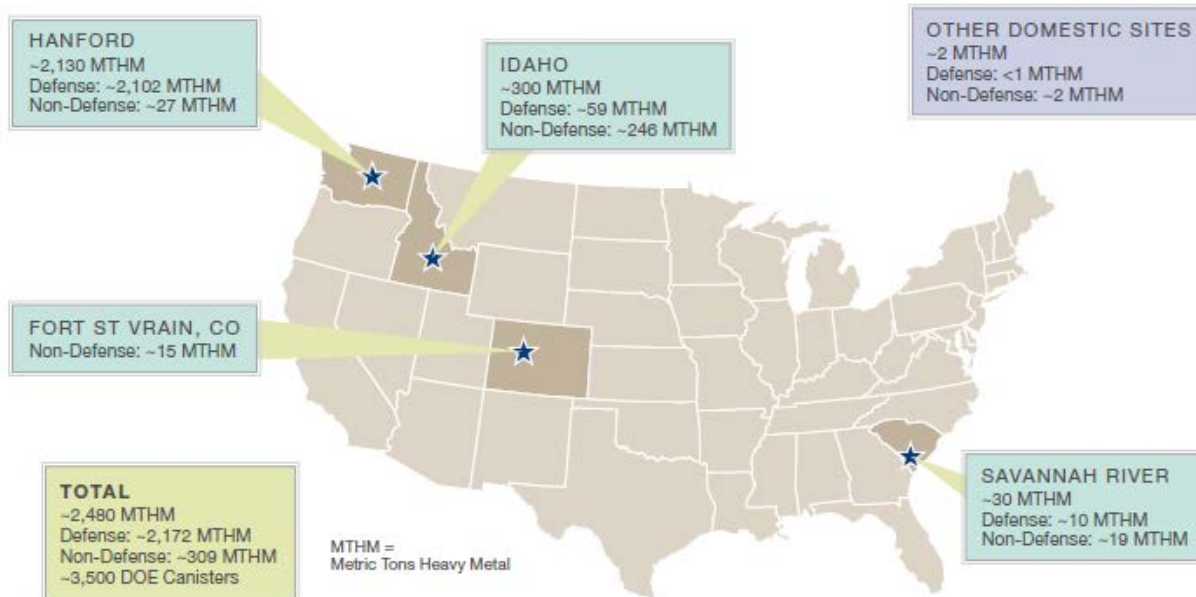
In addition, DOE accepts limited quantities of SNF from other sources under the Foreign Research Reactor (FRR) and Domestic Research Reactor (DRR) programs. The quantities involved are very small relative to the inventories from other domestic sources of spent fuel. The FRR program was established to support U.S. non-proliferation and nuclear security goals; it accepts spent fuel from research reactors in other countries, that have agreed to convert their fuel from highly enriched to low enriched uranium.<sup>11</sup> So far, more than 9,000 spent fuel assemblies (about 6 metric tons) have been accepted from 29 countries under this program (see figure 3), which is currently slated to run until 2019. The DRR program accepts spent fuel from U.S. universities and other government research reactors.

Finally, DOE has statutory responsibility for disposing of greater than Class C (GTCC) low-level radioactive waste. This category of waste includes activated metals from decommissioned power plants, some sealed sources, and non-defense-related transuranic (TRU) waste. The current volume of GTCC waste totals approximately 1,100 cubic meters; future decommissioning of existing nuclear power plants is expected to generate an additional 4,200 cubic meters. GTCC waste may require deep geologic disposal. A path for the ultimate disposal of this class of waste has yet to be identified, although DOE has developed a draft environmental impact statement that evaluates GTCC disposal alternatives and is working toward a final environmental impact statement and record of decision.<sup>12</sup> The alternatives being considered include disposal in a deep geologic repository and disposal in boreholes at depths up to 1,000 feet.

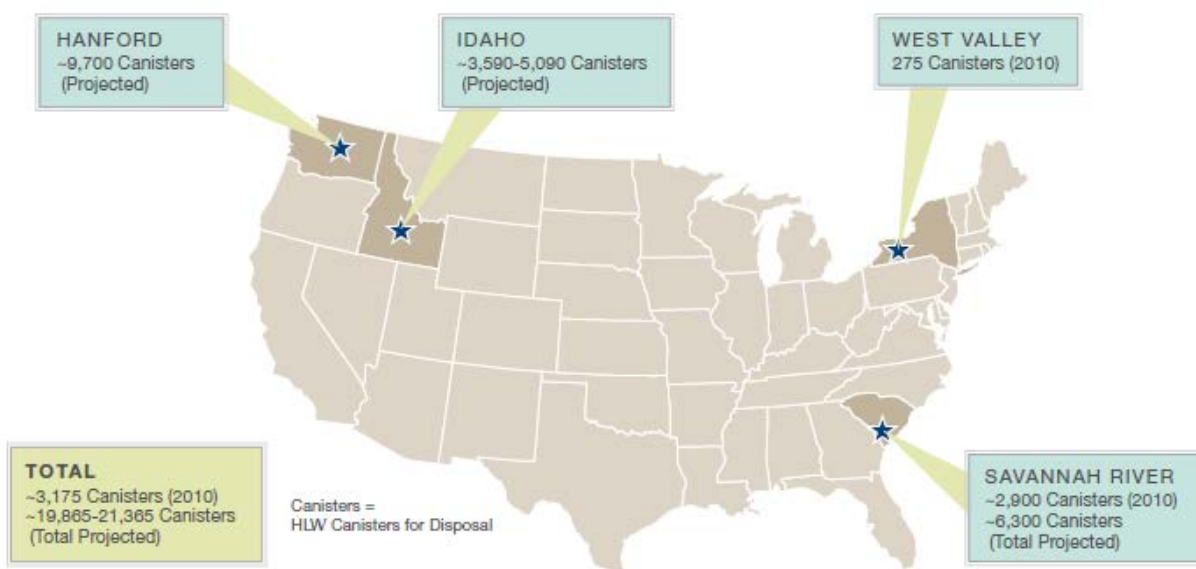
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<sup>11</sup> Low enriched uranium contains the isotope uranium-235 in a concentration of less than 20% and greater than 0.7% (natural level), while in highly enriched uranium concentration of this isotope is greater than 20%.

<sup>12</sup> "Draft Environmental Impact Statement (EIS) for the Disposal of Greater-Than-Class C (GTCC) Low-Level Radioactive Waste (LLRW) and GTCC-like Waste" (DOE/EIA-0375D).



Source: BRC staff using information from DOE and other sources.



Source: BRC staff using information from DOE and other sources.

**Figure 2. Inventory of DOE-Owned Spent Nuclear Fuel and HLW in the United States in 2010.**



Figure 3. Map of countries where spent fuel has been shipped from under the FRR program (Source: National Nuclear Security Administration, Savannah River Site Office).

### 2.3 DOE-Owned High-Level Radioactive Waste

Along with SNF, DOE is responsible for managing and ultimately disposing of some 90 million gallons of liquid high-level waste from past fuel reprocessing operations to recover materials (primarily plutonium at Hanford and Savannah River and highly enriched uranium at Idaho) needed for the nation’s nuclear weapons program. Most of this waste is being stored at DOE’s Hanford, INL, and Savannah River sites—typically in large underground tanks made of stainless or carbon steel. In addition, INL is storing some high-level waste that has been converted to a solid, granular form via a high heat treatment known as calcining. Similarly, DOE has begun converting its inventory of liquid high-level waste into glass, ceramic, or other solid forms suitable for on-site storage in canisters. (The process used to immobilize liquid waste in glass is known as vitrification.) In addition, DOE manages a small quantity of high-level waste from the short-lived operation of a commercial reprocessing facility at West Valley, New York in the late 1960s and early 1970s. This waste is slated for eventual dry cask storage.

High-level radioactive waste from past defense program activities is not considered to be potentially reusable even if the United States were to commence reprocessing; hence, the assumption has always been that this waste would be immobilized and sent to permanent disposal with no further processing. In fact, the NWP assumed that defense high-level waste<sup>13</sup> would be disposed of in a "civilian" repository developed under the Act, unless the President determined (following an evaluation that took into account issues of cost efficiency, health and safety, regulation, transportation, public acceptability, and national security) that a separate repository for the defense high-level waste was needed.

<sup>13</sup> These provisions do not explicitly apply to spent fuel from national defense activities; probably because at the time the Act was passed, there was an assumption that all such spent fuel would be reprocessed.

The Act did not *preclude* a defense-waste-only repository; however, it did not provide for a specific process to site one. It also made clear that such a repository would be subject to full Nuclear Regulatory Commission (NRC) licensing and to all the state/tribal/local participation provisions that would apply to a commercial repository.

After the NWPA was adopted, DOE (acting for the President) evaluated the use of a civilian repository for defense waste disposal and concluded that this option would save on the order of \$1.5 billion compared to developing separate repositories for civilian and defense waste. Besides this cost difference, DOE found no other factors that led to a significant distinction between the options it considered.<sup>14</sup> President Reagan accepted DOE's conclusions in 1985 and since then, DOE's plans have provided for the disposal of defense wastes with commercial spent fuel and high-level waste in repositories developed under the NWPA.

Meanwhile, a permanent disposition path has been successfully established for defense waste that is not considered high-level but that has sufficiently high concentrations of TRU elements that it cannot be disposed of as low-level waste: defense TRU waste is being shipped to the WIPP deep geologic disposal facility in New Mexico, which is described elsewhere in this report and also at length in the Final BRC Report.

Given the circumstances involving Yucca Mountain, the current lack of a "civilian" repository, and uncertainty regarding the economic value of reprocessing commercial spent fuel, some witnesses have suggested that it may now be more efficient to expedite permanent disposal of defense high-level waste in a defense-only geologic repository. Other witnesses believe waste disposal should be driven by the characteristics of the waste and not by the source. As directed by the Commission Co-Chairs, a specially created ad-hoc subcommittee investigated this issue and provided its findings to the full Commission at its public meeting on December 2, 2011. The findings are further discussed in section 5.3 of this updated report and in section 7.3 of the final BRC report.

Tables 1 and 2 summarize current inventories of DOE high-level waste and commercial SNF.

**Table 1. Commercial Spent Nuclear Fuel Estimated Discharge Through 2010<sup>15</sup>**

Total Numbers of Assemblies <sup>b</sup>			Total Initial Uranium (MTU) <sup>a</sup>			Average Enrichment		Average Burnup (MWd/MTU) <sup>c</sup>		Average Age (Yr)		Total Radioactivity (Ci) <sup>d</sup>	
PWR	BWR	Totals	PWR	BWR	Totals	PWR	BWR	PWR	BWR	PWR	BWR	PWR	BWR
97,400	128,600	226,000	42,300	23,000	65,200	3.74	3.12	39,600	33,300	14.9	15.4	16 billion	7 billion

<sup>a</sup> The estimated fuel discharged has been rounded to the nearest 100 metric tons of uranium (MTU), totals may not appear to sum correctly.  
<sup>b</sup> The number of assemblies has been rounded to the nearest 200; totals may not appear to sum correctly.  
<sup>c</sup> The burn-up has been rounded to the next 100 MWd/MTU. MWd stands for megawatt-day.  
<sup>d</sup> Ci stands for Curies, a unit of radioactivity.

<sup>14</sup> *An Evaluation of Commercial Repository Capacity for the Disposal of Defense High-Level Waste*. DOE/DP/0020/1. Washington DC: U.S. Department of Energy, 1985.

<sup>15</sup> Adopted from *U.S. Radioactive Waste Inventory and Characteristics Related to Potential Future Nuclear Energy Systems*," FCRD0USED-2011-000068, Rev 1., prepared by Joe T. Carter, SRS, Robert H. Jones, Jr., SRS, Alan J. Luptak, INL for the US DOE Used Fuel Disposition, May 2011 <http://www.brc.gov/index.php?q=library/documents/commissioned-papers>.

**Table 2. Projected Total Number of High-Level Waste Canisters<sup>16</sup>**

	<i>HLW Canisters <sup>1</sup>Best Estimate</i>	<i>Potential HLW Canister Range</i>
West Valley (government and commercial)	275	275 <sup>2</sup>
Hanford	10,713	9,746-12,100
INL (Calcine)	3,328	1,190-11,200
INL (Electro-chemical processing)	102	82-135
SRS	7,560	7,560-9,450
<b>Total</b>	<b>21,980</b>	<b>18,900-33,200 <sup>3</sup></b>
1. With the exception of Hanford all HLW canisters are 2 feet by 10 feet. Hanford HLW canisters are 2 feet by 14.76 feet. 2. All the West Valley HLW has been solidified and placed into canisters so there is no potential for the number of canisters to increase at this site. 3. Rounded to nearest 100 canisters.		

## 2.4 Navy Spent Nuclear Fuel

The federal inventory includes a relatively small quantity of spent fuel—approximately 27 metric tons—from naval reactors that power the nation's fleet of 83 nuclear-powered submarines and aircraft carriers. The inventory of naval SNF is growing slowly, at a rate of 1 to 2 metric tons per year, due to the continued operation and necessary re-fueling of reactors on these ships. The Navy's current projection is that a total of 65 metric tons will be generated by 2035, all of which would be destined for disposal in a repository (the Navy does not consider reprocessing as an option for its SNF).<sup>17</sup>

The Naval Nuclear Propulsion Program (NNPP), an integrated program carried out jointly by the Navy and DOE, manages spent naval reactor fuel, which for many years has been shipped to the Idaho National Laboratory (INL) for technical studies and storage pending final disposal. Current practice is to transport the Navy's SNF from the shipyards where refueling occurs by rail, in specially-designed casks, to the Naval Reactors Facility (NRF) located on the INL site. At NRF, the spent fuel is placed in a water pool similar to those used for commercial and other DOE spent fuel, examined to confirm that its actual condition is consistent with expectations, and evaluated for other technical studies (e.g., to improve the efficiency of future nuclear fuel). After an appropriate cooling period, the SNF is transferred to specifically-designed multi-purpose canisters suitable for dry storage at INL as well as subsequent transportation and disposal; the naval SNF will, under current plans, never be removed from these canisters.<sup>18</sup> At present, the Navy has about 50 loaded canisters in dry storage at INL; by 2035, it estimates there will be just over 350 canisters ready for disposal. For perspective, the Yucca Mountain license application allocated space for 400 canisters of naval SNF in the total of 11,000 canisters it was designed to hold.

<sup>16</sup> Ibid.

<sup>17</sup> John McKenzie, Presentation to the Blue Ribbon Commission on America's Nuclear Future, March 25, 2010, available at [http://www.brc.gov/pdfFiles/NR\\_Briefing\\_100325.pdf](http://www.brc.gov/pdfFiles/NR_Briefing_100325.pdf).

<sup>18</sup> The Navy has also designed and built large shipping casks which each hold one loaded SNF canister and are designed for shipment by rail. The canisters were intended to be transferred at Yucca Mountain into disposal overpacks and then directly disposed the repository.

In 1995, DOE and the Navy entered into a formal Agreement with the State of Idaho (known as the Batt Agreement). Among numerous other provisions, the Agreement covers the storage, treatment, and disposal of DOE and Navy SNF stored at INL.<sup>19</sup> It allows limited quantities of naval SNF to continue to be shipped to INL (at an average rate of about 20 casks per year). It also sets two deadlines: first, that all SNF then at INL be placed in dry storage by December 31, 2023 and second, that all spent fuel, including Navy SNF<sup>20</sup> be removed from Idaho by January 1, 2035. If this last milestone is not met, the Navy will face a significant financial penalty of \$60,000 for each day the waste remains in Idaho after January 1, 2035.<sup>21</sup> (A 2008 addendum to the Agreement modified its terms to allow for continued management and technical evaluation of a modest in-process inventory of naval SNF at NRF beyond 2035.) The Agreement also allows the State of Idaho to stop further shipments of Navy fuel to INL at any time if any key parts of the Agreement are not kept. In a recent review of how the suspension of work on Yucca Mountain could impact SNF storage at DOE sites, the GAO reported<sup>22</sup> that the Navy’s “greater concern” was not the financial penalties in the Idaho agreement if the 2035 deadline is not met, but instead the possibility that Idaho would bar further Navy shipments of SNF to the state. This would dramatically affect the Navy’s ability to refuel its nuclear fleet.

The Batt agreement also requires that naval SNF be included “among the early shipments to a permanent geologic repository or interim storage site.” However, at the BRC’s September 13, 2011 meeting in Denver, a representative of the State of Idaho stated that “It may not make sense to send DOE SNF to interim storage as most of that waste is already in dry storage and some of it (Navy fuel) is ready for final disposal.”<sup>23</sup> The BRC Transportation and Storage Subcommittee reached a similar but more general conclusion, stating in its updated report that “[t]here appear to be no technical or safety-related reasons to move defense high-level waste and spent fuel from temporary storage at the DOE sites where these materials are now located, before final disposal capacity becomes available.” The Disposal Subcommittee concurs with these conclusions. Furthermore, in recent comments on the draft BRC report,<sup>24</sup> the Navy has stated that the focus should be on disposing of naval SNF in a geologic repository when one becomes available. The Navy’s comments point out that “naval SNF as a waste form is well suited for geologic disposal” and that “the NNPP has invested significant resources in a packaging and transportation infrastructure based on geologic disposal.” That said, it is important to stress that under current law, DOE (not the Navy) is responsible for final disposal of this federally-owned spent fuel.

The importance of providing a path forward for the disposition of Naval spent fuel is yet another reason why the Subcommittee recommends that the U.S. promptly resume a program leading to the development of one or more deep geologic repositories.

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<sup>19</sup> More details on the 1995 Agreement and the 2008 modifications to it can be found at [Federal Commitments Regarding Used Fuel And High-Level Wastes - Van Ness Feldman, P.C., August 31, 2010 - Revised November 12, 2010.](#)

<sup>20</sup> See comment by the Governor of Idaho of October 31, 2011 to the BRC Draft report available at [http://www.brc.gov/sites/default/files/comments/attachments/idahos\\_comments\\_to\\_blue\\_ribbon\\_commission\\_draft\\_report.pdf](http://www.brc.gov/sites/default/files/comments/attachments/idahos_comments_to_blue_ribbon_commission_draft_report.pdf).

<sup>21</sup> There is a similar agreement with the State of Colorado under which Navy SNF has to be moved out of that state by January 1, 2035. The penalty for non-compliance amounts to \$15,000 for each day of delay beyond the deadline.

<sup>22</sup> United States Government Accountability Office, *DOE NUCLEAR WASTE: Better Information Needed on Waste Storage at DOE Sites as a Result of Yucca Mountain Shutdown*, GAO-11-230, March 2011.

<sup>23</sup> See “Idaho’s Perspective on the Blue Ribbon Commission Report,” Susan Burke, Idaho National Laboratory Oversight Coordinator for the State of Idaho, [http://brc.gov/sites/default/files/meetings/presentations/brc\\_comments\\_idahos\\_perspective.pdf](http://brc.gov/sites/default/files/meetings/presentations/brc_comments_idahos_perspective.pdf)

<sup>24</sup> [http://www.brc.gov/sites/default/files/comments/attachments/brc\\_nrcomentletter.pdf](http://www.brc.gov/sites/default/files/comments/attachments/brc_nrcomentletter.pdf).



## 2.5 The Nature and Duration of Risks Associated with Spent Nuclear Fuel and High-Level Radioactive Waste

SNF and high-level wastes are hazardous. The primary hazard from spent fuel arises from radiation emitted by radioactive decay. Spent fuel emits high levels of radiation and thus requires shielding to be handled safely. In wet storage, shielding is provided by a large volume of water—this is the mode of storage used to cool irradiated fuel assemblies when they are first removed from a reactor core. In dry storage configurations, shielding is primarily provided by thick layers of steel and concrete.

The other major hazard from spent fuel arises if its radionuclides are mobilized into air or water. There is no risk of this occurring as long as fuel assemblies are intact. In that case, the fuel is encased in metal tubes or cladding; the tubes in turn are configured in bundles that are designed to withstand 4 to 6 years of exposure to very high temperatures and high levels of radiation in a reactor core. However, for the first few years after fuel is removed from a reactor core, the rapid decay of short-lived radioactive material generates sufficient heat so that overheating has the potential to damage the fuel assemblies and release radioactive material if sufficient cooling is not provided. Likewise, over the very long time periods associated with geologic disposal, gradual corrosion processes may breach the fuel container and allow radioactive material to be mobilized in groundwater.

High-level wastes arise from the chemical reprocessing of spent fuel, a process that also generates large volumes of low-level wastes (including some having radionuclide concentrations greater than those defining the upper boundary of Class C waste as defined in 10 CFR 61).<sup>25</sup> Modern reprocessing facilities convert all high-level waste streams into solid glass, ceramic, or metal waste forms that are typically contained in stainless steel canisters. High-level waste can emit high levels of radiation and thus requires shielding and handling methods similar to spent fuel. As with the disposal of spent fuel, the concern is that corrosion processes could, over very long time periods, result in radioactive material being mobilized into groundwater.

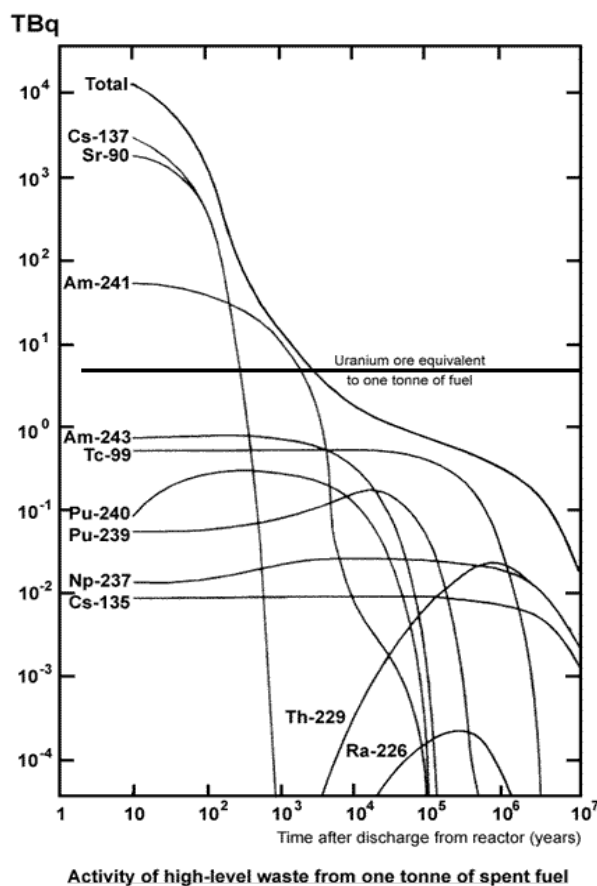
Spent fuel and high-level wastes are also chemically hazardous because of the toxicity of some of their constituent elements (i.e., lead and also plutonium and uranium). These chemical hazards, however, are generally small compared to the radiation hazards associated with these materials.

Exposure to radioactive materials—whether natural or man-made—can be damaging because many forms of radiation have the ability to change the structure of molecules, including the structure of molecules found in the tissues of living organisms. Humans are routinely exposed to low levels of radiation in everyday life. These low-level exposures can come from natural sources (e.g., cosmic rays, certain minerals, some foods) and from man-made sources (e.g., building materials, and medical procedures such as x-rays, CAT scans, certain cancer treatments, etc.). Compared to these sources, the materials associated with the back end of the nuclear fuel cycle (including both spent fuel and high-level waste) emit very high levels of radiation. This creates the risk of exposure to levels of radiation that would cause irreparable damage to living organisms. The consequences of such damage could be very serious – the exposed individual could develop cancer, for example, or suffer genetic effects (i.e., mutations in the reproductive cells that could be damaging to offspring). Exposure to very high doses of radiation can cause burns or even rapidly developing radiation poisoning, which can lead to death in a relatively short period of time (days to weeks).

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<sup>25</sup> The DOE is presently pursuing a NEPA-based process (i.e., environmental impact statement followed by a record of decision) that will identify disposal methods and sites for greater-than-Class C waste. A wide range of disposal methods and sites are presently under consideration as a part of this process.

Some categories of nuclear waste (generally including all high-level waste and virtually all current SNF) remain very radioactive for thousands of years because of the long half-lives<sup>26</sup> of some of the radioisotopes they contain. For instance, plutonium-242 has a half-life of 360,000 years, while the half-lives of neptunium-237 and thorium-232 are more than 2 million and 1.4 billion years, respectively. (The half-life of uranium-238 is nearly 4.5 billion years.<sup>27</sup>) The radioactive decay of a typical spent fuel assembly over time is shown in figure 4. It is worth mentioning, however, that very long-lived isotopes also tend to pose a less acute radiation hazard; by comparison, the more hazardous isotopes tend to be those that decay more quickly (the more rapid the decay, the greater the quantity of the resulting radiation). In sum, the risks associated with different radioactive materials depend on a combination of factors, including the amount of material present, the half-lives of the radioactive isotopes it contains, the type and energy of the radiation emitted, the potential pathways that exist for these isotopes to reach the biosphere, and how these isotopes behave when they enter a living organism.



Source: IAEA, 1992 - radioactive waste management.

**Figure 4. Radiation Decay of Spent Nuclear Fuel after Discharge from Reactor  
(Source: World Nuclear Association).**

<sup>26</sup> Half-life is the time required for half of the initial atoms of a given amount of a radionuclide to decay. Theoretically, these materials remain radioactive forever; however, at some point, they have decayed sufficiently that the remaining radioactivity is deemed insignificant. One rule of thumb for when that threshold of insignificance has been reached is after 10 half-lives: at that point, 0.1% of the original radioactivity remains.

<sup>27</sup> Thorium-232 and uranium-238 are naturally occurring isotopes.

## 2.6 Key Findings

- The United States has a substantial existing inventory of high-level radioactive wastes and SNF. These materials exist in different forms and quantities.
- From a quantity standpoint, spent fuel from commercial nuclear power reactors constitutes the largest part of this inventory, totaling approximately 65,000 metric tons. This inventory continues to grow at an annual rate on the order of 2,000 to 2,400 metric tons per year as a result of the ongoing operation of the nation's commercial nuclear power plants.
- DOE owns a smaller quantity of spent fuel, approximately 2,500 metric tons. A small fraction of this material is naval spent fuel, but this spent fuel has particular importance because a continuing ability to accept and manage naval spent fuel is needed to support ongoing Navy capabilities. In addition, DOE is responsible for managing and ultimately disposing of some 90 million gallons of liquid high-level waste, mostly from past defense operations. DOE has begun the process of vitrifying this waste, much of which is currently being stored in underground tanks. Vitrification converts the waste to a solid, glass form so that it can be packaged in canisters in preparation for final disposal.
- SNF and high-level wastes are hazardous primarily because of the radiation they emit as their radioactive constituents decay. Exposure to radiation—whether natural or man-made—can damage molecular structures and thus cause genetic defects and cancer, which may occur long after the actual exposure. Exposure to high levels such as those found in spent fuel and high-level wastes can cause more serious damage (even death) much more quickly.
- Spent fuel and high-level waste present a management and disposal challenge because they contain some heavy elements and fission products that require very long-term isolation from the accessible environment. (The radioisotopes that dominate the peak dose calculations used to assess risk from these specific materials have half-lives on the order of tens of thousands to millions of years.<sup>28</sup>)

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<sup>28</sup> A few isotopes, such as uranium-238 and thorium-232 have half lives as long as a billion years. Although these isotopes will pose a risk at some point, they have not been shown to significantly affect repository safety.

### **3. THE HISTORY OF U.S. EFFORTS TO MANAGE THE BACK END OF THE NUCLEAR FUEL CYCLE**

If there is one point of universal agreement in the many-sided debate about nuclear waste policy in the United States, it is that future efforts to manage the back end of the fuel cycle must reflect the hard-learned lessons of the past. The fact is that the federal government's more than half-century-long record of policy-setting and program implementation in this area has been marked by more failures than successes. This section reviews some of the highlights of this history in an effort to provide essential context for the Subcommittee's recommendations; of necessity, it omits numerous details and nuances. Readers interested in a more detailed treatment should consult some of the many sources available on the Commission's website ([www.brc.gov](http://www.brc.gov)).

#### **3.1 Early U.S. Policy on Nuclear Waste Management (1940s–1982)**

In the 1940s, during the early days of nuclear weapons development in the United States, national security considerations took precedence over concerns about the safe disposal of nuclear waste. With the emphasis on rapid production of plutonium for use in weapons, storage in large, underground steel tanks was deemed adequate as an interim means of isolating the highly radioactive liquid waste that remained after acid was used to dissolve irradiated nuclear fuel as part of the plutonium separation process. Even at the time, however, the underground tanks were not considered a long-term solution. In a 1949 report, the Atomic Energy Commission (AEC)<sup>29</sup> emphasized that “better means of isolating, concentrating, immobilizing, and controlling wastes will ultimately be required.”

The need for better long-term waste disposal options emerged as an important technical and policy question in the early planning for a commercial nuclear power industry during the 1950s. In 1954, when Congress passed the Atomic Energy Act and established the framework for today's civilian nuclear energy industry, the expectation was that commercial spent fuel would be reprocessed like defense spent fuel for use in breeder reactors. This would result in liquid waste streams, similar to the liquid waste that was already being produced by the government's defense-related reprocessing operations. It was understood, however, that the development of a commercial power industry would greatly increase the amount of radioactivity in high-level liquid waste in need of storage and eventual disposal.

In 1957, the National Academy of Sciences (NAS) issued a report (titled “The Disposal of Radioactive Waste on Land”) that looked specifically at the question of long-term nuclear waste disposal. That report reached several important conclusions, among them that “radioactive waste can be disposed of safely in a variety of ways and at a large number of sites in the United States” and that geologic disposal in salt deposits represents “the most promising method of disposal.” The NAS further concluded that solidifying liquid waste for transport and disposal would be “advantageous” and that transportation issues would need to be considered in the location of waste disposal facilities.

Prompted by these recommendations, the AEC began investigating mined geologic disposal and potential salt bed repository sites in the late 1950s. Its early efforts included experiments with solids and liquids in salt mines and exploratory work on methods for solidifying liquid wastes. In June 1970, the AEC announced plans to investigate an abandoned salt mine in Lyons, Kansas as a potential demonstration site for the disposal of high-level and low-level waste. At the time, the AEC anticipated that the Lyons site could begin accepting low-level plutonium (also known as “transuranic” or “TRU”)

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<sup>29</sup> The AEC was the nation's first overarching nuclear regulatory authority. It was established in 1946.

waste as early as 1974, and high-level waste by 1975. By 1971, however, state opposition to the project was growing and in 1974, after a number of technical problems had emerged that called into question the geological integrity of the site, the AEC announced that Lyons was no longer being considered as a potential disposal site for radioactive waste.

During the same time period (i.e., the early 1970s), the AEC—at the invitation of the local community—began exploring an area of deep salt beds near Carlsbad, New Mexico as a potential repository site for high-level radioactive waste. Disposal at the site—which became known as the Waste Isolation Pilot Plant (WIPP)—was subsequently limited to defense-related TRU waste. Congress authorized WIPP to begin receiving waste as early as 1979; however, it took until 1999 (20 years later) before the first shipments began arriving at the facility. Though ultimately successful, DOE’s efforts to open the WIPP facility (figure 5) were delayed by years of controversy. Despite consistent local support for the project, many state officials were opposed and expressed concern that SNF and high-level waste would eventually be disposed of at the site, along with less hazardous TRU waste. Ultimately, DOE’s slow progress on WIPP prompted congressional action in 1992 and again in 1996 to detail the regulations and procedures DOE would need to follow to open the facility, to address land disposal restrictions, and to provide funding for the construction of bypass roads to be used in transporting waste to the site. WIPP’s operational history since the first waste shipments arrived at the facility in 1999 has been excellent, and the project continues to have local and state support.

## WIPP Facility and Stratigraphic Sequence

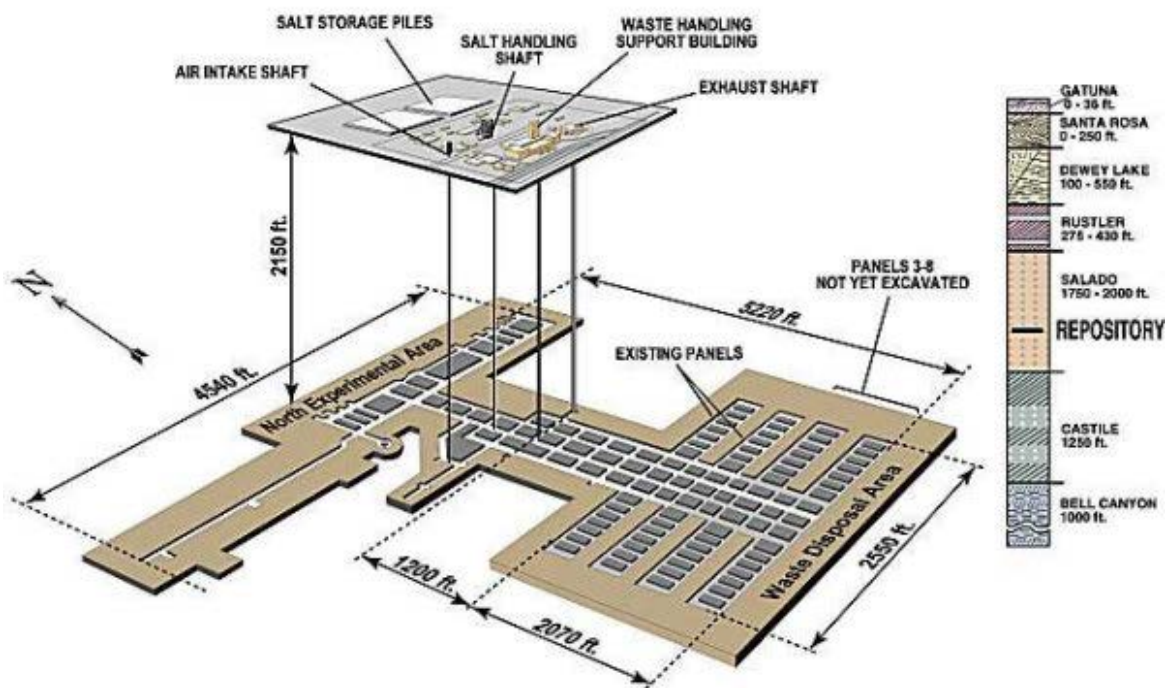


Figure 5. Layout of the Waste Isolation Pilot Plant<sup>30</sup>

<sup>30</sup> <http://infranetlab.org/blog/2008/07/the-advantages-of-being-salty/>.

The search for a suitable site for long-term geologic disposal of high-level waste continued throughout the 1970s, first under the AEC and later under its successor agency, the Energy Research and Development Administration (ERDA).<sup>31</sup> Among the geologic media considered during this period<sup>32</sup> were bedded salt formations in Michigan, Texas, and Utah; salt domes in Louisiana and Mississippi; basalt formations at Hanford; and a variety of rock types (argillite, granite and volcanic tuff at the Nevada test site (see figure 6). Meanwhile, the outlook for future waste management efforts had begun to shift as a result of policy changes prompted by weapons proliferation concerns. In particular, India's test of a nuclear device in 1974 heightened fears that plutonium could be diverted from the civilian nuclear fuel cycle to weapons production.



**Figure 6. Sites Considered for a First Repository in early 1980s<sup>33</sup>.**

Responding to these concerns, President Ford in 1976 issued a presidential directive deferring the commercial reprocessing and recycling of plutonium in the United States. In 1977, President Carter extended this deferral indefinitely and directed the relevant federal agencies to focus on alternative fuel cycles and re-assess future spent fuel storage needs. (The Carter policy was later reversed by President Reagan; for a variety of reasons, however, commercial reprocessing was never resumed.)

Recognizing that the commitment to an open fuel cycle with no spent fuel reprocessing would have an impact on the quantity and type of waste produced by the commercial nuclear power industry going forward, a DOE-led Interagency Review Group in 1979 recommended that a number of potential repository sites for high-level waste be identified in different geologic environments and in different parts of the country.

<sup>31</sup> ERDA, along with the newly formed NRC, took the place of the AEC in 1975. Soon after, in 1977, the functions and responsibilities of ERDA were assumed by the newly formed DOE.

<sup>32</sup> T. F. Lomenick, *The Siting Record: An Account of the Programs of Federal Agencies and Events That Have Led to the Selection of a Potential Site for a Geologic Repository for High-Level Radioactive Waste*, Oak Ridge National Laboratory, ORNL/TM-12940, March 1996.

<sup>33</sup> Adapted from: "Nuclear Waste Policy: How We Got Here," presentation by Mark Holt to the BRC, March 25, 2010. [http://www.brc.gov/sites/default/files/meetings/presentations/crs\\_blueribboncommissionwastepolicyhistory.pdf](http://www.brc.gov/sites/default/files/meetings/presentations/crs_blueribboncommissionwastepolicyhistory.pdf).

## 3.2 U.S. Policy under the Nuclear Waste Policy Act (1982–Present)

Passage of the Nuclear Waste Policy Act (NWPA) in 1982 marked the beginning of a new chapter in U.S. efforts to deal with the nuclear waste issue. The legislation itself was the product of four years of congressional debate marked, on the one hand, by growing concern about an imminent shortage of spent-fuel storage capacity at operating reactors and, on the other hand, by an equally urgent concern on the part of individual states that they not be selected to host a repository site.

Believing that DOE would need a congressional mandate if the agency was ever to succeed in overcoming opposition to the selection of a particular repository site, Congress sought through the NWPA to establish a fair and technically sound process for selecting among potential locations. In fact, to avoid the perception that any one state or locale would be asked to bear the entire burden of the nation's waste management obligations, the Act provided for the selection of two repository sites (though not stipulated in the legislation itself, it was widely assumed that one of these sites would be located in the West, the other in the East). And to further ensure that the end result would not be a single, national repository, Congress included provisions explicitly limiting the capacity of the first repository to 70,000 metric tons until a second repository was opened. As noted earlier, today the combined quantity of civilian spent fuel and defense wastes has already nearly reached this statutory cap. Indeed, pursuant to a requirement of the 1987 Nuclear Waste Policy Amendments Act, DOE reported to Congress in 2008 that a second repository would be needed unless the cap was removed.<sup>34</sup>

The NWPA established separate processes for identifying these two repository sites. For the first repository, the Act directed DOE to nominate at least five sites, with different geologic media to the extent practicable, of which three were to be recommended to the President for detailed study or “characterization” by January 1985. (This tight schedule implied that first repository would be selected from candidate sites that DOE and its predecessor agencies had already been evaluating, including salt domes along the Gulf Coast, bedded salt in the Great Plains and Midwest, volcanic tuff in the West, and basalt in the Pacific Northwest.<sup>35</sup>) Based on the results of this characterization, DOE would make a final recommendation and the President would submit his choice for a first repository site to Congress by March 31, 1987.

The second repository was to be chosen from a list of five sites that included at least three locations that had not been considered previously (this was to ensure that the second site would be located in a geographically different region from the first site). A separate siting program was thus established for the second repository. It focused on crystalline (essentially granitic) sites in the eastern half of the country, the presumption being that the first repository would likely be sited in the west. DOE was required to nominate candidate sites for the second repository (figure 7) by July 1989, and the President was to recommend a final choice to Congress by March 31, 1990. As with the first repository, the Act established a schedule for DOE to submit a license application for the second repository and for the Nuclear Regulatory Commission (NRC) to review it. Unlike the first repository, however, authorization to begin construction of the second repository would require subsequent action by Congress.

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<sup>34</sup> *The Report to the President and the Congress by the Secretary of Energy on the Need for the Second Repository*, DOE/RW-0598, U.S. DOE, Office of Civilian Radioactive Waste Management, Washington DC, December 2008. [http://www.brc.gov/sites/default/files/documents/second\\_repository\\_rpt\\_120908.pdf](http://www.brc.gov/sites/default/files/documents/second_repository_rpt_120908.pdf).

<sup>35</sup> The tight schedule for the first repository siting process led DOE to nominate nine sites for further investigation in February 1983, before the siting guidelines required by the Act were issued. These sites had been identified in pre-NWPA site screening efforts focused on (1) salt sites and (2) Federal lands where radioactive materials were already present (an approach recommended by the Comptroller General of the United States and a House resolution.) U.S. Department of Energy, *Mission Plan for the Civilian Radioactive Waste Management Program*, Vol. 1, DOE/RW-0005, June 1985, pp. 39-40.

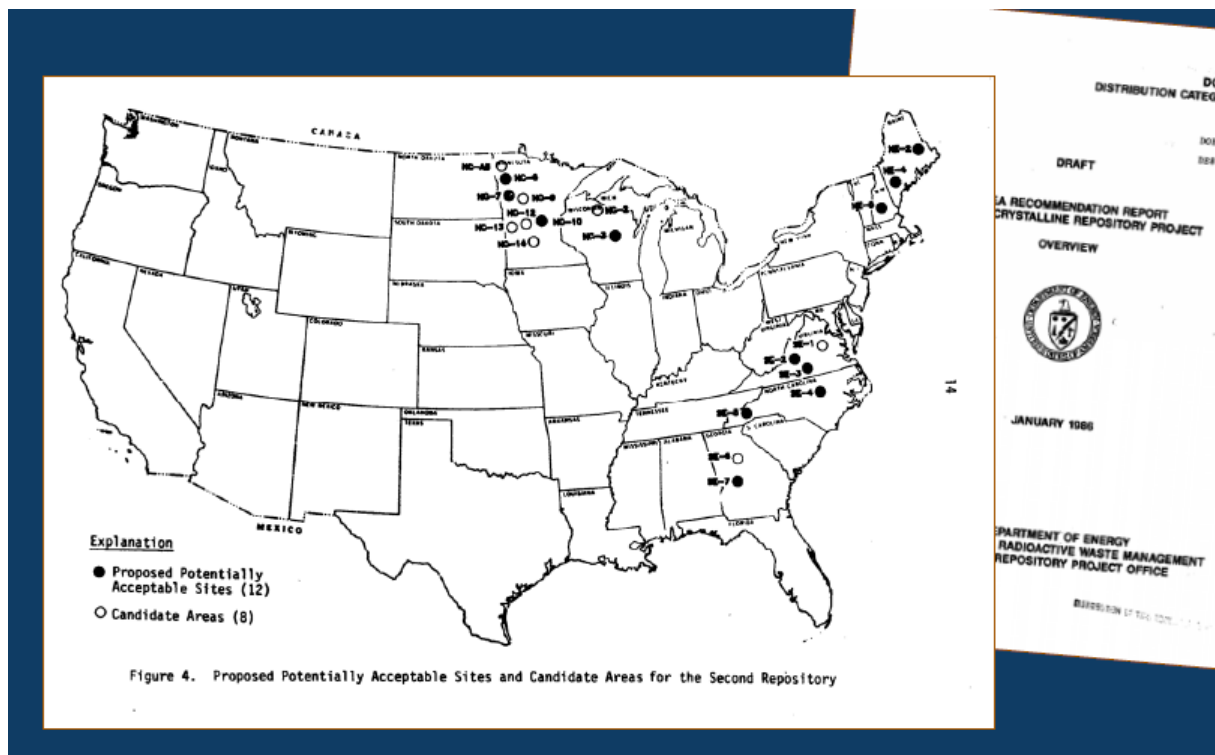


Figure 7. Sites Considered for a Second Repository in the 1980s<sup>36</sup>

Beyond establishing a process for the selection of two permanent geologic high-level waste repositories, the NWSA included a number of other noteworthy provisions:

1. It established a new Office of Civilian Radioactive Waste Management (OCRWM) within DOE, with a director appointed by the President and confirmed by the Senate.
1. It authorized DOE to enter into contracts with utilities for the federal removal of spent fuel from reactor sites beginning by 1998 in return for a fee on utilities' sales of nuclear-generated electricity.
2. It directed DOE to propose a site and design for the "monitored retrievable storage" of nuclear waste prior to the waste being shipped to a permanent disposal site.
3. It provided for federal storage of civilian high-level waste on an interim basis in emergency situations.
4. It granted states certain rights with respect to oversight over waste storage or disposal sites within their borders and the ability to veto DOE siting decisions. However, a state's veto would be subject to override by both houses of Congress.
5. It gave the NRC responsibility for licensing waste facilities, subject to public health and environmental standards established by the U.S. Environmental Protection Agency (EPA).

<sup>36</sup> Adapted from: "Nuclear Waste Policy: How We Got Here," presentation by Mark Holt to the BRC, March 25, 2010. [http://www.brc.gov/sites/default/files/meetings/presentations/crs\\_blueribboncommissionwastepolicyhistory.pdf](http://www.brc.gov/sites/default/files/meetings/presentations/crs_blueribboncommissionwastepolicyhistory.pdf).



In May 1986, Energy Secretary John Herrington recommended the Hanford site in Washington State, Deaf Smith County in Texas, and Nevada’s Yucca Mountain for further site characterization as leading candidates for the nation’s first permanent geologic repository for high-level nuclear waste. By that time, however, DOE’s efforts to identify promising sites—not only for the two permanent repositories but also for a monitored retrievable storage (MRS) facility—were drawing strong opposition from all potentially affected states. Earlier in 1986, DOE had released a list of 12 areas in seven different states with potentially suitable granite or other crystalline rock formations for a second geologic repository. These sites were all located in the upper Midwest, New England, and along the Atlantic Coast and had been identified through a systematic screening methodology developed by DOE in consultation with the seventeen affected states.<sup>37</sup> Nevertheless, citizens, state officials, and congressional delegations from these states objected strongly to DOE’s findings, as did the state of Tennessee, which had been identified as the potential site for a MRS facility that would serve as a central receiving point for waste shipments from nuclear plants east of the Rocky Mountains. Citing rising costs and lower projections for nuclear waste production in the future, Secretary Herrington announced that DOE was suspending efforts to identify and develop a second permanent geologic repository. This announcement also came in May 1986—not surprisingly, it served to intensify the opposition of the three states that had been selected as potential hosts for the first repository.

Faced with a deteriorating political situation<sup>38</sup> and growing recognition that the NWPAA’s original timelines and cost assumptions were unrealistic, Congress revisited the issue of nuclear waste management in 1987. The Nuclear Waste Policy Amendments Act (NWPAA) of 1987 precluded any further research in crystalline rock (the type under consideration for the second repository) of the type found in the East; cancelled the second repository program and directed DOE to report to Congress (between January 1, 2007 and January 1, 2010) on the need for a second repository;<sup>39</sup> nullified the selection of Oak Ridge, Tennessee as a potential MRS site; and designated Yucca Mountain as the sole site to be considered for a permanent geologic repository. The decision was widely viewed as political and it provoked strong opposition in Nevada, where the 1987 legislation came to be known as the “Screw Nevada” bill.

To address concerns about the technical integrity of DOE’s assessments, the NWPAA of 1987 established a new federal agency—the U.S. Nuclear Waste Technical Review Board (NWTRB)—for the sole purpose of providing independent scientific and technical oversight of DOE’s waste management and disposal program and objective expert advice on nuclear waste management to Congress and the Secretary of Energy. Congress also tried a new approach to overcoming state and local opposition: under the 1987 amendments, states could receive up to \$20 million per year for hosting a repository and up to \$10 million per year for hosting an MRS site. The amendments also provided for a presidentially

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<sup>37</sup> Unlike the initial screening process that supported identification of the sites considered for the first repository, which DOE had been conducting prior to passage of the Act, the screening methodology for the second repository was based on the siting guidelines developed pursuant to the Act and was subject to public review and comment before being finalized. U.S. Department of Energy, *Mission Plan for the Civilian Radioactive Waste Management Program, Vol. 1*, DOE/RW-0005, June 1985, pp. 42-43.

<sup>38</sup> A statement by Representative Morris Udall of Arizona, on the floor of the House of Representatives in 1987 during debates leading up to the adoption of the Nuclear Waste Policy Amendments Act, summed up the general mood of dismay. Referring to the site selection process in the original NWPAA, Representative Udall said, “We created a principled process for finding the safest, most sensible place to bury these dangerous wastes. Today, just 5 years later, this great program is in ruins. Potential host states no longer trust the technical integrity of the Department of Energy’s siting decisions.”

<sup>39</sup> The report was delivered in December 2008. (*The report to the President and the Congress by the Secretary of Energy on the Need for the Second Repository*, DOE/RW-0598, U.S. DOE, Office of Civilian Radioactive Waste Management, Washington DC, December 2008) [http://www.brc.gov/sites/default/files/documents/second\\_repository\\_rpt\\_120908.pdf](http://www.brc.gov/sites/default/files/documents/second_repository_rpt_120908.pdf).

appointed “nuclear waste negotiator” who was authorized to reach agreements with states or Indian tribes to host nuclear waste facilities under any “reasonable and appropriate terms.”

So far, however, none of the policy changes introduced in 1987 have succeeded in expediting the development of either a permanent geologic repository or a centralized, interim MRS facility.

### 3.3 Experience with the Yucca Mountain Repository Program

Following the dictates of the 1987 NWPAA, DOE continued detailed site characterization studies at Yucca Mountain through the 1990s and issued a formal finding on the suitability of the site in 2002. This prompted the State of Nevada, which had remained staunchly opposed to the project throughout, to file an official “Notice of Disapproval” A congressional resolution to override the state’s veto, however, was passed and signed by the President, clearing the way for DOE to apply to the NRC for a license to commence construction. The latter step was supposed to follow fairly quickly (within 90 days), but due to litigation over the repository safety standards and for other reasons it took another 6 years before the application for a construction license was filed with the NRC.

In the end, DOE succeeded in completing the world’s first license application for a HLW repository. Submitted to the NRC in June 2008, the license application was deemed suitable for review three months later. Within a year, however, the Obama Administration declared its intent to suspend further work on Yucca Mountain and later moved to withdraw the application for a construction license to the NRC. At this point, with key decisions by the courts and the NRC still pending, the future of the Yucca Mountain project remains uncertain.

Several attributes of the nation’s approach to nuclear waste management generally, and to the selection and characterization of the Yucca Mountain site in particular, are widely viewed as having contributed to the significant difficulties encountered in implementing the NWPAA. First, DOE’s termination of the second repository siting process, combined with Congress’s subsequent action to short-circuit the technical site selection process established under the original NWPA and single out Yucca Mountain as the sole site for consideration, created a widespread perception that the repository location was being determined on the basis of primarily political, rather than technical or scientific, considerations.<sup>40</sup>

Second, neither the original site selection process established by the Act nor the subsequent legislative designation of Yucca Mountain as the sole site for consideration was consent-based. Though the latter project had support from some local constituencies, its designation as the sole site for investigation in 1987 was strongly opposed by the State of Nevada and the majority of its citizens. In comments to the Commission, several counties in Nevada (including Nye, Mineral, and Lincoln counties) have expressed support for the Yucca Mountain project or for at least allowing the license approval process for Yucca Mountain to go forward,<sup>41</sup>

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<sup>40</sup> Yucca Mountain had been the highest-ranked site among those considered for a first repository in the 1980s, based on the scientific and technical siting guidelines in place at that time.

<sup>41</sup> For details, see comments submitted on the draft of this subcommittee report and on the full Commission’s draft report to the Secretary of Energy (e.g., Nye County Staff Comments on the Disposal Subcommittee Report to the Full Commission, June 2011 [http://www.brc.gov/sites/default/files/comments/attachments/brc\\_final\\_draft\\_comments\\_on\\_the\\_disp\\_subcmte\\_report\\_v4.pdf](http://www.brc.gov/sites/default/files/comments/attachments/brc_final_draft_comments_on_the_disp_subcmte_report_v4.pdf). Mineral County Staff Comments on the Disposal subcommittee and T&S subcommittee reports/recommendations [http://www.brc.gov/sites/default/files/comments/attachments/mineral\\_county\\_nuclear\\_projects\\_office\\_comments.pdf](http://www.brc.gov/sites/default/files/comments/attachments/mineral_county_nuclear_projects_office_comments.pdf)).

A third issue, and one that pre-dated the decision to focus only on Yucca Mountain, was the practice of setting unrealistic and rigid deadlines. As DOE failed time and again to meet various deadlines, confidence in the federal government's competence to manage either the Yucca Mountain project or its broader obligations concerning the management of civilian and defense nuclear waste eroded among all parties involved. Key stakeholders, including not only citizens of the communities where these materials were being stored but also nuclear utilities and their customers (who continued to pay into the Nuclear Waste Fund even as the repository program fell further and further behind), became increasingly frustrated. The fact that the delays were in some part attributable to funding shortfalls compounded this frustration, since these funding problems stemmed not from an underlying shortage of resources but from the waste program's lack of full access to the Nuclear Waste Fund (NWF), for reasons discussed extensively in section 6. All the while, the federal government was also opening itself (and ultimately U.S. taxpayers) to legal claims and financial damages arising from its failure to comply, in a timely manner, with its obligations under the Act and with DOE's contractual commitments to utilities.

In fact, the repository development process established under the 1982 Act and its subsequent amendments suffered more generally from a lack of flexibility. Its prescriptiveness made it difficult to adapt or respond to new developments, whether in the form of new scientific information, technological advances, or (just as important) the expressed concerns of potentially affected publics and their representatives. The 1987 NWPA made no provision for an alternative path forward if Yucca Mountain proved unsuitable on either technical or social and political grounds, or both. In fact, the 1987 Amendments explicitly ruled out consideration of other sites. This lack of adaptability further undermined confidence in the analysis and planning conducted by DOE and other federal agencies, making it easy to view these efforts as mere paper exercises, rigged to justify a foreordained conclusion. Similarly, by directing EPA to develop safety standards specific to the Yucca Mountain site in the Energy Policy Act of 1992, Congress undermined confidence that those standards represented an independent and comprehensive scientific judgment about what was necessary to protect human health and the environment.

These attributes of the Yucca Mountain siting process led to a serious erosion of trust, especially among the people of the state of Nevada. The recent decision by the Administration to withdraw the Yucca Mountain license application has further diminished confidence in the government's ability to provide a safe and timely solution for the disposal of SNF and high-level wastes. This is not a comment on the merits of the decision to withdraw the license application; the Subcommittee was not asked to examine that issue and offers no opinion. However, it is clear to the Subcommittee that waste cleanup commitments were made to states and communities across the United States, and to the nuclear utility industry and its ratepayers and shareholders, that have not been upheld. The decision to suspend work on the repository has left all of these parties wondering, not for the first time, if the federal government will ever deliver on its promises.

### **3.4 Key Findings**

- The more-than-half-century-long history of the U.S. nuclear waste management program is a long, complicated, and often difficult one. Though there have been successes—notably the successful opening and operation of the WIPP facility in New Mexico—the overall picture is one of continual delays, major cost overruns, extreme political controversy, and repeated failures to make good on federal commitments. We can improve on this record only by learning from the hard lessons of the past.

- Much of the difficulty encountered in past efforts to site centralized nuclear waste storage and disposal facilities stems from a fundamental federal/state/tribal rights dilemma. Even where local communities or tribal governments have supported a proposed facility, states have often been opposed.
- The effort to site a repository at Yucca Mountain has suffered from several flaws—among them inflexible and unrealistic deadlines and overly prescriptive requirements. In addition, the process used to select this site was not consent-based; throughout, the state of Nevada and the majority of its citizens were strongly opposed. It did not help that the decision to focus solely on this one site was widely seen as being driven by primarily political rather than technical considerations.
- Overall, the performance of the U.S. waste management program to date, and the experience with Yucca Mountain in particular, has led to a serious erosion of trust and confidence in the federal government’s commitment and competence to meet its obligations with respect to nuclear waste. The notable exception is the WIPP facility, which, after 12 years of successful operation, enjoys strong support at the local and state level.

## 4. THE NEED FOR A PERMANENT DISPOSAL SOLUTION

This section takes up the first two of the organizing questions noted in the Introduction:

1. Are one or more high-level nuclear waste disposal facilities needed under all reasonably foreseeable scenarios?
2. If a permanent disposal system is needed, what are the alternative approaches for disposal?

With respect to the first question, the Subcommittee concludes that: **Yes, one or more permanent disposal facilities will be needed under all reasonably foreseeable scenarios.**

With respect to the second question, the Subcommittee concludes that: **Deep geological disposal is the most promising and accepted method currently available for safely isolating spent fuel and high-level radioactive wastes from the environment for very long periods of time.** Deep mined geological disposal is the almost universally supported disposal option among scientists and policy-makers. All other countries with spent fuel and high-level waste disposal programs are pursuing mined geologic disposal.

The remainder of this section provides more detail on different disposal options and provides a rationale for the above conclusions.

### 4.1 The Rationale for Disposal

Because they are highly radioactive and often also contain hazardous/toxic chemicals, SNF and other high-level radioactive wastes must be handled and stored with care. The radiation hazard these materials present diminishes over time, but only very gradually, through decay processes that for some constituents of high-level waste and spent nuclear fuel may take hundreds of thousands of years or more. As a result, these wastes must be stored and finally disposed of in a way that provides adequate protection of the public and the environment over very long periods of time.

Broadly speaking, the only alternative to very long-term disposal for the most hazardous and long-lived radioactive elements in SNF would be to separate these elements and transmute them to short-lived fission products or stable isotopes, if that were proved to be feasible.<sup>42</sup> How this might be done through advanced reactor and fuel cycle technologies—and what challenges and opportunities such options might present—are subjects that were studied by a different subcommittee of the full Commission. The salient point for purposes of this discussion is that even advanced fuel cycles still generate waste streams with a sufficient quantity of long-lived radioactive elements<sup>43</sup> to require a long-term disposal solution. Advanced fuel cycles may reduce the quantities of these long-lived radioactive elements, but cannot eliminate them.

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<sup>42</sup> In the past, a number of concepts have been advanced periodically in hopes of eliminating the need for long-term nuclear waste disposal options (including permanent repositories). One program at Los Alamos National Laboratory, for example, focused on accelerator-driven systems for transmuting waste; it eventually evolved into a more comprehensive effort known as the Advanced Fuel Cycle Initiative. The BRC's Reactor and Fuel Cycle Technology Subcommittee reviewed this and other initiatives.

<sup>43</sup> The mass and radioactivity of the fission products produced per unit of thermal energy from a nuclear reactor is essentially the same no matter what type of nuclear fuel cycle is used.

Given the potential for acts of terror, social unrest, geopolitical changes, and other sources of long-term uncertainty and risk, deep underground disposal of SNF, HLW, and other materials that contain elements of possible interest to terrorists (i.e., plutonium), in a way that relies on both natural and engineered barriers to deter access and assure long-term isolation, is the safest disposition option.

In concluding that one or more permanent disposal facilities will be needed, the Subcommittee is echoing the consensus view, not only of numerous former expert panels that have looked at the situation in the United States, but also of all countries with significant nuclear waste inventories (including those that are currently conducting recycle or reprocessing fuel cycles) and of major international organizations such as the International Atomic Energy Agency (IAEA) and the OECD's Nuclear Energy Agency.<sup>44</sup>

## 4.2 The Obligation to Provide for Disposal

Recent events in Japan have re-focused public attention on our nation's decades-long failure to move decisively toward implementing a permanent disposal solution for SNF and high-level waste. Even leaving aside the safety concerns that the Fukushima disaster have brought to the fore, it would seem self evident—from an ethical standpoint—that the generations who created these wastes and benefited from the activities that produced them have an obligation to ensure that the entire burden of providing for their disposal does not fall to future generations.<sup>45</sup> That means mustering the financial, programmatic, institutional, and political wherewithal to proceed with the development of an integrated waste management system that would combine interim storage and permanent disposal capabilities.

Even as the ethical and pragmatic case for moving forward has become more urgent, it has become apparent that we must choose an approach that can accommodate large uncertainties and adapt to unanticipated developments. The tragedy that unfolded in Japan in March 2011 offers a stark reminder that things do not always go according to plan and that major surprises and disruptions—not only in terms of natural events and disasters but in terms of scientific and technological developments, societal values and priorities, and economic conditions (to name just a few)—must be expected, even if they cannot be predicted, over the many years that nuclear programs will unfold. Not all of these changes will be negative. On the contrary, future developments—whether they involve game-changing technological advances (fusion would be an example) or new institutional arrangements (e.g., the development of international fuel cycle facilities)—have at least as much potential to simplify our nuclear waste management challenges as they have to complicate them.

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<sup>44</sup> According to a report issued by the OECD's Nuclear Energy Agency (NEA) in 2008: "The overwhelming scientific consensus world-wide is that geological disposal is technically feasible. This is supported by the extensive experimental data accumulated for different geological formations and engineered materials from surface investigations, underground research facilities and demonstration equipment and facilities; by the current state-of-the-art in modeling techniques; by the experience in operating underground repositories for other classes of waste; and by the advances in best practice for performing safety assessments of potential disposal systems." See p. 7 of report available at: <http://www.oecd-nea.org/rwm/reports/2008/nea6433-statement.pdf> and [http://www.oecdnea.org/rwm/documents/FSC\\_moving\\_flyer\\_A4.pdf](http://www.oecdnea.org/rwm/documents/FSC_moving_flyer_A4.pdf).

<sup>45</sup> The inter-temporal, inter-generational dimensions of this ethical obligation have long been recognized in the U.S. context and internationally. The 1996 IAEA Joint Convention on the safety of spent fuel and radioactive waste management, for example, speaks of the need to avoid "compromising the ability of future generations to meet their needs and aspirations." Put another way, plans for geologic disposal must not impose reasonably predictable impacts on future generations that are greater than those permitted for the current generation.

In later sections of this report, we argue that the inherently complex and long-term nature of the nuclear waste management challenge warrants a fundamentally different, less prescriptive and more adaptive, approach than has characterized the U.S. waste management program to date. At this point, it suffices to highlight the importance of moving forward even in the face of uncertainty about the details of a solution. Uncertainty is not unique to the nuclear waste disposal issue; on the contrary, the most consequential public policy questions tend to share this feature. Nor is uncertainty necessarily an undesirable thing, provided the approach taken to develop solutions is designed to accommodate and even take advantage of new information and other changes over time. What uncertainty does mean is that any rush to impose outcomes—particularly if those outcomes are highly prescriptive and tend to foreclose rather than expand available options—is very prone to fail.

Meanwhile, it seems clear that there is little to be gained—and potentially a very high price to be paid—for continued deferral and delay. This is particularly true for certain waste forms such as defense HLW and SNF for which there is no anticipated future economic value and for which the debate about recycling is moot. ***The fact that a problem is difficult and will take time to solve argues for getting started sooner rather than later, though of course the opposite tendency too often prevails.*** After Fukushima, the American public will not overlook, much less forgive, an indefinite prolongation of the status quo. Moreover, only by moving forward can some of the key questions and uncertainties about a future disposition path for high-level nuclear waste and spent fuel be identified and resolved. Fortunately, a well-constructed, well-managed, and well-financed disposal program can do both: achieve tangible progress toward meeting our ethical and moral obligations to current and future generations, while also preserving choices that will allow our descendants to make decisions in their own best interests.

### 4.3 Options for Disposal

While several options for disposing of high-level nuclear waste have been considered in the United States and elsewhere, the only option that has been judged technically promising and has been actively pursued to date is deep geologic disposal. At present, ***deep geological disposal remains—in the Subcommittee’s view—clearly the most promising and technically accepted method currently available for safely isolating high-level radioactive wastes from the environment for very long periods of time.***

In a recent statement of principles that the European Union (EU) has since recommended should be adopted by all EU member states, the IAEA articulated the aims of deep geologic disposal as follows:

“Disposal of radioactive wastes in a deep, stable geological environment is intended to provide sufficient isolation, both from human activity and from dynamic natural processes, that eventual releases of radionuclides will be in such low concentrations that they do not pose a hazard to human health and the natural environment.”

–IAEA, *Scientific and Technical Basis for Geological Disposal of Radioactive Wastes*, 2003

This section provides additional detail on deep geologic disposal in a mined repository and on a second geologic disposal concept, deep boreholes. Deep boreholes are a geologic disposal option that is less well understood at this point but that warrants further research, development and demonstration (RD&D). Other disposal concepts that have been advanced, mostly on a theoretical basis, are summarized in a text box later in this section.

**Disposal in a mined geological formation** has been the front-running permanent disposal technology in the United States for more than 50 years.<sup>46</sup> Geologic disposal in a mined repository is also the approach being taken in other countries with spent fuel or high-level waste disposal programs.

In a mined geologic repository, wastes would be placed in engineered arrays in conventionally mined cavities far beneath the earth's surface. The waste itself would be contained in canisters or other packages, as appropriate to its particular form, chemical content, and radiation intensity. As developed and studied around the world, proposals for geologic disposal also employ the concept of multiple barriers.<sup>47</sup> These include both engineered and geologic barriers that improve confidence that radioactive wastes will not return to the biosphere in biologically significant concentrations. Engineered barriers include the waste form itself, canisters, fillers, overpacking, sleeves, shaft and tunnel seals, and backfill materials. Each of these components may be designed to reduce the likelihood that radioactive material would be released and would be selected on the basis of site- and waste-specific considerations. Geologic barriers include the repository host rock and adjacent and overlying rock formations. While engineered barriers are tailored to a specific containment need, geologic barriers are chosen for their in-situ properties with respect to both waste containment and isolation. An artist's rendering of the geologic disposal concept is shown in figure 8.

An international survey of waste management programs conducted by the NWTRB<sup>48</sup> indicates that countries are considering a wide variety of rock types as potential settings for a deep geologic repository. The range of geologic media that have been considered or investigated as potential disposal sites at different times around the world includes bedded and domed rock salts, crystalline rocks (i.e., granite and gneiss), clay, shale, volcanic tuff, basalt, and various other sedimentary rocks. Each of these rock types and their geological environments has advantages and disadvantages from a strictly technical perspective, and different geologic settings and emplacement methods may be especially well suited to particular types of waste. However, many or all of them may ultimately be found to demonstrate acceptable performance for a wide range of wastes. The geologic environment into which waste would be emplaced is a related and perhaps more important consideration than the type of rock by itself.

The Blue Ribbon Commission has benefitted from visits to several facilities, including underground research laboratories. This experience contributes to our collective observation that deep geologic disposal constitutes a vital element of all international waste management programs. The United States is unusual compared to many other countries in that numerous geologic environments potentially favorable for hosting a permanent repository can be found within its borders.<sup>49</sup>

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<sup>46</sup> In 1957, the NAS Published *The Disposal Of Radioactive Waste On Land*. This report recommended geological disposal and specifically recommended disposal in cavities mined in salt beds or domes. It also noted that "disposal could be greatly simplified if waste could be gotten into solid form of relatively insoluble character."

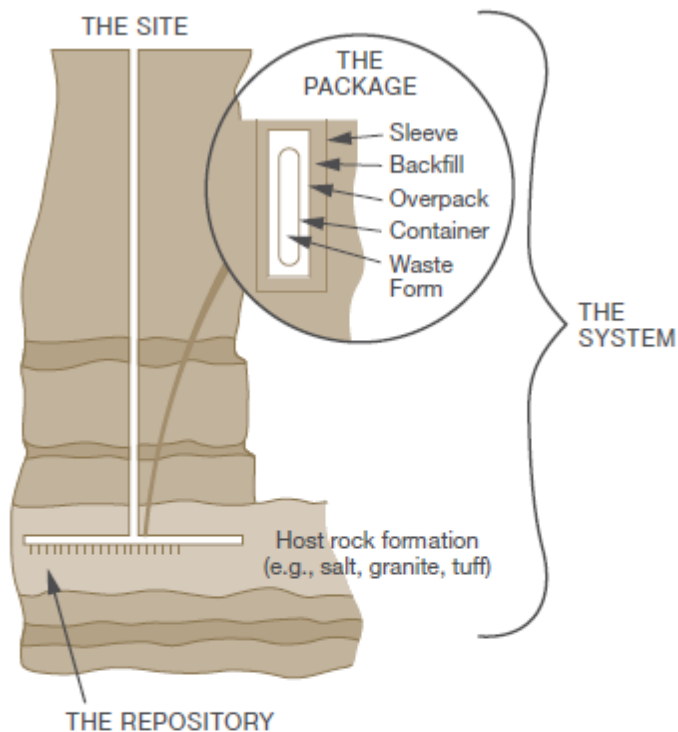
The recent NWTRB report to Congress and the Secretary of Energy *Technical Advancements and Issues Associated With The Permanent Disposal Of High-Activity Waste: Lessons Learned From Yucca Mountain and Other Programs* states that "[a]n international consensus has emerged that burial of high activity waste in a deep geologic repository is technically feasible and that such an approach can provide adequate protection to humans and the environment.", NWTRB, June 2011, p ii <http://www.nwtrb.gov/reports/technical%20lessons.pdf>

<sup>47</sup> The description in this paragraph is adapted from DOE, *Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste*, October 1980, DOE/EIS-0046F Volume 1 of 3 UC-70.

<sup>48</sup> *Survey of National Programs for Managing High-Level Radioactive Waste and Spent Nuclear Fuel*, A Report to Congress and the Secretary of Energy, October 2009, available from the NWTRB website at <http://www.nwtrb.gov/reports/reports.html>.

<sup>49</sup> DOE's report on the need for a second repository notes that when potentially suitable shale deposits are included with the sites and media already considered for a repository, "all states in the contiguous United States have a potential area that could be considered for the second repository." U.S. Department of Energy, *The Report To The President And The Congress By The Secretary Of Energy On The Need For A Second Repository*, December 2008, DOE/RW-0595, p. 12.





Mined geologic disposal will use a system comprised of engineered barriers (the waste package and the mined repository) and naturally occurring barriers (the host rock formation and the chemical and physical properties of the repository site itself) to provide long-term isolation of waste from the biosphere.

Department of Energy

**Figure 8. Mined Geologic Disposal Concept**

The Subcommittee concurs with a point made in several written submissions to the Commission ):<sup>50</sup> many geologic formations that are likely to be technically suitable for deep geologic disposal of nuclear waste can be found in the contiguous 48 states. Given appropriate repository designs, there is substantial confidence that compliance with regulatory standards for waste isolation can be demonstrated for several geologic settings, disposal concepts, and rock types, including salt, shale, volcanic rock, granite, clay and deep boreholes.

In sum, the Subcommittee sees no reason to change the current focus of the U.S. program on developing mined geologic repositories. Whether and how soon additional repositories would be needed after a first repository has been developed is uncertain and would depend on a number of factors. These factors include any physical or statutory limits on the capacity of the first repository, future rates of waste generation, decisions about reprocessing commercial spent fuel, and whether there is any change in current plans to commingle defense and commercial waste in the same repositories.

<sup>50</sup> See, for example, Hansen, et. al., *Geologic Disposal Options in the USA*, SAND2010-7975C.

## Other Disposal Concepts

Besides deep geologic disposal, a number of alternative disposal concepts have been advanced over the years. These options have generally not received as much attention; however, some of them are summarized here to illustrate the range of alternatives that have been considered.

**Disposal on or beneath unoccupied islands** has been considered by the IAEA as one option for siting an international repository or monitored retrievable storage facility.<sup>51</sup> This concept has also been advanced in public comments received by the Commission. Island sites may offer very low hydraulic gradients and the opportunity to place waste in media with no potable water. In addition, local and regional opposition may be lower in comparison to sites with many neighbors<sup>52</sup> However, given the fact that the most unoccupied islands belong to countries that do not have nuclear power; there might be ethical considerations involved in siting a multinational repository.<sup>53, 54</sup> **Disposal by *in situ* melting, perhaps in underground nuclear test cavities** was suggested<sup>55</sup> in the 1970s as an option for disposing of liquid wastes from reprocessing. The idea was that the wastes would have sufficient heat to melt the rock surface and produce a glassy lining that would prevent migration. A rationale for this approach was that the cavities already contain radioactive material, so their use for this purpose would not contaminate an otherwise pristine setting. In addition to uncertainties concerning how such a system would perform, however, and whether leakage could be detected, existing regulations reflect a strong preference for shipping and disposing of wastes in solid rather than liquid form. Recognizing that large-scale shipment of liquid wastes could be problematic, it has been suggested that future reprocessing plants could be located at previous underground nuclear test sites. **Sub-seabed disposal (in stable clay sediments)** is an option that was investigated by the U.S. Sub-Seabed program and the international community in the 1970s and 1980s. U.S. participation in related international activities ended in 1986. The proposed approach was to emplace waste canisters in thick layers of mud on the ocean floor by dropping them in pointed packages (penetrometers) designed to penetrate many feet into the mud. An alternative that was also considered was to emplace the wastes by drilling holes into the mud, as is done in offshore oil production. The idea was that the mud would close behind and around the penetrometer, allowing for very little migration of deep pore water back into the ocean. While many people in the technical community thought that the approach was workable and had some potential advantages over land-based disposal, the concept was very unpopular with most environmental groups, especially those active on ocean issues. Moreover, international treaties on the use of the sea and seabed would likely preclude this disposal concept.

<sup>51</sup> IAEA, *Technical, Institutional and Economic Factors Important for Developing a Multinational Radioactive Waste Repository*, IAEA-TECDOC-1021, Vienna (1998) and *Developing Multinational Radioactive Waste Repositories: Infrastructural framework and scenarios of cooperation*, IAEA-TECDOC-1413, October 2004. These documents address multinational facilities and are not limited to island disposal. However, proposals involving the Marshall Islands and Wake Island are described.

<sup>52</sup> The BRC staff/consultant team is not aware of any quantitative comparison of the risks of shipments via ship versus rail. However, the IAEA has concluded that transportation risks are not a significant consideration. This comment may not refer to island disposal.

<sup>53</sup> Chris Whipple, Ph.D *Disposal of Spent Nuclear Fuel and High-level Radioactive Waste, September 10, 2010* Paper commissioned for the BRC., p.9

[http://brc.gov/sites/default/files/documents/disposal\\_of\\_spent\\_nuclear\\_fuel\\_and\\_high\\_level\\_radioactive\\_waste\\_rev4.pdf](http://brc.gov/sites/default/files/documents/disposal_of_spent_nuclear_fuel_and_high_level_radioactive_waste_rev4.pdf).

<sup>54</sup> However, IAEA-TECDOC-1413, October 2004 concludes that "the multinational repository concept does not contradict ethical considerations."

<sup>55</sup> Disposal of Nuclear Waste by *In Situ* Incorporation in Deep Molten Silicate Rock, J. J. Cohen, A. E. Lewis, R. L. Bra, *American Association of Petroleum Geologists Bulletin*, Volume 55 (1971), at <http://search.datapages.com/data/doi/10.1306/819A3DEA-16C5-11D7-8645000102C1865D>.

### Other Disposal Concepts (cont'd)

**Space disposal**—that is, shooting nuclear wastes into solar orbit or even into the sun—has been proposed, although cost considerations and the risk of an accident during launch have generally kept this option from being taken seriously. The current cost of putting objects in near-earth orbit is around \$10,000 per pound; given that the U.S. inventory of spent fuel and high-level waste is on the order of 100,000 metric tons, the costs involved would be prohibitive. If one wanted to dispose of only very long-lived waste isotopes (i.e., technetium-99, cesium-135, iodine-129, and the long-lived actinides), then the amounts are much more manageable (on the order of thousand tons for the current U.S. inventory). Even then, space disposal would be extremely expensive, particularly when one includes the costs of separating out these waste constituents. There have been proposals to launch separated wastes into space using earth-based lifting devices<sup>56</sup> (e.g., lasers, microwaves, and high speed rail guns); however, the capability of these technologies has not been demonstrated.

**Disposal in deep boreholes** (rather than in a mined repository) is another form of deep geologic disposal. It may offer benefits, particularly for the disposal of certain forms of waste, but it requires further exploration.<sup>57</sup> The Commission has received a number of public comments about deep boreholes.<sup>58</sup> Basically, a deep borehole is a cased hole on the order of 45 centimeters in diameter drilled into crystalline basement rock to a depth of 4 to 5 kilometers. In most designs, the bottom 1 to 2 kilometers would be filled with either vitrified high-level waste or spent fuel and some backfill or sealant would be added to fill in the gaps between the wastes and the well casing. Figure 9 illustrates the deep boreholes disposal concept. A recent study<sup>59</sup> estimated that approximately 600 boreholes would be needed to accommodate 70,000 metric tons of waste (this quantity is comparable to the current U.S. high-level waste and spent fuel inventory).

Deep boreholes could potentially have a number of advantages compared to mined geologic repositories, including: (1) reduced mobility of radionuclides, which would help limit their transport into groundwater and thus the broader environment; (2) greater tolerance for waste heat generation; (3) greater isolation of waste; (4) modularity and flexibility in the sense that disposal capacity can be expanded relatively readily by simply drilling additional boreholes once one or more suitable location(s) have been identified; (5) the possibility of locating several borehole disposal sites across the country, which would reduce risks associated with the transportation of waste to a centralized location; and (6) widespread applicability, which in turn suggests the possibility that this technique could be readily transferred to other countries with high-level waste disposal needs.

<sup>56</sup> Chris Whipple, Ph.D *Disposal of Spent Nuclear Fuel and High-level Radioactive Waste, September 10, 2010* Paper commissioned for the BRC., p.13

[http://brc.gov/sites/default/files/documents/disposal\\_of\\_spent\\_nuclear\\_fuel\\_and\\_high\\_level\\_radioactive\\_waste\\_rev4.pdf](http://brc.gov/sites/default/files/documents/disposal_of_spent_nuclear_fuel_and_high_level_radioactive_waste_rev4.pdf).

<sup>57</sup> For a description of different borehole disposal concepts, see Fergus Gibb, "Deep borehole disposal (DBD) methods," *Nuclear Engineering International*, March 25, 2010, at <http://www.neimagazine.com/story.asp?storyCode=2055862>.

<sup>58</sup> A recent expert workshop sponsored by Sandia National Laboratory (the workshop was held during the comment period for the Subcommittee's draft report) reviewed the current state of information on deep borehole disposal. See Sandia report sent to the BRC on 10/28/2011 at [www.brc.gov](http://www.brc.gov).

<sup>59</sup> Patrick V. Brady, Bill W. Arnold, Geoff A. Freeze, Peter N. Swift, Stephen J. Bauer, Joseph L. Kanney, Robert P. Rechard, Joshua S. Stein, *Deep Borehole Disposal of High-Level Radioactive Waste, SAND2009-4401, August 2009*, at [http://www.mkg.se/uploads/Bil\\_2\\_Deep\\_Borehole\\_Disposal\\_High-Level\\_Radioactive\\_Waste\\_-\\_Sandia\\_Report\\_2009-4401\\_August\\_2009.pdf](http://www.mkg.se/uploads/Bil_2_Deep_Borehole_Disposal_High-Level_Radioactive_Waste_-_Sandia_Report_2009-4401_August_2009.pdf).

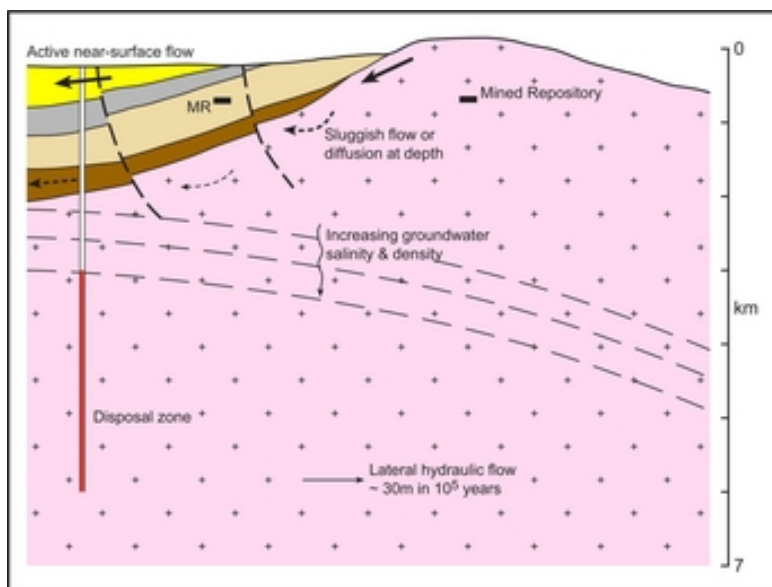


Figure 9. Deep Boreholes Disposal Concept<sup>60</sup>

On the other hand, deep boreholes also have a number of potential disadvantages, including (1) the difficulty and cost of retrieving waste (if retrievability is desired) after a borehole is sealed; (2) relatively high costs per volume of waste accepted, which may limit the usefulness of this disposal concept to small quantities of long-lived radionuclides that pose particular challenges for long-term isolation; and (3) constraints on the diameter of a borehole that could make it difficult—depending on how the waste is packaged—to accommodate some waste streams. Furthermore, the regulatory requirements that would be applied to deep borehole disposal do not yet exist, since the current regulatory structure for disposing of high-level waste and spent fuel was developed for mined repositories.

More generally, the Subcommittee believes that further and more extensive research, development, and demonstration (RD&D) is warranted to help resolve some of the current uncertainties about deep borehole disposal and to allow for a more comprehensive (and conclusive) evaluation of the potential practicality of licensing and deploying this approach, particularly as a potential disposal alternative for certain forms of nuclear waste (e.g., defense high-level wastes and certain types of DOE spent fuel) that have essentially no potential for re-use.<sup>61</sup> Such work would be consistent with section 222 of the NWSA, which requires DOE to “continue and accelerate a program of research, development, and investigation of alternative means and technologies for the permanent disposal of high-level radioactive waste from civilian nuclear activities and federal research and development activities.”<sup>62</sup> Likewise, EPA and NRC should support RD&D efforts by beginning work on a regulatory framework for borehole disposal, in parallel with their development of a site-independent safety standard for mined geologic repositories to support the RD&D effort leading to licensed demonstration of the borehole concept.<sup>63</sup>

<sup>60</sup> Bill W. Arnold, Peter N. Swift, et al, “Into the Deep,” *Nuclear Engineering International*, March 25, 2010.

<http://www.neimagazine.com/story.asp?storyCode=2055856>.

<sup>61</sup> We note that DOE’s 1981 decision to develop geologic repositories also provided for continuing work on backup technologies specifically, including very deep boreholes. “Program of Research and Development for Management and Disposal of Commercially Generated Radioactive Wastes,” dated April 16, 1981. Federal Register 40:26677 (May 1981).

<sup>62</sup> This requirement comes with the proviso that funding for research and development on alternative disposal methods must be provided through direct appropriations for that purpose; the Nuclear Waste Fund can only be used for “non-generic” research and developmental purposes.

<sup>63</sup> EPA’s existing disposal standards (40 CFR Part 191) apply to any disposal method for SNF and HLW.

## 4.4 Retrievability and Reversibility

The concepts of retrievability and reversibility have long been part of the discussion about how best to safely dispose of highly radioactive materials. However, they have assumed increasing visibility with time, particularly over the last 20 years. This has been largely, though not exclusively, due to, (1) a reaction to societal desire in many cases to be able to see and monitor the waste and preserve options to remove it, along with (2) a more programmatic consideration that in countries currently using a once-through fuel cycle, a time may come in the near future when a decision to reprocess and recycle fuel that has been emplaced in a repository may call for its retrieval. Questions regarding the definitions of the terms; the length and terms of maintaining the capabilities to reverse or retrieve; and the safety, security, economic, and societal implications now receive more attention.

While no standardized definitions for “retrievability” and “reversibility” exist, in general their implications are clear. Reversibility means the more generic ability to reconsider and reverse course at any time during the development and implementation of a geologic disposal program. It would include, for example, the ability of potential host communities to decide at a later time that they wish to remove themselves from consideration. Or it could mean that an initial decision to emplace spent fuel in a repository is reversed to instead make the spent fuel available for reprocessing and recycling. Reversibility is largely a reflection of the approach and policies taken in program development. Retrievability is more specifically the technical capability to remove waste that has already been emplaced underground in a geologic disposal facility.<sup>64,65</sup>

The Subcommittee has considered retrievability and reversibility as closely related but distinct issues. The Subcommittee is of the view that the United States should pursue the development of one or more geologic disposal facilities. For mined geologic repositories, the existing requirements concerning retrievability in existing regulations (40 Code of Federal Regulations [CFR] 191 and 10 CFR 60.111 (b)) are appropriate and should be retained. Retrievability, as embodied in these regulations, is intended to allow for the removal of the emplaced waste if the repository is not behaving as anticipated, and its performance is called into question for any reason prior to permanent closure of the repository, and not as a way to retain easy access to emplaced materials for possible later recovery and reuse. Past evaluations of potential mined geologic repository sites in various geological media, including granite, salt and volcanic tuff, have indicated that a wide range of candidate mined repository sites could meet the existing retrievability requirement.

U.S. requirements for the retrievability of high-level waste were established in the NWPA of 1982 and are codified at 10 CFR 60 111 (b):

*(b) Retrievability of waste.*

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<sup>64</sup> It is important to recognize that retrievability is not an absolute or binary characteristic—rather it is a relative one. The question is how easy (or difficult) would it be to retrieve materials from a geologic disposal facility and over what time frame. Wastes that were disposed of geologically could always, if absolutely necessary, be recovered somehow—although different methods of disposal could make it more or less expensive to do so.

<sup>65</sup> The OECD/NEA’s International Project on Reversibility and Retrievability defines retrievability as “[...] the possibility to reverse the step of waste emplacement” and reversibility as term that “implies a disposal programme that is implemented in stages and that keeps options open at each stage, and provides the capability to manage the repository with flexibility over time.” (see: *International Understanding of Reversibility of Decisions and Retrievability of Waste in Geological Disposal* at [http://www.oecd-nea.org/rwm/rr/documents/RR\\_Leaflet.pdf](http://www.oecd-nea.org/rwm/rr/documents/RR_Leaflet.pdf)).

(1) The geologic repository operations area shall be designed to preserve the option of waste retrieval throughout the period during which wastes are being emplaced and, thereafter, until the completion of a performance confirmation program and Commission review of the information obtained from such a program. To satisfy this objective, the geologic repository operations area shall be designed so that any or all of the emplaced waste could be retrieved on a reasonable schedule starting at any time up to 50 years after the waste emplacement operations are initiated, unless a different time period is approved or specified by the Commission. This different time period may be established on a case-by-case basis consistent with the emplacement schedule and the planned performance confirmation program.

(2) This requirement shall not preclude decisions by the Commission to allow backfilling part or all of, or permanent closure of, the geologic repository operations area prior to the end of the period of design for retrievability.

(3) For the purposes of this paragraph, a reasonable schedule is one that would permit retrieval in about the same time as that devoted to construction of the geologic repository operations area and the emplacement of wastes.

Potentially promising nuclear waste management system concepts that incorporate other disposal approaches—including boreholes—may be considered in the future. In such systems, a multi-decade post-closure retrieval requirement may be neither practical nor necessary. In developing the recommended borehole geologic disposal safety standard then, as allowed by the current regulation, the retrievability time period can and should be reassessed as part of a larger evaluation of disposal system performance objectives.

On the subject of reversibility, the Subcommittee views this attribute as an important part of what we believe should be a staged, adaptive approach to waste management and disposal in the United States (the details of this approach are discussed in later sections). In other words, for a program to be adaptive, there needs to be some capacity to reverse course, at least for a period of time. The point of an adaptive approach is to develop a technical method of disposal in combination with a management system<sup>66</sup> where both work together to meet safety and environmental requirements in a societally responsible and responsive manner. Flexibility is needed because implementation of the program will take at least several generations, over which time technology and values are sure to evolve but in unpredictable ways. While there is general consensus that we cannot rely on active management over the many millennia of safety and environmental concern, an adaptive, staged approach plans for a program that is highly adaptive in the near term, when it is reasonable to believe in strong institutional oversight and management capacity.

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<sup>66</sup> Descriptions of an adaptive, staged approach can be found in the National Academy of Sciences “*One Step at a Time*” report and in the Canadian NWMO “*Choosing a Way Forward*” recommendation document.

### International Approaches to Retrievability and Reversibility

Not surprisingly, other countries have also grappled with the issues of retrievability and reversibility in the context of their nuclear waste management programs. For example, retrievability was included as a policy requirement in Finland's decision to move forward with a geologic repository at Olkiluoto; however, it is not something that the implementing entity will need to address from a regulatory standpoint. This is because Finland does not view retrievability as a safety requirement. Sweden's regulations take a different approach: they require that protective capability be the central driver of repository design, but they also state that if any measures are adopted to make access to the waste easier (or to make intrusion more difficult), the effects of such measures on the overall protective capability of the repository must be reported. In effect, the Swedish approach seems to implicitly discourage any serious consideration of retrievability, either for safety or energy resource reasons. In France, current regulations stipulate that the repository must be designed to be "reversible" for at least 100 years, a concept that implies technical retrievability.

In contrast, the Subcommittee has heard that the Canadian public has insisted on retrievability as an element of repository design. This view is apparently rooted in the belief that we cannot know today what technological solutions may eventually become available that would change our preferred approach to nuclear waste disposal. In sum, although there is no international consensus on retrievability, the majority view seems to be that safety, environmental, and public health considerations should be given more weight in addressing this issue than concerns about preserving ready access to previously disposed-of spent fuel as a potential energy resource for the future.

## 4.5 Cost of Disposal

The Subcommittee has heard many comments regarding the cost of nuclear waste management. While it is impossible to prepare detailed cost estimates for an integrated U.S. nuclear waste management system without knowing the specific sites to be used for waste management and many other pertinent details, some general conclusions can be reached based on work performed for the Yucca Mountain project and other information.

A 2008 DOE life-cycle cost estimate<sup>67</sup> arrived at a figure of \$96.2 billion (in 2007 dollars) to license, construct, operate and close a repository at Yucca Mountain of sufficient size to dispose of a total of 122,000 metric tons of commercial and defense-origin spent fuel and high-level waste (note that the legislated capacity of Yucca Mountain is 70,000 metric tons). The cost share assigned to 109,000 tons of commercially-generated wastes assumed for disposal was about 80% of that \$96.2 billion total, or approximately \$77 billion.

That same year, DOE produced a detailed report<sup>68</sup> "to evaluate whether the collection of the [nuclear waste] fee will provide sufficient revenues to offset the commercial utilities' share of the total life cycle costs of the Civilian Radioactive Waste Management Program." The report concluded that the "the fee is adequate and [DOE] finds no reason to adjust the fee at this time." This conclusion echoes past fee evaluations which, over two-plus decades of the nation's nuclear waste management program,

<sup>67</sup> DOE/RW-0591, Analysis of the Total System Life Cycle Cost of the Civilian Radioactive Waste Management Program, Fiscal Year 2007, July 2008.

<sup>68</sup> DOE/RW-0593, Fiscal Year 2007 Civilian Radioactive Waste Management Fee Adequacy Assessment Report, July 2008.

concluded that the current one-tenth of one cent per kilowatt-hour collected for spent fuel management would be sufficient to pay for disposal of the nation's spent commercial reactor fuel.

The 2008 fee evaluation made a further, important observation concerning funding: "The current mechanism for making revenues available to the Program, however, is not adequate to provide the funding needed to allow DOE to execute its mission under the Nuclear Waste Policy Act. A significant assumption in developing all total life cycle cost estimates and fee adequacy analyses is that funding reform will be enacted to provide sufficient annual funds when needed. This fee adequacy analysis did not assess the adequacy of the fee if the Congress continues the historical trend of not appropriating adequate funding to execute the Program's plans." This conclusion reinforces the Subcommittee's view that providing assured access to the nuclear waste fee and fund will be essential to the long-term success of the nation's nuclear waste management program.

It is especially important to stress that judgments about the adequacy of current fee payments to cover anticipated future disposal costs are completely separate from the question of whether the current mechanism is working as intended to make fee payments available to fund the waste management program when they are needed. The second issue is covered elsewhere in this Subcommittee report and dealt with extensively in the final BRC report.

#### **4.6 Key Findings**

- One or more permanent disposal facilities for high-level nuclear waste will be needed in the United States under all reasonably foreseeable scenarios. This conclusion holds even if "full recycle" concepts are eventually developed and adopted for SNF because even advanced fuel cycles still generate some waste streams that will require a permanent disposal solution.
- This generation has an ethical obligation to proceed toward developing permanent disposal capacity for high-level nuclear wastes without further delay. Once such capacity is available, materials that clearly have no potential for re-use (i.e., HLW and some spent fuels) can be disposed, and future decision makers can decide which other materials to dispose of and on what schedule, based on the best information available at that time. But until disposal capacity has been developed, society will have no choice other than continued storage of the wastes. Siting and constructing one or more permanent disposal facilities will undoubtedly take time, so it will be important to ensure that interim storage arrangements for spent fuel and high-level wastes over the next several decades are robust and safe. In the meantime, we must move forward recognizing both (a) that we cannot know all the details of a permanent disposal solution at the outset and (b) that it is nevertheless urgent to begin making tangible progress and restoring confidence in our nation's long-term ability to manage these materials. Developing a specific mission plan with a clear, though adaptable, schedule for opening a first repository should be a first priority (and an early performance milestone) for the new implementing organization.
- Various concepts have been proposed for the long-term disposal of high-level radioactive wastes. Of these, deep geologic disposal has emerged as the most promising and technically accepted option. All countries currently moving to develop disposal capacity are pursuing deep, mined geologic repositories. The Subcommittee believes that the United States should proceed expeditiously to seek sites for one or more mined geologic repositories without waiting for the development of alternative disposal technologies, while also pursuing a parallel RD&D effort and the development of safety standards for deep boreholes.



- Retrievability and reversibility are important considerations for designing disposal facilities and the processes used to site, construct, and operate these facilities. There are several sound reasons for requiring, as is the case under NRC 10 CFR part 60.111 (b), that wastes emplaced in a mined geologic repository be retrievable for a period of time before repository closure. Reversibility—meaning the more generic ability to reconsider and reverse course at any time during the implementation of a policy or program—is likewise important and best achieved by adopting a staged, adaptive approach to developing the elements of a sound waste management system.
- A 2008 DOE analysis estimated that the cost of disposing of a total 122,000 metric tons of commercial and defense-origin spent fuel and high-level waste at Yucca Mountain would be \$96.2 billion (in 2007 dollars). This estimate includes costs for licensing, constructing, operating and closing the repository. Another DOE study concluded that the level of the current waste fee (at one-tenth of one cent per kilowatt-hour) is adequate to cover the costs of commercial SNF disposal. However, it also concluded that providing assured access to the nuclear waste fee and fund will be essential to the long-term success of the nation’s nuclear waste management program.

## 5. A NEW ORGANIZATION TO LEAD THE NATION'S WASTE MANAGEMENT PROGRAM

Having concluded, first, that the United States needs to develop one or more facilities for disposing of high-level waste and second, that deep geological disposal is the most promising and technically accepted option available at this time, the Subcommittee next turned to the following question:

*What changes in the U.S. nuclear waste management program are needed to improve prospects for successfully selecting and developing new disposal sites and what are the relative roles of different entities, including federal, state, county, local, and tribal authorities?*

**The consensus view of the Subcommittee is that a new single-purpose organization and a new approach are needed to successfully manage the storage, transportation, and disposal of SNF and high-level wastes in the United States.**

Clearly, multiple factors have worked against the timely implementation of the NWPA; responsibility for the difficulties of the past does not belong to DOE alone. Nevertheless, the experience of the last 30-plus years leads this Subcommittee to agree with a conclusion that has also been reached by many stakeholders and long-time participants in the nation's nuclear waste management program: that moving responsibility to a single purpose organization—outside DOE— offers the best chance for future success.

Subcommittee members recognize that the process of establishing a new organization will not be easy or fast. Given that DOE's Office of Civilian Radioactive Waste Management has been disbanded, this step may also be unavoidable. In that case, the question is not whether a new organization is needed but whether it will again be housed within DOE or set up as a separate entity. We believe that creating a new, single-purpose organization—independent of DOE—offers the best opportunity for successfully implementing a long-term strategy for the management and disposition of nuclear waste. Remaining parts of this section elaborate on the rationale for a new waste management organization, options and Subcommittee recommendations for structuring such an organization, and options for ensuring effective governance/oversight, addressing financing issues, and structuring stakeholder participation.

### 5.1 Rationale for a New Waste Management Organization

Establishing a new organization dedicated to managing the nation's highest-level nuclear wastes would signal a clear break with the often troubled history of the U.S. waste management program. It would also provide an opportunity to start repairing the legacy of distrust left by the federal government's frequent failure to deliver on past statutory obligations and contractual commitments in this area. By contrast a new organization could establish a new track record by conducting its programs and handling stakeholder interactions in ways that earn trust and confidence.

For example, a new organization dedicated to the safe, secure management and ultimate disposal of high-level wastes could concentrate on this objective in a way that would be difficult for a larger agency that must balance multiple agendas or policy priorities. (Within DOE, waste management is only one of several missions in a program that also includes responsibility for science and technology research and development, nuclear weapons stewardship, and environmental cleanup. Of course, DOE's full portfolio encompasses an even broader array of technologies and policy objectives.) A new organization that is

clearly focused, from the outset, on managing high-level waste and SNF will be in a better position to develop a strong culture of safety, transparency, consultation, and collaboration.<sup>69</sup> And compared to a federal agency such as DOE—where new appointees typically assume top management positions with every change of administrations and often leave in the middle of presidential terms—it should also be able to provide greater organizational stability over time.

Finally, while the Subcommittee recognizes that it will never be possible or even desirable to fully separate future waste management decisions from politics, we believe a new organization with greater control over its finances could operate at a somewhat greater remove from short-term political pressures (the critical issue of how to fund a new organization is discussed in the next section). Not that a new organization should be any less accountable for its actions or use of funds; on the contrary, effective oversight by Congress and by strong, independent regulators will be critical—indeed, this was a subject that received considerable attention from the Subcommittee. But we believe that a new organization, subject to appropriate oversight but with greater control over year-to-year budgets and operations, could more easily maintain the program-level continuity and mission consistency that has often been lacking at DOE.

The Subcommittee recognizes that Congress will need to take legislative action to establish a new waste management organization, address current funding issues, and set a new course for the nation’s nuclear waste program. Numerous questions will need to be answered, fundamental changes in current policy will be needed, and the task of starting up a new organization by itself will require both money and time. From an implementation standpoint, this is clearly among the most difficult recommendations advanced by the Subcommittee. Nevertheless, it is also one of the most important, since even the wisest policies can fail without an institutional structure that is capable of implementing them.

The Subcommittee believes that to be successful over the many decades required to achieve its mission, the waste management organization will need to exhibit a number of key behaviors and attributes, as shown below. Still we must recognize that whatever the structure of a new organization, there is no substitute for competent, inspired leadership. Therefore, the process for selecting the organization’s leader and senior managers must place highest priority on identifying and recruiting the absolute best candidates for the positions. The management of the new organization should also incorporate lessons learned from industry experience managing large nuclear projects and facilities and should incorporate a nuclear quality, safety, and security culture from its inception.

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<sup>69</sup> Outside of the United States, almost all implementing organizations for radioactive waste programs are dedicated public or private entities rather than in a ministry or department of the national government.

### Key Attributes of a New Waste Management Organization

How a new waste management organization behaves and delivers on commitments is more important than what specific organizational form it takes. In presentations, public comments, and written submissions to the Commission, stakeholders and experts repeatedly stressed that actions and behavior, more than policies or promises, would be key to restoring trust in the nation's waste management program and in the institutions responsible for operating that program. Policy makers should therefore consider what design features—including what organizational structure and operational ground rules—would promote the kinds of behaviors and attributes that will be most critical to the new organization's success:

- **Mission orientation**—A well-defined, stable mission, and the organizational capability to focus resources, personnel, and attention on that mission, without being diverted by other priorities.
- **Performance**—Ability to achieve and sustain high standards of technical, managerial and craft performance, through a skilled workforce supported by a high-reliability, safety-oriented culture.
- **Integrity**—the intent to be truthful, honest, accurate and open in conducting the program and to place ethical considerations and public well-being at the center of decision making.
- **Empowerment**—Sufficient authority and independence from political micromanagement to be able to implement the mission.
- **Continuity**—Stability in terms of organizational structure, culture, and leadership, particularly at the senior levels.
- **Flexibility**—The ability to anticipate and adapt to new challenges, including sufficient organizational independence to do so.
- **Transparency**—A clear, open, and transparent decision-making process.
- **Participation**—Straightforward paths for involvement by all interested parties, with adequate staff and funding dedicated to outreach.
- **Responsiveness**—The willingness and ability to respond effectively to the concerns and expectations of diverse stakeholders and constituencies.
- **Funding**—Assured financing to accomplish the mission.
- **Accountability**—Mechanisms to assure responsible action and to ensure effective oversight by Congress, independent regulators, financial and technical reviewers, and the public.
- **Constancy**—Commitment to behavior that builds trust and confidence, most importantly by delivering on promises, contracts, obligations, and deadlines.

Two of these attributes—flexibility and responsiveness—are particularly important for program success. Not coincidentally, they are also supported by most of the other attributes listed. Flexibility is needed because the program must operate over very long timeframes in which major changes in technology, institutions, and societal values are inevitable but frequently unpredictable. The capacity to adapt is essential. Responsiveness means the ability of the new organization to continually understand and reflect the values of stakeholders and the broader public. Finally, accountability to Congress, to other oversight bodies, to key stakeholders, and to the public is also critical to gaining and sustaining trust, as is a consistent commitment to transparency and communication about how decisions are being made and how competing values and interests are being balanced.

## 5.2 Options for Structuring a New Waste Management Organization

Proposals to establish a new waste management organization are not new. In 1982, the original NWPA directed DOE to study alternative approaches for constructing and operating civilian radioactive waste management facilities, specifically including the feasibility of establishing a private corporation for these purposes. More recently, legislation introduced in the 110<sup>th</sup> and 111<sup>th</sup> sessions of Congress<sup>70</sup> would have amended the Atomic Energy Act of 1954 to create a new federal corporation (called the “United States Nuclear Fuel Management Corporation”) that would “assume responsibility for the activities, obligations, and use of resources of the federal government with respect to SNF management.” Over the nearly three-decade period between the original NWPA legislation and this recent proposal, alternative means for financing and managing the nation’s high-level waste program have been extensively studied but never implemented.

Though it is clear to the Subcommittee from its study of this history that a new waste management organization could take a number of forms, we conclude that a federal corporation chartered by Congress offers the most promising model. This is also the organizational form proposed in recent legislation and recommended by an independent advisory committee (the Alternate Means of Financing and Managing or “AMFM” Panel) in 1984.<sup>71</sup> We believe that an independent federal corporation with a well-defined mission, access to adequate resources, ability to make binding contractual commitments, and subject to rigorous external oversight is more apt to achieve the combination of attributes discussed in the previous section.<sup>72</sup> The Tennessee Valley Authority (TVA), which was established in 1933 to promote resource development in the Tennessee Valley region, may provide a useful existing example of such a federally-chartered, mission-oriented corporation. Compared to simply creating a new single-purpose federal agency (even one housed entirely outside DOE), we believe a corporate organization will also (a) be less susceptible to political micromanagement, (b) have more flexibility to respond to changes in external conditions, and (c) have a greater ability to manage costs and schedules.

We emphasize, however, that the crucial underlying objective is the establishment of an independent waste management authority, with independent funding, that (1) is empowered to carry out federal responsibilities for the transportation, storage, and disposal of high-level radioactive waste and spent fuel; (2) has the key attributes (discussed above) that seem to be necessary for success in doing so and (3) is subject to effective third-party oversight. While a corporate structure appears to the Subcommittee to offer particular advantages, previous studies have concluded that a number of different organizational forms could also accomplish the job.

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<sup>70</sup> In 2010, Senator Voinovich introduced the “United States Nuclear Fuel Management Corporation Establishment Act of 2010” (S. 3322) and Congressman Upton introduced a companion bill (H.R. 5979) in the House. There was no legislative activity on these bills in the 111th Congress.

<sup>71</sup> U.S. Department of Energy Review Group, *Report to the Secretary of Energy on the Conclusions of and Recommendations of the Advisory Panel on Alternative Means of Financing and Managing (AMFM) Radioactive Waste Management Facilities*, Undated (Est. April 1985), in the BRC library at [http://www.brc.gov/sites/default/files/documents/amfm\\_doe\\_response\\_s.pdf](http://www.brc.gov/sites/default/files/documents/amfm_doe_response_s.pdf).

<sup>72</sup> Belgium, France, Japan, Spain, and United Kingdom have established public companies to implement high-level waste management programs. In Canada, Finland, Sweden, and Switzerland, waste producers have set up implementing bodies to undertake these tasks. Only the United States and Germany have assigned the job to a government department. International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM), *Report on Radioactive Waste Ownership and Management of Long-Term Liabilities in EDRAM Member Countries*, June 2005, [http://www.edram.info/fileadmin/edram/pdf/EDRAMWGonWOwnershipFinal\\_271005.pdf](http://www.edram.info/fileadmin/edram/pdf/EDRAMWGonWOwnershipFinal_271005.pdf).

Striking the right balance of independence and accountability is the key challenge, whether a new waste management organization is organized as a federal corporation or takes some other form. The Subcommittee envisions a structure in which Congress provides clear policy direction, ongoing oversight, and establishes the necessary funding mechanisms but leaves control of operational decisions and resource commitments for implementing the policy direction to the new organization. Those decisions and commitments, and indeed the performance of the organization as a whole, would, of course, be subject to policy, safety, security, technical, and financial oversight by appropriate government agencies and Congress. Operational direction would come from a board of directors appointed by the President and confirmed by the Senate (for staggered seven-year terms). Members of this board would be selected to provide a range of perspectives and expertise and to ensure that key stakeholder interests are represented.<sup>73</sup>

In addition to an engaged and highly competent board of directors, a new waste management corporation will need the leadership of a strong chief executive officer (CEO). It will therefore be critically important to define the position and powers of the CEO in terms that will attract candidates with exceptional management, political, and technical skills and experience. Under both the original AMFM Panel proposal and recent legislative proposals, the CEO would be appointed by the corporation's board of directors. The Subcommittee supports this approach. Other important questions concerning the scope of responsibilities for the new organization, oversight, and stakeholder participation are taken up below, while the critical issue of funding is discussed in the next section.

### **5.3 Scope of Responsibilities for a New Waste Management Organization**

The Subcommittee's strong view is that to be successful, a new waste management organization must be clearly focused on issues of direct relevance to its primary mission, which is the safe management and disposal of high-level radioactive wastes.

Specifically, the Subcommittee recommends that the scope of the organization be limited to those functions already assigned to the government in the NWPA, as amended, including:

- Responsibility for siting, obtaining licenses for, constructing, operating, and ultimately closing facilities for the disposal of civilian and defense high-level wastes and spent fuel.
- Responsibility for siting, obtaining licenses for, constructing, and operating centralized facilities for the consolidated interim storage of commercial spent fuel.
- Responsibility for the transportation of commercial spent fuel once it has been accepted from utilities for disposition.

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<sup>73</sup> The TVA board provides an example of how the need for expertise and stakeholder representation might be balanced. It has nine members appointed by the President and confirmed by the Senate. Key qualifications specified in law include "management expertise relative to a large for-profit or nonprofit corporate, government, or academic structure" and "support for the objectives and missions, of the Corporation, including being a national leader in technological innovation, low-cost power, and environmental stewardship." That is, Board members must be both capable of and invested in ensuring that the Corporation achieves its mission. In appointing members of the Board, the President must consider recommendations from governors of states in the service area; individual citizens; business, industrial, labor, electric power distribution, environmental, civic, and service organizations; and the congressional delegations of the states in the service area. Furthermore, the President must "seek qualified members from among persons who reflect the diversity, including the geographical diversity, and needs of the service area of the Corporation."

- Responsibility for conducting non-generic RD&D activities related to storage, transportation, and geologic disposal as well as non-generic R&D on the social dimensions of nuclear waste management.<sup>74</sup> (Responsibility for generic research in areas such as alternative disposal methods and advanced fuel cycle and waste form options should remain with DOE and private industry and should continue to be funded by general appropriations and by industry funds.)

We include a lead role in defining and funding related social science research among the new organization's responsibilities because we believe public acceptance and policy preferences will continue to have an important, if not decisive, influence on nuclear materials management policies in the future. Current understanding of these attitudes and preferences is inadequate, and in any event social attitudes and preferences will undoubtedly change with time as views on safety, energy security, environmental protection, and other issues also change. Targeted social science research can help improve understanding of the public's concerns and provide the foundation for an informed consideration of social issues in the research agenda and in waste management decisions.

The Subcommittee heard suggestions that a new federal waste management corporation should also have responsibilities related to the development and potential implementation of reprocessing/recycling capabilities if those prove to be advantageous.<sup>75</sup> Some argue that since developments and decisions taken with regard to reactors and the fuel cycle have direct implications for waste management, it would make sense from a coordination and consultation standpoint to house these two functions together. On balance, however, the Subcommittee concludes that the task of developing and operating facilities for the storage, transportation, and disposal of high-level waste and spent fuel is sufficiently challenging—as demonstrated by the history of difficulties encountered to date—to warrant a sole focus on those activities. From this perspective, it would be best to leave other reactor and fuel cycle developments to DOE and industry, while providing clear direction to the new organization concerning the need to work with industry and DOE to ensure that waste management considerations are integral to future reactor and fuel cycle developments and that the waste management system will have the flexibility to support such developments.<sup>76</sup> The Subcommittee has also taken note of the fact that none of the past studies of organizational options for waste management have recommended broadening the scope beyond storage, transportation, and disposal; in addition, most countries that have confronted this question have opted to separate institutional responsibility for waste disposal and advanced fuel cycle facilities. For example, France, which is one of the principal nations actively engaged in nuclear fuel reprocessing and recycling, has separated responsibility for waste management from other fuel cycle functions and given that responsibility to an independent organization (ANDRA), distinct from the government agency (CEA) that is responsible for reactor and fuel cycle RD&D.

### ***Issue of Commingling of Defense and Commercial SNF and High-Level Wastes***

Relatively late in its work, the BRC received comments from several states that host DOE defense waste in support of leaving responsibility for defense waste disposal with DOE. As a result, the Co-Chairs created an *ad hoc* subcommittee to investigate this issue. The states the BRC heard from generally

<sup>74</sup> Section 302(d) of the NWPA limits use of the Waste Fund to “nongeneric research, development, and demonstration activities under this Act.” An example of such nongeneric research is the OCRWM Science and Technology program. (See Robert J. Budnitz, “Status of OCRWM’s New Science and Technology Program,” Presentation to National Research Council’s Board on Radioactive Waste Management, December 12, 2002).

<sup>75</sup> The Upton/Voinovich legislation proposes to make the organization responsible for all fuel cycle options, technologies and facilities, including reprocessing facilities.

<sup>76</sup> Note: responsibility for treatment and storage of defense waste would remain with DOE.

agreed with the proposal in the Commission's draft report to establish a new organization to manage civilian wastes, but believe the government can more effectively meet its national security obligations and cleanup commitments if responsibility for defense waste disposal remains with DOE. The Commission also heard from interested parties (such as NEI) who provided credible arguments for why the original commingling decision should be sustained. Whatever one's view of the pros and cons of the current policy, a decision to move responsibility for defense wastes to a new organization (versus leaving that responsibility with DOE) would have major implications for the scope of responsibility for the new organization, as well as for key questions of funding, governance, and congressional oversight.

Since a 1985 decision by President Reagan that a separate permanent repository for defense high-level waste was not required,<sup>77</sup> DOE has planned to dispose of all high-level waste and spent fuel from national defense activities and from DOE's own research activities in a repository for commercial waste developed under the NWPA. Any investigation of whether the United States should consider reversing the 1985 decision to commingle defense and civilian waste for disposal will require both a re-examination of the factors that were required by section 8 of the NWPA to be evaluated as part of the presidential decision, and an assessment of facts and factors that have changed since the presidential decision. These facts and factors include:

- The sharp shift in focus at DOE from the production of materials for nuclear weapons to the cleanup and disposal of legacy wastes from the Cold War.
- The establishment of legally-binding site clean-up commitments that require DOE to remove defense wastes from some sites where they are currently stored by 2035.
- The current lack of statutory authority to develop a repository at a site other than Yucca Mountain under the Nuclear Waste Policy Act.
- Successful development and operation of a geologic repository (WIPP), with a mission explicitly limited to the disposal of transuranic waste only from defense nuclear activities.
- The Commission recommendation to establish a new organization outside of DOE to develop and operate repositories under an amended NWPA.

BRC concludes that it is not in a position to comprehensively assess the implications of any actions that might affect DOE's compliance with its cleanup agreements, and that it did not have the time or the resources necessary to thoroughly evaluate the many factors that must be considered by the Administration and Congress in making such a determination. The full Commission therefore has urged the Administration to launch an immediate review of the implications of leaving responsibility for disposal of defense waste and other DOE-owned waste with DOE versus moving it to a new waste management organization. This review should include an assessment of issues associated with the treatment of DOE-owned wastes from non-defense sources (e.g., a portion of the high-level waste now stored at West Valley, New York, and a variety of wastes now in storage at INL such as damaged fuel from the Three Mile Island Unit 2 reactor). The Commission also concluded that the implementation of its other recommendations should not wait for the commingling issue to be resolved and that congressional and Administration efforts to implement these recommendations can and should proceed as expeditiously as possible.

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<sup>77</sup> Based on an evaluation conducted by DOE pursuant to the NWPA: An Evaluation of Commercial Repository Capacity for the Disposal of Defense High-Level Waste. DOE/DP/0020/1. Washington DC: U.S. Department of Energy, 1985.



## 5.4 Governance/Oversight Recommendations for a New Organization

This section turns to the issue of accountability in a new organization. As we have already noted, considerations of independence and accountability are fundamentally intertwined and must be carefully balanced. Put another way, a new waste management organization will only be entrusted with substantial operational and financial autonomy if Congress and the American public are confident that safeguards are in place to ensure that the organization behaves responsibly and uses public resources wisely to achieve national policy objectives. For this reason, all analyses and proposals involving new institutional leadership for the nation’s waste management program, starting with the AMFM Panel report in the 1980s, have paid considerable attention to issues of governance, oversight, and accountability.

### 5.4.1 Congressional Oversight

Congress would play a central role in ensuring the accountability of a new waste management organization in several ways. First, Congress would define—through enabling legislation—the mission, structure, responsibilities, and powers of the new organization.<sup>78</sup> Specifically, we recommend that Congress define:

- The national nuclear waste policy framework within which the organization must operate;
- The institutional form of the new organization;
- Financial resources and funding mechanisms for the new organization;
- The roles of state, local, and tribal governments in siting waste management and disposal facilities, including the nature of public funding for state, local, tribal and other stakeholder participation; and
- The organization’s responsibility to promote the social and economic well-being of communities affected by waste management facilities,<sup>79</sup> as well as the general nature of incentives to be provided and the manner in which states, tribes, and localities are to be funded during the siting process.

(As discussed further below, we recommend that the organization’s authority would *not* extend to self regulating any aspects of environmental protection or worker or public health, safety, and security. These aspects of the organization’s performance should be overseen by independent state and federal regulatory authorities.)

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<sup>78</sup> This general approach, in which government and not the implementing organization defines the policy framework that will guide future waste management activities is common to most countries with a significant waste management program. A review of 11 countries that are members of the International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM) shows that in all cases general waste management policy is set by government, rather than the implementing organization. See: International Association for Environmentally Safe Disposal of Radioactive Materials, *Report on Radioactive Waste Ownership and Management of Long-Term Liabilities in EDRAM Member Countries*, June 2005.

<sup>79</sup> For example, “the economic and social well-being of the people living in [the Tennessee] river basin” is one of the general purposes identified in the legislation that established TVA [48 Stat. 69, 16 U.S.C. sec. 831v]; consequently, TVA sees economic development of the region as a key part of its mission and has an economic development program for that purpose. (<http://www.tva.com/econdev/index.htm>). Similarly, Enresa, which is Spain’s national corporation for radioactive waste management, has established the Enresa Foundation to promote social welfare and socio-economic development, the environment, education, and culture in areas that host Enresa facilities.

To provide oversight on an ongoing basis, we recommend that Congress stay involved through the following mechanisms:

- Senate confirmation of the new organization's board of directors;
- Periodic oversight hearings and review of reports on the activities, expenditures, and progress of the new organization (we recommend that the new organization be required to prepare such reports on a regular basis);<sup>80</sup> and
- Continued policy guidance.

While Congress would define the policy framework at the outset, some mechanism for facilitating later adjustments or course corrections after the initial policy direction is specified in law may be desirable.<sup>81</sup> One option would be to use the Mission Plan already required in the NWPA as a vehicle for ongoing congressional oversight. The new waste management organization could submit a mission plan describing its planned activities, schedules and milestones, and supporting budget to DOE and Congress on a regular basis (e.g., every three to five years). If desired, legislation establishing the new organization could include an expedited process similar to that provided by the Congressional Review Act (CRA) through which Congress could veto a proposed Mission Plan Revision by passing a joint resolution, subject to presidential veto.<sup>82</sup> This approach would allow substantial congressional control over changes of direction without requiring passage of legislation to approve such changes whenever they are needed.

#### **5.4.2 Management Oversight**

In many of the proposals for a new organization advanced to date (including by the original AMFM Panel, the Voinovich/Upton legislation, and this Subcommittee), a first layer of accountability below Congress is provided by a board of directors, whose members would be appointed by the President and confirmed by the Senate (see text box for details). A board of directors to which the organization's management is responsible would provide a degree of ongoing management oversight and control that is not normally present with a typical federal agency program, and is particularly appropriate for the management of a businesslike fee-for-service activity such as the high-level waste program. The board would have the usual powers granted such bodies; specifically, it would establish broad policies and objectives (within the statutory framework set by Congress); select top managers, establish the management structure and define personnel policies; approve annual budgets; and report to external stakeholders on the performance of the organization. This approach appears to be the norm in other nations' waste management programs. A review of organizational arrangements for radioactive waste management in a sample of 12 other countries shows that in all but one case the implementing organization is overseen by a board of directors or supervisors.<sup>83</sup>

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<sup>80</sup> The NWPA already requires annual audits of the activities of OCRWM by GAO, a comprehensive annual report by OCRWM on its activities and expenditures, and an annual report to Congress from the Secretary of the Treasury (after consultation with the Secretary of Energy) on the financial condition and operations of the Waste Fund.

<sup>81</sup> Spain, for example, may offer a useful model: the government provides policy direction to the waste management organization, ENRESA, through ministerial review and approval of a General Radioactive Waste Plan that is revised and resubmitted every four years.

<sup>82</sup> The CRA requires federal agencies that promulgate rules to submit certain information to each House of Congress and the General Comptroller about the rule. Generally, major rules may not become effective until 60 days after submission to Congress. During those 60 days, Congress could pass a joint resolution to disapprove the major rule. The President could veto a congressional joint resolution of disapproval. In that case Congress would have 30 days to override the President's veto. If Congress does not override the veto, the rule becomes effective. In legislation establishing the waste management organization and setting nuclear waste policy direction, Congress could provide itself CRA-like authority to review the organization's mission plan update.

<sup>83</sup> These 11 countries are Belgium, Canada, Finland, France, Germany, Japan, Spain, Sweden, Switzerland, Taiwan, and the UK.

### Example of How the Nuclear Waste Management Corporation's Board of Directors Might Be Structured

**Size:** Eleven members, including the CEO.

**Appointment:** appointed by the President by and with the advice and consent of the Senate (with the exception of the Board-appointed CEO who serves *ex officio*).

**General qualifications:** To be eligible to be appointed as a member of the Board, an individual shall— (1) be a citizen of the United States; (2) with the exception of the CEO, not be an employee of the Corporation; (3) make full disclosure to Congress of any investment or other financial interest that the individual holds in the energy industry; and (4) affirm support for the purposes of the Corporation.

**Composition:** The composition of the board is intended to ensure the ability to exercise sound, professional managerial and financial oversight of the functions of the waste management corporation. The President and the Senate, in making these appointments, will consider individuals who bring that expertise, ability, and experience.

Nominees should be selected from organizations contributing to the Nuclear Waste Fund, state public utility commissions, the environmental non-governmental organization community, representatives of workers involved in the construction or operation of radioactive waste management facilities, and others with demonstrated knowledge and experience relevant to the conduct of the activities of the organization, including technical, scientific, social science, community and stakeholder relations, siting, and public health and safety functions. Not more than six of the members shall be from any one political party.

**Chairman:** Selected by the Board.

**CEO:** Selected by the Board in its sole discretion, and serves as an *ex officio* member of the Board.

**Compensation for members** who are not federal employees would be provided through an annual stipend (e.g., TVA) or through compensation at a specified daily rate (e.g., proposed United States Nuclear Fuel Management Corporation Establishment Act).

**Term of office:** Seven years, renewable once. Staggered terms, a member would continue to serve until his/her successor is appointed.

**Subcommittees and consultants:** The Board is authorized to form subcommittees and hire consultants and advisors as needed.

#### 5.4.3 Independent Regulation

The new organization would be subject to the same federal and applicable state health, safety, and environmental regulations as a private corporation, unless otherwise prescribed by Congress. (Regulatory issues are discussed in more detail in section 8.) The specific division of federal regulatory responsibility should include the following:

- Radiological health and safety—EPA and NRC
- Other environmental impacts—EPA

- Transportation (other than transportation cask design certification)—Department of Transportation (DOT)
- Worker health and safety—Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration
- Security – NRC, DOT and others through implementation of Department of Homeland Security (DHS) standards and requirements. In addition, the waste management organization may accept additional state and/or tribal oversight and regulatory requirements as a part of the legally binding agreements described in Recommendation #4.

#### 5.4.4 Scientific and Technical Oversight

Many proposals for an independent waste management organization provide for broad independent technical oversight in addition to, and separate from, any specific health and safety or environmental standards that might apply to the waste management facilities built and operated by the organization. The existing NWTRB would be an appropriate organization for providing this type of wide-ranging technical oversight on an ongoing basis. The NWTRB should continue to issue formal reports at least twice per year, to Congress and DOE (as it does now) and then to the new organization as soon as it is created. As is currently the case, NWTRB members should be selected by the President from a candidate list prepared by the National Academy of Sciences and should consist of a carefully considered mix of scientists and engineers; the mix of disciplines represented on the NWTRB should change as the new organization's activities move from site screening and selection to design, licensing, construction, operation and closure.

Independent reviews of key aspects of the program on an *ad hoc* basis by independent organizations (e.g., the National Academy of Sciences, the Nuclear Energy Agency [NEA], and the International Atomic Energy Agency [IAEA]) can also be useful in providing guidance and enhancing public confidence in the technical competence of the organization's work. The waste management organization should therefore be given the authority and responsibility to implement programs and procedures aimed at facilitating such independent reviews, including authority to fund such activities, where appropriate.

Assuring the relevance, quality, and comprehensiveness of the scientific, technical, and institutional work undertaken by the new organization is important to program excellence. This is also necessary to earn the confidence of the scientific community and larger public. A rigorous, open, and documented peer review process conducted by a wide range of experts can play a key role in providing this assurance, in conjunction with a rigorous quality assurance program. Peer review provides one mechanism by which outside experts can provide independent critical evaluations of analyses, studies, or proposals put forward by the waste management organization.

To that end, a significant first step toward the goal of continued technical excellence is for the organization to encourage (if not demand) that its scientific professionals publish and in other traditional ways present the results of their work to professional colleagues for scrutiny. In addition to ensuring scientific value, such evaluations can be used by the organization's senior management as tools for verifying or validating the assumptions, results, and conclusions of its own internal work. A second approach to ensure high-quality independent scrutiny is for the new organization to commit in its program plan that a significant number of the scientific and other technical research projects needed to advance its mission will be competitively awarded and conducted by experts outside the organization

itself, for example, at academic institutions, national laboratories, and scientific centers of excellence in other federal agencies (e.g., the U.S. Geological Survey). Experts at these other institutions routinely subject the results of their work to peer review as part of the normal publication process. Explicitly capitalizing on the peer review process in both of these ways will bolster confidence and strengthen the credibility of the organization's scientific endeavors; it can also help improve decision-making by bringing other relevant work to the attention of the organization's top leadership.

In summary, besides ensuring that interested parties and stakeholders have timely access to data and analyses, the new waste management organization should encourage and support the peer-reviewed publication of all work that is important to its activities, including site characterization work as well as analyses aimed at demonstrating the safety and suitability of plans for repository design and operations. The organization should also encourage and support its staff and the external research teams it funds, not only in publishing results in recognized professional journals, but also in delivering presentations and papers at scientific and technical conferences, as well as participating in national and international meetings. This will allow the organization's work to benefit from full exposure to the broader scientific community and other interested stakeholders. We envision that a robust peer review effort will not substitute for, but will rather augment, the oversight provided by relevant regulatory authorities, the NWTRB, and other important organizations (e.g., the National Academy of Sciences).

#### **5.4.5 Financial Oversight**

Providing the new organization with control of its funding independent of the annual budget and appropriations process, as recommended by the Subcommittee and discussed at length in the next section (section 6), will require independent oversight to ensure that the NWF and other public resources are being used appropriately in support of waste program objectives. Beyond a board of directors, most proposals provide for additional oversight in the form of independent audits of the new organization's finances along with reviews by the Government Accountability Office (GAO). The NWPA already requires an annual GAO audit of the activities of DOE's OCRWM, as well as a comprehensive annual report by OCRWM on its activities and expenditures and an annual report to Congress from the Secretary of the Treasury (after consultation with the Secretary of Energy) on the financial condition and operations of the NWF. These requirements could simply be extended to the new organization. A mechanism for Congress to review regular updates of the organization's Mission Plan and associated budget (discussed above) would provide an additional vehicle for overseeing the organization's planned use of funds.

Particular attention must be paid to which entity has authority over the level of the nuclear waste fee. Under current law, the Secretary of Energy is required to make adjustments to the fee, as necessary, to ensure recovery of the full costs of managing and disposing of commercial waste. The AMFM Panel recommended that a "Waste Fund Oversight Commission" be established for the specific purpose of ensuring that NWF fees are being used cost-effectively and to approve or disapprove proposed changes to the level of the fee. In its 2001 update of the AMFM study, DOE instead recommended that the Federal Energy Regulatory Commission (FERC) serve this purpose. Giving authority to review and approve fee increases to an independent organization with suitable expertise and staff would enhance confidence that such increases are just and reasonable and are not simply the result of ineffective use of the program's resources. This would be consistent with an approach that treats the waste management organization as, in effect, a public utility with a natural monopoly over a necessary service.

In such cases, it is common for the rates charged by the organization or utility to be regulated by an independent commission. Since the Federal Energy Regulatory Commission (FERC) already exists and deals with rate issues, the Subcommittee recommends that it be used for this function. As it determines how to carry out this new responsibility, we encourage FERC to consider the development of a “joint board” with state commissioners as provided for under section 209 of the Federal Power Act.

## 5.5 Stakeholder Participation

The NWPA finds that “state and public participation in the planning and development of repositories is essential in order to promote public confidence in the safety of disposal of such waste and spent fuel.” The Subcommittee agrees and recommends that legislation to establish a new waste management organization include appropriate mechanisms to facilitate and support constructive stakeholder participation. Such mechanisms should address two distinct areas of stakeholder participation: interaction with national stakeholder groups and interests and interactions with states, communities, and tribes that would be directly impacted by particular facilities or operations. Each is discussed further below. We recognize that providing for extensive stakeholder participation will require a significant commitment of staff and resources. To ensure that the needed resources are provided, enabling legislation must provide clear direction to the waste management organization that stakeholder involvement is to be regarded as one of its core responsibilities. Accordingly, the new organization’s plans and activities in this area must be covered in annual reports and long-term plans; in addition, enabling legislation should specify that related costs represent an authorized use of the NWF.

### 5.5.1 Interactions with National Stakeholders

There are many stakeholders with an interest in the overall direction and conduct of the national waste management program. These include:

- Utility companies and utility ratepayers who pay the costs of the program and have an interest in monitoring program activities and costs
- Public utility commissions charged with protecting the interests of utility ratepayers
- Taxpayers who pay the costs of managing and disposing of defense wastes, and who are ultimately liable for damages associated with the federal government’s failure to meet its contractual obligations under the NWPA
- States, tribes and local communities that host centralized storage and/or disposal facilities
- States, tribes, and local communities that will be affected by the continued storage of waste at current sites until this waste can be moved to federal facilities
- States, tribes, and local communities affected by the transportation of wastes
- Public interest groups with an interest in radioactive waste management policy and practice
- The nuclear industry
- DOE (in its capacity as the agency responsible for cleaning up former nuclear weapons production sites)

- The U.S. Navy (which generates small but strategically important quantities of spent fuel that will require disposal)
- The non-proliferation and nuclear security policy community.

While the board of directors of a waste management corporation would include representatives of key stakeholders (e.g., those who are impacted by and paying for the waste management program; see section 5.4.2 for details), its role would be to carry out fiduciary responsibilities for management oversight rather than to represent stakeholder views. Furthermore, a board of workable size could not include all stakeholder perspectives in any event. To provide an ongoing conduit for input from the full range of stakeholder perspectives identified above, a larger and more widely representative stakeholder advisory committee should be established. It should report to the waste management organization's CEO and/or board of directors (in a manner similar to DOE's Environmental Management Advisory Board).<sup>84</sup> This committee would not supplant direct interactions between the waste management organization and specific stakeholders, but it would ensure that the organization regularly hears the full range of perspectives represented by these different groups in a way that would be difficult to achieve by relying on one-on-one interactions. Ongoing dialogue with a stakeholder advisory committee can help the organization identify broadly-acceptable policies and plans, as well as areas of disagreement that remain to be resolved.

Of the activities the waste management organization will be involved in, siting high-level waste facilities is the activity that will likely draw the most intense stakeholder attention and concern.

**For this reason, the Disposal Subcommittee considered the possibility that an authority *separate* from the organization charged with developing and operating waste management facilities should undertake siting. Ultimately, however, the Subcommittee concluded that this function should remain under the auspices of the waste management organization.** Nevertheless, there are several reasons for treating siting as a unique function of the organization for which active engagement with a broad range of stakeholders and other experts will be particularly important. First, to be credible to a wide range of stakeholders, the institutions and processes involved in siting must establish a high degree of independence and objectivity. At the same time, keeping responsibility for siting within the waste management organization recognizes that this process cannot be conducted as if it were completely independent of the subsequent development and operation of waste management facilities. Siting decisions will have a major impact on storage and disposal operations, and siting decisions and criteria must meet operational and design standards. Most crucially, the same waste management organization must be accountable on an ongoing basis for living up to all commitments made during the site selection, characterization, and approval process.

Recognizing that the siting and operational phases of facility development are inextricably linked, the Disposal Subcommittee recommends that during the siting phase of the program the stakeholder advisory committee include a special subcommittee focused on the siting process. Its purpose would be to provide guidance to the waste management organization concerning the design of an overall siting approach and specific issues related to siting, and to provide a conduit and focal point to ensure that stakeholder input on these issues is given serious consideration and acted on as appropriate. Members of this subcommittee could include stakeholder representatives from the full committee supplemented by other individuals with additional expertise relevant to siting processes, such as qualified academics

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<sup>84</sup> The National Academies *One Step at a Time* report also recommended a stakeholder advisory board.

including social scientists. Whether a separate subcommittee should be established to oversee the siting of centralized storage facilities as distinct from disposal facilities is a question that should be considered by the new waste management organization.

Finally, it will be important for members of the general public to have opportunities to provide meaningful and regular input into the ongoing activities of the waste management program. Requiring that the organization regularly develop and revise a mission plan (as discussed above), including a transparent process for actively soliciting and incorporating public feedback, would provide an important mechanism for soliciting and benefitting from broad-based input. The subcommittee believes that regular public input is essential to a successful program and encourages the waste management organization to look for other opportunities to seek and incorporate meaningful input.

### **5.5.2 Interactions with Affected States, Tribes, and Local Governments**

States, tribes, and local communities that are potential or actual hosts of waste management facilities<sup>85</sup> have a special interest in being involved in the process of evaluating potential sites and developing and operating the facilities proposed for these sites. As the siting process narrows to consider specific locations, interactions with potential community, state, and tribal hosts will take on increasing importance. The NWPA makes extensive provisions for coordinated planning and consultation with affected states and Indian tribes. For example, section 116 of the NWPA requires OCRWM, after it has approved a site for characterization or upon request, to seek to enter into and negotiate consultation and cooperation (C&C) agreements with eligible states and affected tribes. The purpose of these agreements is to specify the procedures that will be followed in areas of mutual concern, such as:

- Public health and safety,
- Environmental and socio-economic impacts of a facility,
- Access to and sharing of technical data and expertise,
- Joint surveillance and monitoring of project activities,
- Public education programs,
- Procedures for resolving conflicts and off-site concerns,
- Financial assistance to the states and tribes, and
- Notification of the proposed transport of high-level waste and SNF.

These provisions in the NWPA were modeled on the 1981 C&C agreement that defined the relationship between DOE and the State of New Mexico as it pertained to the development of the WIPP facility. (While section 116 relates specifically to repositories, the Act applies these or similar provisions to all the other types of waste management facilities it addresses.)

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<sup>85</sup> Waste management facilities include disposal and interim storage facilities as well as any new transportation infrastructure required to construct, operate or decommission a geologic repository or interim storage facility.



The Subcommittee recommends that the waste management organization be given the responsibility and authority to negotiate similar agreements going forward. At the same time, we recognize that it may be more fruitful for the waste management organization to begin by engaging local communities before reaching out to state officials. Clearly all levels of government must be involved from an early point in the process. How that process unfolds and in what order different agreements are struck between different parties is not something that can or should be dictated in advance. This is also why the attributes described previously, including flexibility, responsiveness, and transparency, will be so important to the success not only of the siting process but of the waste management organization itself.

In this context, it is notable that the NWPA's current consultation and cooperation provisions apply only to relations between the federal government and state or tribal governments, and do not extend to local governments.<sup>86</sup> In its visits to observe waste management activities in Sweden and Finland, the Subcommittee saw the importance of close involvement with the local communities that are/were considering hosting waste management facilities. Significantly, when a community task force in Oak Ridge, Tennessee evaluated DOE's proposal to site a MRS facility in the area, they made their support for the facility conditional on the adoption of specific measures to enhance local authority. These included provisions for C&C agreements directly between DOE and units of local government, as well as between DOE and the state, and granting preferred status to local governments in interactions between the state, DOE, and NRC regarding the MRS.<sup>87</sup> The Subcommittee therefore recommends that the waste management organization's authority and responsibility to negotiate legally-binding agreements with host states and tribes be extended to local host governments.

## 5.6 Transfer of Contracts and Liability to a New Organization

A particularly challenging issue that will have to be addressed concerns the handling of existing liabilities under DOE's current contracts with utilities. A number of lawsuits have already been brought by utilities seeking to recover damages arising from the federal government's failure to meet its statutory obligations under the NWPA, which stipulated that DOE would begin accepting civilian spent nuclear fuel for final disposition by 1998. To date, the courts have awarded some \$2 billion in damages as a result of these suits. DOE's most recent estimate is that current liabilities could total \$20.8 billion if waste acceptance were to begin as early as 2020.<sup>88</sup> DOE further estimates that these liabilities could increase by hundreds of millions of dollars per year for each year that the acceptance of used commercial fuel slips beyond 2021.<sup>89</sup>

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<sup>86</sup> Another section of the Act that provided for a negotiated "benefits agreement" between the federal government and a state or tribe hosting a repository or MRS facility did allow for local government representation on a "review panel" that would (1) advise the Secretary on matters relating to the proposed repository or monitored retrievable storage facility, including issues relating to design, construction, operation, and decommissioning of the facility; (2) evaluate performance of the repository or monitored retrievable storage facility, as it considers appropriate; (3) recommend corrective actions to the Secretary; (4) assist in the presentation of state or affected Indian tribe and local perspectives to the Secretary; and (5) participate in the planning for and review of preoperational data on environmental, demographic, and socioeconomic conditions of the site and the local community. However, local interests accounted for only a small part of the representation on this panel.

<sup>87</sup> Clinch River MRS Task Force, "Position on the Proposed Monitored Retrievable Storage Facility," October 10, 1985.

<sup>88</sup> "Liability Estimate" memorandum to Steve Isakowitz, Chief Financial Officer, DOE, from David K. Zabransky, Director, Office of Standard Contract Management, Office of General Counsel, DOE, October 29, 2010.

<sup>89</sup> Testimony of Kim Cawley, Chief, Natural and Physical Resources Cost Estimates Unit, Congressional Budget Office, on "The Federal Government's Responsibilities and Liabilities under the Nuclear Waste Policy Act," for the Committee on the Budget, U.S. House of Representatives July 27, 2010.

Clearly resolving the treatment of the existing contractual liabilities will require careful consideration in the process of enacting legislation to establish a new waste management organization.<sup>90</sup> A core question will be how to pay for damages accrued until federal facilities are available. A federal court has since found that the NWF cannot be used for this purpose because at-reactor storage is not an allowed use of the Fund under the NWPA and DOE contracts with utilities. As a result, damages are now being paid out of the Judgment Fund, which receives a permanent indefinite appropriation from the Treasury. It will therefore be important to clarify responsibility for contracts and associated liabilities going forward.

## 5.7 Near-Term Steps

Although the Subcommittee strongly believes that new institutional leadership is critical to getting the nation's nuclear waste management program on track, we recognize that it could take several years for a new organization to be authorized, funded, staffed and fully launched. In the meantime it will be important to keep the program moving forward through non-site-specific activities, including R&D on different geological media and work to design improved engineered barriers.

For instance, DOE's Office of Used Nuclear Fuel Disposition Research & Development is implementing the Used Fuel Disposition Campaign. The objectives of the Campaign are to identify alternatives and conduct R&D for transportation, storage and disposal of SNF (in different geological media) from existing and potential future nuclear fuel cycles as well as to provide technical expertise and inform decision-making processes on the issue. We believe that these and other non-site-specific generic activities should be continued.<sup>91</sup>

## 5.8 Key Findings

- History has demonstrated that the current approach, in which waste management is the responsibility of a large cabinet-level agency with multiple competing missions (i.e., DOE), subject to annual and uncertain funding and direction provided by Congress, is not well suited to sustaining the level of performance, trust, and stability needed to implement essential elements of an integrated waste management strategy.
- Options for moving nuclear waste management responsibility out of DOE have been studied for decades. The general conclusion has been that a number of different organizational forms are viable and could work to provide the focus and effectiveness needed to successfully implement program objectives. One concept that features prominently in several past proposals is that of a federally chartered corporation. Such an organization, provided it has a well-defined mission, access to adequate resources, the ability to make binding contractual commitments, and is subject to rigorous external oversight could offer a number of important advantages compared to other alternatives or the status quo.

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<sup>90</sup> The Voinovich/Upton bill deals with this issue by providing that contracts and settlements remain the liability of DOE until 10 years after termination of the license of the reactor involved. The new federal corporation would take liability under the existing contracts no later than 10 years after license termination, as well as for all new contracts and any negotiated transfer of liability between DOE and the corporation.

<sup>91</sup> For more details see "R&D Activities for Used Nuclear Fuel Disposition Storage, Transportation & Disposal," presentation by William Boyle, Director, Office of Used Nuclear Fuel Disposition Research & Development, DOE NE, NWTRB winter meeting, February 16, 2011 at <http://www.nwtrb.gov/meetings/2011/feb/boyle.pdf>.

- More important than what form it takes is that a new waste management organization display certain behaviors and attributes (i.e., competence, transparency, flexibility, responsiveness, accountability, etc.).
- For most of the national disposal programs that the Subcommittee studied, the waste management organizations' responsibilities are limited to storage, transportation, and disposal, and are performed by a private or public corporate entity, not a government department
- Societal confidence in and acceptance of the siting process can be bolstered through the use of a special subcommittee that is specifically focused on the siting process as a part of stakeholder advisory committee. To better serve this goal and provide maximum expertise, the siting subcommittee could include individuals who are not members of the advisory committee, but who have relevant knowledge or experience.
- A new waste management organization will only be entrusted with substantial operational and financial autonomy if Congress and the American public are confident that safeguards are in place to ensure that it behaves responsibly and uses public resources wisely. Mechanisms must be in place for effective congressional oversight, management oversight (in the form of a board of directors), and regulatory oversight, as well as independent scientific, technical, and financial oversight.
- Other issues that require careful attention in developing guidance for a new, single-purpose waste management organization include the organization's approach to stakeholder participation, facility siting, and interactions with affected state, tribal, and local governments. In particular, it will be critically important to give the new waste management organization the responsibility and the authority to negotiate binding agreements with affected governments.
- Congress will need to address the transfer of existing DOE contracts and liabilities to the new organization.
- DOE should continue generic, non-site-specific RD&D efforts, including research into different geological media and engineered barriers, while the new organization is being formed.

## 6. FUNDING A NEW WASTE MANAGEMENT PROGRAM

To succeed, a new waste management organization must have the resources needed to implement an effective program. Since 1983, nuclear utilities and their ratepayers have been paying a nuclear waste fee into the NWF in the Treasury. The Fund is dedicated to covering the cost of disposing of commercial radioactive waste, but for reasons discussed below the money in the Fund is effectively unavailable for its intended purpose. The Commission believes that ***the success of a revitalized nuclear waste management program will depend on making the revenues generated by the nuclear waste fee and the balance in the NWF available when needed and in the amounts needed to implement the program.***

The Subcommittee and the full Commission spent considerable time on this issue. The remainder of this section details our specific recommendations for implementing the funding reforms that are required to support a revitalized U.S. waste program.

### 6.1 Background

The 1982 Nuclear Waste Policy Act created a “polluter pays” funding mechanism<sup>92</sup> to ensure that the full costs of disposing of commercial HLW would be paid by utilities (and their ratepayers), with no impact on taxpayers or the federal budget. Nuclear utilities are assessed a full-cost-recovery user fee on every kilowatt-hour of nuclear-generated electricity as a *quid pro quo* payment in exchange for the government’s contractual commitment to begin accepting commercial spent fuel or high-level waste for disposal beginning by January 31, 1998. The fee is collected from utilities that own or operate nuclear power plants; generally it is passed on to utility ratepayers. The fee was initially set at 1 mill (0.1 cents) per kilowatt-hour (where it still is); however, the Act requires the Secretary of Energy to review the adequacy of the fee annually and adjust it as needed to ensure that going forward the government can recover the full costs of waste management and disposal. In recent years, the fee has generated approximately \$750 million in annual revenues. The total amount collected through 2010 amounted to just over \$16 billion.

Fee revenues go to the government’s Nuclear Waste Fund, which was established for the sole purpose of covering the cost of disposing of civilian spent nuclear fuel. (Costs for disposing of defense nuclear wastes are paid by taxpayers through direct appropriations from the Treasury that do not pass through the Nuclear Waste Fund.) The unspent balance in the Fund is allowed to accumulate and accrue interest with the idea that it will be available as needed to fund program expenditures in future years. The current unspent balance in the Fund (known as the “corpus”) totals nearly \$27 billion, including interest. Federal appropriators are supposed to be able to access the Fund when and in the amounts needed to implement the waste program without facing competition from other funding priorities.

The clear intent of Congress in establishing a self-financing mechanism based on contractually-obligated user fees was to “provide an assured source of funds to carry out the programs and...eliminate...annual budgetary perturbations in an evermore constrained Federal budget,” while at the same time ensuring

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<sup>92</sup> The “polluter pays” principle for high-level waste disposal was first established by the AEC in 1970 when it established rules for the solidification and disposal of high-level wastes from reprocessing. However, the waste generators were going to pay when they actually delivered the waste for disposal, leaving the federal government to come up with the funds needed to develop a disposal system before the government could be reimbursed for this expense by the waste generators. In the NWPA, Congress departed from this approach and opted for an up-front fee to generate the revenues to build the system without having to rely on taxpayer funds, to ensure that adequate funds were available as needed.

that “the Federal budget will not be burdened by repository program expenditures” (see text box). Congressional oversight through the annual appropriations process would ensure that expenditures from the Fund would be made prudently and for their intended purposes. But the Fund was clearly designed to ensure that the waste program's needs and schedules determined its funding, rather than allowing federal budget constraints to limit the program's progress. Indeed, the Nuclear Waste Policy Act's provisions for an expanded and accelerated repository program and its direction to DOE to assume contractual obligations for accepting waste on a defined schedule demanded an assured funding source to support the activities needed to meet these legal obligations.<sup>93</sup>

### The Intent of the Nuclear Waste Fund

**Senator James McClure** (R-ID), chairman of the Senate Committee on Energy and Natural Resources and floor manager of the Senate nuclear waste policy legislation:

“By establishing a 1 mill-per-kilowatt-hour user fee on nuclear generated electricity, this bill for the first time would provide a direct financial linkage between the beneficiaries of nuclear power and the cost for interim management and ultimate disposal for nuclear wastes...This funding mechanism would provide an assured source of funds to carry out the programs and would eliminate not only annual budgetary perturbations in an evermore constrained federal budget, but the too often repeated shifts of policy direction under succeeding administrations. The nuclear waste policy, programs and required financing would be statutorily fixed and quite predictable under this approach.” *Congressional Record-Senate, December 20, 1982, pp. S15655 - S15656.*

**Congressman Morris Udall**, Chairman of the House Committee on Interior and Insular Affairs and key sponsor and manager of nuclear waste legislation in the House:

The cost of the waste disposal program will be borne by the generators of the waste. The program will be financed up-front by nuclear utilities, so that the Federal budget will not be burdened by repository program expenditures. Utility payments will be made into a Nuclear Waste Trust Fund set aside exclusively for repository development purposes... The Nuclear Waste Trust Fund will be isolated from other Federal programs, and will not be used to finance any activities other than repository development. *Congressional Record-House, September 30, 1982, p. H8163.*

**American Nuclear Energy Council, Edison Electric Institute, and Utility Nuclear Waste Management Group:**

“The central concept of the financing plan which we support is premised on complete cost recovery of all reasonable facility costs. ...While the electric utilities do not endorse the precedent of collecting a tax, we recognize that nuclear waste management is a unique Federal responsibility resulting from joint effort of the government and industry to utilize nuclear energy for the public benefit. Such a financing arrangement is not viewed as a precedent, but rather an innovative mechanism for ensuring the financial viability of a successful long-term Federal waste management program...Again, we must emphasize that the full payment for reasonable costs of storage and disposal of commercial spent fuel and radioactive wastes will be paid by the utilities and will be included as part of the cost of the nuclear fuel.” *Joint statement submitted to the House Committee on Science and Technology on October 5, 1981.*

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<sup>93</sup> U.S. Congress Office of Technology Assessment, *Managing the Nation's Commercial High-Level Radioactive Waste*, OTA-O-171, March, 1985, p. 93, pp. 106-107.

## 6.2 Constraints on the Use of the Nuclear Waste Fund

### 6.2.1 A Case of Unintended Consequences and Constraints

The Fund has not worked as intended to insulate the nation’s civilian nuclear waste management program from the vagaries of the federal budget process while at the same time insulating the federal budget from the costs of the waste program. A series of actions by successive administrations and Congresses (see text box below) has made the approximately \$750 million in annual fee revenues and the unspent \$27 billion balance in the Fund effectively inaccessible to federal budgeters and appropriators, forcing them to take money away from other federal priorities to fund activities needed to meet contractual waste management obligations. As a result, waste management needs have had to compete with other priorities in DOE’s annual budget request and in the congressional appropriations process (figure 10), subjecting the program to exactly the sort of “budgetary perturbations” that the funding mechanism was intended to avoid.

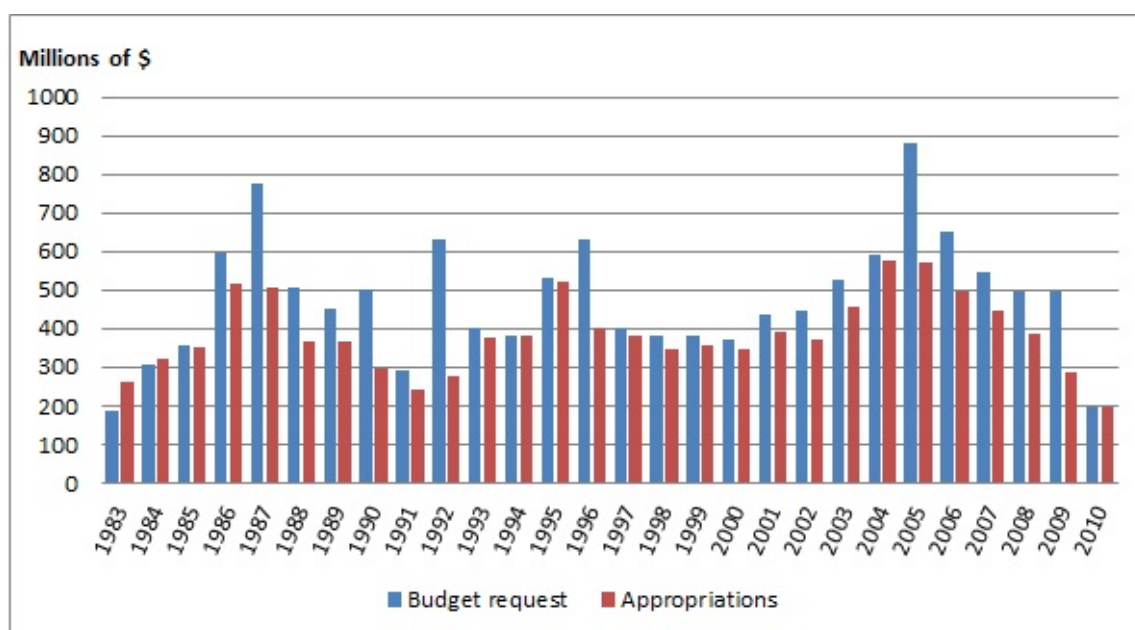


Figure 10. Nuclear Waste Program: Budget Requests versus Appropriations.<sup>94</sup>

Senator Bennett Johnston, then Chairman of the Senate Committee on Energy and Natural Resources, pointed out the problem in 1994:<sup>95</sup>

“We thought we had provided a guaranteed funding source for the waste program when we created the Nuclear Waste Fund in 1982. The Waste Fund consists of money paid by electric ratepayers for the sole purpose of funding this program...Unfortunately, the Waste Fund has become entangled in budget rules adopted in recent years to combat the deficit. The unintended consequence of these rules had been to put most of the Nuclear Waste Fund out of reach of the very program for which the money is being collected.”

<sup>94</sup> Data Source: *Summary of the Program Financial & Budget Information*, DOE Office of Civilian Radioactive Waste Management, Office of Business Management, as of January 31, 2010.

<sup>95</sup> Opening Statement of Senator J. Bennett Johnston, Chairman, at a hearing before the Senate Committee on Energy and Natural Resources, March 1, 1994.

### The Layering of New Budget Requirements on the Nuclear Waste Fund

Since the establishment of the NWF in 1982, Congress enacted several budget control acts that dramatically reduced the funding flexibility originally envisioned in the NWPA:

- The Balanced Budget and Emergency Deficit Control Act of 1985, also known as Gramm-Rudman-Hollings (GRH), made the NWF subject to the government-wide budget sequestration process. In implementing GRH, the Office of Management and Budget (OMB) “split” the NWF; fee receipts were placed on the “mandatory” side of the budget (dealing with activities controlled by permanent laws rather than by annual appropriations), where they are treated like tax revenues and used to offset mandatory spending, while expenditures were placed on the “discretionary” side (dealing with activities controlled by annual appropriation acts), where they are subject to the deficit reduction process.
- The 1987 amendments to GRH placed the appropriations from the NWF under the spending cap applicable to all domestic discretionary programs, even though the NWF was self-financed. This had the effect of forcing spending to meet the NWF’s legal obligations to compete with other annually-funded spending programs which did not have dedicated funding sources. Also, as a result, OMB dropped its historical practice of setting separate budget planning targets for the NWF, forcing it to compete against other DOE programs within a single DOE budget target for domestic discretionary spending.
- The Budget Enforcement Act of 1990 (BEA) set new caps on discretionary spending accounts. BEA also established new pay-as-you-go (PAYGO) requirements to ensure that the net effects of legislative changes affecting mandatory spending were budget neutral.
- In the Conference Report accompanying the Omnibus Budget Reconciliation Act of 1990, the spending from the NWF was included in domestic discretionary appropriation accounts for Fiscal Year (FY) 1991, and was therefore subject to the spending cap set in the BEA.
- The 1997 Amendments to the Balanced Budget Act extended the caps on discretionary spending accounts and PAYGO requirements for mandatory spending accounts through FY 2002.

This layering of budget requirements seriously eroded the NWF’s funding capability in two ways:

- It imposed annual spending and revenue controls on a Fund that was designed to finance a 125-year program on a life-cycle cost basis; and
- It made the NWF dysfunctional by creating separate and unrelated rules applicable to the revenue and spending components of the Fund.

The overall effect, in short, has been to prevent the NWF from being used for its intended purpose. Under PAYGO requirements, increased funding for the waste management program must be offset by cuts in other programs within the annual discretionary appropriations caps. The original NWF requirement for annual appropriations from the NWF was intended to ensure that Congress retained control over the actual activities of the program; its purpose was *never* to limit the funding needed to implement the program, which is what has happened.

*Source: Alternative Means of Financing and Managing the Civilian Radioactive Waste Management Program, U.S. Department of Energy, August 2001, DOE/RW-0546, pp. 12-13*

In other words, a program for commercial spent fuel that was intended to be fully self-financing now has to compete for limited discretionary funding in the annual appropriations process, while the contractual user fees specifically and originally intended to prevent this from happening are treated just like tax revenues and used to reduce the apparent deficit on the mandatory side of the federal budget (which deals with expenditures and receipts that are not subject to annual appropriations).

These problems have also materially contributed to the failure of the federal government to meet its contractual obligations and to the government's large and growing exposure to financial liabilities for resulting damages—damages that are being and will have to continue to be paid by taxpayers. We discuss this issue in detail in section 5.6, but here it is worth pointing out that the damage payments being awarded to compensate utilities for the costs of continued at-reactor storage of spent fuel that was supposed to have been accepted by the federal government do absolutely nothing to advance the objective of providing for the permanent disposal of the spent fuel. Meanwhile, the unspent balance of fee revenues and interest accumulating in the Waste Fund represents a large and growing liability for taxpayers that must be paid at some point in the future. (The Fund has a large positive balance on the books, but the actual dollars have already been spent. The assets in the Fund are not cash but instead are Treasury bills that were issued as IOUs for the fee receipts and interest on the balance in the Fund.) Because DOE's contracts with utilities create a legal obligation, the amounts of money collected since 1982 can and must eventually be used only for the purpose for which they have been collected in order to implement the waste program. At some point in the future the IOUs in the Waste Fund must be redeemed either by future tax revenues or by borrowing from other sources that in turn will eventually have to be repaid.

## 6.2.2 Disadvantages of the Appropriations Process

Even if competition with other programs for limited discretionary funding were not an issue, the current statutory requirement that makes use of the NWF subject to appropriations has led to unforeseen difficulties caused by the appropriations process itself. Although the current system assures Congress explicit and extensive year-to-year oversight and control as intended by the NWPA, it has clearly proven to be a poor mechanism for financing a very long-term and complex effort. First, the annual appropriations process creates substantial funding uncertainty, which can make it difficult for the implementing agency to make and honor longer-term commitments, retain staff expertise, and exercise independent judgment about programmatic priorities and resource allocation. Second, Congress has increasingly failed to pass appropriations bills in a timely manner in recent years, forcing federal agencies to operate on continuing resolutions for extended periods of time while coping with the delayed availability of requested funds.

A 2005 report on the management and funding of nuclear waste management programs in the 11 member nations of the International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM)<sup>96</sup> noted that all these nations have applied the principle that waste producers should pay for the management of their wastes. Where EDRAM members differed was in how they estimated, collected, and managed waste management fees. The United States stands out as the only nation where the national legislature directly controls, on an annual basis, the expenditure of funds collected for nuclear waste management purposes.<sup>97</sup>

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<sup>96</sup> Belgium, Canada, Finland, France, Germany, Japan, Spain, Sweden, Switzerland, UK, and USA.

<sup>97</sup> International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM), *Report on Radioactive Waste Ownership and Management of Long-Term Liabilities in EDRAM Member Countries*, June 2005, tables 7.4 and 7.5, [http://www.edram.info/fileadmin/edram/pdf/EDRAMWGWOwnershipFinal\\_271005.pdf](http://www.edram.info/fileadmin/edram/pdf/EDRAMWGWOwnershipFinal_271005.pdf).



### 6.3 Fixing the Funding Problem

The federal government's failure to deliver on its statutory waste management obligations to date and the fact that the Waste Fund and fee are not working as intended have prompted the National Association of Regulatory Utility Commissions, along with some nuclear utilities and the NEI, to pursue legal action against DOE aimed at suspending the collection of nuclear waste fees until such time as a new waste management plan for the country is in place. The outcome of this and other pending legal actions remains uncertain at present, but they underscore the growing frustration among state regulators, nuclear utilities, and consumer advocates about the continued lack of progress toward a durable waste management solution. In fact, there is a growing sense of outrage that the only aspect of the waste management program that has been implemented in full and on schedule is the part that involves collecting fees for a contractually required service that the federal government has never managed to deliver.

The Subcommittee concludes that for the waste management program to succeed, the nuclear waste funding mechanism must be allowed to work as intended so that the ability to implement the waste program is not subject to unrelated federal budget constraints. If that is not done, key recommendations of the Subcommittee will be undermined – e.g., efforts to develop both storage and disposal facilities will be in conflict rather than mutually supportive, and commitments to provide benefits to host communities over the life of the program will lack credibility. Fixing this problem requires extricating the nuclear waste fee and NWF from the web of budget rules that have made these user-provided resources effectively unavailable to federal budgeters and appropriators, forcing them to take limited discretionary funds away from other federal programs in order to pay for the activities needed to meet federal waste management contractual obligations and thereby put an end to growing taxpayer financial liability for failure to meet those obligations.

The Subcommittee also concludes that a new waste management organization bound by a well-defined mission should be entrusted—subject to an appropriate level of oversight by Congress and relevant regulatory authorities—with greater autonomy and control of its budget over multiple year periods than is possible under the annual appropriations process, just as the TVA has control of the use of its receipts from electricity sales (subject to congressional oversight). This kind of authority is crucial, among other reasons, to allow the new organization to negotiate meaningful, enforceable, and ultimately *credible* commitments with other parties—including with the communities, states, and tribes that will be most directly affected by its activities. Fixing the current funding problem requires removing waste program funding decisions, to the extent they concern activities related to the civilian wastes for which the nuclear waste fee is being paid, from dependence on the annual federal budgeting and appropriations process, while ensuring appropriate oversight by Congress and other third-party agencies.

The Subcommittee recommends that this transition be accomplished in two stages:

1. Near-term non-legislative actions that would allow full access to future waste fee revenues subject to appropriations control but independent of competition with other funding needs.
2. Legislative action as part of the establishment of an independent waste management organization that would allow it to function as an autonomous self-financed entity like TVA or the Bonneville Power Administration, with full control of the use of its revenues subject to Congressional and other independent oversight and with access to future fee receipts and, eventually, the current corpus of the Nuclear Waste Fund.

### 6.3.1 Near-Term Non-Legislative Action to Increase Access to Fee Revenues

The Subcommittee recognizes that legislative action to create a new waste management organization with full access to the nearly \$27 billion balance in the NWF will be difficult in the current political and budgetary climate, despite the fundamental equity arguments for this action. Therefore, we urge the Administration to take prompt action aimed at enabling appropriators to use the annual nuclear waste fee revenues for their intended purpose, free from competition with other spending priorities, while slowing further additions of surplus revenues to the NWF until such access has been guaranteed. We believe this can be accomplished by adopting a combination of measures that are already allowed under existing legislation.<sup>98</sup>

***Specifically, the Administration should (1) change the way in which the nuclear waste fee is collected so that only an amount equal to actual appropriations from the NWF is collected each year, with the remainder retained by utilities in approved trust funds to be available when needed for future use, and (2) work with the congressional budget committees and the Congressional Budget Office to reclassify the fee receipts from mandatory to discretionary so that they can directly offset appropriations for the waste program.***<sup>99</sup> Taken together, these steps would make the nuclear waste program funding mechanism work essentially as Congress intended in the NWPA, at least for future fee revenues. Each is discussed further below.

#### ***Change the Timing of Nuclear Waste Fee Collections***

Under the current approach, the entire 1 mill/kwh fee is collected from contract holders each year (as reported earlier, the total collected amounts to approximately \$750 million per year) and deposited in the Treasury, independent of the sum actually appropriated from the Fund for use by the waste management program. This annual revenue stream is counted in the federal budget baseline as an offset to mandatory spending, which raises the criticism that the fee is simply being used to reduce the budget deficit instead of for its intended purposes. This criticism becomes more acute as the gap between annual fee payments and appropriations from the Fund widens. Figure 11 shows the large and growing gap between cumulative nuclear waste fee receipts (not including interest on the NWF balance) and appropriations from the NWF. The longer annual fee payments continue to accumulate in the Fund, the greater the budgetary and political difficulty of restoring the Fund to its intended purpose will be.

To stop the flow of waste fees to an inaccessible account in the Treasury, to put an end to the perception that the fee is simply being used to reduce the federal budget deficit, and to take the first crucial step towards making future fee revenues accessible to appropriators, the Administration should adopt a modified version of an approach proposed by the Secretary of Energy in 1998 as part of a litigation settlement concept.<sup>100</sup>

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<sup>98</sup> See extended discussion in Joseph S. Hezir's paper: "Budget and Financial Management Improvements to the Nuclear Waste Fund (NWF)," Background report to the Blue Ribbon Commission on America's Nuclear Future, May 2011. [http://brc.gov/sites/default/files/documents/brc\\_hezir\\_nwfbudget\\_051511.pdf](http://brc.gov/sites/default/files/documents/brc_hezir_nwfbudget_051511.pdf).

<sup>99</sup> This specific combination of measures was identified as one of four feasible interim steps for dealing with the funding problem in DOE's 2001 update of the AMFM report. *Alternative Means of Financing and Managing the Civilian Radioactive Waste Management Program*, U.S. Department of Energy, August 2001, DOE/RW-0546.

<sup>100</sup> *Ibid*, Fig. 3.

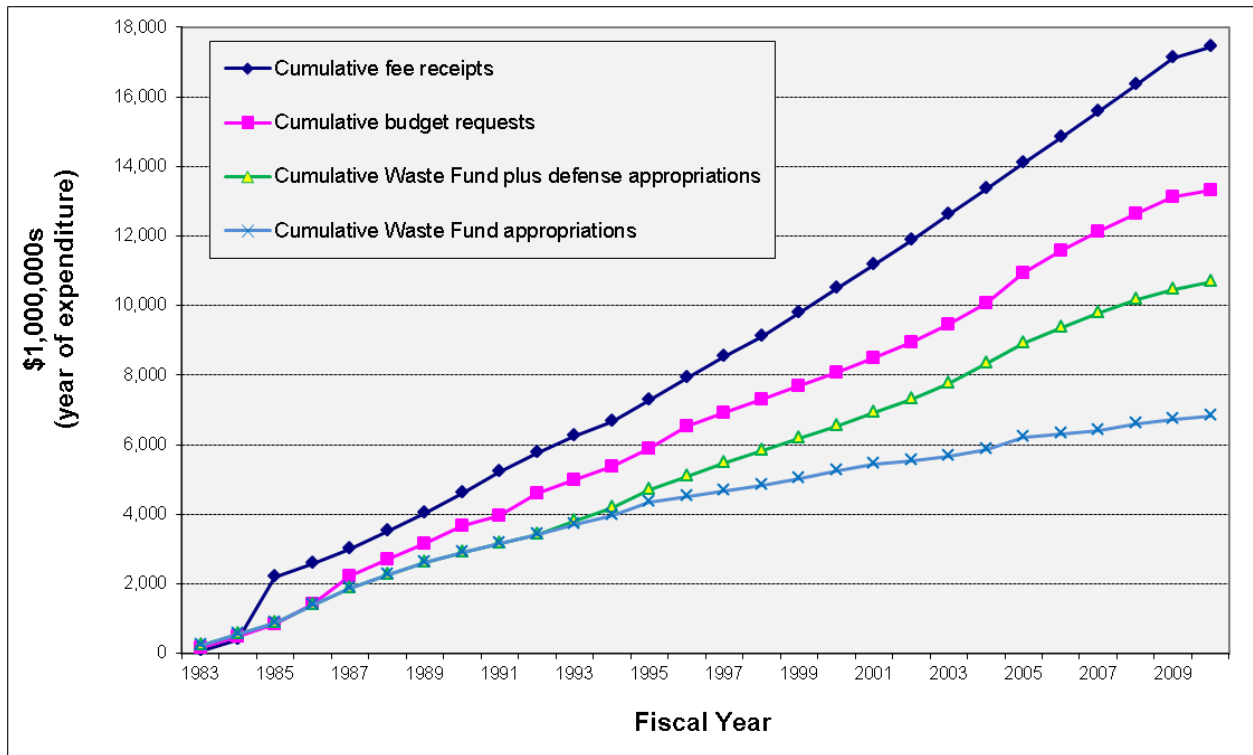


Figure 11. Cumulative Nuclear Waste Fees, Budget Requests, and Appropriations.<sup>101</sup>

The key element of that proposal was to change the timing of fee payments into the NWF through administrative action so as to match the annual flow of cash into the Fund with actual spending from the Fund in support of nuclear waste management activities. Specifically, DOE proposed to offer to amend its contracts with utilities to allow utilities to retain the portion of the 1 mill/kwh fee that exceeded the annual appropriations level. As soon as the federal government began to accept waste, utilities would pay the deferred fees plus interest at the Treasury rate.<sup>102</sup> The modified approach proposed here would require each utility to place the unused fee receipts in an irrevocable trust account at an approved, third-party financial institution, allowing the money to be withdrawn only for the purpose for which the trust account was created, at the time and in the amounts needed to fund the federal waste management program. This would make the “waste disposal trust accounts” similar to the decommissioning “sinking funds” most utilities use to meet NRC requirements that they provide assured funding for reactor decommissioning. Funds in those accounts can only be used for decommissioning. By analogy, if a similar irrevocable trust accounts were created for NWPA purposes, the licensee could only pay out the money to the waste management organization as required to meet program needs. This approach would make the utility waste trust accounts collectively serve the function that the Nuclear Waste Fund was supposed to, providing a source of funds in reserve that can be used in years in which the waste program’s funding needs exceed the total annual fee receipts.

<sup>101</sup> Data source: Office of Civilian Radioactive Waste Management Office of Business Management, Summary of Program Financial & Budget Information as of January 31, 2010.

<sup>102</sup> The proposal was not accepted by the utilities because the *quid pro quo* was their agreement not to seek damages for delay in waste acceptance.

A key feature of this proposal is that it would be accomplished using the Secretary of Energy's existing authority under the NWPA to establish procedures for the collection and payment of the fees.<sup>103</sup> Under current budget rules, any legislative action that has the effect of reducing NWF receipts to the U.S. Treasury will be subject to "pay as you go/cut-as-you-go" or "PAYGO/CUTGO" requirements.<sup>104</sup> This means that new revenues or budget cuts will be needed to cover the change in funds flowing to the Treasury resulting from new legislation. However, any changes to fee revenues resulting from non-legislative action under existing law would have no PAYGO/CUTGO impact.<sup>105</sup> At the same time, by ending the practice of counting revenues from the entire 1 mill/kwh fee in the federal government's budget baseline, this step would substantially ease the PAYGO/CUTGO burden associated with subsequent legislative action to establish an independent organization having access to the fee receipts.<sup>106</sup> Furthermore, tying annual fee collections to actual appropriations for the waste program would strengthen the rationale for reclassifying fee receipts as a discretionary offsetting collection, which is the second step required to implement our recommendations for interim funding.<sup>107</sup>

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<sup>103</sup> In proposing this approach, Secretary of Energy Peña stated that this "can be accomplished promptly within [DOE's] current authority." (See letter from Secretary of Energy Federico Peña to Alfred William Dahlberg, Chairman, President, and Chief Executive Officer, Southern Company, May 18, 1998.) Under the NWPA, the Secretary of Energy has existing authority to establish procedures for the collection and payment of the fees. In addition, the principle that fee payments can be deferred until wastes are accepted has an existing precedent in the form of the one-time fee payment imposed on utilities for spent fuel generated before the Act was passed. See Van Ness Feldman, P.C., Legal Analysis of Commission Recommendations for Near-Term Actions, October 11, 2011, [http://www.brc.gov/sites/default/files/documents/20111011\\_legal\\_authorities\\_memo\\_revised\\_final\\_clean\\_1.pdf](http://www.brc.gov/sites/default/files/documents/20111011_legal_authorities_memo_revised_final_clean_1.pdf).

<sup>104</sup> The original PAYGO requirements in the Budget Enforcement Act of 1990 have since been modified in the Statutory Pay-As-You-Go Act of 2010. The requirements apply to proposed legislation (and not administrative actions) and require that OMB maintain a "PAYGO Scorecard" of the average annual cost over a 5-year period and the annual average cost over a 10-year period of newly enacted legislation. If, at the end of the Congressional session, there is a net increase in budget costs, an across-the-board sequestration of an equal offsetting amount is triggered. Legislation that increases direct spending also is subject to points of order under the Congressional Budget Act and the rules of the House and Senate. For example, the 112th Congress adopted a Cut-As-You-Go (CUTGO) rule (part of H. Res. 5) that establishes a point of order against any legislation that increases net mandatory spending for the period of the current fiscal year, the budget year, the 4 fiscal years following the budget year or the 9 fiscal years following the budget year. There also is a point of order against any legislation that increases mandatory budget costs in excess of \$5 billion in any of the first four consecutive 10-year fiscal-year periods following the period covered by an applicable budget resolution. **It should be emphasized that PAYGO and CUTGO rules apply to legislative and not administrative actions.**

<sup>105</sup> Hezir, op. cit. If this change were a DOE-initiated proposal, rather than implementation by DOE of policy direction from the Administration, it might be subject to review under the administrative PAYGO requirements for agency proposals affecting mandatory spending established by the Bush Administration in 2005 through OMB Memorandum M-05-13 and supported by the Obama Administration in the FY 2011 budget. (The extent of its use in practice is unclear – a report by the Congressional Research Service, "OMB Controls on Agency Mandatory Spending Programs: 'Administrative PAYGO' and Related Issues for Congress," documented only a single instance where administrative PAYGO was applied.) However, the proposed renegotiation of contracts might not fall within the scope of the administrative PAYGO guidelines in any event, and even if it did, it should be subject to the provision for exceptions "...in light of extraordinary need or other compelling circumstances." In this case, the need for assured funding for the SNF management program to mitigate the magnitude of further federal budget liability to the Judgment Fund, plus the fact that reduced receipts in the near term would be offset by higher-than-projected receipts in the long term when the escrow accounts are drawn down to meet the costs of constructing and operating waste management facilities, would provide a compelling argument for the action the Subcommittee recommends.

<sup>106</sup> Hezir, op. cit.

<sup>107</sup> Ibid.

To implement this step, the Administration should direct the DOE to offer contract holders a new fee payment option in which payments to the Waste Fund each year would be based on each contract holder's pro-rated share of the actual appropriations from the Waste Fund, with the remainder of the one mill fee being placed in a third-party escrow account by the contract holder until needed.<sup>108</sup>

### ***Reclassify Waste Fee Revenues from Mandatory to Discretionary***

The above-described step of splitting fee collections does not, by itself, address the problem that appropriations from the Fund are subject to caps on discretionary spending, because the fee receipts have been placed on the other side of the mandatory/discretionary spending firewall where they are not directly available to appropriators. After implementing the fee splitting recommendation, a second step is needed to move the receipts to the discretionary side so they can be used by appropriators to fund the waste program without reducing funds available for other discretionary programs.<sup>109</sup> ***To implement this approach, the Administration should direct OMB to work with the appropriate authorities to re-classify waste fee receipts from mandatory to discretionary offsetting collections so that they can directly offset appropriations for the waste program.*** Combined with the previous step that would tie annual fee receipts to actual appropriations levels, this would enable a funding process similar to that used to fund the NRC (i.e., where funding is provided primarily by user fees that are set at the level of annual budgetary authority established in appropriations bills).

DOE's 2001 analysis of alternative means of financing and managing the waste program, which was prepared at the request of Congress, specifically considered this option and concluded it would be feasible. Current practice would require OMB to seek the concurrence of the Congressional Budget Office and the congressional budget committees for this reclassification. In addition, appropriations language would be required to credit the fee to waste management appropriations once the two recommended steps have been taken.<sup>110</sup>

### ***Importance of the proposed near-term steps***

The two-step approach we propose would accomplish several things:

- It would reduce PAYGO/CUTGO challenges for future legislative action to create a new organization with access to the nuclear waste fee and Fund by lowering the baseline projection of fee receipts for federal budget purposes and by stopping the continued build-up of the corpus of the Fund.
- By eliminating surplus collections, it would address the concern of utilities and public utility commissions about the misuse of the fee and Fund to reduce the annual deficit instead of for the purposes of the NWPA. Instead, the surplus fee revenue would go into approved third-party trust accounts that would be available when needed to meet the operational costs of disposal, when program expenditures can be expected to exceed fee receipts.

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<sup>108</sup> Legal analysis performed for the BRC concluded that it may be possible to amend the Standard Contract in this way without a rulemaking proceeding to amend the rule that established the contract in the first place (10 C.F.R. § 961). Van Ness Feldman, op. cit.

<sup>109</sup> The original classification of the fee receipts as mandatory and program expenditures as discretionary was a judgment made by OMB based on general budget principles rather than on clear legislative requirements. See Hezir, op. cit.

<sup>110</sup> 2001 AMFM Update: U.S. Department of Energy, *Alternative Means of Financing and Managing the Civilian Radioactive Waste Management Program* (DOE/RW-0546), August 2001.

- It would facilitate adequate appropriations for the program in the near term by giving appropriations from the Fund (up to the amount of revenue generated annually by the 1 mill/kwh fee plus any additional amount obtained from balances in the utility trust accounts) a net budgetary impact of zero, since the appropriation would be directly offset by the collection of an equal amount in fee revenues. As noted above, a similar approach is already being used to fund the NRC.
- Finally, it would demonstrate the federal government’s determination to make the funding mechanism established in the NWPA work as originally intended.

At the same time, there are several things this two-step action would *not* do:

- It would not reduce Congress’s oversight role in the budget process for the waste program. Under current practice, OMB would seek the concurrence of the Congressional Budget Office and congressional budget committees for reclassifying fee receipts, appropriations language would be needed to credit fee receipts against appropriations, and congressional appropriations committees would continue to control the annual level of program funding through the appropriations process. Legislation will be required to remove this funding from the annual budget process while retaining an appropriate degree of external oversight of program spending, as recommended earlier.
- It would not increase access to the corpus of the NWF. This must be accomplished in subsequent legislation since DOE’s existing contracts with utilities create a legal obligation for the federal government to ultimately expend these funds for the waste management purposes for which they were collected.
- It would not adversely impact the discretionary funding of any single program or agency since the changes would occur on the mandatory side of the budget, although it would—by removing projected fee revenues from the budget baseline—lead to a very small percentage increase in the federal government’s nominal annual budget deficit.

We understand that nearly 30 years of interpretation and application of general budget concepts and practices have led to the current treatment of the waste fee receipts and program expenditures. But the application of general concepts and practices to unique situations can sometimes have unintended and perverse results – as they have in this case. We cannot believe that anyone intended the current situation: the government is in default on a contractual obligation to dispose of spent fuel from nuclear utilities; the user fees being paid to the government to finance the activities needed to meet that obligation are used to offset the deficit, while expenditures for those activities are constrained under limits on discretionary appropriations; and all the while, taxpayer liabilities resulting from failure to meet the government’s contractual obligations continue to grow. The Financial Report of the United States Government for FY 2011 reports that these liabilities totaled \$49.1 billion – including both the unpaid damages for non-performance and unspent Nuclear Waste Fund fees and interest.<sup>111</sup>

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<sup>111</sup> See <http://www.fms.treas.gov/fr/11frusg.pdf>, pp. 106 and 114. The Financial Report shows \$19.1 billion of unpaid damages and \$30 billion of unspent fees and interest that are categorized as “unearned revenue” (money received in advance of providing goods or services).

We believe that this situation must be changed, in order to put an end to the continuing damage to taxpayers, nuclear utilities and their ratepayers, and the credibility of the federal government's commitment to meet its statutory and contractual obligations. To do so, we believe that budget policy leaders in the Administration and Congress can and should act in the same bipartisan spirit of cooperation that characterized passage of the NWPA to make whatever reinterpretations of, or even exceptions to, the decades of budget interpretations and practices that will be needed to make the waste management funding mechanism work as originally intended.

We recognize that there may be concerns that the actions to give full access to the nuclear waste fee and Fund the Commission recommends might set precedents that would have broader implications for other federal programs. However, we believe that the current circumstances – involving a highly unusual contractual arrangement mandated by the NWPA and the existence of growing taxpayer liabilities for failure to comply with the terms of that arrangement - are so narrowly drawn that any precedents that are set would have at most very limited implications elsewhere.<sup>112</sup>

In summary, we believe that these two near-term actions are vital to enabling key subsequent actions the Commission recommends. For this reason, we urge the Administration to make the policy decision to take these actions and direct that they be implemented as soon as possible by DOE (by offering to amend the contractual fee collection process) and OMB (by working with congressional entities to reclassify the fee receipts), and reflected in its FY 2013 budget proposal.

### **6.3.2 Legislative Action to Provide Budgetary Autonomy (Subject to Oversight)**

The above-described steps would enable appropriators to fund a restart of the waste program from future fee receipts without taking funds from other programs. However, growing delays and uncertainties in the overall federal appropriations process will continue to make long-term planning and commitments difficult; and eventually access to the current unspent balance in the Nuclear Waste Fund will be needed. Legislation to establish a new waste management organization should give the organization the same authority to use its revenues to carry out its civilian nuclear waste obligations independent of annual appropriations (but with congressional oversight) as is now given to the Tennessee Valley Authority and Bonneville Power Administration.

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<sup>112</sup> The Bush Administration addressed precisely this issue in a statement by DOE to Congress explaining the Administration's proposed legislation to reclassify the revenues from the nuclear utility fees as offsetting collections "so they can be used in the way that was intended when the Nuclear Waste Policy Act was passed: to develop a repository for disposal of high-level radioactive waste and SNF." The specific stated objective was the same as that of our non-legislative proposal: "to ensure that Congress can focus its appropriations decisions on ensuring that the funds are used effectively and efficiently to meet the objectives of the Act, without having to worry about the impact on the funding of other programs within the Energy and Water Development appropriation." In that testimony, DOE noted: "[T]he principle supported by the proposal is specific to the highly unusual contractual arrangement required by the Nuclear Waste Policy Act, and is unlikely to be relevant to many other federal activities. Simply stated, whenever the Federal government, (1) pursuant to an explicit statutory requirement, (2) makes a legally binding contractual commitment specified by that statutory requirement (3) to perform a well-defined service (4) in exchange for payments that (5) cover the costs of that service, it should treat those payments in a way that ensures that they are used for the statutorily-specified contracted purpose. It is hard to see how anyone could disagree with that principle. Likewise, it is hard to see how such distinctive-if not unique-statutory obligations could threaten the ability of Congress to weigh competing demands for appropriations in other, unrelated areas." Testimony by Robert G. Card, Under Secretary of Energy, before the hearing on "A Review of the Department of Energy's Yucca Mountain Project, and Proposed Legislation to Alter the Nuclear Waste Trust Fund (H.R. 3429 and H.R. 3981)," held by the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce, March 25, 2004.

As noted earlier, legislation that has the effect of reducing nuclear waste fee receipts to the U.S. Treasury or increasing projected spending from the NWF will be subject to PAYGO/CUTGO requirements, depending on when the changes will occur. The Subcommittee recognizes that there have been numerous unsuccessful legislative proposals to increase access to the fee revenues and the NWF while addressing such requirements.<sup>113</sup> Nonetheless, access to the corpus of the NWF will ultimately be needed to meet the fluctuating revenue demands of the waste management program going forward. This will include covering years when costs peak—for example during the construction of waste management facilities. That the balance in the NWF (including accrued interest) would be fully accessible when and as needed was a fundamental premise underlying the commitments made in the NWPA—that premise must be restored. Anticipating that the near-term non-legislative actions proposed above may be able to provide adequate funding for a restarted waste program for the next decade or perhaps longer, the Subcommittee recommends that legislation establishing a new waste management organization include a defined schedule of payments to transfer the balance of the Fund to the organization over a reasonable future time period, starting 10 years after the organization is established.<sup>114</sup>

As we have already noted, our recommendations for separating the NWF from the congressional budget process are in no way intended to imply a diminished need for rigorous program oversight. On the contrary, we believe these budget and funding reforms—to be acceptable to Congress and the public—must be coupled with strong provisions to ensure that the waste program is being implemented effectively and is making appropriate use of the NWF and its fees with which it has been entrusted.

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<sup>113</sup> For a summary of proposals to change the Nuclear Waste Fund (NWF) funding structure from 1994 through 1999, see Figure 3 in *Alternative Means of Financing and Managing the Civilian Radioactive Waste Management Program*, U.S. Department of Energy, August 2001, DOE/RW-0546. More recently, Senator Hagel introduced a bill in 2007 with provisions specifying that “funds from the Nuclear Waste Fund will not be subject to allocations for discretionary spending under Section 302(a) of the Congressional Budget Act or suballocations of appropriations committees under Section 302(b).” To address the issue of budget neutrality, the Hagel bill would have further required that adjustments be made “In the allocation of new budget authority to appropriate committees in amounts equal to the fees reclassified as discretionary as a result of the above provision.” Legislation introduced by Senator Domenici in 2008 under the title “Strengthening Management of Advanced Recycling Technologies Act” (or SMART Act) would have established a revolving fund using \$1 billion of the current NWF, as well as the annual interest on the Fund. The remaining 95% of the current waste Fund, as well as all future fees, would be placed in a legacy fund for the purposes of constructing a geologic repository. Expenditures from the revolving fund for the provisions of the Act could be made without further appropriations but would be subject to limitations in appropriations acts. In this way, the revolving fund could be put to use without being subject to the uncertainty of the annual appropriations process while still retaining the authority of Congress to oversee the NWF. The recent Voinovich/Upton legislation would establish two funds—an operating fund and a reserve fund—for the new waste management organization. The unexpended balance of already appropriated funds, plus accounts receivable and future revenues from NWF fees and appropriations would go to the operating fund. The corpus of the NWF would be transferred as an unfunded asset to the reserve fund (accruing interest from the NWF would go to the operating fund).

<sup>114</sup> This would need to take account of the current Cut-As-You-Go (CUTGO) rules that establish a point of order against (1) any legislation that increases net mandatory spending for the period of the current fiscal year, the budget year, the 4 fiscal years following the budget year or the 9 fiscal years following the budget year, and (2) any legislation that increases mandatory budget costs in excess of \$5 billion in any of the first four consecutive 10-year fiscal-year periods following the period covered by an applicable budget resolution.



Finally, as noted above, the Subcommittee is aware that efforts to fix the use of the NWF could be caught up in broader questions such as the treatment of trust funds in the federal budget more generally. However, DOE has testified to Congress that proposals to correct the treatment of the waste fee and Fund are unlikely to create wider precedents beyond similar contractual fee-for-service situations (if any exist).<sup>115</sup>

## 6.4 Paying for the Defense Waste Share

The preceding discussion has addressed only the portion of waste program costs that are attributable to the management of commercial waste and that are paid for through the nuclear waste fee and NWF. Since current policy presumes that national defense wastes will be disposed of in a repository developed pursuant to the NWPA, a portion of the costs of the program are paid directly by appropriations from the national defense side of the federal budget.<sup>116</sup> Using a methodology for allocating costs between government-managed nuclear materials and commercial wastes that was first published in 1987,<sup>117</sup> DOE's 2007 Fee Adequacy Assessment estimated the defense share of total program costs at 19.6% for 2007.<sup>118</sup> (The defense share adjusts each year as assumptions change.)

Steady progress on implementing a disposal solution will require that appropriations for the defense share are made as needed to pay the full cost of defense waste disposal. (Note that, in the absence of a disposal facility, the GAO has established that continued storage of defense wastes at DOE sites will cost well over a billion dollars through 2040.)<sup>119</sup> Historically, appropriations from the defense side of the waste management budget have not been nearly as constrained as those from the civilian side. Since the inception of the program through the end of FY 2010, defense appropriations (in nominal dollars) amounted to \$3,756 million compared to \$6,837 million from the NWF, just over 35% of the total, although the defense share of total program cost over the life of the repository was estimated in 2007 at 19.6%. In the last 10 fiscal years, defense appropriations have represented over 61% of total appropriations for the waste program.<sup>120</sup>

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<sup>115</sup> "The principle undergirding this proposal is specific to the highly unusual contractual arrangement required by the NWPA, and is unlikely to be relevant to many other federal activities. Simply stated, whenever the federal government, pursuant to an explicit statutory requirement, makes a legally binding contractual commitment specified by that statutory requirement to perform a well-defined service in exchange for payments that cover the costs of that service, it should treat those payments in a way that ensures that they are used for the statutorily-specified contracted purpose. It is hard to see how anyone could disagree with that principle. Likewise, it is hard to see how such distinctive—if not unique—statutory obligations could threaten the ability of Congress to weigh competing demands for appropriations in other, unrelated areas." Testimony by Robert H. Card, Under Secretary of Energy, before the hearing on "A Review of the Department of Energy's Yucca Mountain Project, and Proposed Legislation to Alter the Nuclear Waste Trust Fund (H.R. 3429 and H.R. 3981)," held by the Subcommittee on Energy and Air Quality of the House Committee on Energy and Commerce, March 25, 2004.

<sup>116</sup> Section 302(b)(4) stipulates that "No high-level radioactive waste or SNF generated or owned by any department of the United States .... may be disposed of by the Secretary in any repository constructed under this Act ... unless such department transfers to the Secretary, for deposit in the NWF, amounts equivalent to the fees that would be paid to the Secretary under the contracts referred to in this section if such waste or spent fuel were generated by any other person." In practice, funds for the defense wastes have been appropriated directly to the program for use each year, with no surplus to be deposited in the Fund.

<sup>117</sup> 52 FR 31508.

<sup>118</sup> U.S. Department of Energy, "Year 2007 Civilian Radioactive Waste Management Fee Adequacy Assessment Report", DOE/RW-0593, July 2008

<sup>119</sup> "NUCLEAR WASTE: Disposal Challenges and Lessons Learned from Yucca Mountain," Statement of Mark Gaffigan, Managing Director Natural Resources and Environment, before the Subcommittee on Environment and the Economy, Committee on Energy and Commerce, House of Representatives, June 1, 2011

<sup>120</sup> Information provided by DOE to the BRC. Blue Ribbon Request 1-6-2010 final.docx.

Given this history, it would not appear that measures are needed to ensure adequate appropriations for the defense share of repository costs in the future.<sup>121</sup> However, once it becomes necessary to fund the construction of a repository (whether that repository is for commingled civilian and defense wastes or for defense wastes only), consideration might be given to mechanisms like multi-year appropriations, which are sometimes used with large defense procurements—such as for the construction of an aircraft carrier—to ensure that expensive and complex projects can be completed in a timely and cost-effective manner.

## 6.5 Key Findings

- The existing nuclear waste fee and NWF have not functioned as intended to provide the waste program with adequate and stable funding. A series of actions by successive administrations and Congresses has had the effect of decoupling the collection of revenues through the nuclear waste fee from the appropriation of funds to carry out the purposes for which the Fund was created. These problems have materially contributed to the failure of the federal government to meet its contractual obligations and the resulting large and growing financial liabilities for damages that will fall to the nation's taxpayers.
- The fact that waste management needs have to compete with other priorities in DOE's annual budget request and in the congressional appropriations process has created budget uncertainty and instability that have undermined DOE's ability to meet waste management program objectives.
- There have been numerous legislative proposals to increase access to the fee revenues and the NWF. However, efforts to address this issue are complicated by larger budget considerations.
- Pending a more comprehensive legislative solution, there are nearer-term administrative options for changing the timing of fee collections in ways that re-establish the intended linkage between these revenues and the purposes for which they are intended—at least for those fees that will be collected going forward. The Administration should direct DOE and OMB to implement these steps as soon as possible, and reflect them in its FY 2013 budget proposal.
- Workable means must be devised to ensure that the new waste management organization can access the corpus of the NWF as needed to meet future funding needs, taking into account the fact that these needs can be expected to fluctuate over time and to "peak" at higher-than-average levels during certain years, especially as the actual construction of waste management facilities commences.
- The costs of disposing of defense wastes are paid directly by appropriations from the national defense side of the federal budget. For the last 10 years, defense appropriations (as a share of total waste program appropriations) have if anything exceeded the defense share of program costs (according to DOE estimates of the relative magnitude of defense waste disposal costs to civilian waste disposal costs).

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<sup>121</sup> Just as the fees paid by utilities to date are credited in determining whether they are fully "paid up" for purposes of being able to begin delivering waste for disposal, so should the defense waste appropriations to date be credited in determining when the defense share has been fully paid.

## 7. A NEW APPROACH TO SITING AND DEVELOPING FACILITIES FOR NUCLEAR WASTE MANAGEMENT AND DISPOSAL

In this section, we turn from the need for new institutional leadership and adequate funding for the U.S. waste program to another central element of our recommendations: **the need for a new approach to siting and developing waste storage and disposal facilities.**<sup>122</sup> These same processes should also be applied after the siting and development of a new facility, if there is a need to alter or expand the facility's mission.

U.S. and international experience suggests that a more flexible, consent-based approach is essential to achieve more timely, cost-effective, socially accepted, and ultimately successful facility siting outcomes than have been typical of the U.S. waste management program to date. The Subcommittee has sought to learn from these experiences through public hearings, visits to other nations, reviews of the scientific literature, public meetings, and Commission-sponsored papers.<sup>123</sup>

The remainder of this section provides context and rationale for designing an improved process to site permanent disposal facilities. We believe that most, if not all, of these lessons learned would also apply to the siting of other facilities

### 7.1 Lessons Learned from Repository Programs to Date

Section 3 of this report describes the checkered history of U.S. nuclear waste management policy in general and of the Yucca Mountain repository program established under the 1987 NWPAA in particular. As is evident from even a cursory overview, the record is one of frequent regulatory and legal deadlock; extreme political controversy; steadily escalating project costs; and delays measured in decades. Even the WIPP facility, which is now operating with broad local and state support and is generally viewed as one of the DOE program's successes, took much longer to complete than originally planned and was eventually opened only after many years of regulatory and legislative activity. In the case of Yucca Mountain, of course, the process was even more dysfunctional. The problems that plagued Yucca Mountain from the outset are not hard to identify:

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<sup>122</sup> As was noted in several comments to the draft of this report and to the BRC draft, the process that we recommend is similar in some respects to the siting process that was prescribed in the NWPA of 1982. However, our recommendations reflect additional lessons learned from both positive and negative experiences with repository siting in the U.S. and abroad.

<sup>123</sup> Commissioned papers can be found at [www.brc.gov](http://www.brc.gov). For example, see: *Nuclear Waste Facility Siting and Local Opposition - Report commissioned by the Blue Ribbon Commission on America's Nuclear Future and prepare*, by Michael O'Hare, University of California, Research assistance by Isabella Alloisio & Kelly Gorton January, 2011 – 02/23/2011 <http://www.brc.gov/index.php?q=document/nuclear-waste-facility-siting-and-local-opposition-report-commissioned-blue-ribbon-commission>.

Thomas Webber, Seth P. Tuller and Eugene A. Rosa, *Options for Developing Public and Stakeholder Engagement Public Beliefs, Concerns and Preferences Regarding the Management of Used Nuclear Fuel and High Level Radioactive Waste* – Hank C. Jenkins, Smith Center for Risk and Crisis Management, Center for Applied Social Research, University of Oklahoma February 2011 - 02/12/2011 [http://www.brc.gov/sites/default/files/documents/hank\\_jenkins-smith\\_brc\\_paper\\_final.pdf](http://www.brc.gov/sites/default/files/documents/hank_jenkins-smith_brc_paper_final.pdf).  
*Public Beliefs, Concerns and Preferences Regarding the Management of Used Nuclear Fuel and High Level Radioactive Waste* – Hank C. Jenkins, Smith Center for Risk and Crisis Management, Center for Applied Social Research, University of Oklahoma February 2011 - 02/12/2011 [http://www.brc.gov/sites/default/files/documents/hank\\_jenkins-smith\\_brc\\_paper\\_final.pdf](http://www.brc.gov/sites/default/files/documents/hank_jenkins-smith_brc_paper_final.pdf)  
*Social Distrust: Implications and Recommendation for Spent Nuclear Fuel and High Level Radioactive Waste Management - Prepared for the Blue Ribbon Commission on America's Nuclear Future*, by Seth P. Tuller, Ph.D., Social and Environmental Research Institute, Greenfield, MA and Roger E. Kasperson, Ph.D., George Perkins Marsh Institute, Clark University, Worcester, MA - 02/23/2011 [http://www.brc.gov/sites/default/files/documents/brc.social\\_trust.17feb11.pdf](http://www.brc.gov/sites/default/files/documents/brc.social_trust.17feb11.pdf).

- Short-circuiting of the initial site selection process that had the effect of tainting all subsequent state-federal interactions over the project;
- Lack of appropriated funds to complete project milestones on time;
- Overly prescriptive requirements and rigid deadlines that made it difficult to respond to stakeholder concerns; and
- Inconsistent program leadership and execution.

All of these flaws only served to exacerbate what was arguably the most important and most enduring problem of all—the fact that the project was strongly opposed, from the time Yucca Mountain was named in 1987 as the only site to be studied for a permanent, high-level waste repository, by the majority of Nevada residents and by the state’s political leaders.

In contrast to Yucca Mountain, experience with the WIPP facility in New Mexico suggests that having a community that demonstrates sustained support for a facility, and a state government that is willing to allow the decision-making process to proceed, can make all the difference. Starting in the early 1970s and continuing to the present, elected officials and other community leaders in and around the WIPP site made it clear that they approved of the development and use of the facility to dispose of TRU wastes. This unwavering local support helped to sustain the project during periods when federal and state agencies had to work through disagreements over issues such as the nature of the wastes to be disposed, the role of different entities in providing oversight, and the standards that the facility would be required to meet. That said, the path to successfully licensing and opening WIPP was anything but straightforward and quick. On the contrary, it involved years of legal, regulatory, and political activity and complex, negotiations between the State of New Mexico and the federal government. No one could have designed the process that was ultimately followed ahead of time nor could that process ever be replicated. What the WIPP process affirmatively demonstrates, however, is that with adequate patience, flexibility, and political and public support, success is possible.

Experiences with repository programs in Finland, Sweden, France, and Canada likewise underscore the importance of a transparent, consent-based approach that is built on a solid understanding of societal values.<sup>124</sup> Of these four countries, Sweden and Finland are considerably further along in selecting and developing a repository site; however, Canada provides perhaps the closer analogue to the United States in terms of political structure and culture.

Although the issue of how to dispose of nuclear waste in France was a major national issue by 1960, it was not until the early 1990s that the public and parliamentarians were given a role in the decision-making process. In 1991, the French Agency for Radioactive Waste Management, ANDRA, was instituted to manage high-level and intermediate level long-lived radioactive waste generated by the French

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<sup>124</sup> Another country that has grappled with the siting issue is Germany, which in the late 1990s commissioned an expert committee (not unlike the BRC) to look at the problem of nuclear waste. The German committee developed a relatively straightforward plan in which the siting organization was to do an initial screening of the entire country for geologically suitable sites, based on a short set of criteria. From the subset of potentially suitable sites, weighted criteria were to be used to reduce the number of potential locations to five. At that point, the five affected municipalities were to be asked whether they wished to go forward with a more detailed evaluation. The hope was that at least two sites would survive this next cut, and assuming approval could be obtained from the local communities, the plan was to build two underground facilities for further technical analysis in preparation for a final decision. However, because of a change of government, the German plan was never implemented.

nuclear fleet (prior to this time the process was largely controlled by the industry and the national government). Lines of authority and decision-making responsibility were further clarified with the passage of the 2006 Planning Act, which established the decision in principle to develop a geological repository, to be located at a site and in a geological formation that had already been studied through an underground laboratory. To date, there has been community support for the siting process: local governments in the Meuse/Haute-Marne region volunteered to host an underground site-characterization program and can expect to benefit from a series of measures designed to support local development, including a dedicated tax on basic nuclear installations, along with additional projects. More recently, ANDRA signed a contract with a joint venture of two engineering companies to conduct industrial design work for a deep geological repository for France's high- and intermediate-level radioactive waste. The first conceptual study phase is to be conducted in 2012 and will lead on to a public consultation that will take place in 2013.<sup>125</sup>

The UK government reinitiated its waste management program relatively recently – in 2001. Engagement and consultation with the public as well as commitment to an open and transparent approach since the very beginning of the process played a significant role<sup>126</sup> and to date three communities in northwestern England (Cumbria CC, Copeland BC and Allerdale BC) have expressed their interest in being involved in the site selection process. It also worth mentioning that Spain recently succeeded in selecting a site for a storage facility using a consent-based process.<sup>127</sup> The Spanish experience is discussed more fully in the revised report of the Transportation and Storage subcommittee.

In Finland, plans to develop a geologic disposal facility for SNF at the island of Olkiluoto have the support of the host community, Eurajoki, which could have vetoed its selection as a repository site<sup>128</sup> and initially opposed the repository. Finland's efforts to site a deep geologic repository and undertake associated environmental impact assessments began in 1983, when the government issued a major policy decision on the management of SNF and on the schedule and process to be used for selecting a final repository site.<sup>129</sup>

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<sup>125</sup> See "Next phase for French geological disposal," January 5, 2012, at [http://www.world-nuclear-news.org/WR-Next\\_phase\\_for\\_French\\_geological\\_disposal-0501127.html](http://www.world-nuclear-news.org/WR-Next_phase_for_French_geological_disposal-0501127.html).

<sup>126</sup> Independent Committee on Radioactive Waste Management (CoRWM) was created to provide recommendations for long-term solutions to manage higher activity radioactive waste. In consultation with technical experts and public members, the Committee recommended geological disposal, coupled with safe and secure interim storage along with a program of ongoing research and development as the way forward. CoRWM also recommended that the siting process will be voluntary with benefit packages available to those communities that expressed an interest in being involved. CoRWM will remain the source of independent scrutiny and advise on the program implementation.

<sup>127</sup> This siting process was described to the Blue Ribbon Commission at the September 20, 2010 meeting. See [http://www.brc.gov/sites/default/files/meetings/presentations/alvaro\\_rodriguez\\_usa\\_21-09-10.pdf](http://www.brc.gov/sites/default/files/meetings/presentations/alvaro_rodriguez_usa_21-09-10.pdf) and [http://www.brc.gov/sites/default/files/meetings/attachments/alvaro\\_atc\\_articulo\\_para\\_la\\_ens.pdf](http://www.brc.gov/sites/default/files/meetings/attachments/alvaro_atc_articulo_para_la_ens.pdf). A complete description of all aspects of the entire process (in Spanish) is found at <http://www.enresa.es/files/multimedios/estratos93.pdf>, issued soon after final selection and designation of the site.

<sup>128</sup> Under Finland's Nuclear Energy Act of 1987, the consent of the host municipality is required for any major nuclear installation (including reactors as well as repositories). Thus, local acceptance was a necessary prerequisite for any decision in principle to approve the Olkiluoto repository. Interestingly, when a proposal for the Olkiluoto repository first came up for a vote by the local town council, it was vetoed. <http://www.finlex.fi/fi/laki/kaannokset/1987/en19870990.pdf>.

<sup>129</sup> Like the U.S. program, the Finnish program included a siting schedule. However, that schedule allowed considerably more time than in the U.S. case: The schedule set by Finnish government in 1983 called for repository construction to begin in 2010, and targeted 2020 as the date when used/spent fuel would begin to be accepted for final disposal. See <http://www.worldenergy.org/documents/p000915.pdf>.

The same Act provided veto power to the local council.

The siting process unfolded in three phases. First, a country-wide screening study was undertaken between 1983 and 1985. This was followed, from 1986 to 1992, by preliminary site investigations. In the third phase, from 1993 through 2000, detailed site investigations and environmental impact assessments were conducted for four sites. All four sites were found to be technically suitable for the final disposal of SNF, but local support for a repository was strongest in the communities of Eurajoki and Loviisa where nuclear infrastructure already existed. Of these two sites, a larger area for surface support facilities was available at Olkiluoto. In addition, because of the two existing reactors at Olkiluoto, a large portion of the country's SNF was already on the island.

Between 1998 and 2000, Eurajoki, TVO (a utility company that operates NPPs) and Posiva Oy (the company responsible for managing spent fuel in Finland) negotiated a compensation package for final disposal. In 1999, Posiva Oy applied to the Finnish government for a decision-in-principle to go forward with a repository at Olkiluoto. At that point, the government requested statements on Posiva Oy's application from the municipality of Eurajoki and from the relevant regulatory authority. Eurajoki's municipal council voted in favor (by 20 votes to 7) and the Finnish government followed with a positive decision-in-principle in December 2000. After further discussion, Finland's Parliament overwhelmingly ratified the government's decision (by a vote of 159 to 3) in May 2001. Detailed site characterization studies at Olkiluoto began in 2004 with the construction of an underground research tunnel. A license application for the facility is now planned for 2012 with an anticipated start date for repository operations in 2020.

The Swedish waste management company, SKB, is likewise moving forward with the development of a geologic repository for SNF with the consent of the host municipal government. Between 1977 and 1985, SKB identified a number of "investigation areas" in different parts of the country. Such areas were selected for further studies on the basis of existing geological data as well as an assessment of the ease of getting permission by the land-owner to carry out such investigations (including borehole drillings). This approach gradually met more and more opposition. In 1985, SKB decided to stop these investigations, partly as the result of a governmental request. At that time, geological information had been collected from about 15 locations. An overall conclusion was that it is possible to find sites that meet the stipulated geological requirements for a deep geological repository in most parts of Sweden.

In early 1992, SKB initiated a new siting process. This process started by a letter from SKB to all Swedish municipalities (about 290) explaining SKB's task to find a site for a repository for spent fuel and inviting interested municipalities to voluntarily apply. SKB's invitation resulted in two municipalities agreeing to a feasibility study. These feasibility studies were followed by referendums in both municipalities to ascertain public opinion regarding further participation in the siting process. In both cases, the referendums resulted in a rejection of further participation.

At that point, SKB conducted further feasibility studies and identified five potentially promising sites. Of these, SKB approached the three geologically appropriate communities that already housed nuclear facilities. In 2001, the government approved SKB's proposal to undertake a detailed investigation of these three sites: (1) the existing Forsmark nuclear site near the municipality of Östhammar, (2) Oskarshamn, which was the site of an underground nuclear research laboratory constructed in the early 1990s and (3) an area in the northern part of Tierp.

A few months later, the municipal councils in Östhammar and Oskarshamn consented to further investigations, while Tierp opted out (importantly, either Östhammar or Oskarshamn could have vetoed its selection as a permanent disposal site for HLW).<sup>130</sup> Ultimately, this process worked. Of the two remaining options, Forsmark—which already hosts a large nuclear power plant and an operating repository for short-lived low- and intermediate-level radioactive waste—was ultimately selected in 2009 because it offered better geology. In March 2011, SKB applied to the Swedish government for permits to construct a repository in Forsmark.

A unique feature in the Swedish approach is that, before the final site decision was made, there was an agreement that the community not selected would receive a larger amount of compensation than the community that was selected. The rationale was that the community selected to host the repository would realize additional economic benefits, in the form of construction activity, infrastructure investments, permanent jobs to operate the repository, and ancillary development (e.g., research and fabrication facilities, etc.) The value of these benefits to the local economy was estimated at about \$300 million.<sup>131</sup> Ultimately, the community near Forsmark will receive approximately 25% of this estimated value for hosting the repository, while the community at Oskarshamn, which was not selected, will receive the remainder—approximately 75% of the estimated benefits—for participating in the siting process. At this point, the anticipated start date for repository operations is 2025.

Canada’s Nuclear Waste Management Organization (NWMO) was formed in 2002 after the failure of a decades-long, technically-oriented effort to establish a repository. NWMO has adapted lessons from the Finnish and Swedish experience to its approach to nuclear waste management in Canada. The very first step taken by the NWMO was to ask how its attempt to develop a repository would be any different from those of the past. The conclusion was reached that NWMO should first seek to understand the deeply held values of citizens, and only then review its options in light of that citizen input.<sup>132</sup>

Members of the Disposal Subcommittee have had an opportunity to hear firsthand from leaders of the Canadian, Finnish, and Swedish nuclear waste management programs. Members also heard from local government officials during a visit to Finland and Sweden in October 2010, and to France, Japan and Russia in February 2011, and the UK in June 2011. In contrast to the U.S. situation, these officials expressed a high degree of confidence in the site identification and selection processes used to locate a repository and in the institutions responsible for implementing and overseeing those processes. They stressed that several elements were critical in establishing a foundation for trust:

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<sup>130</sup> The Swedish Act on the Management of Natural Resources gives municipalities a veto over siting permits. While the government has the right, under certain circumstances, to disregard such vetoes, neither SKB nor the Swedish Parliament favored siting a repository without the consent of the selected municipality. The government’s choice not to exercise its override authority, in other words, represents a discretionary policy decision. SKB RD&D Programme 1998, p. 30 (<http://www.skb.se/upload/publications/pdf/RD&D98webb.pdf>), and Rolf Lidskog & Ann-Catrin Andersson, The management of radioactive waste: A description of 10 countries (<http://www.edram.info/en/edram-home/joint-activities/status-report-skb-report/index.php>), p. 71.

<sup>131</sup> Comment on Disposal Subcommittee Draft to the Full Commission submitted by Mr. Claes Thegerström, CEO of the SKB on June 29th, 2011 (Available at: [http://www.brc.gov/sites/default/files/comments/attachments/brb-text\\_5\\_sweden.pdf](http://www.brc.gov/sites/default/files/comments/attachments/brb-text_5_sweden.pdf)).

<sup>132</sup> In a presentation before the Commission, Liz Dowdeswell, former President of the NWMO, summarized the organization’s perspective this way: “We believed that fundamentally the selection of an approach for long-term management was really about developing a contract between science and society, a contract that would allow all of us to continue to benefit from technology, but also would mitigate risk and, most importantly, would respect the values of our citizens.”

- A clear and understandable legal framework
- An opt-out option for the local affected community, up to a certain point in the process
- The availability of financing for local governments and citizen organizations to conduct their own analyses of the site and siting issues
- Compensation for allowing the investigation and characterization of the proposed site
- A concerted effort to promote knowledge and awareness of the nuclear waste issue and plans for addressing it through mechanisms such as:
  - Seminars, study visits, and reviews conducted by the local government
  - Information to and consultation with local inhabitants
  - Socioeconomic studies and evaluations of impacts on local businesses
- Openness and transparency among and within the implementing organization, the national government, local governments, and the public.

How these elements might be included in a new approach to siting facilities for nuclear waste and spent fuel management and disposal in the United States is the subject of the next section.

## **7.2 Key Elements of a Phased, Adaptive Approach to Siting and Developing Facilities**

Based on the history of waste management efforts at home and abroad, the Subcommittee believes that the United States must commit to a new, more flexible and more adaptive approach to siting and developing facilities in the future. “Learning by doing” has produced substantial improvements in the reliability, safety, and performance of commercial nuclear reactors in the United States. It has also contributed to an impressive track record of safe transport and handling with respect to the transfer of defense TRU wastes to the WIPP facility in New Mexico. Compared to the prescriptive approach used in attempting to develop a repository for spent fuel and high-level waste at Yucca Mountain, other nations—notably Canada, Sweden, and Finland—appear to be proceeding with less controversy using an adaptive, staged management approach (recognizing that some other nations using an adaptive approach have not yet succeeded in identifying repository sites). France also has adopted a process with similar characteristics and has made progress in identifying a future repository site.

The notion that such an approach could produce better outcomes for this nation’s nuclear waste management program is also not a new one. In a comprehensive 2001 report on the status of efforts to provide for the disposition of high-level nuclear waste and spent fuel,<sup>133</sup> the National Academy of Sciences (NAS) concluded that “geological disposal remains the only long-term solution available” and recommended that national waste management programs “should proceed in a phased or stepwise manner.”

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<sup>133</sup> NAS, *Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challenges*, Summary, 2001.



As a follow-on to this report, DOE sponsored a second NAS study to detail options for a staged program. The resulting report, published in 2003,<sup>134</sup> described two approaches to staging: (1) “Linear staging, involving a single, predetermined path to a well-defined end point, with stages viewed as milestones at which cost and schedules are reviewed and modified as needed” (this is the approach that in the NAS’s view characterized the current U.S. program); and (2) “adaptive staging, which emphasizes deliberate continued learning and improvement and in which the ultimate path to success and the end points themselves are determined by knowledge and experience gathered along the way.”<sup>135</sup> The report concluded by recommending that adaptive staging should be the approach used in geologic repository development.

The Subcommittee concurs strongly with the NAS recommendation. In our view, moreover, events since 2003 only bolster the case for a phased, adaptive approach because they demonstrate that without political buy-in and trust, progress toward a resolution of the nation’s waste management challenges cannot be sustained.<sup>136</sup> Put simply, we believe a phased, adaptive approach is more conducive to building and maintaining public support for the long and demanding process of locating, designing, constructing, and operating facilities for the management and disposal of nuclear materials.

#### **Siting New Nuclear Waste Management Facilities – Getting Started**

***First, the Environmental Protection Agency and the Nuclear Regulatory Commission should develop a generic disposal standard and supporting regulatory requirements early in the siting process.*** Generally-applicable regulations are more likely to earn public confidence than site-specific standards. In addition, having a generic standard will support the efficient consideration and examination of multiple sites.

***Once the new waste management organization is established it should:***

- ***Develop a set of basic initial siting criteria*** – These criteria will ensure that time is not wasted investigating sites that are clearly unsuitable or inappropriate.
- ***Encourage expressions of interest from a large variety of communities that have potentially suitable sites*** - As these communities become engaged in the process, the implementing organization must be flexible enough not to force the issue of consent while also being fully prepared to take advantage of promising opportunities when they arise.
- ***Establish initial program milestones*** - Milestones should be laid out in a mission plan to allow for review by Congress, the Administration, and stakeholders, and to provide verifiable indicators for oversight of the organization’s performance.

<sup>134</sup> *One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste*, NAS, Washington, D.C., 2003.

<sup>135</sup> *One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste*, NAS, Washington, D.C., 2003. brief summary, [http://www.brc.gov/sites/default/files/documents/nas\\_one\\_step\\_at\\_a\\_time\\_summary.pdf](http://www.brc.gov/sites/default/files/documents/nas_one_step_at_a_time_summary.pdf).

<sup>136</sup> The OECD/NEA developed similar principles for “stepwise” siting process that are well described in their 2004 report *Stepwise Approach to Decision Making for Long-term Radioactive Waste Management: Experience, Issues and Guiding Principles*. Available at: <http://www.oecd-nea.org/rwm/reports/2004/nea4429-stepwise.pdf>.

Of course, the first requirement in siting any facility centers on the ability to demonstrate adequate protection of public health and safety and the environment. As part of a phased, adaptive approach,<sup>137</sup> the Subcommittee recommends that starting early in the process of exploring any repository site the waste management organization develop a “safety case” that collects in one document the wide range of relevant technical and other information (including information on legal, financial, and managerial aspects of the waste management system) that together provide a basis for confidence in the safety of a repository at the site.<sup>138</sup> The articulation of a safety case starting early in the repository development process is a way to communicate important information to decision-makers, stakeholders, and the public and to promote a broader and more accurate understanding of the scientific, technical, and other bases for decisions about development of the repository, including ultimately the licensing decision. The purpose of the safety case would not be to expand on requirements already included in the existing licensing process,<sup>139</sup> but rather to make the rationale for the safety of disposal in the repository accessible and understandable to the public and to a wide range of decision makers beyond the audience of regulatory experts who are already familiar with the full range of arguments that are considered in that process.<sup>140</sup>

To support the consent-based siting process we have recommended, the safety case should (1) be easily accessible to all concerned stakeholders and to local, tribal, and state government representatives, and (2) should strive to make clear and explicit all the assumptions and evidence that have been considered as part of building the case for confidence in the long-term performance of the proposed facility at the proposed site. In addition, the safety case should be updated as needed to provide an input to decisions throughout the facility development process. It should also be updated periodically after the facility begins operation if agreements with local communities, tribes, or states require a periodic revalidation of the facility’s ability to meet safety requirements.

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<sup>137</sup> The *One Step at a Time* report argues strongly for the use of a periodically-revised safety case as a central feature of adaptive staging: “Two primary roles of the safety case are: (1) to guide the work of the implementer while adapting the program at each stage, and (2) to provide the implementer with a vehicle for making the safety arguments understandable by a wide audience.”

<sup>138</sup> The concept of a broad “safety case” that integrates all available lines of evidence supporting the safety of a repository, including institutional as well as technical factors, has become increasingly prominent internationally over the last decade. See International Atomic Energy Agency and The OECD Nuclear Energy Agency, *Geological Disposal Of Radioactive Waste: Safety Requirements*, No. WS-R-4, International Atomic Energy Agency, Vienna, 2006, Sections 3.40-3.53, [www-pub.iaea.org/MTCD/publications/PDF/Pub1231\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/Pub1231_web.pdf).

<sup>139</sup> The Commission recognizes that many arguments for safety of the repository are distributed throughout the regulatory process in the regulations and the justification documents supporting them, in requirements for reporting, and elsewhere. See EPRI comments on the Blue Ribbon Commission on America’s Nuclear Future (BRC) Disposal Subcommittee Draft Report to the Full Commission, July 1, 2011.

<sup>140</sup> Complex performance assessments may be necessary for licensing, but the public and policy-makers may not find them easy to understand. The probabilistic performance assessment methods and results developed for Yucca Mountain are a state-of-the-art achievement and very valuable. They verge on being incomprehensible because of their complexity, however, except perhaps to organizations able to afford a large cadre of experts. Future repository programs still may have to produce complex performance assessments for compliance purposes, but they also must produce more-realistic, less-complex performance assessments for non-regulators. As experience with the Yucca Mountain program clearly shows, not only the regulators decide the fate of a repository program. The audience for the safety case is much broader. NWTRB, *Technical Advancements And Issues Associated With The Permanent Disposal Of High-Activity Wastes: Lessons Learned from Yucca Mountain and Other Programs*, June 2011.

## Features of Adaptive Staging

Every first-of-a-kind, long-term, and complex project develops in stages. With time, stages and schedules are inevitably revised in light of experience and knowledge gathered along the way. However, many national repository programs, including the U.S., have so far set rigid milestones for full-scale waste emplacement and repository closure.

The NAS 2003 *One Step at a Time* report recommends adaptive staging, a flexible approach where the “ultimate path to success and the end points themselves” are outlined at the beginning of the program and all parties, including stakeholders, acknowledge that the program can be revised as it progresses. Adaptive staging is less “error-prone” than a rigid approach, ensuring that early decisions do not commit the project to a path that later proves inappropriate or unsafe. It also allows the current generation to manage waste using the best available knowledge without foreclosing options if future generations decide to take a different approach.

A central feature of adaptive staging is a series of assessment periods or “decision points.” During these periods, project managers actively collect and evaluate information, including stakeholder input, to develop options for the next stage of the project; reassess the safety of the repository; make their findings public; and engage in dialogue with affected communities and other stakeholders.

According to the 2003 report, adaptive staging is characterized by the simultaneous presence of seven attributes:

1. **Commitment to systematic learning.** Project managers intentionally seek, are open to, and learn from new knowledge and stakeholder input. Stages are designed specifically to increase available scientific, technical, societal, institutional, and operational knowledge.
2. **Flexibility.** Project managers are able and willing to reevaluate earlier decisions and redesign or change course when new information warrants.
3. **Reversibility.** Project managers are able to abandon an earlier path and reverse the course of action to a previous stage if new information warrants.
4. **Transparency.** The decision-making process and the basis for decisions are documented and accessible in real-time and plain language to all stakeholders.
5. **Auditability.** Documentation for the basis of decisions is complete and made available to all interested party for review purposes.
6. **Integrity.** Technical results are accurately and objectively reported and all uncertainties, assumptions, and indeterminacies are identified and labeled.
7. **Responsiveness.** Project managers seek and act on new information in a timely fashion.

It is important to emphasize that the presence of these elements is not meant to delay the program but to allow and encourage learning from experience. Although adaptive staging may result in higher initial costs and a slower pace of waste emplacement in the beginning, it can be more efficient—from both a cost and time standpoint—over the long run because it allows for potential problems to be corrected before they become expensive and time-consuming.

One important implication of pursuing an adaptive staging approach is that the focus is on initial operation of a repository rather than on rapidly disposing of a large inventory of waste.<sup>141</sup> This follows from the NAS description of the characteristics of a successful geologic repository program. One of those characteristics, according to this report, is that “initial waste emplacement has taken place with plans for reversibility.”<sup>142</sup>

It is very important to recognize that the above-described approach implies a need for substantial buffer storage capacity in the waste management system. Such buffer capacity would decouple the program’s ability to accept waste from the emplacement of that waste in a repository for disposal. This in turn would provide the flexibility needed to develop repository capacity in a more gradual and stepwise manner. Issues related to the role of storage in a successful, integrated waste management system have been addressed by the Transportation and Storage Subcommittee.

Explicit recognition that a repository will be developed in stages, and that later stages will incorporate lessons from earlier ones as well as technological advances, in turn implies the need for robust investments in continuous learning going forward. This would include sustained support for science and technology development that can improve the operation of the waste management system.

### **7.3 Specific Steps in an Adaptive, Staged Facility Siting and Development Process**

Experience in other countries and from the WIPP facility in the United States suggests that the identification of potential host communities in an adaptive, phased, and ultimately consent-based process should start with the implementing organization encouraging expressions of interest and engaging a large variety of communities that have potentially suitable geology to host a safe and secure disposal facility. As these communities become engaged in the process, the implementing organization must be flexible enough not to force the issue of consent while also being fully prepared to take advantage of promising opportunities when they arise. Throughout, meaningful consultation with stakeholders to inform them of the siting process and make needed adjustments (much as was done by the NWMO in Canada) will be critical to building credibility and confidence in the implementing organization.

It should be mentioned that a consent-based process faces several challenges. Important questions will need to be answered, including the following:<sup>143</sup>

- (1) How to define the boundaries of “the host community?” -- Political boundaries that are often used can be inequitable to neighbors.
- (2) How to determine the use of consent? – In the US, evidence suggests that local officials may not always represent the diverse views within a community about hosting a controversial facility.
- (3) How to handle the ethical argument that disadvantaged or underdeveloped communities will be driven to volunteer out of a sense of desperation?
- (4) How much will safety be compromised if it needs to be over-engineered due to less-than ideal physical conditions? – In a consent-based process the site will almost certainly not be the

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<sup>141</sup> “If adopted, Adaptive Staging would lead DOE to ...focus more strongly on achieving the degree of technical and societal consensus needed to begin waste emplacement, rather than on the emplacement of all waste.” *One Step at a Time*, pp. 7-8.

<sup>142</sup> *Ibid.*, pp. 22-23.

<sup>143</sup> Thomas Webber, Seth p. Tuller and Eugene A. Rosa, *Options for Developing Public and Stakeholder Engagement*, pp.9-10.

technologically best site and therefore most likely will require more engineering and design work to meet safety standards.

Prior to launching the consent-based siting process, the implementing organization should develop a set of basic initial siting criteria designed to ensure that time and resources are not wasted in the investigation of sites that are clearly unsafe, unsuitable or inappropriate for waste facility development. For instance, these criteria could eliminate sites where valuable minerals are abundant or sites that are too difficult to excavate. At the same time, it will be important to communicate plainly with local communities and stakeholders about the nature of the risks involved in hosting a facility and about options for addressing and managing those risks. As the siting process continues and as various candidate sites pass these initial screening criteria, additional sets of criteria should be applied to eliminate all but the most suitable sites for further characterization. These additional criteria might include geologic features, anticipated socioeconomic effects, transportation access and impacts, costs, and a number of other important elements. Obviously, as a candidate site is characterized in greater and greater detail it will be necessary to demonstrate not only that the preliminary criteria are satisfied, but that all applicable environmental, health and safety, and other requirements set forth by the responsible regulatory authorities can be met.

The Subcommittee takes the view that any site, provided it has met all regulatory requirements and has been selected with consent at a local and state level should require no additional approval, including congressional approval.<sup>144</sup> This approach is consistent with an overall framework that gives the new implementing organization—subject to congressional oversight—the authority to make legally binding, court-enforceable agreements with local communities, tribes, and host states with regard to developing key parts of the nuclear waste management system. Likewise, after a disposal facility enters operation, any modification or expansion of the facility’s mission should be consent-based. As with other details of establishing a new management approach and a new implementing organization (see discussion in the previous section), the specific requirements for moving forward with a particular site would have to be set forth in new legislation.

Lastly, the Subcommittee recommends that pilot, test, and demonstration facilities (including an *in situ* research and demonstration laboratory) be located at the proposed disposal site as part of repository construction. Pilot facilities will make it possible to conduct tests aimed at improving operational efficiency and safety and demonstrating retrievability. An underground test laboratory or a demonstration alcove will help ensure a continuing commitment to R&D for the purpose of confirming and improving performance and safety and to reduce residual uncertainties.<sup>145</sup> It will also provide an invaluable resource to help the interested and affected public understand how a repository will work.

We recognize that reasonable milestones for major phases of program development and implementation are important to keep the program focused and ensure that it is moving forward. The Finnish waste management program demonstrates the usefulness of milestones as a mechanism to help sustain steady and meaningful progress. As an adaptive phased approach requires both clear programmatic planning and flexibility, we recommend that the implementing organization establish reasonable time horizons for the major stages of the program. As one example, the implementing organization might contemplate a stage of, say, 15 to 20 years to accomplish site identification and

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<sup>144</sup> Unless provisions of an agreement would require additional legislative authorizations not already provided in the law establishing the waste management organization.

<sup>145</sup> This is very well demonstrated in Sweden where at first an underground rock laboratory was created. Also, the NAS “*One Step at a Time*” report (described in the previous section) recommends that a demonstration alcove be developed early in the operational phase in parallel with other underground operational activities.

characterization and to conduct the licensing process. The implementing organization will be responsible for setting overall and intermediate milestones for each stage of the process.

Of course, unforeseen circumstances will occur and siting could take a longer or shorter period of time. This is why the program requires flexibility. Program milestones should be laid out in a regularly updated Mission Plan (as discussed earlier) to allow for review by Congress, the Administration, and stakeholders, and to provide verifiable indicators for external oversight of the organization's performance. Any needed changes would be presented in Mission Plan revisions for review as appropriate.

## 7.4 Support for Participation

A noteworthy feature of the Swedish repository program is that funds from the nuclear waste management organization are set aside to be awarded to non-governmental organizations (NGOs) involved in the siting and repository development process. These funds are used by the NGOs to investigate technical and other aspects of the nuclear waste management program.

In the course of the Subcommittee's deliberations, many participants and commenters emphasized the importance of citizen participation. As a letter to the Commission from the South Carolina Governors' Nuclear Advisory Council and others stated, "citizen participation results in better and quicker decisions that are accepted by the larger public."

This contention is supported by a 2008 report of the National Academy of Sciences, titled *Public Participation in Environmental Assessment and Decision Making*, which concluded: "When done well, public participation improves the quality and legitimacy of a decision and builds the capacity of all involved to engage in the policy process. It can lead to better results in terms of environmental quality and other social objectives. It also can enhance trust and understanding among parties. Achieving these results depends on using practices that address difficulties that specific aspects of the context can present."

For a complicated and technically-involved issue like the development of a nuclear waste repository, the inability of citizens and citizen groups to access the necessary technical expertise can be a major barrier to participation. In a large country like the United States, sheer distance can also be an issue; important meetings, conferences, and other events are regularly held in far-flung locations, and travel and lodging expenses can be beyond the means of individuals and groups who would otherwise wish to participate.<sup>146</sup>

Perhaps even more important, states and affected communities—in order to gain trust and confidence in the decisions taken by the waste management organization—must be empowered to meaningfully participate in the decision-making process. This means being in a position to evaluate options and provide substantive input on technical and operational matters of direct relevance to their concerns and interests. Accordingly, we believe it will be important to provide funding for independent monitoring and testing on the candidate repository site, provided that such activities do not interfere with the waste management organization's activities or compromise the integrity of the site.<sup>147</sup> (This limitation is

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<sup>146</sup> For this reason, the BRC has provided funding for key NGO and community stakeholder to travel to its deliberative meetings.

<sup>147</sup> Section 116 of the NWPA provides for grants to states and affected units of local governments for a number of purposes, including "any monitoring, testing, or evaluation activities with respect to site characterization programs with regard to such site," while section 117 adds the proviso "except that such monitoring and testing shall not unreasonably interfere with or delay onsite activities." Funding for monitoring, testing, or evaluation activities is also provided for affected tribes. Under these provisions, over \$4 million was provided to Inyo County, CA for the Inyo Regional Ground Water Monitoring Program, and over \$31 million was provided to Nye County, NV for a Science & Verification Program that included the Nye County Early Warning

needed because one important means of testing used in characterizing potential repository sites is drilling boreholes, which have the potential for degrading the isolation capabilities of the site if their location is not carefully controlled.) Funding for independent monitoring and testing should continue to be provided after the facility enters operation, both as a way to provide important information on facility performance and to inform future decisions related to any proposed modification or expansion of the mission of the disposal facility.

In sum, the Subcommittee believes that a new U.S. waste management organization should adopt the Swedish practice and set aside funding for participation by citizens, citizen groups, and other NGOs. The availability of funding should be widely announced and reasonable criteria should be established against which to evaluate applications for financial support.

## 7.5 Role of States, Tribes, and Communities in an Adaptive, Consent-Based Siting Process

It has long been accepted that host states, tribes, and local governments should play an important role in siting nuclear waste management and disposal facilities.<sup>148</sup> As one early study put it: “If the federal government is to make progress toward a permanent solution of the radioactive waste problem, it cannot go it alone—citizens will insist on assurances (other than federal assurances) that proposed actions will not involve undue risks to the host states.”<sup>149</sup>

In the debates leading up to the original NWPA of 1982, Congress considered a wide range of options for formalizing the host states’ role in repository siting—from merely providing for consultation to giving host states a complete veto over proposed projects within their borders. Ultimately, the formula adopted in the NWPA included provisions for “consultation and cooperation,” combined with some state oversight rights and the ability to veto a proposed site. The state veto, however, was subject to congressional override—an option that was exercised when Congress overrode Nevada’s veto of the Yucca Mountain site in 2002.<sup>150</sup>

In the United States so far, states have generally resisted—in some cases very strongly—efforts to site high-level waste and spent fuel disposal and away-from-reactor storage sites within their borders.<sup>151</sup> By contrast, some local governments and tribes have viewed these facilities more positively—and in some cases have supported them strongly—primarily on the basis of anticipated job creation and economic development benefits.<sup>152</sup> Indeed, some of the most supportive communities have been those with a long

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Drilling Program, which provided data used in the Yucca Mountain project (Office of Civilian Radioactive Waste Management Office of Business Management, Summary of Program Financial & Budget Information as of January 31, 2010).

<sup>148</sup> For example, a report from 1980 on the subject pointed out that states have a “constitutional responsibility to ensure the health and safety of their citizens,” as well as “jurisdiction over local authorities and land use,” and that states therefore believed “it is both undesirable and impartial for disposal procedures to be wholly federally determined” (Pat Choate and John Bowman, *Radioactive Waste Management: State Concerns, A Report to the Office of Technology Assessment from the Academy for Contemporary Problems*, p. 3, 1980).

<sup>149</sup> *Ibid.* p. 11.

<sup>150</sup> An absolute state veto had been opposed by the State Planning Council established by President Carter to provide advice on intergovernmental relations, as well as by others. U.S. Congress Office of Technology Assessment, *Managing the Nation’s Commercial High-Level Radioactive Waste*, OTA-O-171, March, 1985, p. 180.

<sup>151</sup> The state of Nevada’s strong opposition to the proposed Yucca Mountain repository is well known, but other examples abound. In Utah, efforts to site a private centralized storage facility were blocked when the Utah delegation successfully pushed for Congressional designation of a wilderness area that prevented access to the proposed site. Utah reiterated its opposition to the storage facility in comments to the Commission.

<sup>152</sup> Peter C. Chestnut et al, “The Role Of Indian Tribes In America’s Nuclear Future,” BRC Commissioned paper April 29, 2011, p.7 [http://www.brc.gov/sites/default/files/documents/the\\_role\\_of\\_indian\\_tribes\\_in\\_americas\\_nuclear\\_future-2011-04-29\\_final.pdf](http://www.brc.gov/sites/default/files/documents/the_role_of_indian_tribes_in_americas_nuclear_future-2011-04-29_final.pdf).

history of hosting nuclear facilities. Local support, however, has not usually been sufficient to overcome state-level opposition. This suggests that to be successful, a new waste management organization must find ways to address state concerns while at the same time capitalizing on local support for proposed facilities.

What those concerns might be and how the tensions inherent in federal–state and federal–tribe relationships might be successfully navigated in different siting contexts is impossible to anticipate in advance. Clearly, locating and constructing facilities for the management and disposal of SNF and HLW will require complex and possibly lengthy negotiations between the federal government and other relevant units of government. In these negotiations, it will be important to define the roles, responsibilities, and authorities of host state, tribal, and local governments both throughout the siting and licensing process and once a facility is operational.<sup>153</sup> In addition, host jurisdictions should have the option to enter into partnership arrangements or other legally-binding, court-enforceable agreements with the implementing organization to ensure that all commitments concerning the development and subsequent operation of waste management facilities are upheld. A similarly consent-based approach should be used in the future in deciding whether modifications to the scope or mission of an existing facility are appropriate and acceptable. Beyond engaging in substantive negotiations and binding agreements with other units of government as part of the facility siting and development process, the Commission believes that states and tribes should retain—or where appropriate, be delegated—direct authority over aspects of regulation, permitting, and operations where oversight below the federal level can be exercised effectively and in a way that is helpful in protecting the interests and gaining the confidence of affected communities and citizens. Such authorities could be included in the legally-enforceable agreements or partnerships if such arrangements are negotiated between the implementing organization and states, tribes, and or local communities that agree to host a waste management facility.

We recognize that this approach represents a departure from the approach taken toward Yucca Mountain in the 1987 NWPAA. We also recognize that defining a meaningful and appropriate role for states, tribes, and local governments under current law is far from straightforward, given that the Atomic Energy Act of 1954 provides for exclusive federal jurisdiction over many radioactive waste management issues. The Subcommittee has observed that in one notable instance—the NRC Agreement States program—regulatory authorities of the federal government under the Atomic Energy Act have been delegated to States. Although the current Agreement States program does not cover licensing of a repository, it does suggest a similar enforcement model might give a host State or Tribe sufficient regulatory oversight to assure a meaningful public safety role. Alternative approaches through memoranda of understanding or other binding agreements may also be acceptable and should be explored as part of the negotiating process. Nevertheless, we believe it will be essential to affirm a role for states, tribes, and local governments that is at once positive, proactive, and substantively meaningful and thereby reduces rather than increases the potential for conflict, confusion, and delay. At the same time, host state, local, and tribal governments have responsibilities to work productively with the federal government to help advance the national interest.

Here, as in other aspects of facility siting, it is instructive to look to the WIPP experience, since that project was controversial at the state level for many years despite strong support from the local

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<sup>153</sup> The Commission recognizes that more than one community, state, or tribe might be affected by a proposed repository. The waste management organization should therefore be directed to consult with any state, affected unit of local government, or Indian tribe that it determines may be so affected and to include any reasonable and appropriate provisions relating to their interests in negotiated agreements, as the Nuclear Waste Negotiator was directed and empowered to do under Section 403 (b) of the NWPAA as amended.



Carlsbad business community. After years of delay and state–federal disagreements, an important breakthrough came when Congress required EPA (not DOE) to certify that the facility met applicable standards for permanent waste disposal, including requirements under the Resource Conservation and Recovery Act (RCRA) for the disposal of mixed hazardous and radioactive waste.<sup>154</sup> This meant that the State of New Mexico retained authority to regulate mixed waste at WIPP and that the New Mexico Environment Department had to issue a Hazardous Waste Facility Permit for the repository. Even though the state did not have direct regulatory authority over the radioactive components of the waste being brought to the facility,<sup>155</sup> this development made a significant difference in terms of giving state officials and residents beyond the local community confidence that the facility was safe. Similarly, DOE’s decision to work cooperatively with Carlsbad and the Western Governors’ Association to develop a safe transportation program for WIPP was extremely helpful in addressing transportation-related concerns. The resulting Western Governors’ Association WIPP Transportation Safety Program Implementation Guide includes many procedures that would otherwise be considered “extra-regulatory” and could not be mandated by the states without federal consent. And finally, the establishment of the federally-funded, university-housed Environmental Evaluation Group (EEG) was important for gaining the trust of state officials and the local community because it provided an independent and credible source for technical information and review of the WIPP project. For example, the Consultation and Cooperation Agreement established between the State of New Mexico and DOE was developed with EEG participation in all meetings between the State’s Attorney General and DOE.

Another successful example that satisfied concerns of states and DOE was the process undertaken under the Federal Facility Compliance Act of 1992 (FFC Act)<sup>156</sup> which addressed treatment of DOE legacy mixed waste (including transfer of waste between states). During the 3 years of planning period with DOE, many states were represented by a policy expert from Governor’s office and a technical expert from state’s environmental agency. In State of South Carolina this process resulted in issuing a consent order<sup>157</sup> and all but a small portion of the low-level mixed legacy waste at Savannah River Site has been disposed off.<sup>158</sup>

Trust, in fact, is often the core issue whenever different parties are involved in a complex adjudicatory process—and it can be especially difficult to sustain when much of the power or control is viewed as being concentrated on one side. In a recent news article, former Governor Michael Sullivan of Wyoming pointed to a lack of trust as one of the central issues that led him to veto a proposed monitored retrievable storage facility in Wyoming in 1992. According to the article, Sullivan said that “the same problems that existed 20 years ago still exist today. Among them is the lack of trust that western states have of the federal government to either follow through on a long-term policy or to actually work in a state’s own interest.”<sup>159</sup>

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<sup>154</sup> Mixed waste is waste that contains, in addition to radioactive materials, materials that are defined as hazardous under RCRA (an example would be a chemical such as toluene).

<sup>155</sup> Current federal law—including aspects of the Atomic Energy Act, the Commerce Clause, and the doctrine of intergovernmental immunity on federal reservations—has the effect of preempting almost all forms of state regulation over a high-level waste facility.

<sup>156</sup> Under section 102 of the Act, The FFC Act amends section 6001 of the Solid Waste Disposal Act (42 U.S.C. 6961) to specify that federal facilities are subject to “all civil and administrative penalties and fines, regardless of whether such penalties or fines are punitive or coercive in nature.” See also: <http://www.hss.doe.gov/sesa/environment/policy/ffca.html>.

<sup>157</sup> Consent Order 95-22-HW.

<sup>158</sup> See also comment from the South Carolina Department of Health and Environmental Control on the BRC draft report available at the BRC website at [www.brc.gov](http://www.brc.gov).

<sup>159</sup> <http://wyofile.com/2011/02/sullivan-i-was-right-to-veto-nuclear-waste/>.

The WIPP example suggests that having some degree of direct state- or local-level control (in the WIPP case, this was possible through RCRA) can be helpful in instances where faith in federal agencies is lacking. In some cases, states have pursued formal agreements with the federal government that can be enforced in the courts, if necessary. These agreements have been cited by several commenters as a potential model for future federal–state confidence building in repository development. For example, as described in section 2.5, the State of Idaho in 1995 entered into an agreement with DOE and the U.S. Navy that allows DOE to ship a limited quantity of spent fuel from the Navy’s nuclear-powered fleet to INL for interim storage over a 40-year period. The agreement also obligates DOE to move all spent fuel into dry storage by 2023 and to remove all spent fuel from Idaho by no later than 2035. If DOE fails to meet any of the agreement milestones at any point, the State may ask the U.S. District Court to halt any further spent fuel shipments to INL. The Agreement can only be modified (and in fact has been modified) with the agreement of all parties.

The State of Washington recently entered into a similar agreement with DOE concerning the storage of wastes at Hanford. Officials from both states have cited these agreements as providing greater confidence that federal cleanup commitments will be met.

The same issues of trust, consultation, and control arise in the context of the federal government’s interactions with Indian tribes, another important stakeholder group in the context of nuclear waste management decisions. In fact, because many existing and proposed nuclear sites are either on or near tribal lands, tribal governments have been involved in nuclear technology and nuclear waste issues for decades. The 1982 NWPA requires consultation with states and affected Indian tribes and specifically addresses the participation of tribes in repository siting decisions. In the wake of the 1987 NWPAA, several tribes expressed interest in exploring the possibility of hosting nuclear waste on at least an interim basis. As was the case with local communities, however, these expressions of interest generally met with opposition at the state level.

Intergovernmental relationships will require careful attention as the U.S. nuclear waste management program is revived. Experience shows that an unwilling state government can successfully stand in the way of tribal efforts to site nuclear waste management facilities and the Commission believes it would be unrealistic to attempt to locate a facility on tribal land in the face of determined state-level opposition. Yet unlike local communities or state governments, tribes have a unique “government-to-government” relationship with the United States. Their right to make their own laws and be governed by them is limited only by their status as dependent domestic nations and by federal law. Therefore, the federal organization tasked with managing the waste problem will be required to work with federally-recognized tribes on a government-to-government basis.

Legally states have a limited role in Indian affairs. They do not have the power to regulate Indian tribes or tribal lands unless such powers are delegated to them by the federal government. Since 1975, moreover, federal policy has supported tribal self-determination. This means that meaningful consultation with tribal governments is required in the development of federal policies and practices that may impact tribal lands, people, or resources.<sup>160</sup>

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<sup>160</sup> As stated in the Executive Order 13175 *Consultation and Coordination With Indian Tribal Governments* of November 6, 2000 “In formulating or implementing policies that have tribal implications, agencies shall be guided by the following fundamental principles: (a) *The United States* has a unique legal relationship with Indian tribal governments as set forth in the Constitution of the United States, treaties, statutes, Executive Orders, and court decisions [...]; (b) Our Nation under the law of the United States, [...], has recognized the right of Indian tribes to self-government. As domestic dependent nations, Indian tribes exercise inherent sovereign powers over their members and territory. [...] Each agency shall have an accountable process to ensure meaningful and timely input by tribal officials in the development of regulatory policies that have tribal implications.”

The existing State and Tribal Government Working Group (STGWG) provides an example of one mechanism for facilitating regular consultation between states and tribes and the federal government. Established in 1989 at the request of 10 state governors, the group grew to include 15 states and 10 tribes who would meet with DOE to discuss the federal government's cleanup activities at facilities that have been or are still part of the nation's nuclear weapons complex. STGWG now meets twice annually. As with states, some precedent also exists for giving tribes a degree of regulatory control over specific facilities or operations in the nuclear waste management system. In 1991, the Shoshone-Bannock Tribe attempted to stop the shipment of commercial spent fuel across its reservation in Idaho. A lawsuit resulted and while the courts concluded that federal law (in this case, the Hazardous Materials Transportation Act) did not allow the tribes to ban spent fuel shipments from crossing their land, it did allow them to develop regulations for those shipments.<sup>161</sup>

***The experiences of state and tribal governments in improving their working relationships with DOE on waste cleanup lead the Subcommittee to conclude that a program to develop a nuclear waste repository should be governed by partnership arrangements or legally-enforceable agreements negotiated between the federal government and the host state(s) and affected tribal and local governments within the state.*** Host states, tribes and communities should have the opportunity to become partners with the waste management organization in repository development; this could involve, for example, the host state becoming a co-applicant on a repository license application. Of course, not all states may want to enter into a formal partnership arrangement. In that case, a court-enforceable agreement should be negotiated with the waste management organization to ensure that commitments to the state, tribes and communities are upheld.

Of course, the prospect of a federal-state partnership agreement for repository development raises issues regarding a potential conflict with a state's regulatory role. There are many examples of activities that are both sponsored by and regulated by different entities of state government, but given the public's deep concern about issues related to nuclear waste management, the relevant federal and state entities will need to pay careful attention to this issue in negotiating the state role, to ensure that state residents retain confidence that the state will protect the interests of its citizens.

In sum, whatever the specific authorities and resources of a given community, state, or Indian tribe, experience shows that determined opposition at any level of government can at a minimum significantly complicate and delay, and in many cases defeat, the best efforts to site a facility. In this context, it is difficult to overstate the importance of support for a facility or site at the state, tribe, and local level (obviously, public acceptance is not the only criterion; to be considered, any site must also meet safety and technical criteria and other requirements).

The Subcommittee therefore recommends that the process for allowing host communities to make initial expressions of interest must carry no obligations and must make the barriers to expressing such interest as low as possible. A constructive engagement period must be flexible enough that the implementing entity does not need to force the issue but can remain fully prepared to take advantage of siting opportunities when they arise.

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<sup>161</sup> For a detailed explanation and many relevant examples, see Chestnut, *op cit*.

The Subcommittee recognizes that more than one community, state, or tribe might be affected by a proposed repository. The waste management organization should therefore be directed to consult with any state, affected unit of local government, or Indian tribe that it determines may be so affected and to include any reasonable and appropriate provisions relating to their interests in negotiated agreements, as the Nuclear Waste Negotiator was directed and empowered to do.<sup>162</sup>

The NWPA provides for states to be able to veto a DOE-selected repository site (or storage site) but it also allows for Congress to override such a veto. The Subcommittee, however, is recommending a very different type of consent-based site selection and development process. We believe that this approach would obviate the need for a state-level veto, just as the veto/override provisions of the NWPA would not have applied to a repository or MRS facility sited through the Nuclear Waste Negotiator process established in the 1987 amendments.

Several commenters have expressed a desire to see the Commission explicitly define the point at which potential host state, tribal and local governments could no longer unconditionally (that is, without cause) “opt out” of a facility siting process. These commenters correctly note that the level of state, tribal and community acceptance of a proposed waste management facility can and likely will fluctuate over time. The Subcommittee believes that defining the point at which the right to unconditionally opt out expires must be part of the negotiation between affected units of government and the waste management organization. In our view, however, the right to opt out without cause should expire no later than the time when a license application for a proposed facility is submitted.

We believe this approach makes sense given that, under the process we have recommended, the potential host community, tribe, and state would have had to consent to be considered for a waste site, with full knowledge of the relevant safety standards and siting criteria. Further, the host state and affected tribal and local governments would have had to agree to the terms of site study and what was to be built prior to the submission of a license application. When studies were complete, a license application would be prepared, and the Subcommittee believes the host state and affected tribal and local governments should be given the opportunity to sign off on it before submittal. After that time, the state and other units of government would only be allowed to opt out “for cause”—such as bad faith on the part of the operator. Formal agreements, of the type we have recommended elsewhere, would be in place to cover this situation.

A related important question that must be an element of negotiation in the legally binding agreements is potential limits on the types and quantities of waste that can be managed in the facility. While it is possible that quantitative limits might be specified, the Subcommittee recommends that, if possible, performance-based limits be implemented. For example, a periodic reassessment of facility safety and recertification could be required as a condition for continued operation and acceptance of additional waste, rather than an arbitrary quantitative limit on capacity.

This discussion raises another question highlighted in numerous comments to the BRC and this Subcommittee: the question of how to define “consent.” The Subcommittee takes the view that this question ultimately has to be answered by a potential host jurisdiction, using whatever means and timing it sees fit. We believe a good gauge of consent would be the willingness of the host state (and other affected units of government, as appropriate) to enter into legally binding agreements with

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<sup>162</sup> NWPA as amended, Sec. 403. (b).

the facility operator, where these agreements enable states, tribes, or communities to have confidence that they can protect the interests of their citizens.<sup>163</sup>

Commenters have also asked the Subcommittee and the full Commission to provide guidance on how long the nuclear waste management organization should be given to attempt to employ a consent-based siting process. The Subcommittee acknowledges and appreciates the frustration many observers have expressed with the need to resume the effort to identify potentially suitable repository sites. In our view, such an effort will certainly take many years and cannot be rushed if public confidence in the nuclear waste management program is to be restored.

Finally, to engage in meaningful consultation on matters related to nuclear waste storage, transport, and disposal, and to carry out their proper regulatory roles and responsibilities in this context, local, state, and tribal governments need access to sound, independent scientific and technical expertise. The example of the Environmental Evaluation Group in the WIPP context underscores how important it is that all parties to the negotiation over future nuclear waste disposal facilities be empowered to critically review decision-relevant material, reach their own conclusions, substantiate their decisions, and exercise their prerogatives in a constructive and effective way.

Ultimately, legislation will be needed to authorize a new consent-based siting process that incorporates the considerations described above. The Subcommittee notes that the Nuclear Waste Negotiator provisions in Title IV of the Nuclear Waste Policy Act as amended in 1987 define a very flexible process for a representative of the federal government to seek to reach a proposed agreement between the United States and any State or Indian tribe “specifying the terms and conditions under which such State or tribe would agree to host a repository or monitored retrievable storage facility” through consultations with any State, affected unit of local government, or any Indian tribe that may be affected by the siting such a facility. There are no constraints on any proposed agreement other than that it “shall contain such terms and conditions (including such financial and institutional arrangements) as the Negotiator and the host State or Indian tribe determine to be reasonable and appropriate and shall contain such provisions as are necessary to preserve any right to participation or compensation of such State, affected unit of local government, or Indian tribe under [the impact compensation and consultation and cooperation sections of the Act].”<sup>164</sup> The Subcommittee believes that the authority provided to the Nuclear Waste Negotiator under the 1987 NWPA Amendments provides a good model for a flexible, consent-based siting process—one that recognizes different potential host states, tribes, and affected communities will have their own unique concerns and that their interests that cannot be anticipated and spelled out in advance in legislative language.

## **7.6 Benefits to Host States, Tribes, and Communities**

Besides conducting a process that is consent-based, transparent, and responsive to state and local governments’ need for meaningful input and control, it will be important to demonstrate that the decision to host a facility can deliver real benefits (economic and otherwise) to the state and local

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<sup>163</sup> For instance, the Western Governors’ Association (WGA) adopted a definition of consent-based siting for spent fuel storage facilities as part of its Resolution 11-3. The resolution requires the written consent of the governor of the hosting state. Members of the WGA’s WIEB High-Level Waste Committee also believe that written consent would be required for all future disposal and storage decisions. For details see WGA’s comments, dated September 13, 2011, on the BRC draft report.

<sup>164</sup> Sections 116(c), 117, and 118(b).

community.<sup>165</sup> Affected states, tribes, and communities will reasonably expect incentives for helping to address the important national issue of nuclear waste management. To be most effective, such incentives must be provided in ways that are creative and attentive to their symbolic content. In addition, neighbors and others impacted by nuclear waste management facilities need assurance of reasonable compensation for real costs. Experiences in Sweden, Finland, and elsewhere have shown that it may not be possible or even advisable to specify such incentives and funds up front; rather, in keeping with an adaptive approach, these determinations are best left to the discretion of the implementing organization and potential host governments—including communities surrounding the host community. These stakeholders will be in the best position to determine what incentives are both appropriate and in their best interests. These policies will help maximize project benefits for host communities and boost confidence that decision-makers are in touch with local values and concerns.

In the past, DOE often did not make the most of these opportunities. For example, WIPP was managed for years by DOE personnel located in Albuquerque rather than at an office in Carlsbad near the facility. It was only late in the process that DOE relocated its top WIPP management to Carlsbad. Likewise, the TRANSCOM tracking system used in the transportation program was originally based out of Oak Ridge, Tennessee. It was later relocated to Albuquerque and finally moved to Carlsbad in 2005. Similarly, DOE maintained its headquarters for Yucca Mountain in Las Vegas, nearly 100 miles from the proposed repository.

In addition to locating waste management-related activities in the affected state and community, these states and communities could also be given preference in the siting of related federal projects (provided they are otherwise suitable to host those projects). Section 174 of the NWPA titled “Other Benefits—Considerations in Siting Facilities,” already specifies that the Secretary of Energy “in siting Federal research projects, shall give special consideration to proposals from states where a repository is located.” This approach can provide additional benefits to host communities and states without requiring new appropriations or increasing the cost of already planned programs or projects. The Subcommittee recommends that this provision be expanded to include states that host any waste management facilities sited by the new waste management organization and to clarify that the special consideration applies to research, development, and demonstration facilities (not research contracts) that receive federal funding, including any federal matching funds.

Specifically, we believe, that the amount of benefits specified in section 171 of the NWPA is inadequate. Therefore the Subcommittee recommends that the NWPA be amended to authorize the new federal corporation (described in section 5) to negotiate substantial benefits -- well above the amounts currently specified in section 171 of the NWPA -- to be provided to local communities, tribes, governments, or other organizations as appropriate. The specific uses of these funds and the metrics that would determine their amounts should be an element of negotiation between the federal corporation and local communities and governments interested in hosting facilities. Payments could be used for a wide range of uses, including for economic development. All benefit payments should be subjected to external, independent auditing.

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<sup>165</sup> In France, direct financial benefits for the region surrounding the proposed repository are spelled out in law. In addition, a range of other programs to promote development are being provided. While the particular government-utility mechanism that is used for this purpose may be unique to the French situation, the concept of promoting regional development through activities that go beyond financial benefits and waste-management-related employment is worthy of careful examination.

Finally, it is important to recognize that Congress may ultimately have a role in providing or approving benefits and compensation for hosting nationally-needed nuclear waste facilities, particularly since some benefits—such as transfers of federal land to host states, tribes, or communities to compensate for land withdrawn for waste facilities—may be beyond the waste management organization’s authority and could require legislation.

## 7.7 Near-Term Actions

While the Subcommittee recommends that a new waste management organization be created to carry out federal responsibilities for the storage, transportation, and disposal of spent fuel and high-level waste, it also recognizes that some communities have already indicated potential interest in hosting a radioactive waste management facility. Until new legislation has been adopted to establish both a siting process and a new organization, responsibility for meeting the obligations established by the NWPA remains with DOE. The Subcommittee therefore recommends that DOE take near-term steps to work with and support potentially interested states and communities to investigate the possibility of developing new waste management and disposal capabilities, and that Congress support these actions by making funding available from the Nuclear Waste Fund and from defense appropriations. Additionally:

- To ensure that future siting efforts are informed by past experience, DOE should build a database of the experience that has been gained and relevant documentation produced in efforts to site nuclear waste facilities in the United States and abroad. This would include the storage facility and repository siting efforts under the NWPA by both DOE and the Nuclear Waste Negotiator.
- DOE should be prepared and willing to engage in discussions with potential voluntary state/tribal/community hosts that might wish to do so.

Moving ahead with these initial steps now, rather than waiting for creation of a new waste management organization, could allay concerns that a new strategy and approach will produce further delay and would provide a near-term demonstration of the continued determination of the federal government to meet its obligations under the Nuclear Waste Policy Act.

## 7.8 Key Findings

- U.S. and international experience suggests that a more flexible, phased, and consent-based approach is likely to achieve more timely, cost-effective, socially accepted, and ultimately successful facility siting outcomes than have been typical of the U.S. waste management program to date. Programs in Canada, Finland, France and Sweden, in particular, offer useful insights for redesigning the U.S. approach to siting.
- Site screening criteria should be developed prior to the siting process by a new implementing organization in consultation with stakeholders.
- The new waste management organization should be responsible for establishing overall and intermediate program goals and milestones. These goals and milestones should be articulated in a regularly updated mission plan. The need for clear goals and milestones to ensure that the program is moving forward must be balanced with the need for flexibility to ensure that the program can adapt to unforeseen circumstances.

- Any site for a consolidated interim storage or permanent disposal facility that has met all regulatory requirements and has been selected with consent at the local, tribe and state level should require no additional approval, including congressional approval.
- Once one or more sites are selected, pilot, test, and demonstration facilities (including *in situ* RD&D facilities) should be located in parallel with other underground activities and operations undertaken at the site(s) to improve performance and safety and reduce residual uncertainties.
- States, tribes, and local governments have an important role to play in siting and developing of regulations for nuclear waste management and disposal facilities. That said, the Subcommittee believes the veto/override provisions of the NWPA would not be needed in the context of the kind of consent-based siting process we have proposed. Experience with the siting of nuclear facilities and other controversial infrastructure suggests that giving affected state, local, and tribal governments a meaningful degree of input and control in regulatory decision-making is critical to winning their support.
- The waste management organization should consult with any affected state, unit of local government, or Indian tribe, to include all reasonable and appropriate provisions relating to their interests in negotiated agreements. The roles, responsibilities, and authorities of local, state, and tribal governments must be an important element of negotiations with these governments. The host state, tribal and local governments should have the opportunity to become partners with the waste management organization in repository development or should, at a minimum, enter into a court-enforceable agreement with the waste management organization to ensure that commitments to the state, tribes and local governments are upheld. Likewise, after a disposal facility begins operation, any proposals to modify or expand the mission of the facility should also involve the negotiation of a new, legally binding agreement governing changes in the facility mission.
- For a complicated and technically-involved issue like the development of a nuclear waste repository, the inability of citizens and citizen groups to access the necessary technical expertise and to cover other expenses (i.e., traveling to meetings) can be a major barrier to participation. For this reason, making funding and other resources—including access to independent sources of scientific and technical expertise—available to these groups will be critical to enabling their active participation in the siting process.



## 8. REGULATING THE PERFORMANCE OF DISPOSAL FACILITIES

The 1987 NWPA states that “the federal government has the responsibility to provide for the permanent disposal of high-level radioactive waste and SNF to protect the public health and safety and the environment....Appropriate precautions must be taken to ensure that these [radioactive] materials do not adversely affect the public health and safety and the environment for this or future generations.”

EPA and NRC have the responsibility for developing and implementing regulations to ensure that this goal would be met.<sup>166</sup> EPA is responsible for issuing “generally applicable standards for protection of the general environment from offsite releases from radioactive material in repositories.” These standards apply to the management and storage of waste during the operational period, as well as to the performance of a disposal facility during the post-closure period (i.e., after waste is no longer being actively emplaced). The law also directs the NRC to issue “requirements and criteria” to be used in approving construction, operation, and closure of repositories. These criteria, which may not be inconsistent with the standards issued by EPA, must require a repository to use a system of multiple barriers and must include any restrictions on the retrievability of the emplaced waste that the NRC deems appropriate. In addition, the NRC is responsible for regulations dealing with nuclear materials safeguards and security and also with protection of facility workers from radiological exposures. Other categories of worker protections are the responsibility of OSHA. Finally, the DOT has direct regulatory responsibility for important aspects of the systems and practices used to transport radioactive wastes, while the Department of Homeland Security and other agencies play a role in addressing security and counter-terrorism-related issues involving nuclear facilities and materials. The remainder of this section discusses the regulations for final disposal, safeguards and security, and operational health and safety. It also reflects current arrangements under which authority for establishing regulations and evaluating compliance is held by the federal regulatory agencies; as discussed previously, we recommend that state and tribal governments have the opportunity to negotiate important roles in aspects of regulation, permitting and operational oversight.

### 8.1 Issues and Challenges in Setting Regulatory Standards for Disposal Facilities

The greatest challenges in developing regulations for the disposal of high-level waste and spent fuel relate to protecting public health and safety and the environment over the extremely long time periods of concern after a repository has been filled and closed. This section discusses these challenges as they relate to the role of regulations in assuring that the health and safety objectives of the NWPA are met by any future facility for the disposal of high-level radioactive waste in the United States. We begin by reviewing the general aims of geologic disposal, as articulated in international policy guidance.

In its 2006 *Safety Requirements* report, the IAEA elaborated on the basic aims of geological disposal:

- To contain the waste until most of the radioactivity, and especially that associated with shorter lived radionuclides, has decayed;
- To isolate the waste from the biosphere and to substantially reduce the likelihood of inadvertent human intrusion into the waste;

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<sup>166</sup> EPA also has sole responsibility under other federal legislation for regulations to address other types of non-radiological health risks and environmental impacts.

- To delay any significant migration of radionuclides to the biosphere until a time in the far future when much of the radioactivity will have decayed; and
- To ensure that any levels of radionuclides eventually reaching the biosphere are such that possible radiological impacts in the future are acceptably low.

The IAEA also went on to state, however, that “The aim of geological disposal is *not* to provide a guarantee of absolute and complete containment and isolation of the waste for all time” (emphasis added).

The task for regulators is to translate these general aims into specific “standards,” by which we mean the technical performance requirements that must be met to license a facility for the safe disposal of SNF and high-level waste. Governmental authorities in a number of countries have developed such standards; in addition, leading international organizations such as the Nuclear Energy Agency (NEA)<sup>167</sup> and the IAEA have published useful recommendations or guidance in this area. A survey of these efforts reveals considerable variation in the details of different countries’ approaches, as well as a number of common themes and emerging trends. This section summarizes recent general guidance on key aspects of disposal regulations for geologic disposal from the IAEA and NEA, as well as current approaches in individual countries like the United States, Canada, Finland, and Sweden.

In the United States, there are currently two sets of federal regulatory standards for high-level radioactive waste disposal repositories—one set that was developed specifically for Yucca Mountain and another, earlier set that would, under current law, apply to all other sites (this earlier, generic set of standards was essentially complete by the time Congress directed the development of Yucca Mountain-specific standards in 1992; see further discussion in the text box).<sup>168</sup>

Because the thinking about repository regulations evolved considerably during the development of the Yucca Mountain requirements, the Subcommittee concludes that the earlier generic regulations that would currently apply to all other sites will need to be revisited and revised. In addition, the Commission has heard a range of views, both about broader reforms to the current U.S. regulatory framework for geologic disposal facilities and about specific changes to existing repository requirements. We have addressed some of the broader reform questions, but have not attempted to develop specific recommendations concerning the appropriate form and stringency of regulatory standards for disposal facilities. Resolving these issues will involve societal value judgments that should be mediated through the normal regulatory development process. In that process, EPA, NRC, and other agencies can and should draw from an extensive literature and considerable regulatory experience to make appropriate determinations for assuring safe and secure nuclear waste disposal in this country.

The remainder of this section briefly reviews some of the most important and controversial technical and policy issues to be resolved in setting performance standards for disposal facilities, before offering some general principles to guide the development of future regulations in the United States.

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<sup>167</sup> The NEA is an agency of the Organization for Economic Cooperation and Development (OECD), which includes the world’s major industrialized economies.

<sup>168</sup> EPA’s portion of the general standards is also applied to the WIPP and is currently in use there.

## **U.S. Disposal Facility Regulations**

### “Generic” EPA and NRC Regulations

EPA standards for all sites other than Yucca Mountain are defined under 40 CFR Part 191, “Environmental Radiation Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes” (with additional “implementation and compliance criteria” specifically for WIPP found in Part 194.33). This regulation was first issued in 1985, remanded by a federal court for reconsideration of certain provisions, and reissued in 1993 to apply only to geologic disposal facilities other than Yucca Mountain (see below).

The core of Part 191’s disposal standard is a “containment” requirement designed to protect human populations by limiting the cumulative releases of key radioactive isotopes over the 10,000-year period following closure of a disposal facility. Compliance is to be demonstrated by use of quantitative performance assessments that take into account “all significant processes and events” to show that there is a “reasonable expectation” (not absolute proof) that cumulative releases for a number of specific isotopes will have a low likelihood (less than one chance in 10 for low releases and less than one chance in 1,000 for higher releases). The EPA regulation also includes an individual protection requirement, which stipulates that for 10,000 years there should be a reasonable expectation that no member of the public will receive an annual dose greater than 15 millirems (150 microsieverts), considering only the undisturbed performance of the repository (rather than all significant processes and events, as required for the containment standard).

NRC regulations for all sites other than Yucca Mountain are defined in 10 CFR Part 60, “Disposal of High-Level Radioactive Wastes in Geological Repositories.” These regulations were originally issued in 1983 (before EPA’s standards had been completed) and revised in 1987 to reflect the NWPAA Act of 1987. NRC’s regulation applies specifically to mined repositories and incorporates EPA’s first set of generally applicable standards by reference, and includes additional performance requirements for specified individual barriers in the repository system.

### More Recent Yucca Mountain Regulations

The Energy Policy Act of 1992 directed EPA to issue an individual dose standard for Yucca Mountain, based upon and consistent with recommendations by the NAS. The process to develop this EPA standard (40 CFR Part 197) and matching NRC implementing regulations (10 CFR Part 63) was complex—it involved an NAS study, multiple lawsuits, and another court remand that required EPA to reconsider certain provisions it had initially proposed. As a result, it was not completed until 2008. The EPA Yucca Mountain standard limits doses to members of the public (not total releases of specified radioactive materials) and extends to 1,000,000 years (consistent with a recommendation of the NAS study), with a 15 millirem limit for the first 10,000 years and a 100 millirem limit thereafter. The NRC Yucca Mountain regulations incorporated the new EPA standard and dropped the performance standards for individual repository barriers that are contained in the generic regulations (10 CFR Part 60).

### **8.1.1 Health Protection Objectives**

Since long-term protection of human health is one of the core functions of geologic disposal, effectiveness in limiting the public’s future exposure to radioactivity is generally considered to be one of the most important criteria used in deciding whether to move forward with a particular repository site

and design. In the United States and internationally, two general approaches to limiting exposures have been proposed for nuclear waste repositories:

1. A dose-based or risk-based standard (the two are essentially equivalent in practice) that limits the exposure to individuals resulting from radiation releases from the repository; or
2. A release-based standard that limits the amount of radioactive material that is allowed to escape the repository.

To date, several countries and international advisory bodies have developed numeric criteria—either in the form of a dose constraint, a risk limit, or sometimes both—for human health protection in the context of geologic disposal. (The only example of primary reliance on a release-based standard is EPA’s 40 CFR Part 191, applicable to repositories other than Yucca Mountain.<sup>169</sup>) Dose constraints are commonly given in millisieverts (mSv) per year (where 1 mSv equals 100 millirems), while risk limits are typically expressed in terms of the probability that an exposed individual would suffer adverse genetic or health impacts (i.e., cancer). Dose constraints can be converted to risk limits and vice versa (e.g., a dose constraint of 0.3 mSv per year translates to a risk equivalent of 1 in 100,000 per year or  $10^5$ /yr) risk of getting cancer.

Based on recommendations developed by the International Commission on Radiological Protection, current NEA and IAEA guidance recommends a dose constraint of 0.3 mSv/year. Dose limits in place for different countries’ waste management programs range from less than 0.1 mSv/year up to 1.0 mSv per year—an order of magnitude difference. (By comparison, regulations for the proposed Yucca Mountain repository in the United States established an annual peak dose constraint of 0.15 mSv for the first 10,000 years and 1.0 mSv<sup>170</sup> for the period after 10,000 years and up to 1 million years.<sup>171</sup>) However, ***the stringency of a given standard depends critically not only on the numeric level of the standard but on the timeframe over which it is applied, the methodology that is used to demonstrate compliance, and the standard of proof (or level of confidence) that is required for the demonstration.*** Each of these parameters is discussed further below.

### 8.1.2 Regulatory Timeframe

The long-lived nature of the radiological hazard posed by SNF and high-level waste creates a tension between the objective of protecting future generations on the one hand, and the inherent practical difficulties of making very long-term predictions about human and natural systems on the other hand. As a result, the question of appropriate timescales for purposes of risk assessment and regulatory compliance determinations remains a subject of active national and international debate.<sup>172</sup>

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<sup>169</sup> This standard has been successfully applied at the WIPP.

<sup>170</sup> The recommended dose limit for members of the public from all practices is an effective dose of 1.0 mSv in a year. The 0.3 mSv criterion for a repository is derived through a process called apportionment, which divides the total dose limit into a smaller limit for any individual practice so that the total from all allowed practices would be below the overall limit. EPA adopted the total limit for the very long term based on a view that it would not be necessary to allow for other human-produced sources of exposures in the far future.

<sup>171</sup> To put these numbers in perspective, the National Council on Radiation Protection and Measurements estimates that the average American is currently exposed to approximately 6.2 mSv (620 millirems) of radiation per year, of which roughly half is from natural background sources and half is from man-made sources.

<sup>172</sup> A good discussion of this and other issues involved in setting standards for geologic disposal is found in Edward D. Blandford, Robert J. Budnitz, and Rodney C. Ewing, “What does 1 million years mean to a regulator?,” *Nuclear News* (November 2011).

In the United States, the EPA initially proposed a compliance timeframe of 10,000 years for the proposed Yucca Mountain repository; however, this limit was later increased to 1 million years.<sup>173</sup> Many individuals have told the Commission that it is unrealistic to have a very long (e.g., 1 million year) requirement for demonstrating compliance in a traditional regulation; the Commission agrees. Meanwhile, several countries have not yet decided this issue, while others have opted for shorter timeframes (10,000 to 100,000 years), developed different kinds of criteria for different timeframes, or avoided the use of a hard “cut-off” altogether and instead opted to require a demonstration that the proposed facility is at very low risk for catastrophic disruptions that could lead to large-scale releases of radioactivity.

Some countries (i.e., Finland and Sweden) have more stringent regulations for the first few thousand years after repository closure, compared with the period from 1,000 years to 100,000 or 1,000,000 years. In doing so, they acknowledge the fact that uncertainties in predicting geologic processes, and therefore the behavior of the waste in the repository, increase with time. NEA and IAEA have not issued guidance on timeframes, although the IAEA has cautioned that “[c]are needs to be exercised in using the criteria beyond the time where the uncertainties become so large that the criteria may no longer serve as a reasonable basis for decision making.”<sup>174</sup> Different approaches to this issue could include developing different kinds of criteria for different timeframes. For example, Finland has developed specific release limits for several different types of radionuclides to apply in the long term, beyond the period for which the dose constraint applies. Alternatively, a practical goal for very long timeframes may be to demonstrate that the proposed facility is at very low risk for catastrophic failure. Along these lines, Swedish regulations call for a risk analysis that illustrates “the long-term development of the repository’s barrier functions and the importance of major external disturbances...such as earthquakes and glaciations” beyond 100,000 years, but also state that “a strict quantitative comparison of calculated risk in relation to the criterion for individual risk in the regulations is not meaningful.”

### 8.1.3 Compliance Methodology

As critical as the form and stringency of the standards is the decision about what approach or methodology will be used to determine whether they have been met. Since the promulgation of EPA’s standards for geologic disposal facilities in 1985, the use of quantitative performance assessment to project the levels of the primary performance measures (cumulative radionuclide releases in 40 CFR 191 and individual dose in 40 CFR 197) for comparison with the standards has been central to the test of compliance. In fact, the requirement that compliance be based on performance assessment is embedded directly in the statement of the EPA standards.<sup>175</sup> (Notably, the statements of secondary

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<sup>173</sup> The change came in response to a legal challenge charging that EPA was required by law to follow the recommendation issued by the NAS in 1995 that compliance should be measured at the time of peak dose within the period of geologic stability for Yucca Mountain, which the NAS found to be on the order of 1 million years.

<sup>174</sup> IAEA, *Geological Disposal of Radioactive Waste*, IAEA Safety Standards Series No WS-R-4, IAEA, Vienna, 2006

<sup>175</sup> 40 CFR § 191.13 Containment requirements. (a) Disposal systems for SNF or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, **based upon performance assessments**, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall: (1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to table 1 (appendix A); and (2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to table 1 (appendix A).

40 CFR § 197.20 What standard must DOE meet? (a) The **DOE must demonstrate, using performance assessment**, that there is a reasonable expectation that the reasonably maximally exposed individual receives no more than the following annual committed effective dose equivalent from releases from the undisturbed Yucca Mountain disposal system: (1) 150 microsieverts (15 millirems) for 10,000 years following disposal; and (2) 1 millisievert (100 millirems) after 10,000 years, but within the period of geologic stability. (b) The DOE’s performance assessment must include all potential pathways of radionuclide transport and exposure.

performance standards – groundwater protection in parts 191 and 197, and human intrusion in 197 – do not include performance assessment as part of the standard,<sup>176</sup> and use of performance assessment to demonstrate compliance with those standards is not absolutely required. Over the last decade or more, however, there has been increasing attention worldwide to approaches that integrate both quantitative and qualitative lines of argument in a comprehensive safety case to show that a repository will remain safe after the ability to monitor the repository is lost.<sup>177</sup> This shift has been motivated in part by increasing recognition of the inherent limitations to quantitative projections over geologic time periods.<sup>178</sup>

Instead of focusing on comprehensive calculations of projected dose levels to populations hundreds of thousands of years or more in the future, for example, the safety case analysis used to support regulatory demonstrations of compliance might use such calculations for an initial period of time over which the calculations would be most defensible, and then follow the evolution of troublesome radionuclides in the given geologic environment over the longer term using other existing and compelling scientific knowledge.<sup>179</sup> For example, Finnish regulators require quantitative assessment where possible, but also call for the use of complementary considerations when quantitative analyses are not feasible or are too uncertain.<sup>180</sup>

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<sup>176</sup> For example, 40 CFR § 197.30, what standards must DOE meet? The DOE must demonstrate that there is a reasonable expectation that, for 10,000 years of undisturbed performance after disposal, releases of radionuclides from waste in the Yucca Mountain disposal system into the accessible environment will not cause the level of radioactivity in the representative volume of ground water to exceed the limits in the following table 1:”

<sup>177</sup> Canada’s regulations, for example, call for developing a long term safety case that combines a safety assessment with complementary arguments based on (1) appropriate selection and application of assessment strategies, (2) demonstration of system robustness, (3) the use of complementary indicators of safety, and (3) any other evidence available to provide confidence in the long term safety of the proposed system. Similarly, Finnish regulations call for a safety analysis that includes (1) a description of the disposal system and definition of barriers, (2) an analysis of the future evolution of the system, (3) definition of performance targets for individual barriers, (4) functional description of the disposal system by means of conceptual and mathematical modeling, (5) analysis of activity releases and resulting doses from radionuclides that penetrate the barriers and enter the biosphere, (6) estimates of the probabilities of activity releases and radiation doses arising from unlikely disruptive events, (7) uncertainty and sensitivity analyses, and (8) comparison of the outcome of the safety analysis with safety requirements.

<sup>178</sup> “We have recognized the strong consensus in the international radioactive waste community that dose projections extending many tens to hundreds of thousands of years into the future can best be viewed as qualitative indicators of disposal system performance, rather than as firm predictions that can be compared against strict numerical compliance criteria. In fact, international organizations have treated such numerical criteria in a more flexible way and supported their application in conjunction with other qualitative considerations in applying them to regulatory determinations over very long time frames. Further, we agree that confidence in the way the projections were performed, and the consideration of supporting qualitative information, may be more important to an overall judgment of safety at longer times.” U.S. Environmental Protection Agency (EPA), Preamble to 40 CFR Part 197, Public Health And Environmental Radiation Protection Standards For Yucca Mountain, Nevada, Final Rule, 73 FR 61266, October 15, 2008.

<sup>179</sup> See, for example, Rodney C. Ewing, “Standards & regulations for the Geological Disposal of Spent Nuclear Fuel and High Level Waste,” prepared for the Blue Ribbon Commission on America’s Nuclear Future, March 4th, 2011 [http://www.brc.gov/library/commissioned\\_papers/EWING%20BRC%20white%20paper%20FINAL.pdf](http://www.brc.gov/library/commissioned_papers/EWING%20BRC%20white%20paper%20FINAL.pdf) .

<sup>180</sup> Jukka Laaksonen (Director General, Radiation and Nuclear Safety Authority (STUK), Finland), “Regulatory Aspects of Radioactive Waste Disposal – the Finnish Approach,” presented at the conference on Geological Repositories: A Common Objective, a Variety of Paths, October 15 – 17, 2007, Berne, Switzerland.

We recognize that performance assessment is valuable as a systematic method for organizing the understanding of a geologic repository<sup>181</sup> and focusing the information used to support a compliance demonstration.<sup>182</sup> We also recognize that a broader range of factors than the results of the performance assessment alone, such as the demonstration of multiple barriers and a performance confirmation program, are to be considered in a licensing decision,<sup>183</sup> so that many elements of a broader safety case are already required.<sup>184</sup> Nonetheless, the heavy emphasis on quantitative performance assessment as an integral part of the safety standards in US repository regulations may lead to an overemphasis on showing numerical compliance that could obscure understanding of the actual operation of the disposal facility system<sup>185</sup> and divert attention from the overall strategy for the safe disposal of nuclear waste.<sup>186</sup> Furthermore, a focus on meeting a quantitative goal may foster adoption of conservative assumptions in the performance assessment that can potentially skew design decisions.<sup>187</sup> In issuing its final rule for Yucca Mountain, which includes a quantitative limit on peak dose out to a period of about 1 million years, EPA recognized the diminishing weight that should be placed on quantitative calculations over such long time periods, noting that emphasizing small differences in highly uncertain dose projections

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<sup>181</sup> “Despite these possible shortcomings, no one can seriously doubt the value of a performance assessment as a systematic and disciplined means of organizing one’s understanding of a geologic repository. The results of a performance assessment can be used to identify the major sources of uncertainty and the deficiencies in conceptual models; focus intellectual and financial resources on the key issues that most affect repository performance; and evaluate alternative designs and strategies for nuclear waste containment.” Rodney C. Ewing, “Performance Assessments: Are They Necessary or Sufficient?”, in *Uncertainty Underground: Dealing with the Nation’s High-Level Nuclear Waste Policy and Scientific Issues*, R. Ewing and A. Macfarlane, eds., MIT Press, 2006, P. 76.

<sup>182</sup> The NRC points out that “Current U.S. regulations for Yucca Mountain use a performance assessment as a focal point for organizing the information used to support the compliance demonstration...” *U.S. Nuclear Regulatory Comments Regarding Blue Ribbon Commission July 2011 Draft Report to the Secretary of Energy*

<sup>183</sup> “In response to concerns expressed during development of 10 CFR 63 that performance assessments would be relied upon as the sole quantitative technique for evaluating compliance with postclosure safety requirements, the NRC stated: “Although repository post-closure performance is evaluated with respect to a single performance measure for individual protection, the NRC considers a broad range of information in arriving at a licensing decision. In the case of the proposed repository at Yucca Mountain, Part 63 contains a number of requirements (e.g., qualitative requirements for data and other information, the consideration and treatment of uncertainties, the demonstration of multiple barriers, performance confirmation program, and QA program) designed to increase confidence that the post-closure performance objective is satisfied. The Commission will rely on the performance assessment as well as these other requirements in making a decision ...” 66 Federal Register 55746, November 2, 2001.

<sup>184</sup> “The Nuclear Regulatory Commission does not use the term “safety case” for the analysis of post-closure safety (which is of most relevance here), but the applicant is required to carry out a performance assessment and a safety analysis. Regulations describe specific requirements for the safety analysis (see Title 10 of the Code of Federal Regulations Part 63.114) and these are broadly similar to the safety case concept described by the committee. When one compares requirements for the safety analysis with the characteristics of the safety case, a similar set of technical issues is addressed in each.” National Research Council, *One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste*, 2003, p. 6.

<sup>185</sup> An independent NEA/IAEA review of the performance assessment of Yucca Mountain performed to support the site recommendation (TSPA-SR) concluded that it provided an adequate basis for statements concerning likely compliance with the regulations, but noted the need for more realistic assessments that demonstrated an understanding of system behavior that is masked by more conservative compliance-oriented analysis. The review also noted that “The way the regulations are formulated has contributed to the tendency of the TSPA-SR to focus more on demonstrating numerical compliance with quantitative criteria than on demonstrating an understanding of repository performance.” OECD, *Joint NEA-IAEA International Peer Review of the Yucca Mountain Site Characterisation Project’s Total System Performance Assessment Supporting the Site Recommendation Process, Final Report*, December 2001.

<sup>186</sup> “Treating the results [of performance assessment] as “quantitative” causes regulatory agencies to concentrate on the numbers rather than the strategy for the safe disposal of nuclear waste. PA is a necessary part of the political and regulatory process, but it may be of limited value in supporting strategies for safe disposal of nuclear waste. PA is not, by itself, a sufficient basis for determining that a site is safe for the disposal of SNF or HLW. In fact, PA can become an Achilles Heel of such an effort, as controversy focuses on details of the analysis rather than the overall case for safety.” Ewing 2011, op. cit.

<sup>187</sup> Electric Power Research Institute, *Occupational Risk Consequences of the Department of Energy’s Approach to Repository Design, Performance Assessment and Operation in the Yucca Mountain License Application*, Technical Update, August 2008, [http://my.epri.com/portal/server.pt?Abstract\\_id=00000000001018058](http://my.epri.com/portal/server.pt?Abstract_id=00000000001018058).

“inappropriately takes attention away from an evaluation of the overall safety of the disposal system, which may rest equally on other lines of evidence, such as confidence in the long-term stability of the site or reference to natural analogues.”<sup>188</sup> Nonetheless, the language of the EPA regulation itself does not reflect this recognition, since it makes no distinction between the role of the performance assessment in demonstrating compliance for the first 10,000 years and its role in demonstrating compliance over the very long term, retaining the use of performance assessment as an integral part of the standard for both time periods. The Subcommittee believes that the need for flexibility in the demonstration of compliance with any very long term quantitative performance standard would better be reflected by removing the requirement for performance assessment from the statement of the standard itself (making it similar to the current human intrusion standard) and instead including it as one of the set of methods to be used in formulating the overall safety case for compliance.<sup>189</sup>

#### **8.1.4 Standard of Proof for Compliance Demonstrations**

The "standard of proof" for compliance demonstration should be viewed as integral to a long-term repository performance standard. While EPA disposal facility regulations (both generic and Yucca Mountain-specific) require the use of quantitative performance assessments to show compliance with quantitative standards, EPA also stated that “unequivocal proof of compliance is neither expected nor required because of the substantial uncertainties inherent in such long-term projections.” Instead the licensee must demonstrate a “reasonable expectation” of compliance with standards for the post-closure period. EPA included the same standard of proof in the Yucca Mountain regulation.

EPA explicitly chose not to use the traditional NRC standard of proof, “reasonable assurance,” for the post-closure compliance demonstration because the phrase “reasonable assurance” (which was developed in the context of operating facilities under active institutional controls during their lifetimes) “... has come to be associated with a level of confidence that may not be appropriate for the very long-term analytical projections that are called for by [the disposal standard]. The use of a different test of judgment is meant to acknowledge the unique considerations likely to be encountered upon implementation of these disposal standards.” The NRC used “reasonable assurance” as the standard of proof for both pre-closure and post-closure standards in 10 CFR Part 60 and during most of the development of the Yucca Mountain regulations. However, the NRC also made it clear that in the context of assessing the long-term safety of geological disposal, “reasonable assurance” was meant to convey the same concept as “reasonable expectation”—in other words, that “proof” cannot be provided in the ordinary sense of the word because of uncertainties inherent in the understanding of geologic setting, biosphere, and engineered barriers. The implementation of this concept for regulatory purposes would be expected to be the same, regardless of the difference in terminology; “reasonable assurance” was not intended to imply a requirement for more stringent analyses.<sup>190</sup> To avoid any misunderstanding and to achieve consistency with final EPA standards, the NRC adopted EPA’s approach of applying a “reasonable expectation” standard to the post-closure period while using a “reasonable assurance” standard for the operation of the facilities during the pre-closure period (consistent with the NRC’s practice for other licensed operating facilities subject to active licensee oversight and control).<sup>191</sup>

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<sup>188</sup> EPA, *op. cit.*, pp. 61265- 61266.

<sup>189</sup> Such an approach is found in EPA’s regulations for mill tailings, which allow the 1,000-year quantitative standards to “be implemented through analysis of the physical properties of the site and the natural processes over time..... Computational models, theories, and prevalent expert judgment may be used to decide that a control system design will satisfy the standard.” 40 CFR § 192.20

<sup>190</sup> U.S. Nuclear Regulatory Comments Regarding Blue Ribbon Commission July 2011 Draft Report to the Secretary of Energy.

<sup>191</sup> 66 FR 55740; November 2, 2001



### 8.1.5 Other Protection Requirements

Protection of the natural environment (along with, but distinct from, human health *per se*) is widely accepted as an important objective of geologic disposal; however, there has been less convergence internationally around how to assess this objective and develop appropriate criteria. A recent (2010) NEA review of regulatory developments pertaining to geologic disposal describes a number of national and international efforts—some ongoing—to develop ways of accounting for the long-term protection of flora and fauna. Meanwhile, existing regulations in Canada, Finland, Sweden, Switzerland, and the UK address impacts on non-human organisms and biodiversity in qualitative terms; several countries also require that these impacts be explicitly included in future risk and performance assessments. In addition, EPA’s standards for the disposal of high-level radioactive waste and TRU waste include a separate groundwater standard designed to protect groundwater as a resource.

### 8.1.6 Division of Regulatory Responsibility between EPA and NRC

Many witnesses have recommended that future EPA and NRC regulatory requirements be made fully consistent with each other. Some have also pointed out that it would be far better if such a rationalization or harmonization happened before any future disposal sites were identified, even for screening purposes, to avoid or at least minimize the perception by stakeholders and the general public that standards are being set to ensure that one or more (pre-selected) sites will meet them. The Subcommittee strongly agrees with both points. The need for consistency between the standards of the two agencies seems particularly important for individual protection requirements, which have been a clear point of contention in the past; however, it is likely to be relevant for many other specific issues as well.

Based on comments to the BRC draft report received from both the NRC and the EPA on the BRC draft report as well as additional investigation of the issue, the Subcommittee concludes that while coordination between 1982 and 1987 was not what it could have been, it has markedly improved since then. Several institutional improvements have been made over the last 15 years that provide a basis for optimism that the new sets of regulations called for elsewhere in this report can be developed in a timely manner and in a way that ensures consistency between them while preserving the long-standing definition of the various realms of responsibility of the two agencies.<sup>192</sup>

The following example demonstrates the current situation for exchange of information and other coordination activities. In 1995, a formal interagency committee, the Interagency Steering Committee on Radiation Standards (ISCORS), was established to improve consistency in Federal radiation protection programs and to create a forum for Federal agencies to keep informed of national and international

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<sup>192</sup> The distinction between the legal responsibilities of EPA and NRC can be traced back for decades, in the case of the NRC, to the original Atomic Energy Act, and for EPA, to the Presidential Executive Order that first created it (primarily by transferring both legal authorities and personnel from other federal agencies) in 1970. A useful if colloquial distinction is that EPA’s responsibilities are primarily for conditions “outside the fence” of disposal facilities (e.g., exposure standards, releases to the general environment, etc.), while NRC’s responsibilities are for equipment and operations “inside the fence” (e.g., equipment design and operation, emergency response capabilities, etc.) Two other important distinctions which have been relevant for WIPP and are likely to be important for future high-level waste disposal facilities is that EPA regulates primarily through the issuance of permits, and under many federal laws, this permitting authority can be delegated to other level of government, e.g. states. In contrast, the NRC exercises its authority primarily through licenses (e.g., a license to construct a facility), and for the types of wastes associated with the back end of the nuclear fuel cycle, it cannot delegate this authority to another level of government (e.g., a state).

radiation protection activities. The ISCORS consists of eight Federal agencies<sup>193</sup>, three Federal observer agencies<sup>194</sup> and two state observer agencies<sup>195</sup> with other state representatives routinely participating on different subcommittees. It is co-chaired by NRC and EPA representatives and meets publicly at least once in year. Current subcommittees include those on Cleanup, Federal Guidance, MARSSIM (Multi-Agency Radiation Survey and Site Investigation Manual), NORM (Naturally- Occurring Radioactive Materials) and Risk Harmonization.

Finally, we note that the Subcommittee and indeed the full Commission received and carefully considered recommendations for a fundamental redrawing of regulatory roles and responsibilities at the federal level (i.e., transferring all regulatory authority to either the NRC or EPA). The Subcommittee has concluded that while there are opportunities for improvement in the EPA/NRC regulatory process and in the working relationship between these agencies, the general division of roles and responsibilities that currently exists between EPA and NRC is appropriate and should be preserved. We return to this point in the next section.

### **8.1.7 Developing New Standards for New Repository Sites**

The Disposal Subcommittee has heard comments from many parties urging that the NRC's review of the Yucca Mountain license application be completed so that the results of this review may inform future repository licensing efforts in the U.S. and abroad. The Subcommittee has also heard a range of views from witnesses concerning the appropriate regulatory elements to be applied to future geologic repository development efforts. However, we have not attempted to develop specific recommendations concerning the form and stringency of regulatory standards for geologic disposal facilities in the United States. It is clear to us that after more than 30 years of experience developing and applying EPA and NRC regulations—both for repositories in general and for WIPP and Yucca Mountain in particular—the critical questions have been identified even if there is not yet full agreement on how they should be answered (see text box below).

The Subcommittee has not attempted to reach consensus about how to resolve these questions since they involve societal value judgments that should be mediated through the regulatory development process. In sum, we believe existing regulatory authorities—notably EPA and NRC—can draw from an extensive literature and considerable regulatory experience (including both the original generic regulations and Yucca Mountain specific regulations) to make the regulatory determinations that are appropriate and necessary to guarantee safe and secure nuclear waste disposal in this country. Most of the philosophy that has guided regulatory development to date evolved in the context of developing of regulations for Yucca Mountain. Some of these regulations have been already challenged and resolved in the courts. Those aspects of the Yucca Mountain regulations that are not uniquely associated with that particular site should serve as a good starting point for developing a new set of generic regulations.

Without making specific recommendations regarding the standards to be applied to geologic disposal facilities or other waste management facilities, the Subcommittee does offer a number of general principles or propositions to guide the development of future regulations:

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<sup>193</sup> US NRC, US EPA, US DOE, US DOD, US DHS, US DOT, the Occupational Safety and Health Administration of the US Department of Labor and US Department of Health and Human services

<sup>194</sup> Office of Science and Technology Policy, Office of Management and Budget, Defense Nuclear Facilities Safety Board

<sup>195</sup> The current state representatives are Steve Collins (Illinois) and David j. Allard (Pennsylvania).

1. The standard and supporting regulatory requirements to license a geologic repository should be completely generic—that is, applicable to all potential sites.

While there may be advantages to developing standards and requirements that recognize the specific features and characteristics of a particular site, experience with Yucca Mountain indicates that this approach can create suspicions that the regulations are simply being tailored to make a pre-selected site “work”. Generally-applicable regulations are more likely to earn public confidence. In addition, having a generic standard will support the efficient consideration and examination of multiple sites.

2. Regulatory standards and requirements for compliance demonstrations (including the required level of confidence in the demonstration or “standard of proof”) should not go beyond what is scientifically possible and reasonable.

Both the standards themselves and the process used to demonstrate that they have been met must be credible to the scientific community and the public. The Subcommittee has heard the view that some aspects of the current Yucca Mountain regulations lack credibility in both areas. A specific concern is the requirement that the compliance demonstration be primarily based on a complex quantitative projection of repository performance for 1 million years. While making calculations over such a long time horizon might be appropriate as a part of establishing a broader safety case, the Subcommittee believes that over-reliance on million-year calculations can reduce credibility rather than enhance it. We note again the IAEA’s warning that “care needs to be exercised in using the criteria beyond the time where the uncertainties become so large that the criteria may no longer serve as a reasonable basis for decision making.”<sup>196</sup>

Whatever the time frame, the standard of proof for compliance should likewise be based on what is scientifically achievable. As discussed above, both existing sets of generic repository and Yucca Mountain-specific regulations emphasize that absolute proof in the normal sense of the word is not possible over long time periods. They therefore stipulate that compliance determinations should be based on a “reasonable expectation” that the standards will be met. This is the standard of proof defined by EPA<sup>197</sup> and ultimately adopted by the NRC for its Yucca Mountain regulations. The Subcommittee has heard that this approach has proved workable in both the WIPP and Yucca Mountain contexts; accordingly, we recommend that it be carried over into new regulations.

3. Rules for demonstrating compliance and for documenting the required level of confidence in the compliance demonstration (i.e., the standard of proof) should be defined at the same time that the performance standards are developed.

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<sup>196</sup> *Geological Disposal of Radioactive Waste: Safety Requirements*, IAEA Safety Standards Series No WS-R-4, IAEA, Vienna, 2006 (available at: [http://www-pub.iaea.org/MTCD/publications/PDF/Pub1231\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/Pub1231_web.pdf)).

<sup>197</sup> EPA’s position on reasonable expectation was challenged as being arbitrary and capricious in the lawsuit that led to the remand of parts of 40 CFR 191 in 1987. Nevertheless, EPA’s position was upheld by the Court: “Given that absolute proof of compliance is impossible to predict because of the inherent uncertainties, we find that the Agency’s decision to require “reasonable expectation” of compliance is a rational one. It would be irrational for the Agency to require proof which is scientifically impossible to obtain. Any such purported absolute proof would be of questionable veracity, and thus of little value to the implementing agencies. Nor can we say that this provision is arbitrary and capricious because it will afford the implementing agencies a degree of discretion, since such imprecision is unavoidable given the current state of scientific knowledge” (Natural Resources Defense Council v. U.S.E.P.A., 824 F.2d 1258).

### Key Questions in Setting a Regulatory Standard for Deep Geological Disposal

- What should the basis be: a desired level of protection or what is reasonably achievable using today's technology?
- For how long must compliance be demonstrated?
- Who is to be protected—individuals or populations?
- What is the desired level of protection?
- What is the measure of compliance (e.g., doses to individuals vs. releases to the environment)?
- How should compliance be demonstrated—primarily through quantitative calculations or through a broader safety case that involves qualitative as well as quantitative considerations?
- What level of confidence is required?
- How should the potential for human intrusion be addressed?
- How should retrievability be addressed?
- Can compliance take credit for institutional controls and if so, for how long?
- Should groundwater be separately protected?
- Should there be performance requirements for sub-elements of a repository (e.g., the waste package or the geologic setting)?

Rules for demonstrating compliance (including meeting the standard of proof) are an integral part of any regulatory standard. These rules should be developed as a part of the process for developing the overall standard and should be applied in the way that was expected when the performance standard was adopted. This is particularly important when different agencies are charged with setting the standard (EPA) and implementing the standard (NRC). In these cases, the potential exists for different agencies to apply different regulatory philosophies to the same standard.<sup>198</sup>

#### 4. Standards for a disposal facility should explicitly recognize and facilitate an adaptive, staged approach to development.

Current EPA and NRC regulations were developed before international thinking about repository development shifted in favor of a more staged, adaptive approach (this is also the approach the Subcommittee is recommending in the United States). The NRC, in particular, has a robust and exacting regulatory process for reactor operators and other facility licensees that generally requires very high levels of design specificity and performance assessment at the initial licensing phase. This structure is not necessarily incompatible with a staged, adaptive approach; in fact, the NAS study of staged repository development observed that the “The U.S. licensing process already follows a staged approach” and concluded that “there are no restrictions precluding DOE from implementing

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<sup>198</sup> “As a historic matter, differences in the NRC and EPA standards are rooted in the two agencies’ philosophical approach to setting limits. EPA has tended to set very aggressive goals (often based on best technology) but has been very forgiving when best efforts at compliance with the goals are made (thus: “Reasonable Expectation”). The NRC, on the other hand, has set more achievable, science-based, standards and has been very strict in enforcing the standards once set (thus: “Reasonable Assurance”). Report of the American Nuclear Society on the EPA proposed standard for the Yucca Mountain High-Level Waste Repository, November 1999, <http://www.ans.org/pi/news/sd/944200800-report.html>.

Adaptive Staging.”<sup>199</sup> However, future disposal facility regulations should be designed to accommodate a process in which decisions about design, construction, and operations might be kept open beyond the initial license application.<sup>200</sup> Recent NRC planning documents suggest the agency has already recognized that it may need to develop new performance assessment tools that are flexible enough to accommodate different scenarios for the management of spent fuel and HLW (in part to respond to the findings of the BRC).<sup>201</sup> In general, adaptive staging could make the licensing process more complex by increasing the number of changes made in the course of the process. This in turn would increase the number of regulatory review steps and the potential need for license amendments.<sup>202</sup> A revised regulatory structure for future disposal facility development should be designed, with specific attention to providing the flexibility needed to support this kind of process.

5. Safety and other performance standards and regulations should be finalized prior to the site-selection process.

If site selection occurs before final performance standards are defined, there are two risks. The first is that time and effort could be spent on a site that should have been ruled out as unsuitable earlier in the process. The second risk is one of perception. The public and other stakeholders could suspect that standards are being adjusted to fit the site. These considerations argue for setting generic standards that would be applicable to any facility wherever it is located, *before* any particular site is selected for further study. In developing such regulations, however, it will be important to avoid setting excessively detailed and rigid requirements that could prove unworkable when applied to an actual site or that could have the effect of screening out potentially suitable and otherwise promising sites.<sup>203</sup> The Subcommittee believes there is no reason to wait to start the process of developing generic regulations for future geologic repositories. As discussed below, we are not recommending any change in the current allocation of regulatory responsibilities and authorities that would require enabling legislation. Given that we are recommending a flexible process for finding new repository sites, standards development need not delay early progress on the siting front. Moreover, the fact that the regulatory issues to be resolved have been well defined and extensively analyzed over more than 30 years of EPA and NRC experience in this area, and the fact that some of the key issues have already been tested in court and in the regulatory process, should help expedite the process of developing generic disposal facility safety and performance standards.

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<sup>199</sup> National Research Council, *One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste*, National Academies Press, 2003. <http://www.nap.edu/catalog/10611.html>, pp. 130-131.

<sup>200</sup> *Ibid.* at p. 92.

<sup>201</sup> In Appendix E of its recent “Plan for Integrating Spent Nuclear Fuel Regulatory Activities,” the NRC identifies “Development of an assessment tool (“Flexible Performance Assessment”—FPA) that allows a scoping-level evaluation of the regulatory and technical aspects of various spent fuel and HLW disposition scenarios that may be identified by the Blue Ribbon Commission on America’s Nuclear Future,” as one of several activities to be completed by the end of FY 2010.

<sup>202</sup> *Ibid.*, p. 91.

<sup>203</sup> In 1990, in the midst of ongoing debates about the EPA and NRC repository regulations, the NAS warned against the risks of establishing excessively rigid regulatory requirements before data on actual sites were available. *Rethinking High-Level Radioactive Waste Disposal*, Board on Radioactive Waste Management, NAS, , 1990.

6. EPA and NRC should coordinate closely in the development of new disposal facility regulations.

As was mentioned earlier, problems of coordination between EPA and the NRC in developing repository standards have been widely cited as having contributed to negative perceptions of, and loss of confidence in, the Yucca Mountain project. The Commission has heard proposals for a fundamental redrawing of regulatory roles and responsibilities for repositories at the federal level (e.g., by consolidating all regulatory authority in the NRC or the EPA). In this case, there would be no need for coordination between different sets of regulations. While we are not recommending a change in the regulatory roles of EPA and NRC (see section 8.1.6), we believe the process of developing EPA standards, and NRC regulations for implementing those standards, should be carefully coordinated to avoid repeating past problems. For example, the Subcommittee has heard testimony that the processes used to develop standards in the past were confusing and frustrating to the public,<sup>204</sup> and that more coordinated and dedicated efforts are needed in the future to draw not only on the expertise of EPA and NRC but also on input from the knowledgeable public. We have also heard that public disagreements between these agencies over matters of regulatory philosophy can confuse the public and undermine confidence in the regulatory system,<sup>205</sup> and that it is important that such disputes be resolved promptly.<sup>206</sup>

The Subcommittee believes that a coordinated and open process should be used to develop new generic regulations for future disposal facilities, and that that any differences in regulatory philosophy between the two agencies be laid out clearly and resolved as early in the process as possible. Both EPA and NRC have developed mechanisms for obtaining outside inputs that could be useful. Within EPA itself, the National Advisory Council for Environmental Policy and Technology (NACEPT), created in 1988, has provided a useful mechanism for bringing outside knowledge and insight to bear on major EPA regulatory initiatives. In fact, NACEPT created a subcommittee on WIPP -- the Waste Isolation Pilot Plant (FY 93-99) Review Committee -- which advised the Administrator on policy and technical matters arising from EPA's regulation of the WIPP.<sup>207</sup> NRC has also expanded its approaches to obtaining public inputs, for example through use of public meetings combined with internet "webinars" to provide an opportunity for stakeholder input and dialogue.<sup>208</sup>

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<sup>204</sup> According to a statement submitted by Steve Frishman: "The regulatory arena associated with deep geologic disposal of high-level radioactive waste and used nuclear fuel has been subject to an array of policy changes, changes in philosophy, and internal struggles within and between the two affected regulatory agencies -- the NRC and the EPA. The interested and affected public often has been confused about the roles of the respective agencies, and the motivation, scope and meaning of the regulations proposed, while being confined in their responses to the review and comment provisions of the Administrative Procedures Act (APA), and ultimately the federal courts. Having been a participant in this process, at the affected state government level, for its entire nearly 30-year history, has been frustrating, to say the least." Summary of Statement by Steve Frishman, Consultant, Agency for Nuclear Projects, State of Nevada, before the hearing on "A Review of the Department of Energy's Yucca Mountain Project, and Proposed Legislation to Alter the Nuclear Waste Trust Fund (H.R. 3429 and H.R. 3981)," held by the Disposal Subcommittee of the BRC, September 1, 2010, Washington D.C. ([http://brc.gov/Disposal\\_SC/docs/sep-01\\_mtg/Summary%20of%20Steve%20Frisham%20to%20the%20Disposal%20Subcommittee.pdf](http://brc.gov/Disposal_SC/docs/sep-01_mtg/Summary%20of%20Steve%20Frisham%20to%20the%20Disposal%20Subcommittee.pdf)).

<sup>205</sup> At a hearing in Maine concerning spent fuel stored at the shutdown Maine Yankee reactor site, an elected official described open disagreement between EPA and NRC about whether the final cleanup standard for decommissioning of the site should be 15 mrem or 25 mrem. According to this official, her constituents did not understand the technical basis for the disagreement, but the simple fact that there was a dispute between the regulatory agencies undermined public confidence in the regulatory system and the ability to safely store spent fuel at the Maine Yankee site. This ongoing dispute between the EPA and NRC was also mentioned in a paper prepared for the Commission by Dr. Rodney Ewing and described in a GAO report in 2000.

<sup>206</sup> Presentation by Robert Neill, December 2, 2010.

<sup>207</sup> The Committee consisted of a group of 10 independent experts drawn from academic institutions, Federal, State and local government agencies, environmental groups, industry and nonprofit entities. A list of members can be found at <http://epa.gov/ofacmo/nacept/wipp/wippmems.htm>

<sup>208</sup> See, for example, the summary of a meeting/webinar on the impacts of limited availability of low-level waste disposal capacity at <http://pbadupws.nrc.gov/docs/ML0928/ML092880909.pdf>.

We believe that actions to coordinate the development of new disposal regulations can be undertaken by the Executive Branch without any additional action needed by Congress. Specifically, we recommend that EPA and NRC begin working together to define an appropriate process (with opportunity for public input) for developing a generic disposal facility safety standard and the associated implementing regulations, and continue to coordinate their efforts during the regulatory development process.<sup>209</sup> The Subcommittee is convinced that by using (and if needed expanding on) existing coordination and advisory techniques that have worked effectively in recent years, EPA and NRC can accomplish the task of developing a mutually consistent set of standards for new high-level waste and SNF disposal facilities in a timely manner. This joint effort should be started at once and completed, with openness and full access by interested parties of all types, even before site screening efforts for site selection have been resumed.

The ultimate goal of this effort should be an overall federal regulatory structure that has no gaps or inconsistencies between EPA and NRC requirements that could lead to delays in siting and licensing a repository. This process should be designed to accomplish the following:

- A clear definition of the regulatory issues to be resolved,
- A comprehensive identification of alternative approaches to resolving these issues,
- A thorough and fair analysis of the alternatives,
- A clear explanation of the regulatory choices that are made, and
- A shared understanding between the two agencies and with other stakeholders about the compliance demonstration methods and standard of proof that are to be used in implementing the standards.

We also recommend that the administration and Congress ensure that NRC and EPA have sufficient resources to complete this process in a thorough and timely way. The cost of delays in being able to move ahead with finding new repository sites would certainly be far higher than the cost of a process to establish the necessary standards as soon as possible.

7. The EPA and NRC should also develop a new regulatory framework and standards for deep borehole disposal facilities.

As noted earlier in the report, the Subcommittee has also identified deep boreholes as a potentially promising technology for geologic disposal that could increase the flexibility of the national system for nuclear waste management, and therefore merits research, development and demonstration.. While a regulatory framework and safety standards for deep boreholes would have a large commonality with those for mined geologic repositories, the technologies also have key differences. For this reason the Subcommittee recommends that EPA and NRC develop a new safety standard

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<sup>209</sup> For example, the Subcommittee has also heard a proposal that would involve forming a panel of experts from each agency and from academia or the private sector to conduct a process in accord with the Administrative Procedures Act. The aim would be to produce a report that could be used as the basis for an integrated set of disposal safety regulations to be adopted by both EPA and NRC (as was proposed by Steven Frishman at the Subcommittee meeting on September 1, 2010 (see: [http://www.brc.gov/sites/default/files/meetings/attachments/summary\\_of\\_steve\\_frishman\\_to\\_the\\_disposal\\_subcommittee.pdf](http://www.brc.gov/sites/default/files/meetings/attachments/summary_of_steve_frishman_to_the_disposal_subcommittee.pdf)) Other options such as regulatory negotiations might be possible.

and regulatory framework for deep boreholes (consistent with the new standard recommended for mined repositories) informed by RD&D efforts aimed at leading to a licensed demonstration of the borehole concept. In its comments on the draft BRC report, EPA specifically noted that EPA's existing disposal standards (40 CFR Part 191) apply to any disposal method for SNF and HLW, including deep borehole disposal. However, since the potential use of boreholes was not a primary concern at the time its regulations were developed and adopted, the Subcommittee recommends that, as an element of its review and potential revision of its current standards, that EPA specifically consider whether current thinking about the potential use of boreholes for selected types of SNF and/or HLW requires any changes or additions to its existing regulations. In addition, if the recommendation for research and development on boreholes is adopted, EPA should stay abreast of developments from that work and its implications, if any, for EPA standards.

## 8.2 Security and Safeguards for Nuclear Disposal Facilities

Robust security arrangements are needed at storage and disposal facilities for SNF and high-level waste, as well as during the transport of these materials, to prevent unauthorized access and acts of sabotage or theft. From a security standpoint, the most sensitive stages at a deep geological repository are when materials are above ground (transported or in a pre-load stage) and during the pre-closure period when materials are emplaced in the disposal facility, but the facility itself is not sealed and could therefore be accessed more easily. As the IAEA has recommended, the regulatory authority will need to provide guidance to the implementing organization concerning the effective application of security measures. Such measures could include physical protection, control and accounting, and verification procedures. Current NRC regulations for geologic disposal provide requirements for physical protection (10 CFR 60.21(b)(3) and 63.21(b)(3), Part 73) and material control and accounting (10 CFR 60.78 and 63.78). The NRC is currently conducting a rulemaking to enhance these requirements. Recognizing the importance of international safeguards commitments, the United States should ensure that future geologic disposal facilities are offered for IAEA safeguards.<sup>210</sup>

## 8.3 Occupational Safety and Health

Another important area of regulation for waste management facilities pertains to the health and safety of facility workers and personnel, rather than to the protection of the general public. Currently, responsibility for occupational safety and health at nuclear facilities is the shared responsibility of the NRC, the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) and (in some cases) the Mine Safety and Health Administration.

In the United States, experience with constructing two deep geological facilities, WIPP in the 1980s and the Yucca Mountain Exploratory Studies Facility (ESF) in the 1990s, provides useful insights for managing the kinds of occupational safety and health risks involved in constructing and operating facilities of this

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<sup>210</sup> The IAEA identifies three main phases of a permanent repository development: (1) pre-operational phase that includes site characterization, underground exploration and access construction and construction of the repository; (2) operational phase that starts with the commissioning of the repository system and/or receipt of the first package and might include among others emplacement of packages and installation of engineered barriers; backfilling of disposal drifts and vaults, repository backfilling sealing; and (3) post-operational phase i.e., post-closure period. Consultations with IAEA and sharing of information between operator, national regulator and the IAEA should begin at the pre-operational phase to allow developing of specific safeguards approach. The implementation of safeguards should start at the beginning of the operational stage and remain through the post-operational phase. (Safeguards during post operation phase may include surveillance and inspections). For more details see Technological Implications of International Safeguards for Geological Disposal of Spent Fuel and Radioactive Waste, IAEA Nuclear Energy Series No. NW-T-1.21, International Atomic Energy Agency, Vienna, 2010.



kind.<sup>211</sup> Constructing facilities deep underground is in and of itself a complex undertaking that poses inherent risks. The major risks to workers at a deep geological repository are the same as those associated with any large-scale underground construction project; they include, principally, traumatic injuries from working around heavy equipment and explosives, lung disease from both dust and diesel exhaust fumes, and noise-induced hearing loss. That said, current construction procedures and technologies make it possible to minimize the risk of traumatic injuries, suppress dust and other respiratory irritants, and protect workers' hearing.

Although the overall occupational safety record for both the WIPP and Yucca Mountain facilities was generally better than would be typical for most comparable civil engineering work, these projects were not without risk. During the construction of the WIPP facility, for example, one worker fell down a shaft and was killed. This single incident translates into a fatality rate of about six per 100,000 working years, or about one-fourth the average fatality rate for all mining activities at that time. Also, in 1987 the hoist at WIPP had two near-miss failures even though the risk of this type of accident had been assessed at the very low probability of one in 60 million.<sup>212</sup>

## 8.4 Key Findings

- Oversight by independent, outside regulators is a critical link in ensuring that nuclear materials are safely managed and disposed of in ways that protect public health and the environment.
- Currently, most regulatory responsibility for nuclear waste facilities and activities rests with EPA and NRC. Both agencies set standards intended to limit the potential for members of the public to be exposed to radiological risks from nuclear wastes. EPA has sole responsibility for regulations to address other types of environmental impacts and primary responsibility for regulating the performance of a disposal facility during the post-closure period. The NRC is the primary regulator for the period covering facility construction, licensing, and operation and for protecting facility workers from radiological exposures. Other worker protections are the responsibility of OSHA.

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<sup>211</sup> During the construction of WIPP, one construction worker was fatally injured in 1984 when he fell 1000 feet down a 6-foot diameter borehole. See: "Safety Violations Led to WIPP Worker's Death", *Albuquerque Journal*, July 4, 1984, p. D-2. Overall this was the one traumatic fatality in an estimated 17,000 person-working years needed to construct the facility. Since WIPP opened in 2000, there have been no significant accidents involving workers. In the case of Yucca Mountain, concerns were raised about the adequacy of the industrial hygiene procedures in place to protect workers from silica exposure. A study of some 413 individuals (out of almost 3000) who worked at Yucca Mountain between 1993 and 2002 found three individuals with silicosis, however all of these individuals had previously worked in mines and two of them had been diagnosed before working at Yucca Mountain, so it was difficult to determine whether and to what extent exposures at Yucca Mountain might have contributed to their condition. The other case was a new diagnosis, but that worker also reported previous mining experience so it was not possible to attribute his disease solely to exposure at Yucca Mountain. The study was performed between 2003 and 2005 out of almost 3000 individuals who had been known to have worked in some capacity at Yucca Mountain in during the study. (See *An Investigation into the Silica Exposure of Yucca Mountain Project Workers*. Special Hearing before a Subcommittee of the Committee on Appropriations, US Senate, Las Vegas, March 15, 2004. Available at: <http://www.gpo.gov/fdsys/pkg/CHRG-108shrg94749/pdf/CHRG-108shrg94749.pdf>.) In contrast to Yucca Mountain, the WIPP facility is mined out of halite (salt) deposits. There has not been any study of whether mining halite has had any adverse health impact on workers at WIPP, even though there are significant salt dust exposures in the facility and even though exposure to salt dust is considered a risk factor for cardiovascular, gastric and kidney diseases.

<sup>212</sup> More information on this issue, including the comparison of nuclear power industry with other energy generation industries could be found at the BRC Commissioned Paper by Stoneturn Consultants "From Three Mile Island to the Future: Improving Worker Safety and Health In the U.S. Nuclear Power" *Industry*, March 14, 2011" available at [www.brc.gov](http://www.brc.gov).

- Different countries have taken different approaches to the multi-faceted and technically complex task of setting regulatory standards for disposal facilities. Issues to be decided include not only the form and stringency of the standard but the timeframe(s) over which the standard applies and the approach or methodology that will be used to determine compliance. Over the last decade, the concept of a “safety case” has become increasingly prominent. Definitions vary, but the general idea is to integrate multiple arguments and lines of evidence to build a convincing and broadly understandable qualitative and quantitative case for the safety of any proposed facility over the relevant timeframe(s).
- At this time, there are two sets of federal regulatory standards for radioactive waste disposal sites in the United States. One was developed specifically for Yucca Mountain; the other generic set applies to a repository at any other site and would, unless changed, be applied to future disposal sites. Differences between these standards and between the EPA and NRC approaches more generally have sometimes emerged as a point of contention in past debates over proposed facilities and policies.
- General principles or propositions to guide the development of future regulations should include the following: (1) generic standards and regulatory requirements should be applicable to all potential sites; (2) compliance determinations should be based on the “reasonable expectation” standard and should not go beyond what is scientifically possible and realistic; (3) rules for demonstrating compliance should be defined at the same time that the performance standards are developed; (4) standards for a disposal facility should explicitly recognize and facilitate an adaptive, staged approach to repository development; (5) safety and other performance standards and regulations should be finalized prior to the site-selection process; (6) EPA and NRC should coordinate closely in the development of new repository regulations and; (7) a regulatory framework for geologic disposal in deep boreholes needs to be developed.
- The current division of roles between EPA and NRC is appropriate, but coordination needs to be improved.
- The assessment of whether a candidate site for a disposal facility meets regulatory requirements should be based in part on the development of a robust “safety case.”
- Robust security arrangements must be provided at storage and disposal facilities for SNF and high-level waste, as well as during the transport of these materials, to prevent unauthorized access or acts of sabotage or terrorism. The United States should also offer to place all future disposal facilities under IAEA safeguards.
- Experiences with both the Yucca Mountain Project and WIPP demonstrate a good occupational safety record. However, the additional risks associated with emplacing materials underground and working around packages that contain highly radioactive material require an additional layer of radiological safety requirements and efforts to foster a strong workplace safety culture.

## 9. CONCLUSION

A half century of civilian nuclear power production, and an even longer legacy of defense-related nuclear activities, have left the United States with a substantial inventory of SNF and high-level radioactive waste. Having benefited from the activities that produced these materials, this generation has an ethical obligation to dispose of them in a safe and environmentally responsible manner and in a reasonable timeframe. The recent disaster in Japan has cast a harsh light on our collective failure (over more than 40 years) to come to grips with the nuclear waste problem. It reminds us that delay and deferral also have consequences—that the failure to decide is also a decision, with its own costs and risks. Public awareness of those risks has undeniably changed as a result of Fukushima. The problem is not that our political leaders and government institutions haven't tried to find a solution nor is the problem that we lack a technical answer for managing the hazardous radioactive materials present. Efforts to site a deep geological repository for the permanent disposal of SNF and high-level waste in the United States date back 50 years. Deep geologic isolation continues to be the most promising and technically accepted disposal option available today. It is also the option all other countries with civilian nuclear waste management programs are pursuing, with three countries—Finland, Sweden and France—having already been successful in identifying sites for deep, mined geologic repositories. The United States has not lacked the understanding, the technology, or even the resources to implement deep geologic disposal. What we have lacked is the collective political will to locate, characterize, and win broad acceptance at all the levels needed—not only nationally, but also at the local and state level—to move forward decisively with one or more particular repository sites.

The mistakes that have led to the current impasse are easy enough to identify. Almost from the beginning, DOE's waste management program was hampered by:

- Inconsistent funding,
- Lack of mission constancy,
- Frequent changes of leadership and policy direction,
- Inflexible and unrealistic deadlines, and
- Overly prescriptive requirements.

The result was a program that too often fell short of meeting commitments, that too often failed to operate in a transparent manner, and that ultimately lost the trust of the public and key stakeholders. Success from this point on will require a decisive break with this legacy.

The Subcommittee is making several recommendations that we believe are critical to getting the U.S. nuclear waste management program back on track, restoring the confidence of the American people in the program, and achieving tangible progress toward a long-term solution for SNF and high-level waste.

First, we believe responsibility for the U.S. waste management program must be transferred to a new, single-purpose organization. That organization must have the leadership, the authority, the political independence, the resources and independent oversight to pursue its mission effectively and to establish a new track record of consistently delivering on commitments.

Second, resources in the NWF and from the ongoing collection of NWF fees must be made fully available to the new organization to be used for the purposes for which they are intended—that is, to provide a secure and dedicated source of funding to cover the cost of safely managing and disposing of civilian nuclear waste. Specifically, this means (1) extricating the NWF from the web of budget rules that have created an unintended and dysfunctional competition between expenditures from the Fund and spending on other federal programs, (2) removing waste program funding decisions from the annual federal budgeting and appropriations process, and (3) pairing full access to the NWF and fees with robust accountability and oversight mechanisms to ensure that these resources are used effectively to advance waste program objectives.

Third, a new management approach is needed to successfully site, develop, and operate geologic disposal facilities and other major components of the waste management system. Based on experience here and in other countries, we concur with an earlier finding by the National Academy of Sciences that an adaptive, staged approach offers the necessary flexibility and capacity for learning and self-correction to successfully navigate a multi-decade process marked by a high degree of complexity, indeterminacy, and uncertainty. In the United States, opposition to the siting of facilities—particularly at the state level—has been a consistent and often intractable barrier to progress. Experience with WIPP and with repository siting programs in Finland and Sweden suggests that a stepwise, consent-based strategy that affords states, tribes and communities a high-degree of consultation and control may succeed where past efforts have not.

The Subcommittee recognizes that none of these three steps will be easy to implement; nor do they, individually or in combination, guarantee success. Put simply, we can't be sure that what has worked at other times and in other places will work again in the new circumstances our nation confronts today and in the decades ahead. We are sure, however, that there is no good alternative to trying. Based on the full spectrum of perspectives we have heard, and particularly in light of the ultimate success of the WIPP facility, the Subcommittee is optimistic that a new approach can work—not only because an indefinite prolonging of the status quo is unacceptable (which it is) but for a whole set of more positive reasons. The key will be to find solutions that serve not only our national interest, our public policy goals, and our obligation to future generations, but the particular interests of those states, tribes and communities that are willing be a part of them. Our search for those solutions must resume without further delay.