ISSUE 15

Nuclear Waste: Should the United States Continue to Focus Plans for Permanent Nuclear Waste Disposal Exclusively at Yucca Mountain?

YES: Spencer Abraham, from *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)

NO: Jon Christensen, from "Nuclear Roulette," *Mother Jones* (September/October 2001)

ISSUE SUMMARY

YES: Secretary of Energy Spencer Abraham argues that the Yucca Mountain, Nevada, nuclear waste disposal site is suitable technically and scientifically and that its development serves the U.S. national interest in numerous ways.

NO: Science writer Jon Christensen argues that it is impossible to forecast with confidence that nuclear waste entombed in Yucca Mountain will not threaten the environment over the next 10,000 (or more) years.

Nuclear waste is generated when uranium and plutonium atoms are split to make energy in nuclear power plants, when uranium and plutonium are purified to make nuclear weapons, and when radioactive isotopes that are useful in medical diagnosis and treatment are made and used. These wastes are radioactive, meaning that as they break down they emit radiation of several kinds. Those that break down fastest are most radioactive and are said to have a short half-life (the time needed for half the material to break down). Uranium-238, the most common isotope of uranium, has a half-life of 4.5 billion years and is not very radioactive at all. Plutonium-239 (which is used in bombs) has one of 24,000 years and is radioactive enough to be quite hazardous to humans.

weapons production (91 million gallons). Transuranic waste includes clc equipment, and other materials contaminated with plutonium and otl dioactive materials (11.3 million cubic feet, some of which has been l in the Waste Isolation Pilot Plant salt cavern in New Mexico). Low- and r level waste includes waste from hospitals and research labs, remnants of d missioned nuclear plants, and air filters (472 million cubic feet). The higl waste is the most hazardous and poses the most severe disposal proble general, experts say, such materials must be kept away from people and living things—with no possibility of contaminating air, water (including gı water), or soil—for 10 half-lives.

Since the beginning of the nuclear age in the 1940s, nuclear waste has accumulating. A sense of urgency about finding a place to put the waste wh would not threaten humans or ecosystems for a quarter-million years or has also developed. The 1982 Nuclear Waste Policy Act called for locating didate disposal sites for high-level wastes and choosing one by 1998. Sinc people of the states containing candidate sites were unhappy about it, and many of the investigated sites were less than ideal for various reasons, the sc ule proved impossible to meet. In 1987 Congress attempted to settle the m by designating Yucca Mountain, Nevada, as the one site to be intensively stu and developed. It was scheduled to be opened for use in 2010. Risk assessı expert D. Warner North, in "Unresolved Problems of Radioactive Waste: Mo tion for a New Paradigm," *Physics Today* (June 1997), asserted that the techı and political problems related to nuclear waste disposal remained formid and that a new approach was needed. Luther J. Carter and Thomas H. Pigf in "Getting Yucca Mountain Right," *The Bulletin of the Atomic Scientists* (Ma April 1998), wrote that those formidable problems could be defeated, gi technical and congressional attention, and that the Yucca Mountain strat was both sensible and realistic. However, problems have continued to pla the project; see Chuck McCutcheon, "High-Level Acrimony in Nuclear Sto Standoff," *Congressional Quarterly Weekly Report* (September 25, 1999) and S Paige, "The Fight at the End of the Tunnel," *Insight on the News* (November 1999).

In February 2002 Secretary of Energy Spencer Abraham recommendec the president that the United States go ahead with development of the Yu Mountain site. His report, which is excerpted in the following selection, ma the points that a disposal site is necessary, that Yucca Mountain has been th oughly studied, and that moving ahead with the site best serves "our ene future, our national security, our economy, our environment, and safety." Ab ham further argues that objections to the site are not serious enough to stop t project. In the second selection, Jon Christensen argues that far too much cor dence in Yucca Mountain's long-term safety is based on probabilistic compu models that are too uncertain to trust.

Spencer Abraham

YES

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

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.

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 a 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 country today.

This point bears emphasis. We are not confronting a hypothetical lem. We have a staggering amount of radioactive waste in this country—1 100,000,000 gallons of high-level nuclear waste and more than 40,000 ric tons of spent nuclear fuel with more created every day. Our choice between, on the one hand, a disposal site with costs and risks held to a mum, and, on the other, a magic disposal system with no costs or risks. Instead, the real choice is between a single secure site, deep under the gr at Yucca Mountain, or making do with what we have now or some varia it—131 aging surface sites, scattered across 39 states. Every one of those was built on the assumption that it would be temporary. As time goes b ery one is closer to the limit of its safe life span. And every one is at a potential security risk—safe for today, but a question mark in decad come.

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

The benefits of nuclear power are with us every day. Twenty perce our country's electricity comes from nuclear energy. To put it another way "average" home operates on nuclear-generated electricity for almost five h a day. A government with a complacent, kick-the-can-down-the-road nu waste disposal policy will sooner or later have to ask its citizens which hours of electricity they would care to do without.

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

Our national security interests are likewise at stake. Forty percent of warships, including many of the most strategic vessels in our Navy, are powe by nuclear fuel, which eventually becomes spent fuel. At the same time, the of the Cold War has brought the welcome challenge to our Nation of dispos of surplus weapons-grade plutonium as part of the process of decommission our nuclear weapons. Regardless of whether this material is turned into reac fuel or otherwise treated, an underground repository is an indispensable cc ponent in any plan for its complete disposition. An affirmative decision Yucca Mountain is also likely to affect other nations' weapons decommissi

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." 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.

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 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

Background

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 been known in this country at least since World War II. As early as 1957, a tional Academy of Sciences report to the Atomic Energy Commission sugge burying radioactive waste in geologic formations. Beginning in the 1970s, United States and other countries evaluated many options for the safe and manent disposal of radioactive waste, including deep seabed disposal, rem island siting, dry cask storage, disposal in the polar ice sheets, transmutati and rocketing waste into orbit around the sun. After analyzing these optic disposal in a mined geologic repository emerged as the preferred long-term vironmental solution for the management of these wastes. Congress recogni this consensus 20 years ago when it passed the Nuclear Waste Policy Act of 19

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

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

Following the provisions of the Act and the Department's siting Guid lines, the Department prepared draft environmental assessments for the ni sites. Final environmental assessments were prepared for five of these, inclu ing Yucca Mountain. In 1986, the Department compared and ranked the sit under construction for characterization. It did this by using a multi-attribu methodology—an accepted, formal scientific method used to help decision ma ers compare, on an equivalent basis, the many components that make up complex decision. When all the components of the ranking decision were co sidered together, taking account of both preclosure and post-closure concern Yucca Mountain was the top-ranked site. The Department examined a variety o ways of combining the components of the ranking scheme; this only confirme the conclusion that Yucca Mountain

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.

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. 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.

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.

As previously noted, the National Research Council of the National Academy of Sciences concluded in 1990 (and reiterated [recently]) 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." 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.

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.... 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

the completion of these stages that the Act directs the Secretary, if he : the site suitable, to determine whether to recommend it to the Presiden development as a permanent repository.

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

Following a Recommendation by the Secretary, the President may rec mend the Yucca Mountain site to Congress "if... [he] considers [it] qual for application for a construction authorization...." If the President sub a recommendation to Congress, he must also submit a copy of the staten setting forth the basis for the Secretary's Recommendation.

A Presidential recommendation takes effect 60 days after submission less Nevada forwards a notice of disapproval to the Congress. If Nevada sub such a notice, Congress has a limited time during which it may neverth give effect to the President's recommendation by passing, under exped procedures, a joint resolution of siting approval. If the President's recomm dation takes effect, the Act directs the Secretary to submit to the NRC a c struction license application.

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

Decision

The Recommendation

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

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

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 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 have 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. 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....

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 [illegible] maintenance of the Nation's

both medical and scientific. All these activities produce radioactive wa: that have been accumulating since the mid-1940s. They are currently scatte among 131 sites in 39 states, residing in temporary surface storage facilities a awaiting final disposal. In exchange for the many benefits of nuclear power, assume the cost of managing its byproducts in a responsible, safe, and sec fashion. And there is a near-universal consensus that a deep geologic facilit the only scientifically credible, long-term solution to a problem that will o grow more difficult the longer it is ignored.

Energy Security

Roughly 20 percent of our country's electricity is generated from nucl power. This means that, on average, each home, farm, factory, and business 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 e ergy, rather than becoming dependent entirely on generating electricity fro a single source, such as natural gas—is important to economic growth. Our vu nerability to shortages and price spikes rises in direct proportion to our failu to maintain diverse sources of power. To assure that we will continue to ha reliable and affordable sources of energy, we need to preserve our access t nuclear power.

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

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

National Security

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, [illegible]

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.

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 respository 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.

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 [illegible] The production of nuclear weapons at the end 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 and John Engler of Michigan 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.

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 of Yucca Mountain is indispensable to the maintenance and potential expansion of the use of this environmentally efficient source of energy. . . .

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 decommissioning 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 [illegible]

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.

NO

Jon Christensen

Nuclear Roulette

We're on our way to Yucca Mountain. And there are some things you should know before we get there. That is, before the Bush administration and Congress decide once and for all to entomb the nuclear age's most deadly legacy in the Nevada desert about 100 miles northwest of Las Vegas. The most important thing to remember is this: It's not about Yucca Mountain. And yet it is.

The other thing to keep in mind is that there is not just one Yucca Mountain. There are three. There is Yucca Mountain the place, a heap of ash and rubble that was blasted from a volcano some 12 million years ago and cemented together and eroded over eons into the shape of a wave breaking westward across a desert sea. There is little love lost for this Yucca Mountain, even among Nevadans like me who cultivate a taste for such unworldly landscapes. If I didn't have to come to Yucca Mountain, I wouldn't. And neither would you.

But we do. Because there is another Yucca Mountain. And this Yucca Mountain is the political answer to the question of what to do with spent fuel from 118 commercial nuclear reactors, 10 nuclear-weapons plants, and 37 research reactors around the country. This Yucca Mountain offers salvation for a nuclear industry poised for a comeback—and for politicians from states that don't want the highly radioactive waste stockpiled within their borders. Nearly 20 years ago, the federal government signed a contract promising that it would take charge of the spent fuel, which is now stored in dry casks and cooling pools at the plant sites. The political Yucca Mountain is the reason we are here.

And finally, there is Yucca Mountain the computer model. This Yucca Mountain is the most difficult to see, let alone understand. It is the virtual product of a program called a Monte Carlo simulation that calculates how much risk the real mountain's specific flaws—water percolating through the rock, groundwater flowing beneath, potential earthquakes and volcanic eruptions—will pose over the thousands of years that the waste will remain dangerously radioactive. In its ethereal way, this ghost of Yucca Mountain embodies both the technocratic hubris and the gambler's faith in the odds that have brought us to the brink of a decision whose consequences, as acknowledged by everyone involved, we cannot foresee.

By the end of [2001], the Department of Energy is scheduled to issue its final recommendation on turning Yucca Mountain into the nation's first and

only high-level radioactive-waste repository—a permanent graveyard for 70,000 tons of some of the most deadly and long-lasting toxins ever made. There is very little doubt about which way the recommendation will go. President Bush has called nuclear power "a major component" of his energy plan; the administration wants to extend the licenses of existing reactors and encourage the building of new ones. And as Energy Secretary Spencer Abraham told CNN's "Moneyline" in May, "If we can't find a repository for the waste, then it is very unlikely we would see new plants built."

Once the recommendation is made and the president formally endorses it, the state of Nevada will most certainly file a formal objection. That protest will send the decision to Congress, where a simple majority of both the House and the Senate will be all that is needed to override the state's pro forma veto.

Congress doesn't much care about the real Yucca Mountain. Earlier this year, an Energy Department document put it succinctly: "The technical suitability of the site is less of a concern to Congress than whether the nuclear waste problem can be solved at an affordable price in both financial and political terms." (Officials quickly disavowed the memo, blaming a contractor for the inadvertently telling wording.)

The "technical suitability" of Yucca Mountain, however, is what has proved most difficult to establish. Over 20 years of poking and prodding, this spot has become one of the most intensely studied pieces of real estate in the world, at a cost of close to $3.4 billion so far (and an estimated $50 billion more if the repository is built). Researchers have found that the mountain is crisscrossed by earthquake faults and that there are dormant volcanoes nearby. But the main concern in this arid spot turns out to be water.

Only an average six inches of rain fall on Yucca Mountain each year, barely enough to keep a sparse covering of grass and creosote bush alive. At first, the volcanic ash that makes up the mountain was thought to be so tightly compressed that what little water there is would not flow through the layers of rock. But as geologists dug into the mountain, they found that the rock is riddled with fractures. On average, they discovered a fracture every couple of inches. And they found water moving through the fractures.

They thought the water was moving slowly. But in 1996, they found chlorine 36—an isotope left by atmospheric bomb testing at the nearby Nevada Test Site in the 1950s—in water sampled at the level where waste would be stored, 800 feet underground. That meant rainwater could percolate down to the waste-storage area in just 50 years, and in another 50 years or so could reach the aquifer 1,000 feet farther down.

Originally, scientists also believed that if contamination escaped to the aquifer, most of it would cling to the rock and was unlikely to reach the nearby Amargosa Valley, now home to 1,500 people and a dairy farm that produces 41,000 gallons of milk a day. But studies have since found that plutonium from underground bomb tests hitched a ride on microscopic specks of clay suspended in groundwater and moved nearly a mile in 30 years—much faster than expected.

Add all of that up, and Yucca Mountain no longer looks like the perfect

10,000 years (though the half-lives of some of the most potent elements in waste, such as plutonium, are much longer). In fact, the Energy Department essentially conceded as much. It now asserts that what will protect the was not the mountain itself, but a special kind of canister made from a nickel-b metal called Alloy 22. The department says the metal—which has been aro for a few decades but tested for just three years—will last about 12,000 year.

That is where Yucca Mountain the computer model (officially know a "total system performance assessment") comes into the picture. The anal uses a Monte Carlo simulation, a technique commonly employed in science business to model the probability of various outcomes in a complex situati Take the probability that water will drip through the cracks in the mount and onto the waste canisters; mix that with the likelihood that the canisters corrode; add to that the probability that water will carry the contaminatior the aquifer below; and finally, factor in the chances that a family living nea will drink that water. Incorporate the possibility of a volcanic eruption, a of another ice age making this a much wetter place, and then throw in probability that a future prospector—let's call him the "unluckiest man in world," as Energy Department scientists do—will decide to drill or dig at the s

After sampling all of these variables many times, as if drawing cards hundreds of poker hands, the Monte Carlo simulation spits out a probabil curve. It estimates that radiation is unlikely to leak from the site for the n 10,000 years (if the canisters last that long; if they don't, all bets are off). then, the model suggests, the radiation will have diminished, and contamii tion from the repository will be partially absorbed in the rock and dilut in the water under Yucca Mountain. So the dose to a hypothetical family Amargosa Valley won't rise above 15 millirems—the maximum allowed by t Environmental Protection Agency—for hundreds of thousands of years.

"In some sense, it is science fiction to project out 300,000 years," Abi ham Van Luik, the official in charge of the modeling, once commented whi showing me around Yucca Mountain. "It gets more and more difficult to defer your assumptions as you move into the future." But, he hastened to add, "o modeling is overconservative. Absolutely no one is going to get hurt by th repository for hundreds of thousands of years."

The problem, some experts warn, is that "absolutely" is not somethir that can be said about a model based on probabilities. The Energy Departmer likes to say that the model has revealed "no showstoppers" at Yucca Mountai —no single factor that would disqualify the site. But Rodney Ewing, a nuclea waste management expert who served on the peer review panel for the Yucc Mountain model in 1998, says the computer simulation wouldn't know a show stopper if it saw one. "The uncertainty in these analyses was so large as to mak them unusable," explains Ewing, who in 1999 published a scathing article in th journal *Science*, criticizing the department's reliance on the computer model "One should not expect greater success with such a prediction than we have i other fields," he says, "such as predicting which presidential candidate gets th electoral votes from Florida."

engineering will perform over thousands of years. "If an airplane were built in this way," he says, "that is, smaller versions of the plane hadn't been test-flown, but you were assured that, good and competent engineers and scientists had modeled the plane's ability to fly, would you fly on the first airplane based on these analyses?"

If that prospect makes you nervous, just try to remember this: It's not about Yucca Mountain.

And yet it is.

POSTSCRIPT

Nuclear Waste: Should the United States Continue to Focus Plans for Permanent Nuclear Waste Disposal Exclusively at Yucca Mountain?

Abraham notes that the state of Nevada has the right to object to his recommendation. Not surprisingly, Nevada governor Kenny Guinn did exactly that on April 8, 2002. On May 8 the House of Representatives promptly voted to set aside the veto, and on July 9 the Senate voted to do the same. News reports said that this ends "years of political debate over nuclear waste disposal," but Nevada still has half a dozen lawsuits challenging the project pending.

Even those who favor using Yucca Mountain for high-level nuclear waste disposal admit that in time the site is bound to leak. The intensity of the radioactivity emitted by the waste will decline rapidly as short-half-life materials decay, and by 2300, when the site is expected to be sealed, that intensity will be less than 5 percent of the initial level. After that, however, radiation intensity will decline much more slowly. The nickel-alloy containers for the waste are expected to last at least 10,000 years, but they will not last forever. The Department of Energy's computer simulations predict that the radiation released to the environment will rise rapidly after about 100,000 years, with a peak annual dose after 400,000 years that is about double the natural background exposure. Many people are skeptical that the site can be protected for any significant fraction of such time periods. These are among the considerations that lead James Flynn et al., in "Overcoming Tunnel Vision," *Environment* (April 1997), to urge stopping work on the Yucca Mountain project and rethinking the entire nuclear waste disposal issue. On the other hand, Jonah Goldberg, in "Dead and Buried," *National Review* (April 8, 2002), contends that such considerations are irrelevant and that critics exaggerate the dangers of storing waste at Yucca Mountain.

The nuclear waste disposal problem in the United States is real, and it must be dealt with. If it is not, America may face the same kinds of problems created by the former Soviet Union, which disposed of some nuclear waste simply by dumping it into the sea. For a recent summary of the nuclear waste problem and the disposal controversy, see Michael E. Long, "Half Life: The Lethal Legacy of America's Nuclear Waste," *National Geographic* (July 2002). Gary Taubes, in "Whose Nuclear Waste?" *Technology Review* (January/February 2002), argues that a whole new approach may be necessary.