

Nuclear Waste Management in the United States

The Nuclear Waste Technical Review Board's Perspective

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Introduction

This paper provides the perspective of the members of the Nuclear Waste Technical Review Board (the Board) on the impact that current developments could have on the future of the U.S. program for managing spent nuclear fuel and high-level radioactive waste. It discusses the Board's opinion on how to address the issues these developments raise in a way which moves the U.S. civilian radioactive waste management program forward.

Background and Description of the U.S. Civilian Radioactive Waste Management Program

In 1982, the U.S. Congress enacted the Nuclear Waste Policy Act (Public Law 97-425). The NWPA created the Office of Civilian Radioactive Waste Management (OCRWM), within the Department of Energy (DOE). The OCRWM is responsible for developing a system to manage the disposal of commercial spent nuclear fuel. The act also established a process for evaluating the suitability of a number of potential sites for two permanent repositories. Utilities were given the primary responsibility for storing spent fuel until the DOE accepts it for disposal at a repository.

In 1987, Congress amended the Nuclear Waste Policy Act and designated Yucca Mountain, Nevada, as the sole site to be characterized for the possible development of the first high-level radioactive waste repository (Public Law 100-203). Yucca Mountain is located in the southern part of the state of Nevada, 100 miles northwest of the city of Las Vegas. Yucca Mountain is a very dry, arid region with mountain ranges and valleys, sparse vegetation, and low rainfall. The DOE's 1988 baseline plan to characterize the site calls for the burial of spent fuel and high-level radioactive defense waste in a repository consisting of more than 100 miles of tunnels excavated in rock about 300 meters below the surface of the mountain but 250 to 350 meters above the water table (DOE, December 1988). Federal standards and regulations will serve as a basis for licensing the repository, if the site is deemed suitable.

Organizations Involved in the U.S. Civilian Radioactive Waste Management Program

Within the OCRWM, site-characterization activities are directed by the Yucca Mountain Site Characterization Project Office located in Las Vegas, Nevada. Several years ago, TRW Environmental Safety Systems, Inc., (TESS) was hired as the management and operating (M&O) contractor. The M&O contractor performs or is responsible for all project work.

Other organizations and major government agencies that are involved with the OCRWM program include regulatory and advisory organizations. (See Fig. 1)

The *Nuclear Regulatory Commission* (NRC) is an independent federal agency responsible for regulating and licensing civilian (not defense-related) nuclear facilities. For the OCRWM program, the NRC licenses the construction of a repository for permanent disposal of spent fuel, any kind of interim storage facility, and the transportation casks.

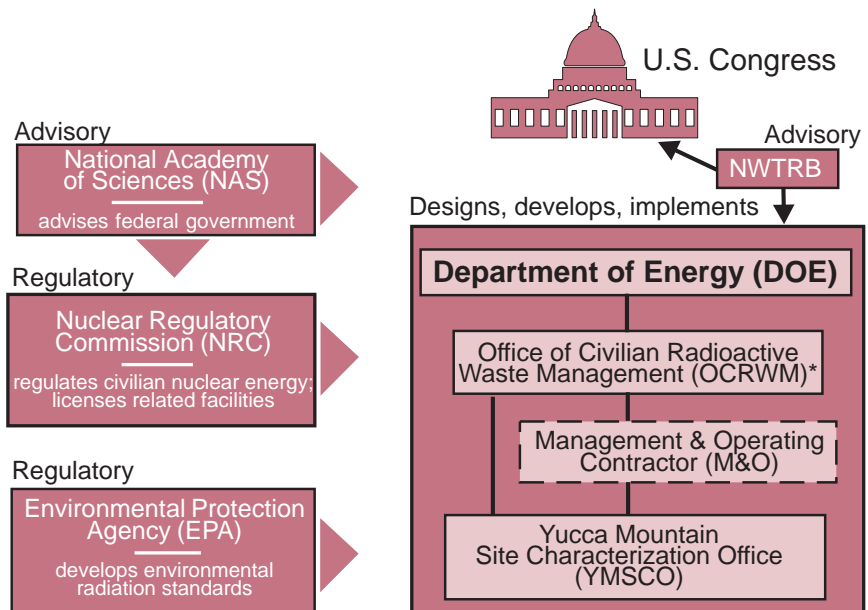
The other major regulator involved in the civilian radioactive waste management program is the *Environmental Protection Agency* (EPA). The EPA has two jobs related to the program: (1) developing environmental radiation protection standards and (2) reviewing all of the DOE's environmental impact statements.

An advisory organization that is often involved with the program is the 135-year-old *National Academy of Sciences* (NAS). The NAS is an academy-elected group of eminent scientists from a broad range of disciplines, but it is not a government agency. Federal government agencies request reviews through the committees of the NAS's operating arm, the *National Research Council*.

The advisory body that is charged specifically by law with oversight of the U.S. civilian radioactive waste management program is the *Nuclear Waste Technical Review Board*. The Board is *independent* of the DOE or any other government agency. It was created to advise both the Congress and the Secretary of Energy on the technical and scientific validity of the DOE's civilian radioactive waste management program.

The stakeholders, or those who have an interest in the program, are another important group involved in the U.S. waste program. They include state and local governments, especially those in Nevada, the host state of the proposed repository; Native American tribes; public utility commissions; environmental organizations; interested citizens; public utilities; and nuclear industry vendors.

Figure 1:
Spent Fuel Disposal:
General U.S. Organizational
Framework



* The U.S. Geological Survey, a bureau of the U.S. Department of the Interior, and the national laboratories, part of the DOE complex, carry out significant R&D work on this program. In addition, many contractors and subcontractors provide support to the DOE.

Current Status of DOE Efforts to Characterize the Yucca Mountain Site

The U.S. program is funded by ratepayer fees collected by nuclear utilities and deposited into a special Nuclear Waste Fund (NWF). Under current U.S. law, generators of commercial spent fuel pay 1 mill (\$.001) per kilowatt hour of nuclear electricity generated. The NWF is made up of these fees and the interest they accrue.

Since 1987, the DOE has spent roughly \$1.7 billion characterizing the site at Yucca Mountain, Nevada. Site evaluation progress has been much slower than initial expectations. In the Board's view, that is not surprising, given that characterizing a site and building a repository have yet to be accomplished anywhere in the world. Furthermore, the proposed site at Yucca Mountain is the only one in the world in unsaturated rock.

Recently, however, the program progress has been quite encouraging to the Board. As of April 12 a large diameter (approximately 8 meters) tunnel boring machine had excavated into Yucca Mountain to the point of and well across the

level of the proposed repository — a distance of approximately 5 kilometers. Four test alcoves have been excavated off the north ramp and the main tunnel.

In 1998, the DOE intends to prepare a viability assessment of the Yucca Mountain site's potential to host an engineered repository. According to the OCRWM director, this assessment is an early and integral step on the path to recommending the site to the President, and preparing both a repository environmental impact statement and a construction license application. The 1998 assessment will incorporate information collected from scientific studies conducted since the 1970s, site-specific data collected over the past three years, work on the conceptual design for the repository, and understanding gained from the latest series of iterative total system performance assessments (Dreyfus, March 1996).

The viability assessment is *not* a site-suitability decision, however. The Board continues to urge the DOE to make a technical and scientific decision on site suitability. By suitable, the Board means that there is a high probability that the site, along with appropriate engineered barriers, can provide long-term isolation. The Board believes that if the rate of progress the program achieved during the last few months of 1995 could be maintained, the DOE ought to be able to complete enough exploration, testing, repository design, and performance assessment activities to determine within five years whether Yucca Mountain is suitable for repository development. In correspondence to the DOE the Board stated its views on the specific work at the site that needs to be accomplished to make a technically credible site-suitability determination. (Cantlon, December 1994)

The DOE Waste Isolation Strategy

The Board has recommended that the DOE clearly articulate a waste isolation strategy, and during 1995 the DOE made progress in articulating such a strategy. Developing a waste isolation strategy is an iterative process and the strategy *must be seen* as an “evolving document” that is updated periodically as additional information is acquired about site conditions, engineering options, and regulatory standards.

Currently, the key objectives of the DOE's strategy are:

- to contain the wastes within robust waste packages for thousands of years and
- to keep the radiation dose rate to any member of the general public at any time below levels of regulatory concern.

The DOE strategy is based on five hypotheses about how natural and engineered barriers might contribute to achieving these goals, given the arid environment of the potential repository site at Yucca Mountain.

1. There will be little seepage of water into the repository's emplacement drifts.
2. Waste packages will provide radionuclide containment for thousands of years.
3. The rate of radionuclide mobilization will remain low after waste packages are breached by corrosion.
4. Engineered barriers will limit the rate of release of the radionuclides to the host rock.
5. The site's natural barriers will provide substantial dilution of the radionuclides as they migrate toward the accessible environment. (TESS, March 1996)

The Board strongly supports the progress that is being made on the waste isolation strategy, and is encouraged to see that the OCRWM is beginning to use the strategy to prioritize activities and to allocate resources for the Yucca Mountain project. Since its inception, the Board has advised the DOE to develop a stronger multi-barrier (defense-in-depth) strategy for projecting long-term radionuclide isolation. The Board supports the DOE's current direction to include greater reliance on a *combination* of engineered and natural barriers.

One of the Board's remaining concerns is that the strategy seems to depend heavily on the site's continued aridity when conditions over the long regulatory time periods cannot be unequivocally demonstrated. Given the uncertainties that are likely to exist, the Board will continue to advise the DOE to seek and evaluate cost-effective ways to make the waste isolation strategy more robust.

Proposed Legislative and Regulatory Changes

Changes in the legislative and regulatory environment have affected the U.S. nuclear waste program from its inception. The following sections discuss some of these changes.

Changes in Regulation

Historical difficulties and delays in developing health and safety standards prompted Congress to address this issue in the Energy Policy Act of 1992. (Public Law 102-486) The act established a process for setting a standard specifically to protect public health and safety at a Yucca Mountain repository. It directed the EPA to contract with the NAS to analyze and recommend the scientific bases to be used in developing such a standard. The EPA would then promulgate a health and safety standard for the Yucca Mountain site *based on and consistent with* the NAS recommendations. The NRC is directed to enforce the new standards through its regulatory, licensing and, oversight procedures.

In its report, *Technical Bases for Yucca Mountain Standards*, released on August 1, 1995, the NAS recommends risk-based standards that emphasize protection of individual members of the public. The report recommends that institutional controls not be relied upon as the means to prevent unacceptable exposures to releases from a repository. Furthermore, it finds that there is no scientifically supportable way to predict the probability of human intrusion over the long term.

The NAS report also recommends that performance standards for a Yucca Mountain repository apply for a time limited only by “the long-term stability of the fundamental geologic regime — a time scale that is on the order of 1,000,000 years at Yucca Mountain.” The report stated that many of the details related to the standards involve making public policy choices that can be illuminated by, but not determined by, science alone (NRC, 1995).

Currently, the EPA is working on a safety standard that will be compatible with the NAS recommendations. While the EPA is revising the health and safety standard for the potential site at Yucca Mountain, proposed federal legislation, if enacted, would once again change the regulatory criteria for a repository. The legislation would establish the regulatory requirements for a permanent repository at an individual dose limit of 1 mSv/yr (100mrem/yr) for the average person living near the repository. This is a factor of three to ten higher than other nations’ dose limits, but it would become the standard unless the NRC determined that it would constitute an unreasonable risk to health and safety. It also would limit the period of regulatory compliance to 10,000 years, and it would stipulate that institutional controls would be effective in preventing human intrusion into, or disruption of, the repository (U.S. Congress, House of Representatives, 1995 and Senate, 1995).

Board Reactions to Proposed Regulatory Changes

For some time the Board has stated its belief that current U.S. regulations and perhaps the health and safety standards governing spent fuel disposal need to be updated. The current EPA health and safety standard, and the NRC and DOE regulations, were overly detailed and enacted too early in the process of searching for a permanent repository site. Scientific and technical knowledge, particularly when applied to a first-of-a-kind undertaking, takes time to evolve. In retrospect, the wiser course may have been to collect that knowledge and use it in developing a regulatory framework. In the absence of that approach, the Board believes that the NAS report and current scientific and technical understanding of the conditions at the Yucca Mountain site should provide a basis for revising safety standards and regulations.

In response to a request from the EPA, the Board expressed its views on several key issues raised by the NAS report (Cantlon, December 1995). The Board stated its belief that if the EPA standards for a Yucca Mountain repository are to apply for more than about 10,000 years, appropriate language should be included in the standards to accommodate the increased levels of uncertainty in projected human health risks over a very long period of time.

The Board noted that the stringency of the standards for the long-term performance of a repository at Yucca Mountain also will depend on the definition of the critical group. The Board endorsed the general concept of a probabilistic critical group, but the alternative suggested in the NAS report — a subsistence farmer critical group — seemed overly conservative for a site like Yucca Mountain, which has a harsh climate and lacks arable land. A reasonable analysis using a probabilistic approach should consider alternative lifestyles by which individuals could be exposed to releases from a repository.

The Board stated its belief that the incremental risk, if any, associated with gaseous carbon-14 releases from a Yucca Mountain repository should be considered negligible and beyond regulatory concern.

The Board stated that it agreed with the NAS that there is no scientific basis for predicting the probability of inadvertent human intrusion over the long times of interest for a Yucca Mountain repository. Accordingly, intrusion analyses should not be required and should not be used during licensing to determine the acceptability of the candidate repository.

In its letter to the EPA, the Board noted that the form the standards eventually take could have significant implications for repository design. For example, if

the repository standards are of unlimited duration, this may serve as a disincentive to spend money to develop more robust engineered barriers or to seek a better quantitative assessment of retardation in natural barriers. The Board believes that, whenever practical, releases should be delayed through the use of repository design and engineered barriers.

Above all, the Board has urged the EPA to keep the standards simple. *In the Board's view, there are limits to what scientific knowledge can accomplish, and the standards should recognize and be consistent with those limits.* The Board also thinks it may be time to look at the overall *process* the United States uses to site, build, license, and close a permanent repository. The time may have come to establish a process that acknowledges the need to adapt to changing information. There are a variety of ways to accomplish this — from changing the program's organizational structure to changing the manner in which the repository is licensed. For example, a more realistic approach to developing a repository may be to license and construct it in increments of 10,000 to 20,000 metric-ton capacities, while maintaining assured retrievability, instead of securing a license for the full 70,000 or more metric tons before any construction begins. Plans for continued testing and monitoring during a repository's initial operating phase also seems to be a prudent step. The Board has not discussed these issues in any detail, but does believe there may be some merit in looking at different ways to license a repository site.

Legislative changes

The principal legislative proposals currently being considered by Congress would authorize the development of a storage facility as soon as possible at the Nevada Test Site, adjacent to the proposed repository site at Yucca Mountain. (U.S. Congress, House of Representatives, 1995, and Senate, 1995)) This legislation was proposed primarily to address the concerns of nuclear utilities about acceptance of their spent nuclear fuel. These utilities signed contracts with the DOE with the expectation that the DOE would begin acceptance of their commercial spent nuclear fuel for disposal at an operating repository beginning in 1998 or soon thereafter. Since then, a large group of state agencies and utilities have sued the DOE in the U.S. Court of Appeals for the District of Columbia to obtain a judgment making the DOE legally responsible to begin accepting utility spent fuel in 1998. (State of Michigan)

Concurrent with the introduction of these legislative proposals, Congress reduced the OCRWM's fiscal year 1996 appropriation by approximately 40 percent — from \$520 million to \$315 million. Congress appropriated an additional

\$85 million for development of a centralized storage facility and related transportation system, pending authorization of such a facility by the congressional committees responsible for nuclear waste programs (Public Law 104-46).

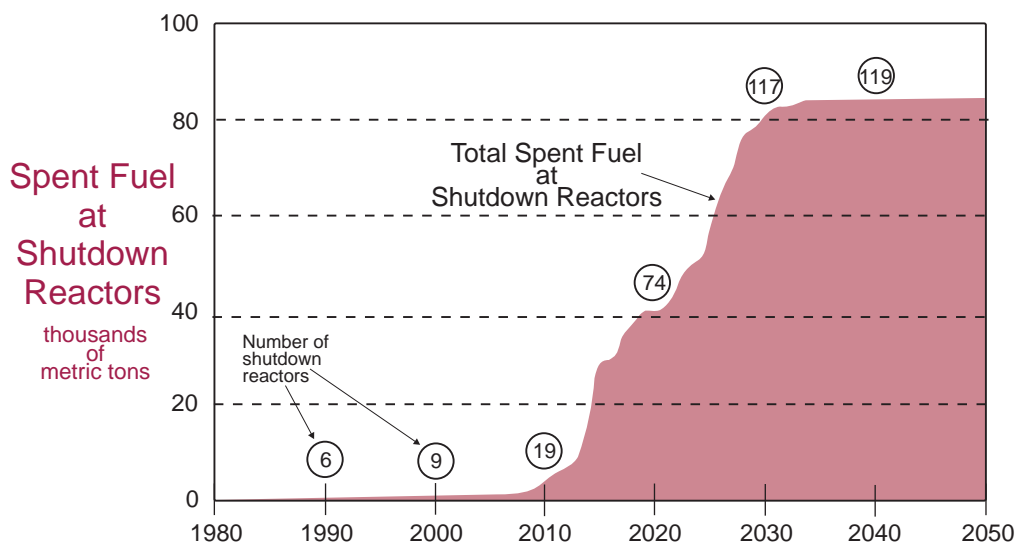
Together, these initiatives portend a possible change in focus of U.S. spent fuel and high-level waste management, from permanent disposal to temporary storage.

Board’s Advice to Congress: Keep Focus on Disposal

On March 20, 1996, the Board submitted a report to Congress and the U.S. Secretary of Energy summarizing its views on disposal and storage of spent nuclear fuel (NWTRB, March 1996). The Board recommends that the focus of U.S. policy should continue to be on the permanent disposal of spent fuel and high-level waste. The Board observes, however, that centralized storage capacity, which currently is not available in the United States, will be needed in the future, especially when reactors begin to shut down in large numbers.

A large centralized storage facility will be necessary (1) to facilitate repository operations and waste handling and (2) to address storage needs, which will increase markedly around 2010. (See Fig. 2)

Figure 2:
Projected amounts of spent fuel at shutdown reactors under an indefinitely delayed repository scenario



Note: Unless spent fuel is moved from shutdown reactors at the rate of 3,000 metric tons/year beginning in 2010, it will be very difficult to avoid significant accumulations of spent fuel at shutdown reactors. Shutdown projections are based on several assumptions, including expiration of 40-year operating licenses with no license renewals and no new plant orders.

Source: Adapted from DOE, Spent Fuel Storage Requirements: 1992–2036. Dec. 1993.

In an effort to strike a balance between permanent disposal and temporary storage, the Board made the following recommendations.

- The DOE should continue to assess the Yucca Mountain, Nevada, site as a potential repository site for the permanent disposal of the nation's spent nuclear fuel and high-level radioactive waste.
- Planning should begin now for a federal storage facility and supporting transportation structure that can be operating at full scale (3,000 metric tons/year) by 2010 — when U.S reactors will begin shutting down in large numbers. Ideally, it should be located at the repository site.
- Construction of a large storage facility should be deferred, however, until a decision is made on the suitability of the Yucca Mountain site. In the Board's view, this can be accomplished within about five years if the current pace of site characterization activities is maintained.
- Limited capacity storage should be made available at an existing federal nuclear facility to accommodate utility hardship cases.

The Board concluded that efforts to develop a federal storage facility at the Yucca Mountain site *prior* to the site-suitability decision could seriously jeopardize the credibility of the site-assessment work, could result in competition for limited funds, could cause a real or perceived prejudicing of any decision about the site's suitability for permanent disposal, and eventually could erode public support for the disposal program. The Board also concluded that there are no compelling technical or safety reasons to move spent fuel to a centralized storage facility for the next few years.

Concluding Thoughts

The U.S. program for the management of spent nuclear fuel and high-level waste is again in a period of potential programmatic, regulatory, and legislative change. The process for reviewing the health and safety standard for a permanent repository is in place. The NAS has issued its report, and the EPA is completing work on its task of issuing a new standard that will apply solely to the potential site at Yucca Mountain. The Board believes that this process should be allowed to proceed to its conclusion.

In the meantime, the DOE should continue to assess the site at Yucca Mountain, Nevada, and to develop a waste isolation strategy and a repository design

for that site. The Board believes that, if the DOE can maintain the recent pace of underground exploration, testing, design, and analysis, sufficient information should be available to determine within five years whether there is a high probability that the site, along with the appropriate engineered barriers, can provide long-term waste isolation.

The Board believes that permanent disposal of spent nuclear fuel and high-level waste should continue to be the top priority of U.S. national policy related to spent fuel and high-level radioactive waste management. Lack of, or even a long delay in the development of, a permanent repository, could not only undermine the success of spent fuel storage initiatives, but also could raise serious questions about the fate of defense spent fuel and high-level radioactive wastes. These wastes are currently being stored around the United States, often under less-than-ideal conditions. If, in the end, the Yucca Mountain site proves unsuitable, the Board believes it makes sense to promptly begin the search for other potential sites for *both* storage and disposal.

Finally, no approach is risk-free, but the Board believes its proposed approach will increase the program's credibility with the scientific and technical community and the public. Earning that trust requires proceeding without confidence-eroding shortcuts.

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