Recommendation by the Secretary of Energy Regarding the Suitability of the Yucca Mountain Site for a Repository Under the Nuclear Waste Policy Act of 1982

February 2002

1. Introduction

For more than half a century, since nuclear science helped us win World War II and ring in the Atomic Age, scientists have known that the Nation would need a secure, permanent facility in which to dispose of radioactive wastes. Twenty years ago, when Congress adopted the Nuclear Waste Policy Act of 1982 (NWPA or "the Act"), it recognized the overwhelming consensus in the scientific community that the best option for such a facility would be a deep underground repository. Fifteen years ago, Congress directed the Secretary of Energy to investigate and recommend to the President whether such a repository could be located safely at Yucca Mountain, Nevada. Since then, our country has spent billions of dollars and millions of hours of research endeavoring to answer this question. I have carefully reviewed the product of this study. In my judgment, it constitutes sound science and shows that a safe repository can be sited there. I also believe that compelling national interests counsel in favor of proceeding with this project. Accordingly, consistent with my responsibilities under the NWPA, today I am recommending that Yucca Mountain be developed as the site for an underground repository for spent fuel and other radioactive wastes.[1]

The first consideration in my decision was whether the Yucca Mountain site will safeguard the health and safety of the people, in Nevada and across the country, and will be effective in containing at minimum risk the material it is designed to hold. Substantial evidence shows that it will. Yucca Mountain is far and away the most thoroughly researched site of its kind in the world. It is a geologically stable site, in a closed groundwater basin, isolated on thousands of acres of Federal land, and farther from any metropolitan area than the great majority of less secure, temporary nuclear waste storage sites that exist in the country today.

This point bears emphasis. We are not confronting a hypothetical problem. We have a staggering amount of radioactive waste in this country – nearly 100,000,000 gallons of high-level nuclear waste and more than 40,000 metric tons of spent nuclear fuel with more created every day. Our choice is not between, on the one hand, a disposal site with costs and risks held to a minimum, and, on the other, a magic disposal system with no costs or risks at all. Instead, the real choice is between a single secure site, deep under the ground at Yucca Mountain, or making do with what we have now or some variant of it – 131 aging surface sites, scattered across 39 states. Every one of those sites was built on the assumption that it would be temporary. As time goes by, every one is closer to the limit of its safe life span. And every one is at least a potential security risk – safe for today, but a question mark in decades to come.

The Yucca Mountain facility is important to achieving a number of our national goals. It will promote our energy security, our national security, and safety in our homeland. It will help strengthen our economy and help us clean up the environment.

The benefits of nuclear power are with us every day. Twenty percent of our country's electricity comes from nuclear energy. To put it another way, the "average" home operates on nuclear-generated electricity for almost five hours a day. A government with a complacent, kick-the-

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[1] For purposes of this Recommendation, the terms "radioactive waste" and "waste" are used to cover high-level radioactive waste and spent nuclear fuel, as those terms are used in the Nuclear Waste Policy Act.

can-down-the-road nuclear waste disposal policy will sooner or later have to ask its citizens which five hours of electricity they would care to do without.

Regions that produce steel, automobiles, and durable goods rely in particular on nuclear power, which reduces the air pollution associated with fossil fuels – greenhouse gases, solid particulate matter, smog, and acid rain. But environmental concerns extend further. Most commercial spent fuel storage facilities are near large populations centers; in fact, more than 161 million Americans live within 75 miles of these facilities. These storage sites also tend to be near rivers, lakes, and seacoasts. Should a radioactive release occur from one of these older, less robust facilities, it could contaminate any of 20 major waterways, including the Mississippi River. Over 30 million Americans are served by these potentially at-risk water sources.

Our national security interests are likewise at stake. Forty percent of our warships, including many of the most strategic vessels in our Navy, are powered by nuclear fuel, which eventually becomes spent fuel. At the same time, the end of the Cold War has brought the welcome challenge to our Nation of disposing of surplus weapons-grade plutonium as part of the process of decommissioning our nuclear weapons. Regardless of whether this material is turned into reactor fuel or otherwise treated, an underground repository is an indispensable component in any plan for its complete disposition. An affirmative decision on Yucca Mountain is also likely to affect other nations' weapons decommissioning, since their willingness to proceed will depend on being satisfied that we are doing so. Moving forward with the repository will contribute to our global efforts to stem the proliferation of nuclear weapons in other ways, since it will encourage nations with weaker controls over their own materials to follow a similar path of permanent, underground disposal, thereby making it more difficult for these materials to fall into the wrong hands. By moving forward with Yucca Mountain, we will show leadership, set out a roadmap, and encourage other nations to follow it.

There will be those who say the problem of nuclear waste disposal generally, and Yucca Mountain in particular, needs more study. In fact, both issues have been studied for more than twice the amount of time it took to plan and complete the moon landing. My Recommendation today is consistent with the conclusion of the National Research Council of the National Academy of Sciences – a conclusion reached, not last week or last month, but 12 years ago. The Council noted "a worldwide scientific consensus that deep geological disposal, the approach being followed by the United States, is the best option for disposing of high-level radioactive waste."[2] Likewise, a broad spectrum of experts agrees that we now have enough information, including more than 20 years of researching Yucca Mountain specifically, to support a conclusion that such a repository can be safely located there.[3]

Nonetheless, should this site designation ultimately become effective, considerable additional study lies ahead. Before an ounce of spent fuel or radioactive waste could be sent to Yucca

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[2] *Rethinking High-Level Radioactive Waste Disposal: A Position Statement of the Board on Radioactive Waste Management*, Washington, D.C., National Academy Press, 1990.

[3] Letter and attached report, Charles G. Groat, Director, U.S. Geologic Survey, to Robert G. Card, October 4, 2001 (hereafter *USGS Letter & Report*); Letter and attached report, Hans Riotte, NEA-IAEA Joint Secretariat, to Lake H. Barrett, November 2, 2001 (hereafter *NEA-IAEA Letter & Report*); Letter, Charles V. Shank, Director, Lawrence Berkeley National Laboratory, to Spencer Abraham, September 6, 200 (hereafter *Lawrence Berkeley National Laboratory Letter*).

Mountain, indeed even before construction of the permanent facilities for emplacement of waste could begin there, the Department of Energy (DOE or "the Department") will be required to submit an application to the independent Nuclear Regulatory Commission (NRC). There, DOE would be required to make its case through a formal review process that will include public hearings and is expected to last at least three years. Only after that, if the license were granted, could construction begin. The DOE would also have to obtain an additional operating license, supported by evidence that public health and safety will be preserved, before any waste could actually be received.

In short, even if the Yucca Mountain Recommendation were accepted today, an estimated minimum of eight more years lies ahead before the site would become operational.

We have seen decades of study, and properly so for a decision of this importance, one with significant consequences for so many of our citizens. As necessary, many more years of study will be undertaken. But it is past time to stop sacrificing that which is forward-looking and prudent on the altar of a *status quo* we know ultimately will fail us. The *status quo* is not the best we can do for our energy future, our national security, our economy, our environment, and safety – and we are less safe every day as the clock runs down on dozens of older, temporary sites.

I recommend the deep underground site at Yucca Mountain, Nevada, for development as our Nation's first permanent facility for disposing of high-level nuclear waste.

2. Background

2.1. History of the Yucca Mountain Project and the Nuclear Waste Policy Act

The need for a secure facility in which to dispose of radioactive wastes has been known in this country at least since World War II. As early as 1957, a National Academy of Sciences report to the Atomic Energy Commission suggested burying radioactive waste in geologic formations. Beginning in the 1970s, the United States and other countries evaluated many options for the safe and permanent disposal of radioactive waste, including deep seabed disposal, remote island siting, dry cask storage, disposal in the polar ice sheets, transmutation, and rocketing waste into orbit around the sun. After analyzing these options, disposal in a mined geologic repository emerged as the preferred long-term environmental solution for the management of these wastes.[4] Congress recognized this consensus 20 years ago when it passed the Nuclear Waste Policy Act of 1982.

In the Act, Congress created a Federal obligation to accept civilian spent nuclear fuel and dispose of it in a geologic facility. Congress also designated the agencies responsible for implementing this policy and specified their roles. The Department of Energy must characterize, site, design, build, and manage a Federal waste repository. The Environmental Protection Agency (EPA) must set the public health standards for it. The Nuclear Regulatory Commission must license its construction, operation, and closure.

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[4] *Final Environmental Impact Statement for Management of Commercially Generated Radioactive Waste*, DOE/EIS-0046, 1980.

The Department of Energy began studying Yucca Mountain almost a quarter century ago. Even before Congress adopted the NWPA, the Department had begun national site screening research as part of the National Waste Terminal Storage program, which included examination of Federal sites that had previously been used for defense-related activities and were already potentially contaminated. Yucca Mountain was one such location, on and adjacent to the Nevada Test Site, which was then under consideration. Work began on the Yucca Mountain site in 1978. When the NWPA was passed, the Department was studying more than 25 sites around the country as potential repositories. The Act provided for the siting and development of two; Yucca Mountain was one of nine sites under consideration for the first repository program.

Following the provisions of the Act and the Department's siting Guidelines,[5] the Department prepared draft environmental assessments for the nine sites. Final environmental assessments were prepared for five of these, including Yucca Mountain. In 1986, the Department compared and ranked the sites under consideration for characterization. It did this by using a multi-attribute methodology – an accepted, formal scientific method used to help decision makers compare, on an equivalent basis, the many components that make up a complex decision. When all the components of the ranking decision were considered together, taking account of both pre-closure and post-closure concerns, Yucca Mountain was the top-ranked site.[6] The Department examined a variety of ways of combining the components of the ranking scheme; this only confirmed the conclusion that Yucca Mountain came out in first place. The EPA also looked at the performance of a repository in unsaturated tuff. The EPA noted that in its modeling in support of development of the standards, unsaturated tuff was one of the two geologic media that appeared most capable of limiting releases of radionuclides in a manner that keeps expected doses to individuals low.[7]

In 1986, Secretary of Energy Herrington found three sites to be suitable for site characterization, and recommended the three, including Yucca Mountain, to President Reagan for detailed site characterization.[8] The Secretary also made a preliminary finding, based on Guidelines that did not require site characterization, that the three sites were suitable for development as repositories.[9]

The next year, Congress amended the NWPA, and selected Yucca Mountain as the single site to be characterized. It simultaneously directed the Department to cease activities at all other potential sites. Although it has been suggested that Congress's decision was made for purely political reasons, the record described above reveals that the Yucca Mountain site consistently ranked at or near the top of the sites evaluated well before Congress's action.

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[5] The Guidelines then in force were promulgated at 10 CFR part 960, General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories, 1984.
[6] *Recommendation by the Secretary of Energy of Candidate Sites for Site Characterization for the First Radioactive Waste Repository*, DOE/S-0048, May 1986.
[7] Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes, Final Rule, 40 CFR Part 191, December 20, 1993.
[8] Letter, John S. Herrington, Secretary of Energy, to President Ronald Reagan, May 27, 1986, with attached report, *Recommendation by the Secretary of Energy of Candidate Sites for Site Characterization for the First Radioactive Waste Repository*, DOE/S-0048, May 1986.
[9] *Ibid.*

As previously noted, the National Research Council of the National Academy of Sciences concluded in 1990 (and reiterated last year) that there is "a worldwide scientific consensus that deep geological disposal, the approach being followed by the United States, is the best option for disposing of high-level radioactive waste."[10] Today, many national and international scientific experts and nuclear waste management professionals agree with DOE that there exists sufficient information to support a national decision on designation of the Yucca Mountain site.[11]

2.2. The Nuclear Waste Policy Act and the Responsibilities of the Department of Energy and the Secretary

Congress assigned to the Secretary of Energy the primary responsibility for implementing the national policy of developing a deep underground repository. The Secretary must determine whether to initiate the next step laid out in the NWPA – a recommendation to designate Yucca Mountain as the site for development as a permanent disposal facility. The criteria for this determination are described more fully in section 5. Briefly, I first must determine whether Yucca Mountain is in fact technically and scientifically suitable to be a repository. A favorable suitability determination is indispensable for a positive recommendation of the site to the President. Under additional criteria I have adopted above and beyond the statutory requirements, I have also sought to determine whether, when other relevant considerations are taken into account, recommending it is in the overall national interest and, if so, whether there are countervailing arguments so strong that I should nonetheless decline to make the Recommendation.

The Act contemplates several important stages in evaluating the site before a Secretarial recommendation is in order. It directs the Secretary to develop a site characterization plan, one that will help guide test programs for the collection of data to be used in evaluating the site. It directs the Secretary to conduct such characterization studies as may be necessary to evaluate the site's suitability. And it directs the Secretary to hold hearings in the vicinity of the prospective site to inform the residents and receive their comments. It is at the completion of these stages that the Act directs the Secretary, if he finds the site suitable, to determine whether to recommend it to the President for development as a permanent repository.

If the Secretary recommends to the President that Yucca Mountain be developed, he must include with the Recommendation, and make available to the public, a comprehensive statement of the basis for his determination.[12] If at any time the Secretary determines that Yucca Mountain is not a suitable site, he must report to Congress within six months his recommendations for further action to assure safe, permanent disposal of spent nuclear fuel and high-level radioactive waste.

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[10] *Rethinking High-Level Radioactive Waste Disposal: A Position Statement of the Board on Radioactive Waste Management*, Washington, D.C., National Academy Press, 1990. And: *Disposition of High-Level Waste and Spent Nuclear Fuel: The Continuing Societal and Technical Challenges*, Board on Radioactive Waste Management, Washington, D.C., National Academy Press, 2001.

[11] *USGS Letter & Report, supra; NEA-IAEA Letter & Report, supra; Lawrence Berkeley National Laboratory Letter, supra.*

[12] This document together with accompanying materials comprises the recommendation and the comprehensive statement. The accompanying materials are described in footnote 26.

Following a Recommendation by the Secretary, the President may recommend the Yucca Mountain site to Congress "if… [he] considers [it] qualified for application for a construction authorization…."[13] If the President submits a recommendation to Congress, he must also submit a copy of the statement setting forth the basis for the Secretary's Recommendation.

A Presidential recommendation takes effect 60 days after submission unless Nevada forwards a notice of disapproval to the Congress. If Nevada submits such a notice, Congress has a limited time during which it may nevertheless give effect to the President's recommendation by passing, under expedited procedures, a joint resolution of siting approval. If the President's recommendation takes effect, the Act directs the Secretary to submit to the NRC a construction license application.

The NWPA by its terms contemplated that the entire process of siting, licensing, and constructing a repository would have been completed more than four years ago, by January 31, 1998. Accordingly, it required the Department to enter into contracts to begin accepting waste for disposal by that date.

3. Decision

3.1. The Recommendation

After over 20 years of research and billions of dollars of carefully planned and reviewed scientific field work, the Department has found that a repository at Yucca Mountain brings together the location, natural barriers, and design elements most likely to protect the health and safety of the public, including those Americans living in the immediate vicinity, now and long into the future. It is therefore suitable, within the meaning of the NWPA, for development as a permanent nuclear waste and spent fuel repository.

After reviewing the extensive, indeed unprecedented, analysis the Department has undertaken, and in discharging the responsibilities made incumbent on the Secretary under the Act, I am recommending to the President that Yucca Mountain be developed as the Nation's first permanent, deep underground repository for high-level radioactive waste. A decision to develop Yucca Mountain will be a critical step forward in addressing our Nation's energy future, our national defense, our safety at home, and protection for our economy and environment.

3.2. What This Recommendation Means, and What It Does Not Mean

Even after so many years of research, this Recommendation is a preliminary step. It does no more than start the formal safety evaluation process. Before a license is granted, much less before repository construction or waste emplacement may begin, many steps and many years still lie ahead. The DOE must submit an application for a construction license; defend it through formal review, including public hearings; and receive authorization from the NRC, which has the statutory responsibility to ensure that any repository built at Yucca Mountain meets stringent

[13] NWPA section 114(a)(2)(A).

tests of health and safety. The NRC licensing process is expected to take a minimum of three years. Opposing viewpoints will have every opportunity to be heard. If the NRC grants this first license, it will only authorize initial construction. The DOE would then have to seek and obtain a second operating license from the NRC before any wastes could be received. The process altogether is expected to take a minimum of eight years.

The DOE would also be subject to NRC oversight as a condition of the operating license. Construction, licensing, and operation of the repository would also be subject to ongoing Congressional oversight.

At some future point, the repository is expected to close. EPA and NRC regulations require monitoring after the DOE receives a license amendment authorizing the closure, which would be from 50 to about 300 years after waste emplacement begins, or possibly longer.
The repository would also be designed, however, to be able to adapt to methods future generations might develop to manage high-level radioactive waste. Thus, even after completion of waste emplacement, the waste could be retrieved to take advantage of its economic value or usefulness to as yet undeveloped technologies.

Permanently closing the repository would require sealing all shafts, ramps, exploratory boreholes, and other underground openings connected to the surface. Such sealing would discourage human intrusion and prevent water from entering through these openings. DOE's site stewardship would include maintaining control of the area, monitoring and testing, and implementing security measures against vandalism and theft. In addition, a network of permanent monuments and markers would be erected around the site to alert future generations to the presence and nature of the buried waste.[14] Detailed public records held in multiple places would identify the location and layout of the repository and the nature and potential hazard of the waste it contains. The Federal Government would maintain control of the site for the indefinite future. Active security systems would prevent deliberate or inadvertent human intrusion and any other human activity that could adversely affect the performance of the repository.

4. Decision Determination Methodology and the Decision-Making Process

I have considered many kinds of information in making my determination today. I have put on a hard hat, gone down into the Mountain, and spoken with many of the scientists and engineers working there. Of course my decision-making included a great deal more than that. I have also personally reviewed detailed summaries of the science and research undertaken by the Yucca Mountain Project since 1978. I relied upon review materials, program evaluations, and face-to-face briefings given by many individuals familiar with the Project, such as the acting program manager and program senior staff.

My consideration included: (a) the general background of the program, including the relevant legislative history; (b) the types, sources, and amounts of radioactive waste that would be disposed of at the site and their risk; (c) the extent of Federal responsibilities; (d) the criteria for a

[14]During characterization of the Yucca Mountain site, Nye County began to develop its Early Warning Monitoring program and boreholes. These boreholes not only provide information about water movement in the area of the site, but also can serve as monitoring points should a repository be built at Yucca Mountain.

suitability decision, including the NWPA's provisions bearing on the basis for the Secretary's consideration; the regulatory structure, its substance, history, and issues; DOE's Yucca Mountain Suitability Guidelines promulgated under the NWPA;[15] the NRC licensing regulations,[16] and EPA radiation protection standards[17] as referenced in the Suitability Guidelines; (e) assessments of repository performance, including technical data and descriptions of how those data were gathered and evaluated; assessments of the effectiveness of natural and engineered barriers in meeting applicable radiation protection standards, and adjustments for uncertainties associated with each of these; (f) the Yucca Mountain Site Suitability Evaluation; (g) the views of members of the public, including those expressed at hearings and through written comments; (h) environmental, socioeconomic, and transportation issues; (i) program oversight history, technical issues, and responses, including the role and views of the NRC, the Nuclear Waste Technical Review Board, the General Accounting Office, the Inspector General, and the State of Nevada; and the role and views of the National Laboratories, the United States Geological Survey, and peer reviews; and (j) public policy impact.

I also requested an external review of program briefing materials. It was conducted by Dr. Chris Whipple, a member of the National Academy of Engineering and an experienced independent peer reviewer of programs for both the Waste Isolation Pilot Plant and the Yucca Mountain Project. Dr. Whipple previously had led a peer review team that critically analyzed Total System Performance Assessment (TSPA) work of the Yucca Mountain Project.

I also reviewed the comment summary documents from both the Environmental Impact Statement (EIS) and NWPA Section 114 site recommendation hearing process in order fully to take into account public views concerning a possible recommendation of the Yucca Mountain site. This review enabled me to evaluate scientific and research results in the context of both strongly held local concerns and issues of national importance. I took particular note of comments and concerns raised by the Governor of Nevada, governors of other states, state agencies, Native American tribes, and members of the public at large.

5. Decision Criteria

My charge to make a recommendation to the President on this matter stems from the Nuclear Waste Policy Act of 1982. That statute directs the Secretary of Energy to determine "whether to recommend to the President that he approve [the Yucca Mountain] site for development of a repository."[18] The NWPA establishes certain guideposts along the way to making this determination, but it also gives the Secretary significant responsibility for deciding what the relevant considerations are to be.

Pursuant to that responsibility, I concluded that I should use three criteria in determining whether to recommend approval of the Yucca Mountain Project. First, is Yucca Mountain a scientifically

[15] 10 CFR Part 963, Yucca Mountain Site Suitability Guidelines, November 14, 2001.
[16] 10 CFR Part 63, Disposal of High-Level Radioactive Waste in a Geologic Repository at Yucca Mountain, Nevada, November 2, 2001.
[17] 40 CFR Part 197, Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada, June 13, 2001.
[18]NWPA section 114(a)(1).

and technically suitable site for a repository, *i.e.*, a site that promises a reasonable expectation of public health and safety for disposal of spent nuclear fuel and high-level radioactive waste for the next 10,000 years? Second, are there compelling national interests that favor proceeding with the decision to site a repository there? And third, are there countervailing considerations that outweigh those interests?

The first of these criteria is expressly contemplated by the NWPA, although the NWPA also confers considerable discretion and responsibility on the Secretary in defining how to determine scientific and technical suitability and in making a judgment on the question. The two other criteria are not specified by the NWPA, but I am convinced that they are appropriate checks on a pure suitability-based decision.

5.1. Scientific and Technical Suitability

Under the NWPA, the first step in a Secretarial determination regarding Yucca Mountain is deciding whether it is scientifically and technically suitable as a repository site. Although the NWPA does not state explicitly that this is the initial step, the language and structure of the Act strongly suggest that this is so. Most significantly, section 114(a)(1) of the NWPA states that the Secretary's recommendation is to be made at the conclusion of site characterization.[19] Section 113, in turn, makes clear that the function of site characterization is to provide enough site-specific information to allow a decision on Yucca Mountain's scientific suitability.[20]

As to what a determination of site suitability entails, the only real guidance the Act provides is that in several places it equates a favorable suitability judgment with a judgment that a repository could (1) be built at that site and (2) receive a construction authorization from the NRC.[21] This suggests that a determination that the site is suitable entails a judgment on my part that a repository at Yucca Mountain would likely be licensable by the NRC.

Beyond that, the NWPA largely leaves the question to the Secretary of Energy by charging him with establishing "criteria to be used to determine the suitability of ... candidate site[s] for the location of a repository."[22] On November 14, 2001, following NRC's concurrence, the Department issued its final version of these criteria in a rule entitled, "Yucca Mountain Site Suitability Guidelines." I shall describe these in detail in the next section of this Recommendation, but outline them here. In brief, DOE's Guidelines envision that I may find the Yucca Mountain site suitable if I conclude that a repository constructed there is "likely" to meet

[19] Ibid.

[20] This is apparent from two related provisions of section 113: section 113(c)(1), which states that, "The Secretary may conduct at the Yucca Mountain site only such site characterization activities as the Secretary considers necessary to provide the data required for evaluation of the suitability of such site for an application to be submitted to the Commission for a construction authorization for a repository at such site" (as well as for NEPA purposes); and its companion provision, section 113(c)(3), which states that, "If the Secretary at any time determines the Yucca Mountain site to be unsuitable for development as a repository, the Secretary shall ... terminate all site characterization activities [there]."

[21] NWPA section 112(b)(1)(D)(ii); NWPA section 113(c)(1); NWPA section 113(c)(3).

[22] NWPA section 113(b)(1)(A)(iv). That section contemplates that these criteria are to be included in the first instance in the site characterization plan for each site and thereafter may be modified using the procedures of section 112(a).

extremely stringent radiation protection standards designed to protect public health and safety.[23] The EPA originally established these standards.[24] They are now also set out in NRC licensing rules.[25]

The EPA and NRC adopted the standards so as to assure that while the repository is receiving nuclear materials, any radiation doses to workers and members of the public in the vicinity of the site would be at safe levels, and that after the repository is sealed, radiation doses to those in the vicinity would be at safe levels for 10,000 years. These radiation protection levels are identical to those with which the DOE will have to demonstrate compliance to the satisfaction of the NRC in order to obtain a license to build the repository.

Using the Department's suitability Guidelines, I have concluded that Yucca Mountain is in fact suitable for a repository. The reasons for this conclusion are set out in section 7 of this Recommendation. However, I want to pause to make one thing clear at the outset. If for any reason I found that the site were not suitable or licensable, then, irrespective of any other consideration, I would not recommend it. Specifically, however much as I might believe that proceeding toward a repository would advance the national interest in other ways, those additional considerations could not properly influence, and have not influenced, my determination of suitability.

5.2. National Interest Considerations

Beyond scientific suitability, the NWPA is virtually silent on what other standard or standards the Secretary should apply in making a recommendation. It does direct me to consider certain matters. It requires that I consider the record of hearings conducted in the vicinity of Yucca Mountain, the site characterization record, and various other information I am directed to transmit to the President with my Recommendation.[26] The Act does not, however, specify how I

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[23] 10 CFR part 963.
[24] 40 CFR part 197.
[25] 10 CFR part 63.
[26] The statutorily required information is set out in Section 114(a)(1) of the NWPA, which states:
Together with any recommendation of a site under this paragraph, the Secretary shall make available to the public, and submit to the President, a comprehensive statement of the basis of such recommendation, including the following:
(A) a description of the proposed repository, including preliminary engineering specifications for the facility;
(B) a description of the waste form or packaging proposed for use at such repository, and an explanation of the relationship between such waste form or packaging and the geologic medium of such site;
(C) a discussion of data, obtained in site characterization activities, relating to the safety of such site;
(D) a final environmental impact statement prepared for the Yucca Mountain site pursuant to subsection (f) and the National Environmental Policy Act of 1969 [42 U.S.C. 4321 et seq.], together with comments made concerning such environmental impact statement by the Secretary of the Interior, the Council on Environmental Quality, the Administrator, and the Commission, except that the Secretary shall not be required in any such environmental impact statement to consider the need for a repository, the alternatives to geological disposal, or alternative sites to the Yucca Mountain site;
(E) preliminary comments of the Commission concerning the extent to which the at-depth site characterization analysis and the waste form proposal for such site seem to be sufficient for inclusion in any application to be submitted by the Secretary for licensing of such site as a repository;
(F) the views and comments of the Governor and legislature of any State, or the governing body of any affected Indian tribe, as determined by the Secretary, together with the response of the Secretary to such views;

am to consider these various items or what standard I am to use in weighing them. And finally among the items it directs me to take into account is, "such other information as the Secretary considers appropriate."

The approach taken in the Act led me to conclude that, after completing the first step of reaching a judgment as to the scientific suitability of Yucca Mountain, if I concluded the site was scientifically suitable, I should also address a second matter: whether it is in the overall national interest to build a repository there. In considering that issue, I have addressed two further questions: are there compelling national interests favoring development of the site, and if so, are there countervailing considerations weighty enough to overcome the arguments for proceeding with development? Sections 8 and 9 of this Recommendation set forth my conclusions on these questions.

In my view, the statute's silence on the factors that go into the recommendation process makes it at a minimum ambiguous on whether I should conduct any inquiry beyond the question of scientific suitability. In light of that ambiguity, I have elected to construe the statute as allowing me, if I make a favorable suitability determination based on science, also to consider whether development of a repository at Yucca Mountain is in the national interest. For several reasons, I believe this is the better way to interpret the NWPA. First, given the significance of a siting

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(G) such other information as the Secretary considers appropriate; and
(H) any impact report submitted under section 116(c)(2)(B) [42 U.S.C. 10136(c)(2)(B)] by the State of Nevada.
This material is attached to this Recommendation, as follows:

- The description of the repository called for by section 114(a)(1)(A) is contained in Chapter 2 of the Yucca Mountain Science and Engineering Report (YMS&ER), Revision 1.
- The material relating to the waste form called for by section 114(a)(1)(B) is contained in Chapters 3 and 4 of the YMS&ER, Revision 1.
- The discussion of site characterization data called for by section 114(a)(1)(C) is contained in Chapter 4 of the YMS&ER, Revision 1.
- The EIS-related material called for by section 114(a)(1)(D) is contained in the *Final Environmental Impact Statement (EIS) for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada*, along with letters received from the Secretary of the Interior, the Chair of the Council on Environmental Quality, the Administrator of the Environmental Protection Agency, and the Chairman of the Nuclear Regulatory Commission (NRC), transmitting their respective comments on the final EIS.
- The information called for by section 114(a)(1)(E) is contained in a letter from NRC Chairman Meserve to Under Secretary Card, dated November 13, 2001.
- The information called for by section 114(a)(1)(F) is contained in Section 2 of two separate reports, the *Comment Summary Document* and the *Supplemental Comment Summary Document*, and in a separate document providing responses to comments from the Governor of Nevada sent to the Department after the public comment periods on a possible site recommendation closed.
- Section 114(a)(1)(G) provides for the inclusion of other information as the Secretary considers appropriate. The report, *Yucca Mountain Site Suitability Evaluation* (DOE/RW-0549, February 2002), has been included as other information. This report provides an evaluation of the suitability of the Yucca Mountain site against Departmental Guidelines setting forth the criteria and methodology to be used in determining the suitability of the Yucca Mountain site, pursuant to section 113(b)(1)(A)(iv). In addition, impact reports submitted by the various Nevada counties have been included as other information to be forwarded to the President. In transmitting these reports to the President, the Department is neither deciding on, nor endorsing, any specific impact assistance requested by the governmental entities in those reports.
- The State of Nevada submitted an impact report pursuant to section 114(a)(1)(H). In transmitting this report to the President, the Department is likewise neither deciding on, nor endorsing this report.

decision and the nature of the officers involved, one would expect that even if a Cabinet Secretary were to find a site technically suitable for a repository, he should be able to take broader considerations into account in determining what recommendation to make to the President. A pure suitability-based decision risks taking insufficient heed of the views of the people, particularly in Nevada but in other parts of the country as well. Second, it is difficult to envision a Cabinet Secretary's making a recommendation without taking into account these broader considerations. Finally, it is plain that any conclusion on whether to recommend this site is likely to be reviewed by Congress. Since that review will inevitably focus on broader questions than the scientific and technical suitability of the site, it seems useful in the first instance for the Executive Branch to factor such considerations into its recommendation as well. I note, however, that if my interpretation of the statute in this regard is incorrect, and Congress has made a finding of suitability the sole determinant of whether to recommend Yucca Mountain, my Recommendation would be the same.

6. Is Yucca Mountain Scientifically and Technically Suitable for Development of a Repository?

The Department of Energy has spent over two decades and billions of dollars on carefully planned and reviewed scientific fieldwork designed to help determine whether Yucca Mountain is a suitable site for a repository. The results of that work are summarized in the *Yucca Mountain Science and Engineering Report, Revision 1*, and evaluated in the Yucca Mountain Site Suitability Evaluation (YMSSE), which concludes, as set out in 10 CFR part 963, that Yucca Mountain is "likely" to meet the applicable radiation standards and thus to protect the health and safety of the public, including those living in the immediate vicinity now and thousands of years from now. I have carefully studied that evaluation and much of the material underlying it, and I believe it to be correct.

6.1. Framework for Suitability Determination

6.1.1. General Outline

The general outline of the analytic framework I have used to evaluate the scientific suitability of the site is set out in the Department's Yucca Mountain Site Suitability Guidelines, found at 10 CFR part 963.

The framework has three key features. First, the Guidelines divide the suitability inquiry into sub-inquiries concerning a "pre-closure" safety evaluation and a "post-closure" performance evaluation. The "pre-closure" evaluation involves assessing whether a repository at the site is likely to be able to operate safely while it is open and receiving wastes. The "post-closure" evaluation involves assessing whether the repository is likely to continue to isolate the materials for 10,000 years after it has been sealed, so as to prevent harmful releases of radionuclides.

Second, the Guidelines set out a method and criteria for conducting the pre-closure safety evaluation. The method is essentially the same as that used to evaluate the safety of other proposed nuclear facilities; it is not particularly novel and should be recognized by those familiar with safety assessments of existing facilities. This is because, while it is open and receiving nuclear materials, a repository at Yucca Mountain will not be very different, in terms of its functions and the activities expected to take place there, from many other modern facilities built to handle such materials. A pre-closure evaluation to assess the probable safety of such a facility entails considering its design, the nature of the substances it handles, and the kinds of activities and external events that might occur while it is receiving waste. It then uses known data to forecast the level of radioactivity to which workers and members of the public would be likely to be exposed as a result.

Third, the Guidelines set out a method and criteria for evaluating the post-closure performance of the repository. This is the most challenging aspect of evaluating Yucca Mountain's suitability, since it entails assessing the ability of the repository to isolate radioactive materials far into the future. The scientific consensus is, and the Guidelines specify, that this should be done using a "Total System Performance Assessment." This approach, which is similar to other efforts to forecast the behavior of complex systems over long periods of time, takes information derived from a multitude of experiments and known facts. It feeds that information into a series of models. These in turn are used to develop one overarching model of how well a repository at Yucca Mountain would be likely to perform in preventing the escape of radioactivity and radioactive materials. The model can then be used to forecast the levels of radioactivity to which people near the repository might be exposed 10,000 years or more after the repository is sealed.[27]

6.1.2. Radiation Protection Standards

A key question to be answered, as part of any suitability determination is, "What level of radiation exposure is acceptable?"

[27] The selection of the 10,000-year compliance period for the individual-protection standard involves both technical and policy considerations. EPA weighed both during the rulemaking for 40 CFR Part 197. EPA considered policy and technical factors, as well as the experience of other EPA and international programs. First, EPA evaluated the policies for managing risks from the disposal of both long lived, hazardous, nonradioactive materials and radioactive materials. Second, EPA evaluated consistency with both 40 CFR Part 191 and the issue of consistent time periods for the protection of groundwater resources and public health. Third, EPA considered the issue of uncertainty in predicting dose over the very long periods contemplated in the alternative of peak dose within the period of geologic stability. Finally, EPA reviewed the feasibility of implementing the alternative of peak risk within the period of geologic stability.
As a result of these considerations, EPA established a 10,000-year compliance period with a quantitative limit and a requirement to calculate the peak dose, using performance assessments, if the peak dose occurs after 10,000 years. Under this approach, DOE must make the performance assessment results for the post-10,000-year period part of the public record by including them in the EIS for Yucca Mountain.
The relevance of a 10,000-year compliance period can also be understood by examining hazard indices that compare the potential risk of released radionuclides to other risks. One such analysis, presented in the *Final Environmental Impact Statement for the Management of Commercially Generated Radioactive Waste*, DOE/EIS-0046F, examined the relative amounts of water required to bring the concentration of a substance to allowable drinking water standards. The relative hazard for spent fuel compared to the toxicity of the ore used to produce the reactor fuel at one year after removal of the spent fuel from the reactor is about the same hazard as a rich mercury ore. The hazard index is about the same as average mercury ores at about 80 years. By 200 years the hazard index is about the same as average lead ore; by 1,000 years it is comparable to a silver ore. The relative hazard index is about the same as the uranium ore that it came from at 10,000 years. This is not to suggest that the wastes from spent fuel are not toxic. However, it is suggested that where concern for the toxicity of the ore bodies is not great, the spent fuel should cause no greater concern, particularly if placed within multiple engineered barriers in geologic formations, at least as, if not more, remote from the biosphere than these common ores.

DOE's Site Suitability Guidelines use as their benchmark the levels the NRC has specified for purposes of deciding whether to license a repository at Yucca Mountain. The NRC, in turn, established these levels on the basis of radiation protection standards set by the EPA. The standards generally require that during pre-closure, the repository facilities, operations, and controls restrict radiation doses to less than 15 millirem a year[28] to a member of the public in its vicinity.[29] During post-closure, they generally require that the maximum radiation dose allowed to someone living in the vicinity of Yucca Mountain be no more than 15 millirem per year, and no more than four millirem per year from certain radionuclides in the groundwater.[30]

This level of radiation exposure is comparable to, or less than, ordinary variations in natural background radiation that people typically experience each year. It is also less than radiation levels to which Americans are exposed in the course of their everyday lives – in other words, radiation "doses" to which people generally give no thought at all.

To understand this, it is important to remember that radiation is part of the natural world and that we are exposed to it all the time. Every day we encounter radiation from space in the form of cosmic rays. Every day we are also exposed to terrestrial radiation, emitted from naturally radioactive substances in the earth's surface.

In addition to natural background radiation from these sources, people are exposed to radiation from other everyday sources. These include X-rays and other medical procedures, and consumer goods (*e.g.*, television sets and smoke detectors).

Americans, on average, receive an annual radiation exposure of 360 millirem from their surroundings. The 15 millirem dose the EPA standard set as the acceptable annual exposure from the repository is thus slightly over four percent of what we receive every year right now.

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[28]Risk to human beings from radiation is due to its ionizing effects. Radionuclides found in nature, commercial products, and nuclear waste emit ionizing radiation. The forms of ionizing radiation differ in their penetrating power or energy and in the manner in which they affect human tissue. Some ionizing radiation, known as alpha radiation, can be stopped by a sheet of paper, but may be very harmful if inhaled, ingested or otherwise admitted into the body. Long-lived radioactive elements, with atomic numbers higher than 92, such as plutonium, emit alpha radiation. Other ionizing radiation, known as beta radiation, can penetrate the skin and can cause serious effects if emitted from an inhaled or ingested radionuclide. The ionizing radiation with the greatest penetrating power is gamma radiation; it can penetrate and damage critical organs in the body. Fission products can emit both gamma and beta radiation depending on the radionuclides present. In high-level nuclear waste, beta and gamma radiation emitters, such as cesium and strontium, present the greatest hazard for the first 300 to 1,000 years, by which time they have decayed. After that time, the alpha-emitting radionuclides present the greatest hazard.
Radiation doses can be correlated to potential biologic effects and are measured in a unit called a rem. Doses are often expressed in terms of thousandths of a rem, or millirem (mrem); the internationally used unit is the Sievert (S), which is equivalent to 100 rem.

[29] The NRC regulations also require that the annual dose to workers there be less than 5 rem. See 10 CFR part 63, referencing 10 CFR part 20. This is the general standard for occupational exposure that applies in numerous other settings, such as operating nuclear facilities.

[30] During both pre- and post-closure, the NRC licensing rules, 10 CFR part 63, also contain a number of more particularized standards for specific situations. These are referenced in the results tables contained in the following sections. Pursuant to EPA's groundwater standard, 40 CFR part 197, they also contain concentration limits on certain kinds of radionuclides that may be present in the water, whether or not their presence is attributable to a potential repository. These are also referenced in the results tables.

Moreover, background radiation varies from one location to another due to many natural and man-made factors. At higher elevations, the atmosphere provides less protection from cosmic rays, so background radiation is higher. In the United States, this variation can be 50 or more millirem. Thus, if the repository generates radiation doses set as the benchmark in the Guidelines, the incremental radiation dose a person living in the vicinity of Yucca Mountain would receive from it would be about the same level of increase in radiation exposure as a person would experience as a result of moving from Philadelphia to Denver.

Ordinary air travel is another example. Flying at typical cross-country altitudes results in increased exposure of about one-half millirem per hour. If the Yucca Mountain repository generates radiation at the 15 millirem benchmark, it would increase the exposure of those living near it to about the same extent as if they took three round trip flights between the East Coast and Las Vegas.

Rocks and soil also affect natural background radiation, particularly if the rocks are igneous or the soils derived from igneous rock, which can contain radioactive potassium, thorium, or uranium. In these cases, the variation in the background radiation is frequently in the tens of millirem or higher. Wood contains virtually no naturally occurring radioactive substances that contribute to radiation exposures, but bricks and concrete made from crushed rock and soils often do. Living or working in structures made from these materials can also result in tens of millirem of increased exposure to radiation. Thus, if the repository generates radiation at the levels in the Guidelines' benchmark, it is likely to result in less additional exposure to a person living in its vicinity than if he moved from a wood house to a brick house.

Finally, it is noteworthy that the radiation protection standards referenced by the Guidelines are based on those selected by the NRC for licensing the repository. They in turn relied on the EPA rule establishing these as the appropriate standards for the site. The NRC and EPA acted pursuant to specific directives in the NWPA, in which Congress first assigned to the EPA the responsibility to set these standards, and later in the Energy Policy Act of 1992, which directed the EPA to act in conjunction with the National Academy of Sciences and develop a standard specifically for Yucca Mountain. The EPA carefully considered the question of how to do so. The 15 millirem per year standard is the same it has applied to the Waste Isolation Pilot Plant in New Mexico.[31] And it is well within the National Academy of Sciences-recommended range, a range developed in part by referring to guidelines from national and international advisory bodies and regulations in other developed countries.[32]

For all these reasons, there is every cause to believe that a repository that can meet the 15 millirem radiation protection standard will be fully protective of the health and safety of residents living in the vicinity of the repository.[33]

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[31] 40 CFR part 191.

[32] *Technical Bases for Yucca Mountain Standards,* National Academy of Sciences, National Research Council, 1995.

[33] As noted above, the EPA, in 40 CFR part 197, also established groundwater protection standards in the Yucca Mountain rule; these are compatible with drinking water standards applied elsewhere in the United States, and apply maximum contaminant levels, as well as a 4 mrem/yr dose standard.

6.1.3. Underlying Hard Science

As explained in section 6.1.1, the Guidelines contemplate the use of models and analyses to project whether the repository will meet the 15 millirem dose standard.[34] To have confidence in the model results, however, it is important to understand the kind of science that went into constructing them.

For over 20 years, scientists have been investigating every aspect of the natural processes – past, present and future – that could affect the ability of a repository beneath Yucca Mountain to isolate radionuclides emitted from nuclear materials emplaced there. They have been conducting equally searching investigations into the processes that would allow them to understand the behavior of the engineered barriers – principally the waste "packages" (more nearly akin to vaults) – that are expected to contribute to successful waste isolation. These investigations have run the gamut, from mapping the geological features of the site, to studying the repository rock, to investigating whether and how water moves through the Mountain. To give just a few examples:

<u>At the surface of the repository:</u>

- Yucca Mountain scientists have mapped geologic structures, including rock units, faults, fractures, and volcanic features. To do this, they have excavated more than 200 pits and trenches to remove alluvial material or weathered rock to be able to observe surface and near-surface features directly, as well as to understand what events and processes have occurred or might occur at the Mountain.

- They have drilled more than 450 surface boreholes and collected over 75,000 feet of geologic core samples and some 18,000 geologic and water samples. They used the information obtained to identify rock and other formations beneath the surface, monitor infiltration of moisture, measure the depth of the water table and properties of the hydrologic system, observe the rate at which water moves from the surface into subsurface rock, and determine air and water movement properties above the water table.

- They have conducted aquifer testing at sets of wells to determine the transport and other properties of the saturated zone below Yucca Mountain. These tests included injecting easily identified groundwater tracers in one well, which were then detected in another; this helped scientists understand how fast water moves.

- They have conducted tectonic field studies to evaluate extensions of the earth's crust and the probability of seismic events near Yucca Mountain.

[34] As well, of course, as the other radiation protection standards such as the groundwater standard.

Underground:

The Department's scientists have conducted a massive project to probe the area under the Mountain's surface where the repository will be built.

- They constructed a five mile-long main underground tunnel, the Exploratory Studies Facility, to provide access to the specific rock type that would be used for the repository. This main tunnel is adjacent to the proposed repository block, about 800 feet underground. After completing the main tunnel, they excavated a second tunnel, 1.6-miles long and 16.5 feet in diameter. This tunnel, referred to as the Cross-Drift tunnel, runs about 45 feet above and across the repository block.

- They then mapped the geologic features such as faults, fractures, stratigraphic units, mineral compositions, etc., exposed by the underground openings in the tunnels.

- They collected rock samples to determine geotechnical properties.

- They conducted a drift-scale thermal test to observe the effects of heat on the hydrologic, mechanical, and chemical properties of the rock, and chemical properties of the water and gas liberated as a result of heating. The four yearlong heating cycle of the drift-scale test was the largest known heater test in history, heating some seven million cubic feet of rock over its ambient temperature. This test also included samples of engineered materials to determine corrosion resistance in simulated repository conditions.

In various laboratory-based studies:

Yucca Mountain scientists have supplemented with laboratory work the surface and underground tests previously described.

- They have tested mechanical, chemical, and hydrologic properties of rock samples in support of repository design and development of natural process models.

- They have tested radionuclides to determine solubility and colloid formation that affect their transport if released.

- They have tested over 13,000 engineered material samples to determine their corrosion resistance in a variety of environments.

- They have determined the chemical properties of water samples and the effects of heat on the behavior and properties of water in the host rock.

The findings from these numerous studies were used to develop computer simulations that describe the natural features, events, and processes that exist at Yucca Mountain or that could be changed as the result of waste disposal. The descriptions in turn were used to develop the models discussed in the next section to project the likely radiation doses from the repository.

7. Results of Suitability Evaluations and Conclusions

As explained above, the Guidelines contemplate that the Secretary will evaluate the suitability of the Yucca Mountain site for a repository on two separate bases.

The Guidelines first contemplate that I will determine whether the site is suitable for a repository during the entire pre-closure or operational period, assumed to be from 50 to 300 years after emplacement of nuclear materials begins. To answer this question, the Guidelines ask me to determine whether, while it is operating, the repository is likely to result in annual radiation doses to people in the vicinity and those working there that will fall below the dosage levels set in the radiation protection standards.[35] The Guidelines contemplate that I will use a pre-closure safety evaluation to guide my response.[36]

Second, the Guidelines contemplate that I will determine whether the repository is suitable – in other words, may reasonably be expected to be safe – after it has been sealed. To answer that question, the Guidelines ask me to determine whether it is likely that the repository will continue to isolate radionuclides for 10,000 years after it is sealed, so that an individual living 18 kilometers (11 miles) from the repository is not exposed to annual radiation doses above those set in the radiation protection standards.[37] The Guidelines contemplate that I will use a Total System Performance Assessment to guide my response to this question.[38]

The Department has completed both the Pre-Closure Safety Evaluation and TSPA called for by the Guidelines. These project that a repository at Yucca Mountain will result in radioactive doses well below the applicable radiation protection standards. As I explain below, I have reviewed these projections and the bases for them, and I believe them to be well founded. I also believe both the Pre-Closure Safety Evaluation and the Total System Performance Assessment have properly considered the criteria set out in the Guidelines for each period. Using these evaluations as set out in the Guidelines,[39] I believe it is likely that a repository at Yucca Mountain will result in radiation doses below the radiation protection standards for both periods. Accordingly, I believe Yucca Mountain is suitable for the development of a repository.

7.1. Results of Pre-Closure Evaluations

As explained in section 6.1.1, the Pre-Closure Safety Evaluation method I have employed is commonly used to assess the likely performance of planned or prospective nuclear facilities. Essentially what it involves is evaluating whether the contemplated facility is designed to prevent or mitigate the effects of possible accidents. The facility will be considered safe if its design is likely to result in radioactive releases below those set in the radiation protection standards.

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[35] 10 CFR part 963.
[36] Ibid.
[37] Ibid.
[38] Ibid.
[39] Ibid.

The Department has conducted such a Pre-Closure Safety Evaluation, which is summarized in the *Yucca Mountain Science and Engineering Report, Revision 1*.[40] In conducting this evaluation, the Department considered descriptions of how the site will be laid out, the surface facilities, and the underground facilities and their operations. It also considered a series of potential hazards, including, for example, seismic activity, flooding, and severe winds, and their consequences. Finally, it considered preliminary descriptions of how components of the facilities' design would prevent or mitigate the effects of accidents.

The Pre-Closure Safety Evaluation concluded that the preliminary design would prevent or dramatically mitigate the effects of accidents, and that the repository would therefore not result in radioactive releases that would lead to exposure levels above those set by the radiation protection standards. It considered the pre-closure criteria of 10 CFR 963.14 in reaching this conclusion. In particular, it found that the preliminary design has the ability to contain and limit releases of radioactive materials; the ability to implement control and emergency systems to limit exposures to radiation; the ability to maintain a system and components that perform their intended safety functions; and the ability to preserve the option to retrieve wastes during the pre-closure period. The annual doses of radiation to which the Pre-Closure Safety Evaluation projected individuals in the vicinity of the repository and workers would be exposed are set out in the following table. These doses fall well below the levels that the radiation protection standards establish.

I have carefully reviewed the Pre-Closure Safety Evaluation and find its conclusions persuasive. I am therefore convinced that a repository can be built at Yucca Mountain that will operate safely without harming those in the repository's vicinity during the pre-closure period. Finally, I would note that although many aspects of this project are controversial, there is no controversy of which I am aware concerning this aspect of the Department's conclusions. This stands to reason. The kinds of activities that would take place at the repository during the pre-closure period – essentially, the management and handling of nuclear materials including packaging and emplacement in the repository – are similar to the kinds of activities that at present go on every day, and have gone on for years, at temporary storage sites around the country. These activities are conducted safely at those sites, and no one has advanced a plausible reason why they could not be conducted equally if not more safely during pre-closure operations at a new, state-of-the-art facility at Yucca Mountain.

That is not an insignificant point, since the pre-closure period will last at least 50 years after the start of emplacement, which will begin at the earliest eight years from today. Moreover, the Department's Pre-Closure Safety Evaluation also assumed a possible alternative pre-closure period of 300 years from the beginning of emplacement, and its conclusions remained unchanged. Thus, the Department's conclusion that the repository can operate safely for the next 300 years – or for about three generations longer than the United States has existed – has not been seriously questioned.

[40] *Yucca Mountain Science and Engineering Report, Revision 1*.

Table 1. Summary Pre-Closure Dose Performance Criteria and Evaluation Results[41]

Standard	Limits	Results
Public Exposures[a]		
Pre-closure standard: 10 CFR 63.204, referenced in 10 CFR 963.2; Pre-Closure Performance Objective for normal operations and Category 1 event sequences per 10 CFR 63.111(a)(2), referenced in 10 CFR 963.2	15 mrem/yr[b]	0.06 mrem/yr[b]
Constraint specified for air emissions of radioactive material to the environment (not a dose limitation): 10 CFR 20.1101 (d)[c]	10 mrem/yr[b,d]	0.06 mrem/yr[b]
Dose limits for individual member of the public for normal operations and Category 1 event sequences: 10 CFR 20.1301[c]	100 mrem/yr[b,d]	0.06 mrem/yr[b]
	2 mrem/hr in any unrestricted area from external sources	<<2 mrem/hr
Pre-Closure Performance Objective for any Category 2 event sequence: 10 CFR 63.111(b)(2), referenced in 10 CFR 963.2	5 rem[b]	0.02 rem[b]
	50 rem organ or tissue dose (other than the lens of the eye)	0.10 rem
	15 rem lens of the eye dose	0.06 rem
	50 rem skin dose	0.04 rem
Workers' Exposures		
Occupational Dose Limits for Adults from normal operational emissions and Category 1 event sequences: 10 CFR 20.1201[e]	5 rem/yr[b]	0.01 rem/yr[b]
	50 rem/yr organ or tissue dose (other than the lens of the eye)	0.10 rem/yr
	15 rem/yr lens of the eye dose	0.15 rem/yr
	50 rem/yr skin dose	0.13 rem/yr
Routine Occupational Dose Limits for Adults: 10 CFR 20.1201[e]	5 rem/yr[b]	0.06 to 0.79 rem/yr[b]

NOTES:
[a] Results for public exposures are calculated at the site boundary.
[b] Total effective dose equivalent.
[c] 10 CFR 63.111(a)(1), which is referenced in 10 CFR 963.2, would require repository operations area to meet the requirements of 10 CFR part 20.
[d] 10 CFR 20.1301(a)(1), which is cross-referenced through 10 CFR 963.2; dose limit to extent applicable.
[e] 10 CFR 63.111(b)(1), which referenced in 10 CFR 963.2, would require repository design objectives for Category 1 and normal operations to meet 10 CFR 63.111(a)(1) requirements (10 CFR part 20).

7.2. Results of Post-Closure Evaluations

The most challenging aspect of evaluating Yucca Mountain is assessing the likely post-closure performance of a repository 10,000 years into the future. As previously explained, the Department's Guidelines contemplate that this will be done using a Total System Performance Assessment. That assessment involves using data compiled from scientific investigation into the natural processes that affect the site, the behavior of the waste, and the behavior of the

[41] *Yucca Mountain Site Suitability Evaluation.*

engineered barriers such as the waste packages; developing models from these data; then developing a single model of how, as a whole, a repository at Yucca Mountain is likely to behave during the post-closure period. The model is then used to project radiation doses to which people in the vicinity of the Mountain are likely to be exposed as a result of the repository. Finally, the assessment compares the projected doses with the radiation protection standards to determine whether the repository is likely to comply with them.

The challenge, obviously, is that this involves making a prediction a very long time into the future concerning the behavior of a very complex system. To place 10,000 years into perspective, consider that the Roman Empire flourished nearly 2,000 years ago. The pyramids were built as long as 5,000 years ago, and plants were domesticated some 10,000 years ago. Accordingly, as the NRC explained, "Proof that the geologic repository will conform with the objectives for post-closure performance is not to be had in the ordinary sense of the word because of the uncertainties inherent in the understanding of the evolution of the geologic setting, biosphere, and engineered barrier system"[42] over 10,000 years. The judgment that the NRC envisions making is therefore not a certainty that the repository will conform to the standard, certainty being unattainable in this or virtually any other important matter where choices must be made. Rather, as it goes on to explain, "For such long-term performance, what is required is reasonable expectation, making allowance for the time period, hazards, and uncertainties involved, that the outcome will conform with the objectives for post-closure performance for the geologic repository."[43] The Nuclear Waste Technical Review Board recently summarized much the same thought (emphasis added): "Eliminating all uncertainty associated with estimates of repository performance would never be possible at <u>any</u> repository site."[44]

These views, in turn, inform my understanding of the judgment I am expected to make at this stage of the proceeding in evaluating the likely post-closure performance of a repository at Yucca Mountain. To conclude that it is suitable for post-closure, I do not need to know that we have answered all questions about the way each aspect of the repository will behave 10,000 years from now; that would be an impossible task. Rather, what I need to decide is whether, using the TSPA results, and fully bearing in mind the inevitable uncertainties connected with such an enterprise, I can responsibly conclude that we know enough to warrant a predictive judgment on my part that, during the post-closure period, a repository at Yucca Mountain is likely to meet the radiation protection standards.

I believe I can. Essentially, the reason for this is the system of multiple and redundant safeguards that will be created by the combination of the site's natural barriers and the engineered ones we will add. Even given many uncertainties, this calculated redundancy makes it likely that very little, if any, radiation will find its way to the accessible environment.

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[42] Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada, Final Rule, 66 Fed. Reg. 55731, 55804, November 2, 2001.
[43] Ibid.
[44] Nuclear Waste Technical Review Board Letter Report from all Board members to Speaker Hastert, Senator Byrd, and Secretary Abraham, January 24, 2002.

Before I describe in broad terms how the TSPA results and the criteria used in the regulations lead to this conclusion, I would like to give an illustration of how this works. The illustration draws on the TSPA analyses, but also explains what these analyses mean in the real world.

An Example

The most studied issue relating to Yucca Mountain, and the single most pressing concern many have felt about the post-closure phase of a repository there, is whether there might be a way for radionuclides from the emplaced nuclear materials to contaminate the water supply. This is not a problem unique to Yucca Mountain. Rather, besides disruptive events discussed later, water is the primary mechanism to transport radionuclides to people and is also the most likely mechanism for radionuclides to escape from the storage facilities we have now.

In the case of Yucca Mountain, the concern has been that rainwater seeping into the Mountain might contact disposal casks and carry radionuclides down to the water table in sufficient amounts to endanger sources of groundwater. In my judgment, when one considers everything we have learned about the multiple natural and engineered barriers that lie at the core of the Department's planning for this Project, this concern turns out to have virtually no realistic foundation.

Yucca Mountain is in the middle of a desert. Like any desert, it has an arid climate, receiving less than eight inches of rain in an average year. Most of that runs off the Mountain or evaporates. Only about five percent, less than four-tenths of an inch per year, ever reaches repository depth.

In order to reach the tunnels where the waste casks would be housed, this water must travel through about 800 feet of densely welded and bedded tuffs,[45] a trip that will typically require more than 1,000 years. The amount of water that eventually reaches the repository level at any point in time is very small, so small that capillary forces tend to retain it in small pores and fractures in the rock. It is noteworthy that all our observations so far indicate that no water actually drips into the tunnels at this level and all of the water is retained within the rock.

In spite of this finding, our TSPA ran calculations based on the assumption that water does drip into the tunnels. At that point, even just to reach radionuclides in the waste, the water would still have to breach the engineered barriers. These include waste packages composed of an outer barrier of highly corrosion-resistant alloy and a thick inner barrier of high quality stainless steel.

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[45]Yucca Mountain consists of alternating layers of welded and nonwelded volcanic material known as welded and non-welded tuff: welded tuff at the surface, welded tuff at the level of the repository, and an intervening layer of nonwelded tuffs. These nonwelded units contain few fractures; thus, they delay the downward flow of moisture into the welded tuff layer below, where the repository would be located. At the repository level, water in small fractures has a tendency to remain in the fractures rather than flow into larger openings, such as tunnels. Thus, the small amount of water traveling through small fractures near any emplacement tunnel would tend to flow around the tunnel, rather than seeping, forming a drip, and falling onto the drip shields below. Non-welded tuffs below the repository also provide a significant barrier to radionuclide transport. Deposits of minerals in the fractures demonstrate that for the last several million years the repository host rock has been under unsaturated conditions, even when higher precipitation, owing to the continent's overall glacial conditions, prevailed at the Mountain's surface.

The waste package is designed to prevent contact between the waste pellets and water that might seep into the tunnels unexpectedly, and thus to prevent release of radionuclides.[46] In addition, anchored above each waste package is a titanium drip shield that provides yet more protection against seepage. But even assuming the water defeats both the titanium shield and the metal waste package, the waste form itself is a barrier to the release of radionuclides. Specifically, the spent fuel is in the form of ceramic pellets, resistant to degradation and covered with a corrosion-resistant metal cladding.

Nevertheless, DOE scientists ran a set of calculations assuming that water penetrated the titanium shield and made small holes in three waste packages, due to manufacturing defects (even though the manufacturing process will be tightly controlled). The scientists further assumed that the water dissolves some of the ceramic waste. Even so, the analyses showed that only small quantities of radionuclides would diffuse and escape from the solid waste form. In order to reach the water table from the repository, the water, now assumed to be carrying radionuclides, must travel another 800 feet through layers of rock, some of which are nearly impenetrable. During this trip, many of the radionuclides are adsorbed by the rock because of its chemical properties.

The result of all this is instructive. Even under these adverse conditions, all assumed in the teeth of a high probability that not one of them will come to pass, the amount of radionuclides reaching the water table is so low that annual doses to people who could drink the water are well below the applicable radiation standards, and less than a millionth of the annual dose people receive from natural background radiation. Extrapolating from these calculations shows that even if <u>all</u> of the waste packages were breached in the fashion I have described above, the resulting contribution to annual dose would still be below the radiation safety standards, and less than one percent of the natural background.[47]

<u>Total System Performance More Generally</u>

It is important to understand that there is nothing unique about the kind of planning illustrated in the water seepage scenario described above. Rather, the scenario is characteristic of the studies DOE has undertaken and the solutions it has devised: deliberately pessimistic assumptions incorporated sometimes to the point of extravagance, met with multiple redundancies to assure safety. For example, one of our scenarios for Nevada postulates the return of ice ages, and examines Yucca Mountain assuming that it would receive about twice as much rain as it does today with four times as much infiltration into the Mountain.

As in the example above, the Department evaluated physical and historical information used to develop models of repository components, and then employed those models to forecast how the repository would perform in the post-closure period. These results are described at length in the

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[46] These engineered barriers will protect the waste under a wide range of conditions. For example, the barriers are protected by their underground location from the daily variations in temperature and moisture that occur above ground. As a result, the Mountain provides favorable conditions for the performance of these barriers. Indeed, the battery of tests we have conducted suggests that the waste packages are extremely resistant to corrosion.

[47] *Yucca Mountain Science and Engineering Report, Revision 1*.

TPSA analyses and summarized in Chapter 4 of the *Yucca Mountain Science and Engineering Report*.[48]

The Department used the suitability criteria set forth in 10 CFR 963.17 in the TSPA analyses. It carefully evaluated and modeled the behavior of characteristics of the site, such as its geologic, hydrologic, geophysical, and geochemical properties. Likewise it evaluated what are called unsaturated zone flow characteristics, such as precipitation entering the Mountain and water movement through the pores of the rock – in other words, natural processes which affect the amount of water entering the unsaturated zone above the repository and potentially coming in contact with wastes inside. DOE also evaluated and modeled near-field environment characteristics, such as effects of heat from the waste on waterflow through the site, the temperature and humidity at the engineered barriers, and chemical reactions and products that could result from water contacting the engineered barriers.

The Department carefully studied and modeled the characteristics of the engineered barriers as they aged. DOE emphasized specifically those processes important to determining waste package lifetimes and the potential for corroding the package. It examined waste form degradation characteristics, including potential corrosion or break-down of the cladding on the spent fuel pellets and the ability of individual radionuclides to resist dissolving in water that might penetrate breached waste packages. It examined ways in which radionuclides could begin to move outward once the engineered barrier system has been degraded – for example, whether colloidal particles might form and whether radionuclides could adhere to these particles as they were assumed to wash through the remaining barriers. Finally, the Department evaluated and modeled saturated and unsaturated zone flow characteristics, such as how water with dissolved radionuclides or colloidal particles might move through the unsaturated zone below the repository, how heat from the waste would affect waterflow through the site, and how water with dissolved radionuclides would move in the saturated zone 800 feet beneath the repository (assuming it could reach that depth).

Consistent with 10 CFR 963.17, the Department also evaluated the lifestyle and habits of individuals who potentially could be exposed to radioactive material at a future time, based, as would be required by NRC licensing regulations,[49] on representative current conditions. Currently, there are about 3,500 people who live in Amargosa Valley, the closest town to Yucca Mountain. They consume ground or surface water from the immediate area through direct extraction or by eating plants that have grown in the soil. The Department therefore assumed that the “reasonably maximally exposed individual” – that is, the hypothetical person envisioned to test whether the repository is likely to meet required radiation protection standards – likewise would drink water and eat agricultural products grown with water from the area, and built that assumption into its models.

Using the models described above, as well as a host of others it generated taking account of other relevant features, events and processes that could affect the repository’s performance, the Department developed a representative simulation of the behavior of the proposed Yucca Mountain site. It then considered thousands of possibilities about what might happen there. For

[48] Ibid.
[49] 10 CFR part 63.

example, it considered the possibility that waste packages might be manufactured defectively. It considered the possibility that the climate would change. It considered earthquakes. Our studies show that earthquakes probably will occur at Yucca Mountain sometime in the future. Because the occurrence of earthquakes is difficult to predict, our models conservatively treat earthquakes by assuming that they will occur over the next 10,000 years.

Essentially, if the Department believed that there was close to a 1 in 10,000 per year probability of some potentially adverse occurrence in the course of the 10,000 year post-closure period (which comes to a probability close to one during the entire period) the Department considered that possibility, unless it concluded the occurrence would not affect the repository's performance. It then used the simulation model to calculate what the resulting dose would be based on each such possibility. Finally, it used the mean peak values of the results of these calculations to project the resulting dose.

The Department then proceeded to consider the impact of disruptive events, such as volcanism, with a lower probability of occurrence, on the order of one in 10,000 over the entire 10,000 year period (meaning roughly a one in a 100 million per year of occurring during that time). This led it to analyze, for example, the effects that a volcano might have on the repository's waste containment capabilities. Scientists started with a careful analysis of the entire geologic setting of Yucca Mountain. Then, with substantial data on regional volcanoes, they used computer modeling to understand each volcanic center's controlling structures. Experts then estimated the likelihood of magma intruding into one of the repository's emplacement tunnels. The DOE estimates the likelihood of such an event's occurring during the first 10,000 years after repository closure to be one chance in about 70 million per year, or one chance in 7,000 over the entire period.

Including volcanoes in its analyses, the TSPA results still indicate that the site meets the EPA standards.[50] What the calculations showed is that the projected, probability-weighted maximum mean annual dose to an individual from the repository for the next 10,000 years is one-tenth of a millirem. That is less than one-fifth of the dose an individual gets from a one-hour airplane flight. And it is less than one one-hundredth of the dose that DOE's Guidelines, using the EPA standards, specify as acceptable for assessing suitability.

Finally, in a separate assessment, analysts studied a hypothetical scenario under which people inadvertently intruded into the repository while drilling for water. The Guidelines' radiation protection standards, based on EPA and NRC rules, specify that as part of its Total System Performance Assessment, DOE should determine when a human-caused penetration of a waste package could first occur via drilling, assuming the drillers were using current technology and practices and did not recognize that they had hit anything unusual. If such an intrusion could occur within 10,000 years, the 15 millirem dose limit would apply.

DOE's analyses, however, indicate that unrecognized contact through drilling would not happen within 10,000 years. Under conditions that DOE believes can realistically be expected to exist at

[50] The results produced under volcanic scenarios are weighted by probability under the NRC method specified for how to treat low probability events. 10 CFR Part 63.

the repository, the waste packages are extremely corrosion-resistant for tens of thousands of years. Even under pessimistic assumptions, the earliest time DOE could even devise a scenario under which a waste package would be unnoticeable to a driller is approximately 30,000 years. Before then, the waste package structure would be readily apparent to a driller who hit it.

Table 2 presents the summary results of the Total System Performance Assessment analyses and how they compare to the radiation protection standards.[51]

<u>In Summary</u>

Using the methods and criteria set out in DOE's Yucca Mountain Site Suitability Guidelines, I am convinced that the Yucca Mountain site is scientifically suitable – in a word, safe – for development of a repository. Specifically, on the basis of the safety evaluation DOE has conducted pursuant to 10 CFR 963.13, it is my judgment that a repository at the site is likely to meet applicable radiation protection standards for the pre-closure period. And on the basis of the Total System Performance Assessment DOE has conducted pursuant to 10 CFR 963.16, it is my judgment that a repository at the site is likely to meet applicable radiation protection standards for the post-closure period as well. Additionally, I have evaluated the pre-closure suitability criteria of 10 CFR 963.14 and the post-closure suitability criteria of 10 CFR 963.17, and am convinced that the safety evaluations were done under the stringent standards required. Accordingly, I find the Yucca Mountain site suitable for development of a repository.

8. The National Interest

Having determined that the site is scientifically suitable, I now turn to the remaining factors I outlined above as bearing on my Recommendation. Are there compelling national interests favoring going forward with a repository at Yucca Mountain? If so, are there countervailing considerations of sufficient weight to overcome those interests? In this section I set out my conclusions on the first question. In section 9 I set out my views on the second.

8.1. Nuclear Science and the National Interest

Our country depends in many ways on the benefits of nuclear science: in the generation of twenty percent of the Nation's electricity; in the operation of many of the Navy's most strategic vessels; in the maintenance of the Nation's nuclear weapons arsenal; and in numerous research and development projects, both medical and scientific. All these activities produce radioactive wastes that have been accumulating since the mid-1940s. They are currently scattered among 131 sites in 39 states, residing in temporary surface storage facilities and awaiting final disposal. In exchange for the many benefits of nuclear power, we assume the cost of managing its byproducts in a responsible, safe, and secure fashion. And there is a near-universal consensus that a deep geologic facility is the only scientifically credible, long-term solution to a problem that will only grow more difficult the longer it is ignored.

[51] *Yucca Mountain Site Suitability Evaluation.*

Table 2. Summary Post-Closure Dose and Activity Concentration Limits and Evaluation Results

Standard	Limits	Results[e]
Individual protection standard: 10 CFR 63.311, referenced in 10 CFR 963.2	15 mrem/yr TEDE	0.1 mrem/yr[a] (HTOM) 0.1 mrem/yr[a] (LTOM)
Human intrusion standard: 10 CFR 63.321, referenced in 10 CFR 963.2	15 mrem/yr TEDE	NA[b]
Groundwater protection standard: 10 CFR 63.331, referenced in 10 CFR 963.2	5 pCi/L combined radium-226 and radium-228, including natural background	1.04 pCi/L[c] (HTOM) 1.04 pCi/L[c] (LTOM)
	15 pCi/L gross alpha activity (including radium-226 but excluding radon and uranium), including natural background	1.1 pCi/L[c,d] (HTOM) 1.1 pCi/L[c,d] (LTOM)
	4 mrem/yr to the whole body or any organ from combined beta-and photon-emitting radionuclides	.000023 mrem/yr (HTOM) .000013mrem/yr (LTOM)

NOTES: [a] Probability-weighted peak mean dose equivalent for the nominal and disruptive scenarios, which include igneous activity; results are based on an average annual water demand of approximately 2,000 acre-ft; the mean dose for groundwater-pathway-dominated scenarios would be reduced by approximately one-third by using 3,000 acre-ft.

[b] Human-intrusion-related releases are not expected during the period of regulatory compliance; the DOE has determined that the earliest time after disposal that the waste package would degrade sufficiently that a human intrusion could occur without recognition by the driller is at least 30,000 years, so the dose limits do not apply for purposes of the site suitability evaluation.

[c] These values represent measured natural background radiation concentrations; calculated activity concentrations from repository releases are well below minimum detection levels, background radiation concentrations, and regulatory limits.

[d] Gross alpha background concentrations are 0.4 pCi/L $\pm$ 0.7 (for maximum of 1.1 pCi/L).

[e] Peak value of the mean probability-weighted results within the regulatory timeframe.

TEDE= total effective dose equivalent; HTOM= higher temperature operating mode; LTOM= lower-temperature operating mode; NA= not applicable. Source: Williams 2001a, Section 6, Tables 6-1, 6-2, 6-3, and 6-4.

8.2. Energy Security

Roughly 20 percent of our country's electricity is generated from nuclear power. This means that, on average, each home, farm, factory, and business in America runs on nuclear fuel for a little less than five hours a day.

A balanced energy policy – one that makes use of multiple sources of energy, rather than becoming dependent entirely on generating electricity from a single source, such as natural gas – is important to economic growth. Our vulnerability to shortages and price spikes rises in direct proportion to our failure to maintain diverse sources of power. To assure that we will continue to have reliable and affordable sources of energy, we need to preserve our access to nuclear power.

Yet the Federal government's failure to meet its obligation to dispose of spent nuclear fuel under the NWPA – as it has been supposed to do starting in 1998 – is placing our access to this source of energy in jeopardy. Nuclear power plants have been storing their spent fuel on site, but many are running out of space to do so. Unless a better solution is found, a growing number of these plants will not be able to find additional storage space and will be forced to shut down prematurely. Nor are we likely to see any new plants built.

Already we are facing a growing imbalance between our projected energy needs and our projected supplies. The loss of existing electric generating capacity that we will experience if nuclear plants start going off-line would significantly exacerbate this problem, leading to price spikes and increased electricity rates as relatively cheap power is taken off the market. A permanent repository for spent nuclear fuel is essential to our continuing to count on nuclear energy to help us meet our energy demands.

8.3. National Security

8.3.1. Powering the Navy Nuclear Fleet

A strong Navy is a vital part of national security. Many of the most strategically important vessels in our fleet, including submarines and aircraft carriers, are nuclear powered. They have played a major role in every significant military action in which the United States has been involved for some 40 years, including our current operations in Afghanistan. They are also essential to our nuclear deterrent. In short, our nuclear-powered Navy is indispensable to our status as a world power.

For the nuclear Navy to function, nuclear ships must be refueled periodically and the spent fuel removed. The spent fuel must go someplace. Currently, as part of a consent decree entered into between the State of Idaho and the Federal Government, this material goes to temporary surface storage facilities at the Idaho National Environmental and Engineering Laboratory. But this cannot continue indefinitely, and indeed the agreement specifies that the spent fuel must be removed. Failure to establish a permanent disposition pathway is not only irresponsible, but could also create serious future uncertainties potentially affecting the continued capability of our Naval operations.

8.3.2. Allowing the Nation to Decommission Its Surplus Nuclear Weapons and Support Nuclear Non-Proliferation Efforts

A decision now on the Yucca Mountain repository is also important in several ways to our efforts to prevent the proliferation of nuclear weapons. First, the end of the Cold War has brought the welcome challenge to our country of disposing of surplus weapons-grade plutonium as part of the process of decommissioning weapons we no longer need. Current plans call for turning the plutonium into “mixed-oxide” or “MOX” fuel. But creating MOX fuel as well as burning the fuel in a nuclear reactor will generate spent nuclear fuel, and other byproducts which themselves will require somewhere to go. A geological repository is critical to completing disposal of these materials. Such complete disposal is important if we are to expect other nations to decommission their own weapons, which they are unlikely to do unless persuaded that we are truly decommissioning our own.

A repository is important to non-proliferation for other reasons as well. Unauthorized removal of nuclear materials from a repository will be difficult even in the absence of strong institutional controls. Therefore, in countries that lack such controls, and even in our own, a safe repository is essential in preventing these materials from falling into the hands of rogue nations. By permanently disposing of nuclear weapons materials in a facility of this kind, the United States would encourage other nations to do the same.

8.4. Protecting the Environment

An underground repository at Yucca Mountain is important to our efforts to protect our environment and achieve sustainable growth in two ways. First, it will allow us to dispose of the radioactive waste that has been building up in our country for over fifty years in a safe and environmentally sound manner. Second, it will facilitate continued use and potential expansion of nuclear power, one of the few sources of electricity currently available to us that emits no carbon dioxide or other greenhouse gases.

As to the first point: While the Federal government has long promised that it would assume responsibility for nuclear waste, it has yet to start implementing an environmentally sound approach for disposing of this material. It is past time for us to do so. The production of nuclear weapons at the end of the Second World War and for many years thereafter has resulted in a legacy of high-level radioactive waste and spent fuel, currently located in Tennessee, Colorado, South Carolina, New Mexico, New York, Washington, and Idaho. Among these wastes, approximately 100,000,000 gallons of high-level liquid waste are stored in, and in some instances have leaked from, temporary holding tanks. In addition to this high-level radioactive waste, about 2,100 metric tons of solid, unreprocessed fuel from a plutonium-production reactor are stored at the Hanford Nuclear Reservation, with another 400 metric tons stored at other DOE sites.

In addition, under the NWPA, the Federal government is also responsible for disposing of spent commercial fuel, a program that was to have begun in 1998, four years ago. More than 161 million Americans, well more than half the population, reside within 75 miles of a major nuclear facility – and, thus, within 75 miles of that facility's aging and temporary capacity for storing this material. Moreover, because nuclear reactors require abundant water for cooling, on-site storage tends to be located near rivers, lakes, and seacoasts. Ten closed facilities, such as Big Rock Point, on the banks of Lake Michigan, also house spent fuel and incur significant annual costs without providing any ongoing benefit. Over the long-term, without active management and monitoring, degrading surface storage facilities may pose a risk to any of 20 major U.S. lakes and waterways, including the Mississippi River. Millions of Americans are served by municipal water systems with intakes along these waterways. In recent letters, Governors Bob Taft of Ohio[52] and John Engler of Michigan[53] raised concerns about the advisability of long-term storage of spent fuel in temporary systems so close to major bodies of water. The scientific consensus is that disposal of this material in a deep underground repository is not merely the safe answer and the right answer for protecting our environment but the only answer that has any degree of realism.

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[52] Letter, Governor Bob Taft to Secretary Spencer Abraham, July 30, 2001.
[53] Letter, Governor John Engler to Secretary Spencer Abraham, September 5, 2001.

In addition, nuclear power is one of only a few sources of power available to us now in a potentially plentiful and economical manner that could drastically reduce air pollution and greenhouse gas emissions caused by the generation of electricity. It produces no controlled air pollutants, such as sulfur and particulates, or greenhouse gases. Therefore, it can help keep our air clean, avoid generation of ground-level ozone, and prevent acid rain. A repository at Yucca Mountain is indispensable to the maintenance and potential expansion of the use of this environmentally efficient source of energy.

8.5. Facilitating Continuation of Research, Medical, and Humanitarian Programs

The Department has provided fuel for use in research reactors in domestic and foreign universities and laboratories. Research reactors provide a wide range of benefits including the production of radioisotopes for medical use – *e.g.*, in body-scan imaging and the treatment of cancer. To limit the risk to the public, and to support nuclear non-proliferation objectives, these laboratories are required to return the DOE-origin spent fuel from domestic research reactors and from foreign research reactors. These spent fuels are temporarily stored at Savannah River, South Carolina, and at the Idaho National Engineering and Environmental Laboratory while awaiting disposal in a permanent repository.

Again, we can either implement a permanent solution – Yucca Mountain – or risk eroding our capacity to conduct this kind of research. The chances of a person becoming sick from the nuclear materials to be stored at the Yucca Mountain site are, as shown above, all but non-existent. Responsible critics must balance that against the chance of a person becoming sick as a result of the research that may not be undertaken, remaining sick for want of the drug that may not be found, or dying for lack of the cure that may not be developed – all because the nuclear fuel-dependent science that could produce these things was never done, our country having run out of places to dispose of the waste.

8.6. Assisting Anti-Terrorism at Home

As I have noted previously, spent fuel and other high level radioactive waste is presently stored at temporary storage facilities at 131 locations in 39 states. Ten of these are at shutdown reactor sites for which security would not otherwise be required. Moreover, many reactors are approaching their storage capacity and are likely to seek some form of off-site storage, thereby creating potential new targets.

Storage by reactor-owners was intended to be a temporary arrangement. The design of the storage facilities reflects that fact. They tend to be less secured than the reactors themselves, and the structures surrounding the fuel stored in aboveground containers are also less robust.

These storage facilities should be able to withstand current threats. But as the determination and sophistication of terrorists increases, that may well change. That means we will have to choose one of two courses. We can continue to endeavor to secure each of these sites, many of which, as noted above, are close to major metropolitan areas and waterways. Or we can consolidate this fuel in one remote, secure, arid underground location and continue to develop state-of-the-art security arrangements to protect it there.

To me the choice is clear. The proposed geologic repository in the desert at Yucca Mountain offers unique features that make it far easier to secure against terrorist threats. These include: 1) disposal 800 feet below ground; 2) remote location; 3) restricted access afforded by Federal land ownership of the Nevada Test Site; 4) proximity to Nellis Air Force Range; 5) restricted airspace above the site; 6) far from any major waterways. The design and operation of a geologic repository, including surface operations, can also incorporate from the beginning appropriate features to protect against a terrorist threat and can be changed, if necessary, to respond to future changes in the terrorist threat.

An operational repository will also be an important signal to other nuclear countries, none of which have opened a repository. Inadequately protected nuclear waste in any country is a potential danger to us, and we can't expect them to site a facility if we, with more resources, won't. A fresh look at nuclear material security should involve new concepts such as those inherent in a geologic repository, and should set the standard for the manner in which the international community manages its own nuclear materials.

To understand Yucca Mountain's relative advantage in frustrating potential terrorist attacks compared to the *status quo*, one need only ask the following: If nuclear materials were already emplaced there, would anyone even suggest that we should spread them to 131 sites in 39 states, at locations typically closer to major cities and waterways than Yucca Mountain is, as a means of <u>discouraging</u> a terrorist attack?

8.7. Summary

In short, there are important reasons to move forward with a repository at Yucca Mountain. Doing so will advance our energy security by helping us to maintain diverse sources of energy supply. It will advance our national security by helping to provide operational certainty to our nuclear Navy and by facilitating the decomissioning of nuclear weapons and the secure disposition of nuclear materials. It will help us clean up our environment by allowing us to close the nuclear fuel cycle and giving us greater access to a form of energy that does not emit greenhouse gases. And it will help us in our efforts to secure ourselves against terrorist threats by allowing us to remove nuclear materials from scattered above-ground locations to a single, secure underground facility. Given the site's scientific and technical suitability, I find that compelling national interests counsel in favor of taking the next step toward siting a repository at Yucca Mountain.

9. None of the Arguments Against Yucca Mountain Withstands Analysis

As explained above, after months of study based on research unique in its scope and depth, I have concluded that the Yucca Mountain site is fully suitable under the most cautious standards that reasonably might be applied. I have also concluded that it serves the national interest in numerous important ways. The final question I shall examine is whether the arguments against its designation not rise to a level that outweighs the case for going forward. I believe they do not, as I shall explain. I do so by briefly describing these principle arguments made by opponents of the Project, and then responding to them.

9.1. Assertion 1: The Citizens of Nevada Were Denied an Adequate Opportunity to Be Heard

Critics have claimed that the decision-making process under the NWPA was unfair because it allowed insufficient opportunity for public input, particularly from the citizens of Nevada. That is not so. There was ample opportunity for public discussion and debate; the Department in fact went well beyond the Act's requirements in providing notice and the opportunity to be heard.

My predecessors and I invited and encouraged public, governmental, and tribal participation at all levels. The Department also made numerous Yucca Mountain documents available to the public. These included several specifically prepared to inform any who might be interested of the technical information and analyses that I would have before me as I considered the suitability of the site. There was no statutory requirement for producing these documents; I considered it important to make them available, and thus to provide a timely sharing of information that would form the basis of my consideration and, ultimately, decision.

To assist in discharging part of the Secretarial responsibilities created by the Act, the Department conducted official public meetings before starting the Environmental Impact Statement. Subsequently, the Department held a total of 24 public hearings on the draft and the supplemental draft Environmental Impact Statements. With the release of the *Yucca Mountain Science and Engineering Report* in May 2001, the DOE opened a public comment period lasting approximately six months; the period continued through the release of the *Preliminary Site Suitability Evaluation* in July 2001 and closed on October 19, 2001. After publishing DOE's final rule, "Yucca Mountain Site Suitability Guidelines," on November 14, 2001, I announced an additional 30-day supplemental comment period with a closing date of December 14, 2001. During these combined public comment periods, the DOE held 66 additional public hearings across Nevada and in Inyo County, California, to receive comments on my consideration of a possible recommendation of the Yucca Mountain site. More than 17,000 comments were received.[54]

The lengths to which the Department went to solicit public comment can be seen in the details: from 1995 through 2001, there were 126 official hearings with a court reporter present. The Nevada cities where these hearings were held included: Amargosa Valley, Battle Mountain, Caliente, Carson City, Crescent Valley, Elko, Ely, Fallon, Gardnerville, Goldfield, Hawthorne, Las Vegas, Lovelock, Pahrump, Reno, Tonopah, Virginia City, Winnemucca, and Yerington. Elsewhere, meetings were held in Independence, Lone Pine, Sacramento, and San Bernardino in California; Washington, DC; Boise, ID; Chicago, IL; Denver, CO; Dallas/Ft. Worth, TX; Salt Lake City, UT; Baltimore, MD; Albany, NY; Atlanta, GA; Kansas City, MO.; Cleveland, OH; and St. Louis, MO.

There were 600 hours of public meetings for the 2001 hearings alone. All in all, there were a total of 528 comment days, or about a year and a half. Additionally, the science centers were

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[54] *Comment Summary Document* and *Supplemental Comment Summary Document*, February 2002.

open for 340 hours (both with and without court reporter) to receive comments. Since 1991, there have been 2,062 tours of Yucca Mountain, and 49,073 visitors have been to the site.

In light of the extensive opportunities DOE has provided for public input, it is my judgment that the opportunities for hearing and consideration of comments were abundant and met any procedural measure of fairness.

9.2. Assertion 2: The Project Has Received Inadequate Study

Critics have said that there has been inadequate study to determine Yucca Mountain's suitability. To the contrary, and as I believe section 6 of this Recommendation makes clear at length, the characterization process at Yucca Mountain is unprecedented for any even remotely comparable undertaking. Indeed, Yucca Mountain studies have now been under way for nearly five times as long as it took to build the Hoover Dam and more than six times the entire duration of the Manhattan Project. Yucca Mountain is, by any measure, the most exhaustively studied project of its kind the world has ever known.

Beginning in 1978 and continuing to the present day, the Department has spent billions of dollars on characterization studies. There has been ongoing dialogue between the Department and the NRC over the goals, content and results of the test programs. As noted, there have been ample opportunities for public involvement. At this still early stage, and with many more years before the Yucca Mountain site could become operational, the request for yet more preliminary study, even before seeking a license from the NRC, is unsupportable. Additional study will be undertaken at stages to come as an appropriate part of the licensing process.

For these reasons, I have concluded that the current body of accumulated scientific and technical knowledge provides a more than adequate technical basis to designate the Yucca Mountain site, thereby beginning the licensing phase of the project. For convenience, a listing of the types of tests that have been performed is provided in Table 3.

9.3. Assertion 3: The Rules Were Changed in the Middle of the Game

The State of Nevada claims that at some point the Department concluded that Yucca Mountain was not suitable under earlier regulations, and then changed the rules to fit the site. That is not true. Even the most elementary knowledge of the history of the program shows this claim is baseless.

The Guidelines did change, but not in a way that disadvantaged critics from making their case, and certainly not to suit any pre-existing agenda at the Department. Rather, they were changed to conform to changes in the statutory and regulatory framework governing the siting process and in the scientific consensus regarding the best approach for assessing the likely performance of a repository over long periods of time.

Table 3: Types of Tests Performed to Collect Data for Site Characterization of Yucca Mountain [55]

Process Models	Types of Tests and Studies
Unsaturated Zone (the rocks above the water table containing little water that limit the amount of water that can contact waste packages)	Future climate studies Infiltration model studies Unsaturated zone flow model studies Seepage model studies Unsaturated zone transport studies
Near-Field Environment (moisture, temperature, and chemistry conditions surrounding and affecting the waste packages)	Drift scale test Single heater test Large block test Field tests on coupled processes Laboratory coupled processes tests
Engineered Barrier System (EBS) (man-made features comprising the repository that influence how radionuclides might move)	Cementicious materials tests EBS design tests In-drift gas composition tests In-drift water chemistry, precipitates and salts tests Microbial communities tests Radionuclide transport tests Drift degradation analysis tests Rock mass mechanical properties tests
Waste Package (metal container that the wastes would be placed in)	Waste package environment tests Materials selection studies General corrosion tests Localized corrosion tests Stress corrosion cracking tests Hydrogen-induced cracking tests Metallurgical stability/phases tests Manufacturing defects tests Filler material tests Welding tests
Waste Form (high-level wastes and spent fuel that are the source of radionuclides)	Radioisotope inventory study In-package chemistry tests Commercial spent nuclear fuel cladding degradation tests Defense spent nuclear fuel degradation tests High level waste glass degradation tests Dissolved radioisotope concentration tests Colloid radioisotope concentration tests
Saturated Zone (movement of water in rocks below the water table)	Saturated zone characterization studies Saturated zone flow studies Saturated zone transport studies

[55] Summary information about progress in testing is provided to the NRC twice each year. There are 23 Semiannual Progress Reports available, covering all testing for the Yucca Mountain site. These documents include references to numerous technical reports of the Program, which number in the thousands.

Table 3: Types of Tests Performed to Collect Data for Site Characterization of Yucca Mountain, continued

Integrated Site Model (computer models of the geology)	Geologic framework model studies
	Rock properties model studies
	Mineralogical model studies
Site Description (description of the repository)	Geologic mapping studies
	Fracture data collection studies
	Natural resources assessment studies
	Erosion studies
	Natural and man-made analog studies
Disruptive Events (unlikely disruptions to the repository)	Probability of igneous activity studies
	Characteristics of igneous activity studies
	Seismic hazards studies

The DOE's original siting Guidelines were promulgated in 1984. At the time, the Nuclear Waste Policy Act called on the Department to evaluate and characterize multiple sites and to recommend one or more among them. Also at the time, consistent with the scientific and regulatory consensus of the late 1970's, the Nuclear Regulatory Commission had in place regulations for licensing repositories that sought to protect against radioactive releases by focusing on the performance of individual subparts, or subsystems, that were part of the repository. Finally, the EPA had proposed rules for repositories that also focused on limiting the amount and type of radionuclides released from a repository. Consistent with this framework, DOE's Guidelines focused on making comparative judgments among sites and emphasized mechanisms for evaluating the performance of potential repository subsystems against the NRC subsystem performance requirements and the EPA release limits.

Starting in 1987, however, both the regulatory framework and scientific consensus began to change. To begin with, Congress changed the law governing evaluation and selection of a repository site. In 1987, it amended the Nuclear Waste Policy Act to eliminate any authority or responsibility on the part of the Department for comparing sites, directed the Department to cease all evaluation of any potential repository sites other than Yucca Mountain, and directed it to focus its efforts exclusively on determining whether or not to recommend the Yucca Mountain site. This change was important, as it eliminated a central purpose of the Guidelines – to compare and contrast multiple fully characterized sites for ultimate selection of one among several for recommendation.

Next, Congress reinforced its directive to focus on Yucca Mountain in section 801 of the Energy Policy Act of 1992. This provision also gave three new directives to EPA. First, it directed EPA, within 90 days of enactment, to contract with the National Academy of Sciences for a study regarding, among other topics, whether a specific kind of radiation protection standard for repositories would be protective of public health and safety. The question posed was whether standards prescribing a maximum annual effective dose individuals could receive from the repository – as opposed to the then-current standards EPA had in place focusing on releases –

would be reasonable standards for protecting health and safety at the Yucca Mountain site. Second, Congress directed EPA, consistent with the findings and recommendations of the Academy, to promulgate such standards no later than one year after completion of the Academy's study. Finally, it directed that such standards, when promulgated, would be the exclusive public health and safety standards applicable to the Yucca Mountain site. Section 801 also contained a directive to the NRC that, within a year after EPA's promulgation of the new standards, NRC modify its licensing criteria for repositories under the NWPA as necessary to be consistent with the EPA standards.

Pursuant to the section 801 directive, in 1995 the National Academy of Sciences published a report entitled "Technical Bases for Yucca Mountain Standards."[56] This report concluded that dose standards would be protective of public health and safety.[57] It also concluded that if EPA adopted this kind of standard, it would be appropriate for the NRC to revise its licensing rules, which currently focused on subsystem performance, to focus instead on the performance of the total repository system, including both its engineered and natural barriers. It noted that this would be a preferable approach because it was the performance of the entire repository, not the different subsystems, that was crucial, and that imposition of separate subsystem performance requirements might result in suboptimal performance of the repository as a whole.[58] Finally, National Academy of Sciences noted that its recommendations, if adopted, "*impl[ied] the development of regulatory and analytical approaches for Yucca Mountain that are different from those employed in the past*" whose promulgation would likely require more than the one-year timeframe specified in the Energy Policy Act of 1992.

Along with these changes in regulatory thinking, the scientific and technical understanding of repository performance at Yucca Mountain was advancing. The DOE's use of Total System Performance Assessment to evaluate repository performance became more sophisticated, and helped focus DOE's research work on those areas important to maximizing the safety of the repository and minimizing public exposure to radionuclide releases from the repository.

In 1999, the culmination of years of scientific and technical advancements and careful regulatory review resulted in EPA and NRC proposals for new regulations specific to a repository at Yucca Mountain based on state-of-the-art science and regulatory standards.[59] Since section 113(c) of the NWPA directed DOE to focus its site characterization activities on those necessary to evaluate the suitability of the site for a license application to the NRC, the proposed changes to the EPA and NRC rules in turn required DOE to propose modifications to its criteria and methodology for determining the suitability of the Yucca Mountain site. Accordingly, DOE proposed new state-of-the-art Yucca-Mountain-specific site suitability Guidelines consistent with NRC licensing regulations.[60] After EPA and NRC finalized their revisions,[61] DOE promptly

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[56] *Technical Bases for Yucca Mountain Standards,* National Academy of Sciences, National Research Council, 1995.
[57] *Ibid.*
[58] *Ibid.*
[59] Disposal of High-Level Radioactive Wastes in a Proposed Geological Repository at Yucca Mountain, Nevada, Proposed Rule, 64 Fed. Reg. 8640, February 22, 1999; Environmental Radiation Protection Standards for Yucca Mountain, Nevada, Proposed Rule, 64 Fed. Reg. 46975, August 27, 1999.
[60] General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories, Yucca Mountain Site Suitability Guidelines, 64 Fed. Reg. 67054, November 30, 1999.

finalized its own.[62] For the reasons explained in the National Academy of Sciences study, the revised Guidelines' focus on the performance of the total repository system also makes them a better tool for protection of public safety than the old Guidelines, since the old subsystem approach might have resulted in a repository whose subsystems performed better in one or another respect but whose total performance in protecting human health was inferior.

In short, far from seeking to manipulate its siting Guidelines to fit the site, DOE had no choice but to amend its Guidelines to conform with the new regulatory framework established at Congress's direction by the National Academy of Sciences, the EPA, and the NRC. Moreover, this framework represents the culmination of a carefully considered set of regulatory decisions initiated at the direction of the Congress of the United States and completed nine years later, in which top scientists in the country have participated, and in which expert regulatory authorities, the NRC and the EPA, have played the leading role. These authorities likewise agree that the new regulatory framework, of which the Department's revised Guidelines are a necessary part, forms a coherent whole well designed to protect the health and safety of the public.

9.4. Assertion 4: The Process Tramples States' Rights

Some have argued that a Federal selection of siting disrespects states' rights. That is incorrect. Indeed, Nevada's interests have been accorded a place in Federal law to an extent seldom, if ever, seen before.

As provided by the NWPA, the State of Nevada has the right to veto any Presidential site recommendation. It may do so by submitting a notice of disapproval to Congress within 60 days of the President's action.

If Nevada submits a notice of disapproval, Congress has 90 calendar days of continuous session to override the notice by passing a resolution of siting designation. If it does not do so, the State's disapproval becomes effective.

The respect due Nevada has not stopped with grudging obedience to the statutory commands. Instead, as noted previously, the Department has held hearings over a range of dates and places well in excess of what reasonably could have been viewed as a statutory mandate. And I have taken full account of Governor Guinn's comment and those of Nevada's other elected officials who oppose this Project. Although they reflect a view I do not share, I will continue to accord them the highest degree of respect.

Finally, the Federal Government has appropriated more funds to Nevada to conduct its own Yucca Mountain studies than any other State has ever been given for any remotely similar purpose. Since the start of the Program in 1983, the State of Nevada has received over $78 million in oversight funding. Since 1989, when the affected units of local government requested

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[61]Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada, Final Rule, 66 FR 32073, June 13, 2001; Disposal of High-Level Radioactive Wastes in a Proposed Geologic Repository at Yucca Mountain, Nevada; Final Rule, 66 FR 55732, November 2, 2001.

[62] General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories, Yucca Mountain Site Suitability Guidelines, Final Rule, 66 Fed. Reg. 57303, November 14, 2001.

oversight funding, they have received over $67 million. In total, the State of Nevada and the affected units of local government have received over $145 million over that timeframe; with Nye County, home to Yucca Mountain, receiving over $22 million and Clark County, home to Las Vegas, receiving about $25 million. In addition, over the last 10 years, the State of Nevada and the affected units of local government have been given over $73 million to compensate for taxes they would have collected on the site characterization and the development and operation of a repository if they were legally authorized to tax activities of the Federal Government. Nye County has also conducted its own oversight drilling program since 1996, for which over that time Nye has received almost $21 million. Thus, the grand total that has been awarded to the state and its local governments simply on account of Yucca Mountain research has been nearly $240 million.

Given the extensive evidence that the state has been, and will be, accorded a degree of involvement and authority seldom if ever accorded under similar circumstances, it is my judgment that the assertion of an infringement on state's rights is incorrect.

9.5. Assertion 5: Transportation of Nuclear Materials is Disruptive and Dangerous

Critics have argued that transporting wastes to Yucca Mountain is simply too dangerous, given the amount involved and the distances that will need to be traversed, sometimes near population centers.

These concerns are not substantiated for three principal reasons. First, they take no account of the dangers of not transporting the wastes and leaving them to degrade and/or accumulate in their present, temporary facilities. Second, they pay no heed to the fact that, if the Yucca Mountain repository is not built, some wastes that would have been bound for that location will have to be transported elsewhere, meaning that our real choice is not between transporting or not transporting, but between transporting with as much planning and safety as possible, or transporting with such organization as the moment might invite. And third, they ignore the remarkable record of safe transportation of nuclear materials that our country has achieved over more than three decades.

The first point is not difficult to understand. The potential hazards of transporting wastes are made to appear menacing only by ignoring the potential hazards of leaving the material where it is – at 131 aging surface facilities in 39 states. Every ton of waste not transported for five or ten minutes near a town on the route to Yucca Mountain is a ton of waste left sitting in or near someone else's town – and not for five or ten minutes but indefinitely. Most of the wastes left where they are in or near dozens of towns (and cities) continue to accumulate day-by-day in temporary facilities not intended for long-term storage or disposal.

The second point is also fairly simple. Many of these older sites have reached or will soon reach pool storage limits. Over 40 are projected to need some form of dry storage by 2010. Additional facilities will therefore be required. There are real limits, however, to how many of these can realistically be expected to be built on site. Many utilities do not have the space available to build them, and are likely to face major regulatory hurdles in attempting to acquire it.

Therefore one way or another, unless all these reactors shut down, off-site storage facilities will need to be built, substantial amounts of waste will have to be transported there, and this will happen not in the distant future but quite soon. For example, today nuclear utilities and a Native American tribe in Utah are working toward construction of an "interim" storage facility on tribal land. Whether or not this effort ultimately succeeds, it is likely that some similar effort will. Thus, if we are merely to keep our present supply of nuclear energy, at some fast-approaching point there will be transportation of nuclear wastes. The only question is whether we will have (a) numerous supplemental storage sites springing up, with transportation to them arranged *ad hoc*, or (b) one permanent repository, with transportation to it arranged systematically and with years of advance planning. The second alternative is plainly preferable, making the Yucca Mountain plan superior on this ground alone.

Finally, transportation of nuclear waste is not remotely the risky venture Yucca's critics seek to make it out to be. Over the last 30 years, there have been over 2,700 shipments of spent nuclear fuel. Occasional traffic accidents have occurred, but there has not been one identifiable injury related to radiation exposure because of them. In addition, since 1975, or since the last stages of the war in Vietnam, national security shipments have traveled over 100 million miles – more than the distance from here to the sun – with no accidents causing a fatality or harmful release of radioactive material.[63]

Our safety record is comparable to that in Europe, where nuclear fuel has been transported extensively since 1966.[64] Over the last 25 years, more than 70,000 MTU (an amount roughly equal to what is expected to be shipped over the entire active life of the Yucca Mountain Project) has been shipped in approximately 20,000 casks. France and Britain average 650 shipments per year, even though the population density in each of those countries grossly exceeds that of the United States.

Even so, we need not, and should not, be content to rest upon the record of the past no matter how good. For transportation to Yucca Mountain, the Department of Transportation has established a process that DOE and the states must use for evaluating potential routes. Consistent with Federal regulations, the NRC would approve all routes and security plans and would certify transportation casks prior to shipment.

In short, for all these reasons, I have concluded that the stated concerns about transportation are ill-founded and should not stand in the way of taking the next step toward designation of the Yucca Mountain site.

9.6. Assertion 6: Transportation of Wastes to the Site Will Have a Dramatically Negative Economic Impact on Las Vegas

There have been repeated assertions that shipments of radioactive waste through the Las Vegas valley could have effects on the local, entertainment-based, economy. Such effects could include, for example, discouraging tourism and lowering property values. These assertions are

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[63] *About the Transportation Safeguards System*, Office of Transportation Safeguards Fact Sheet.

[64] Presentation by Ronald Pope, Head of Transport Safety Unit for the Internal Atomic Energy Agency, at 13th International Symposium for Packing of Radioactive Materials 2001, Chicago, IL, September 2001.

largely unsupportable by any evidence and are addressed in the Final Environmental Impact Statement.

Much of what has been said in the preceding section applies here as well. The record speaks for itself. In addition to the history of safe shipment on interstate highways through relatively open spaces, five metric tons of spent nuclear fuel from 27 countries have, over the last 16 years, been transported without incident through Concord, California, and Charleston, South Carolina (the latter, like Las Vegas, a tourist destination). There is no reason to believe that a similar safe record will not be achieved in Nevada.

The truth of it is that many tourists coming to Las Vegas will be farther from nuclear sites when they get there than when they left home. All major nuclear power generation facilities in the United States are located near large metropolitan centers in order to minimize the amount of power lost during transmission. It is thus not surprising that more than 161 million Americans are closer to a commercial nuclear facility than anyone in Las Vegas is to Yucca Mountain, as shown in Table 4. Indeed there are few large metropolitan centers that do not have a major nuclear facility located within 75 miles.[65]

Table 4. U.S. Population in Contiguous United States Living Within Various Distances of Commercial Nuclear Facilities

State	**Zone (miles from facilities)**				
	0 - 25	***25 - 50***	***50 - 75***	***0 - 50***	***0 - 75***
AL	327,488	617,283	452,817	944,771	1,397,588
AR	91,993	159,544	859,399	251,537	1,110,936
AZ	25,803	1,550,878	1,608,816	1,576,682	3,185,497
CA	2,488,467	8,666,094	11,962,159	11,154,561	23,116,719
CO	*	*	*	*	*
CT	962,725	2,394,573	55,292	3,357,298	3,412,590
DC		153,634	418,425	153,634	572,059
DE	457,523	184,324	123,438	641,847	765,285
FL	1,135,427	2,865,538	3,550,098	4,000,965	7,551,063
GA	186,028	886,879	1,145,585	1,072,907	2,218,491
IA	512,517	566,867	474,723	1,079,384	1,554,107
ID	*	*	*	*	*
IL	2,068,321	7,970,381	835,971	10,038,701	10,874,673
IN	34,431	945,514	468,802	979,945	1,448,747
KS	19,797	161,268	686,554	181,065	867,619
KY					
LA	786,052	1,592,771	772,888	2,378,823	3,151,710
MA	740,668	4,346,548	1,275,039	5,087,217	6,362,255
MD	438,958	2,528,095	2,007,566	2,967,053	4,974,619

[65] It is noteworthy that Atlantic City has three reactor sites closer than 75 miles at the same time its tourism-based economy has been expanding. Yucca Mountain, by contrast, would be one of the few nuclear facilities in the country in a remote area with no metropolitan center within 75 miles.

Table 4. U.S. Population in Contiguous United States Living Within Various Distances of Commercial Nuclear Facilities, continued

ME	151,828	521,691	280,266	673,520	953,785
MI	898,433	3,815,786	2,491,128	4,714,219	7,205,346
MN	450,935	2,999,162	330,754	3,450,097	3,780,850
MO	72,929	393,186	952,824	466,115	1,418,939
MS	36,411	169,211	561,585	205,622	767,207
MT					
NC	1,864,567	2,265,107	2,577,799	4,129,674	6,747,239
ND					
NE	564,594	181,950	379,944	746,544	1,126,488
NH	278,528	649,119	188,301	927,646	1,115,947
NJ	795,512	5,628,139	2,023,890	6,423,650	8,447,540
NM	*	*	*	*	*
NV					
NY	1,866,267	9,017,732	5,435,801	10,883,999	16,319,800
OH	656,156	2,790,959	2,074,628	3,447,115	5,521,743
OK			5,479		5,479
OR	45,053	1,381,995	432,829	1,427,047	1,859,876
PA	3,206,819	6,437,719	1,564,624	9,644,538	11,209,162
RI	19,252	284,282	744,786	303,534	1,048,320
SC	705,470	1,760,435	747,457	2,465,906	3,213,363
SD			569		569
TN	532,368	456,157	927,261	988,525	1,915,786
TX	136,390	1,337,035	3,766,243	1,473,425	5,239,668
UT	*	*	*	*	*
VA	597,715	2,377,308	2,221,770	2,975,024	5,196,794
VT	54,257	43,739	77,319	97,996	175,315
WA	331,397	500,577	585,734	831,974	1,417,708
WI	542,083	2,065,518	1,646,584	2,607,601	4,254,185
WV	43,813	65,183	37,095	108,996	146,090
WY					
Grand Total	24,126,975	80,732,181	56,752,239	104,859,156	161,651,160
Proposed Repository at Yucca Mountain					
Population around Yucca Mountain	1,678	13,084	19,069	14,762	33,831

*State with no commercial facilities but with other nuclear facilities depending on a repository for waste disposition.

As shown in Table 5, 22 of the 30 most populous metropolitan areas in the United States have 36 operating nuclear reactors closer to them than a waste repository at Yucca Mountain would be to Las Vegas, some 90 miles distant.

Table 5. Top 30 Metropolitan Areas in Contiguous U.S. by Population - Distance to Nearest Commercial Power Reactor (does not include other nuclear facilities that are dependent on a high-level repository for waste disposition)

Rank	Area Name	Population 2000 Census (Note 1)	Major Population Centers	State	Nearest Commercial Nuclear Reactor	Distance (Miles) (Note 4)
1	New York—Northern New Jersey—Long Island, NY—NJ—CT—PA CMSA (Note 2)	21,199,865	New York	NY	INDIAN POINT	45.0
			Jersey City	NJ	INDIAN POINT	44.4
2	Los Angeles—Riverside—Orange County, CA CMSA	16,373,645	Los Angeles	CA	SAN ONOFRE	61.5
			Riverside	CA	SAN ONOFRE	41.2
3	Chicago—Gary—Kenosha, IL—IN—WI CMSA	9,157,540	Chicago	IL	ZION	44.9
			Rockford	IL	BYRON	17.7
4	Washington—Baltimore, DC—MD—VA—WV CMSA	7,608,070	Baltimore	MD	PEACH BOTTOM	43.0
			Washington D.C.	DC	CALVERT CLIFFS	51.2
5	San Francisco—Oakland—San Jose, CA CMSA	7,039,362	San Francisco	CA	RANCHO SECO	81.3
			Oakland	CA	RANCHO SECO	73.3
			San Jose	CA	RANCHO SECO	81.8
6	Philadelphia—Wilmington—Atlantic City, PA—NJ—DE—MD CMSA	6,188,463	Philadelphia	PA	LIMERICK	34.1
7	Boston—Worcester—Lawrence, MA—NH—ME—CT CMSA	5,819,100	Boston	MA	PILGRIM	45.2
			Worcester	MA	VERMONT YANKEE	60.3
8	Detroit—Ann Arbor—Flint, MI CMSA	5,456,428	Detroit	MI	FERMI	30.4
9	Dallas—Fort Worth, TX CMSA	5,221,801	Dallas	TX	COMANCHE PEAK	69.3
			Fort Worth	TX	COMANCHE PEAK	41.7
10	Houston—Galveston—Brazoria, TX CMSA	4,669,571	Houston	TX	SOUTH TEXAS PROJECT	82.7
11	Atlanta, GA MSA (Note 3)	4,112,198	Atlanta	GA	SEQUOYAH	121.7
12	Miami—Fort Lauderdale, FL CMSA	3,876,380	Fort Lauderdale	FL	TURKEY POINT	57.9
			Miami	FL	TURKEY POINT	29.6
13	Seattle—Tacoma—Bremerton, WA CMSA	3,554,760	Seattle	WA	TROJAN	111.4
			Tacoma	WA	TROJAN	86.4
14	Phoenix—Mesa, AZ MSA	3,251,876	Glendale	AZ	PALO VERDE	40.4
			Scottsdale	AZ	PALO VERDE	56.3
			Phoenix	AZ	PALO VERDE	45.8
			Tempe	AZ	PALO VERDE	55.2
			Mesa	AZ	PALO VERDE	60.2
			Chandler	AZ	PALO VERDE	59.4
15	Minneapolis—St. Paul, MN—WI MSA	2,968,806	Minneapolis	MN	MONTICELLO	39.1
			Saint Paul	MN	PRAIRIE ISLAND STATION	34.2
16	Cleveland—Akron, OH CMSA	2,945,831	Cleveland	OH	PERRY	39.3
			Akron	OH	PERRY	59.3
17	San Diego, CA MSA	2,813,833	San Diego	CA	SAN ONOFRE	50.7
18	St. Louis, MO—IL MSA	2,603,607	Saint Louis	MO	CALLAWAY	91.7
19	Denver—Boulder—Greeley, CO CMSA	2,581,506	Denver	CO	FORT CALHOUN	495.6
20	Tampa—St. Petersburg—Clearwater, FL MSA	2,395,997	Tampa	FL	CRYSTAL RIVER	81.9
21	Pittsburgh, PA MSA	2,358,695	Pittsburgh	PA	BEAVER VALLEY	29.6

Table 5. Top 30 Metropolitan Areas in Contiguous U.S. by Population - Distance to Nearest Commercial Power Reactor, continued

22	Portland—Salem, OR—WA CMSA	2,265,223	Portland	OR	TROJAN	37.2
23	Cincinnati—Hamilton, OH—KY—IN CMSA	1,979,202	Cincinnati	OH	DAVIS BESSE	206.8
24	Sacramento—Yolo, CA CMSA	1,796,857	Sacramento	CA	RANCHO SECO	26.1
25	Kansas City, MO—KS MSA	1,776,062	Kansas City	MO	WOLF CREEK	88.2
			Kansas City	KS	WOLF CREEK	87.0
26	Milwaukee—Racine, WI CMSA	1,689,572	Milwaukee	WI	ZION	44.2
27	Orlando, FL MSA	1,644,561	Orlando	FL	CRYSTAL RIVER	98.7
28	Indianapolis, IN MSA	1,607,486	Indianapolis	IN	CLINTON	156.5
29	San Antonio, TX MSA	1,592,383	San Antonio	TX	SOUTH TEXAS PROJECT	161.3
30	Norfolk—Virginia Beach—Newport News, VA—NC MSA	1,569,541	Newport News	VA	SURRY	23.2
			Virginia Beach	VA	SURRY	53.4
			Norfolk	VA	SURRY	37.3

Notes

1 Populations from 2000 Census data for Continental USA
2 CMSA means "Consolidated Metropolitan Statistical Area"
3 MSA means "Metropolitan Statistical Area"
4 Distances shown are relative to a central feature such as a city hall, county seat, or capitol building.

Many cities with strong tourism industries are located closer to existing storage facilities than Las Vegas would be to a repository at Yucca Mountain. Therefore, those who assert that a repository 90 miles from Las Vegas would have dramatically negative effects on local tourism have the burden of producing strong evidence to back up their claims. They have not done so. Thus, I know of no reason to believe that there is any compelling argument that the Las Vegas economy would be harmed by a repository at Yucca Mountain.

9.7. Assertion 7: It is Premature for DOE to Make a Site Recommendation for Various Reasons

9.7.1. The General Accounting Office has concluded that it is premature for DOE to make a site recommendation now

The GAO did make this statement in its draft report, *Technical, Schedule, and Cost Uncertainties of the Yucca Mountain Repository Project*, which was prematurely released.[66] After receiving the Department's response, however, in the final version of this report, released in December 2001, GAO expressly acknowledged that "the Secretary has the discretion to make such a recommendation at this time." [67]

[66] *Nuclear Waste: Technical, Schedule, and Cost Uncertainties of the Yucca Mountain Repository Projec*t, Unpublished Draft.
[67] *Nuclear Waste: Technical, Schedule, and Cost Uncertainties of the Yucca Mountain Repository Project*, GAO-02-191, December 21, 2001.

9.7.2. DOE is not ready to make a site recommendation now because DOE and NRC have agreed on 293 technical items that need to be completed before DOE files a license application

The Nuclear Regulatory Commission provided a sufficiency letter to DOE on November 13, 2001, that concluded that existing and planned work, upon completion, would be sufficient to apply for a construction authorization. The agreed upon course of action by DOE and the NRC is intended to assist in the license application phase of the project, not site recommendation. In consultation with the Nuclear Regulatory Commission staff concerning *licensing*, DOE agreed it would obtain certain additional information relating to nine "key technical issues" to support license application. The DOE agreed to undertake 293 activities that would assist in resolution of these issues.

The NRC has *never* stated that this was work that DOE needed to complete before *site recommendation*. In fact, it went out of its way not to do so. The Commission is well aware that section 114(a)(1)(E) of the NWPA requires a Secretarial recommendation of Yucca Mountain to be accompanied by a letter from the Commission providing its preliminary comments on the sufficiency of the information the Department has assembled for a construction license application. Had it been of the view that site recommendation should not proceed, its preliminary views would have stated that this information is not sufficient and that the Commission has no confidence that it ever will be.

Instead, in its section 114(a)(1)(E) letter, the Commission said the opposite: "[T]he NRC believes that sufficient at-depth characterization analysis and waste form proposal information, although not available now, *will be available at the time of a potential license application such that development of an acceptable license application is achievable*" (emphasis added). It also listed the outstanding issues as "closed pending," meaning that the NRC staff has confidence that DOE's proposed approach, together with the agreement to provide additional information, acceptably addresses the issue so that no information beyond that provided or agreed to would likely be required for a license application.

The DOE has completed over one-third of the actions necessary to fulfill the 293 agreements and has submitted the results to the NRC for review. The NRC has documented 23 of these as "complete." The remaining work consists largely of documentation (improve technical positions and provide additional plans and procedures) and confirmation (enhance understanding with additional testing or analysis or additional corroboration of data or models).

As I explained earlier, the NWPA makes clear that site recommendation is an intermediate step. The filing of a construction license application is the step that comes after site recommendation is complete. It is entirely unsurprising that the Department would have to do additional work before taking that next step. But the fact that the next step will require additional work is no reason not to take this one.

9.7.3. It is premature for DOE to make a recommendation now because DOE cannot complete this additional work until 2006. The NWPA requires DOE to file a license application within 90 days of the approval of site designation

When Congress enacted the NWPA in 1982, it included in the Act a series of deadlines that represented its best judgment regarding how long various steps should take. These deadlines included the 90-day provision referenced above. They also included a requirement that DOE begin disposing of waste in 1998, in the expectation that a repository would by then have been built and licensed.

Obviously, the timeframes set in the Act have proven to be optimistic. That is no reason, however, for the Department not to honor what was plainly their central function: to move along as promptly and as responsibly as possible in the development of a repository. Accordingly, to read the 90-day provision at issue as a basis for proceeding more slowly stands the provision on its head.

Our current plans call for filing a license application at the end of 2004, not 2006. Assuming Congressional action on this question this year, that would mean that DOE could be two years late in filing the application. But any delay in site recommendation will only result in *further* delay in the filing of this application. For the reasons explained in section 7, I believe I have the information necessary to allow me to determine that the site is scientifically and technically suitable, and I have so determined. That being so, I am confident that I best honor the various deadlines set out in the Act, including the central 1998 deadline (already passed) specifying when the Department was to begin waste disposal, by proceeding with site recommendation as promptly as I can after reaching this conclusion.

10. Conclusion

As I explained at the outset of this document, the Nuclear Waste Policy Act vests responsibilities for deciding how this country will proceed with regard to nuclear waste in a number of different Federal and state actors. As Secretary of Energy, I am charged with making a specific determination: whether to recommend to the President that Yucca Mountain be developed as the site for a repository for spent fuel and high-level radioactive wastes. I have endeavored to discharge that responsibility conscientiously and to the best of my ability.

The first question I believe the law asks me to answer is whether the Yucca Mountain site is scientifically and technically suitable for development as a repository. The amount and quality of research the Department of Energy has invested into answering this question — done by top-flight people, much of it on the watch of my predecessors from both parties — is nothing short of staggering. After careful evaluation, I am convinced that the product of over 20 years, millions of hours, and four billion dollars of this research provides a sound scientific basis for concluding that the site can perform safely during both the pre- and post-closure periods, and that it is indeed scientifically and technically suitable for development as a repository.

Having resolved this fundamental question, I then turned to a second set of considerations: are there compelling national interests that warrant proceeding with this project? I am convinced that there are, and that a repository for nuclear waste at Yucca Mountain will advance, in important ways, our energy security, our national security, our environmental goals, and our security against terrorist attacks.

Finally, I examined the arguments that opponents of the project have advanced for why we should not proceed. I do not believe any of them is of sufficient weight to warrant following a different course.

Accordingly, I have determined to recommend to the President that he find Yucca Mountain qualified for application for a construction authorization before the Nuclear Regulatory Commission, and that he recommend it for development of a repository.