As Decision Time Approaches for Radioactive Waste Repository, a Mountain of Issues Still Unresolved

The debate over Yucca Mountain has focused mainly on safety concerns thousands of years in the future. The 11 September terrorist attacks are changing the debate and making safety issues more immediate.

When Abe Van Luik talks about the enormously complex scientific and political issues that envelop the Department of Energy's multibillion nuclear waste repository development program at Yucca Mountain, Nevada, he remembers a time when the project seemed so simple. Yucca Mountain is a remote, harsh place that is as hot, dry, and uninviting as nearby Death Valley. And it stands hard by the Nevada Test Site, where nuclear bombs were detonated underground. What better place to bury thousands of tons of highly radioactive nuclear waste?

"When we first evaluated this back in 1986, we looked at the mountain and it seemed so dry that we thought we could put nuclear waste in thin-walled containers, then put the waste in the mountain and just leave it," said Van Luik, a senior policy adviser for DOE's Yucca Mountain project. "But the mountain's not perfect anymore."

Indeed, as Secretary of Energy Spencer Abraham prepares to make a recommendation to President Bush by the end of this year on the viability of Yucca Mountain as the nation's nuclear waste repository, the list of unresolved questions remains long. The mountain's rock is filled with small fractures that provide pathways for moisture to move into the waste repository; ancient volcanic cones nearby have raised concern from the Nuclear Regulatory Commission (NRC) and others about "igneous intrusion" from future volcanoes; and nearby fault lines have raised earthquake concerns.

Those are merely the geologic issues. Some scientists and government officials worry about the potential effects of climate change because DOE climate models indicate that over long time scales the region is typically cooler and wetter than it is now. There are also concerns about the structure of the society that must oversee the nuclear waste several thousand years from now. Will there be a responsible government capable of handling problems with the waste repository?

"You can't bank on the nature of institutional controls even 100 years from now," said Debra Knopman, an engineer with the Rand Corp and a member of the Nuclear Waste Technical Review Board (NWTRB), a government panel that oversees the science and engineering at Yucca Mountain. "For perspective, consider that the United States itself has only been around for 225 years. DOE's plans assume closure in 50 years after the repository opens, but the program leaves open the possibility that the mountain may be kept open for as long as 300 years. You can't assume now that you will know what controls will be there in the future."

But resolution of the many questions surrounding Yucca Mountain, particularly the scientific and engineering concerns, is not required for the site to be considered safe enough to become the nation's nuclear waste repository. DOE, in its *Preliminary Site Suitability Evaluation*, issued in July, found that, with the proposed design, radiation exposure to the public in the future would "fall below the EPA [Environmental Protection Agency] standards and proposed NRC requirements."

Located about 100 miles northwest of Las Vegas, the mountain has been under study since Congress passed the Nuclear Waste Policy Act of 1982. In a 1987 amendment to the act, Congress selected the mountain as the sole candidate for the repository. It was a political decision that has driven the science ever since, program observers say, because the charge to DOE became one of determining if Yucca Mountain was "safe enough," instead of determining if it was the best of several alternatives.

Environment seemed ideal

Back in the mid-1980s, as Van Luik noted, almost everyone assumed the mountain would be ideal because of its isolation, rainfall of less than six inches per year, and very deep water table 800 to 1000 feet below the proposed repository. The mountain is made of 13-million-year-old volcanic rock called tuff.

DOE officials originally thought the tuff and other geologic features could prevent radiation from leaking into the environment for the prescribed 10 000 years, and probably much longer. But over the past several years, studies of the geology, hydrology, seismology, and volcanic properties of the region have eroded the early confidence that the mountain itself can safely contain an anticipated 70 000 metric tons of spent fuel and high-level waste.

YUCCA MOUNTAIN PROJECT/DOE

YUCCA MOUNTAIN, adjacent to the Nevada Test Site, is the proposed location for a nuclear waste repository

The primary concern is that over thousands of years the "waste packages" that hold the radioactive material will corrode and radionuclides will leak out and be carried by moisture down into the water table. Once there, the radionuclides might flow out to a region where future generations could unknowingly tap into the contaminated water.

As problems with the mountain's geology have increased, DOE scientists have shifted toward engineered barriers. The current design calls for the waste to be placed in dual-metal containers consisting of two cylinders. The inner cylinder would be made of a special stainless steel two inches thick. The inch-thick outer cylinder, made of a nickel-based metal called Alloy 22, would protect the inner cylinder from corrosion. These containers would be lined up, end-to-end, on specially designed metal stands inside the repository's tunnels. Titanium drip shields would arch over all of the containers as an additional barrier against moisture.

The temperature created by the radioactive waste would be above the boiling point of water for at least 1800 years, keeping the surrounding rocks hot and dry and serving as yet another defense against moisture. DOE officials believe the engineered barriers alone, regardless of the surrounding geology, will keep the radionuclides contained for the required 10 millennia. Yet virtually every aspect of the DOE design is being challenged by government panels, independent scientists, and experts working with the state of Nevada.

Bob Loux, director of Nevada's agency for nuclear waste management and a strong opponent of the project, said he is troubled by DOE's increasing reliance on engineered barriers, when the whole point of Yucca Mountain was to create safe geologic disposal. "We're not sure it is geologic disposal anymore," he said. "It seems the site has become a liability, not an asset."

Loux said state scientists believe there could be groundwater contamination in as little as 300 to 500 years. His numbers are by far the most dire, and supporters of the project note that Nevada officials are opposed to the very idea of a Yucca Mountain repository. State officials are suing the EPA over standards that govern the site, have hired a Washington, DC, law firm to fight the project, and have vetoed in advance President Bush's possible approval of Yucca Mountain.

Congress can overturn the state's veto, so on Capitol Hill the entire Nevada delegation, led by Democratic Senator Harry Reid, is trying to corral enough votes to stop the project. Yet the nuclear power industry is insisting that the federal government meet its legal obligation to create a permanent repository for the waste, so the political pressure to approve Yucca Mountain is enormous.

One emerging area of concern at the mountain is the accuracy of the computer modeling being used to forecast what will happen in the distant future. The process, known as total system performance assessment (TSPA), consists of the "mathematical integration of everything we know, so it tends to be complicated," DOE's Van Luik said.

An international group recently completed a review, at DOE's request, of the TSPA process, "and they said that in some places we are being absurdly conservative," Van Luik said. The review panel said that so many of the assumptions were so conservative that the forecasts did not reflect reality. "We've compounded conservatism with conservatism," he said. The NWTRB, which has endorsed DOE's use of performance assessment techniques, shares some of the review group's concerns, noting that the strategy of using consistently conservative assumptions doesn't give reviewers anything to measure those assumptions against.

The international review group was also critical of the TSPA model of the all-important saturated zone, that area underneath the depository where water can carry radioactivity away from the mountain. "We thought we understood the saturated zone pretty well," Van Luik said. The peer review was so critical of that aspect of the model that he called it "mean spirited," although not necessarily wrong.

Irreducible uncertainties

All of the criticism and open questions do not necessarily reflect on the likelihood of Yucca Mountain getting its license and receiving its first shipments of waste around 2010, as DOE officials hope. "When you're doing something this complex, looking so far into the future, some uncertainties are irreducible," Van Luik said.

The recent terrorist attacks on the US added a new factor to the debate, said the NWTRB's Knopman. "For some it may make Yucca Mountain a no-brainer," she said. "The argument is you have to get the waste out of the 70 nuclear plant sites and get it to one location. Others may view the transportation to Yucca Mountain to be a bigger risk."

A range of possibilities exists for the political decision on the fate of Yucca Mountain. The repository could be approved as DOE proposes, or canceled based on Nevada's objections. There could be a commitment to the site, but not the design, with waste stored on the surface while a new design is developed. Or waste could be put in the mountain on a temporary basis while experts search for a better site. Like everything with Yucca Mountain, the political end game is expected to be unusually complex as it is played out over the next few years.

JIM DAWSON

AIP Urges Documenting Big Physics for Posterity

Want your grandchildren to know how you built that satellite? Measured salinity and other properties of the world's oceans? Discovered the top quark or conducted some other major collaborative project? If so, start thinking now about saving records, says a new report by AIP's Center for History of Physics.

Matters have only gotten messier since Richard Feynman said, in his Nobel lecture in 1965, "We have a habit in writing articles published in scientific journals to make the work as finished as possible, to cover all the tracks, to not worry about the blind alleys or to describe how you had the wrong idea first. . . ."

It's a problem that Joan Warnow-Blewett recognized years ago. And one that is exacerbated by the trend in recent decades toward large collaborations. "If you have an experiment spread among many institutions, and even countries, no one feels responsible for saving the documents," she says. Science historians ask questions like, "What is the economy of very large projects? How are they paid for? What structure do they have?" says Peter Galison, a historian and high-energy physicist at Harvard University. "There are a whole host of issues that surround the way knowledge is certified and enters circulation. Scientists don't write letters as they once