Science and engineering

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Nature and engineering working together for a safe repository

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If a repository were built at Yucca Mountain, it would rely on two distinct systems to prevent radioactive materials from escaping into the environment. These systems act as barriers to the movement of radionuclides. The first system involves natural barriers — the rocks, water, and climate at Yucca Mountain. The second system is comprised of an array of engineered, or man-made, barriers that give the repository defense in depth and add safety margins. These systems would work together to protect the public and the environment.

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The mountain's natural features present a formidable line of defense against possible movement by radionuclides. These barriers include Yucca Mountain's unique geology, the region's dry climate, and, in general, a range of enclosed water systems that should slow water that contains radioactive particles from reaching rivers or other groundwater systems. The mountain's natural barriers and planned man-made barriers should prevent most moisture from ever reaching the waste packages within a repository. Moreover, the natural barriers would slow the movement of radioactive particles that do dissolve in water.

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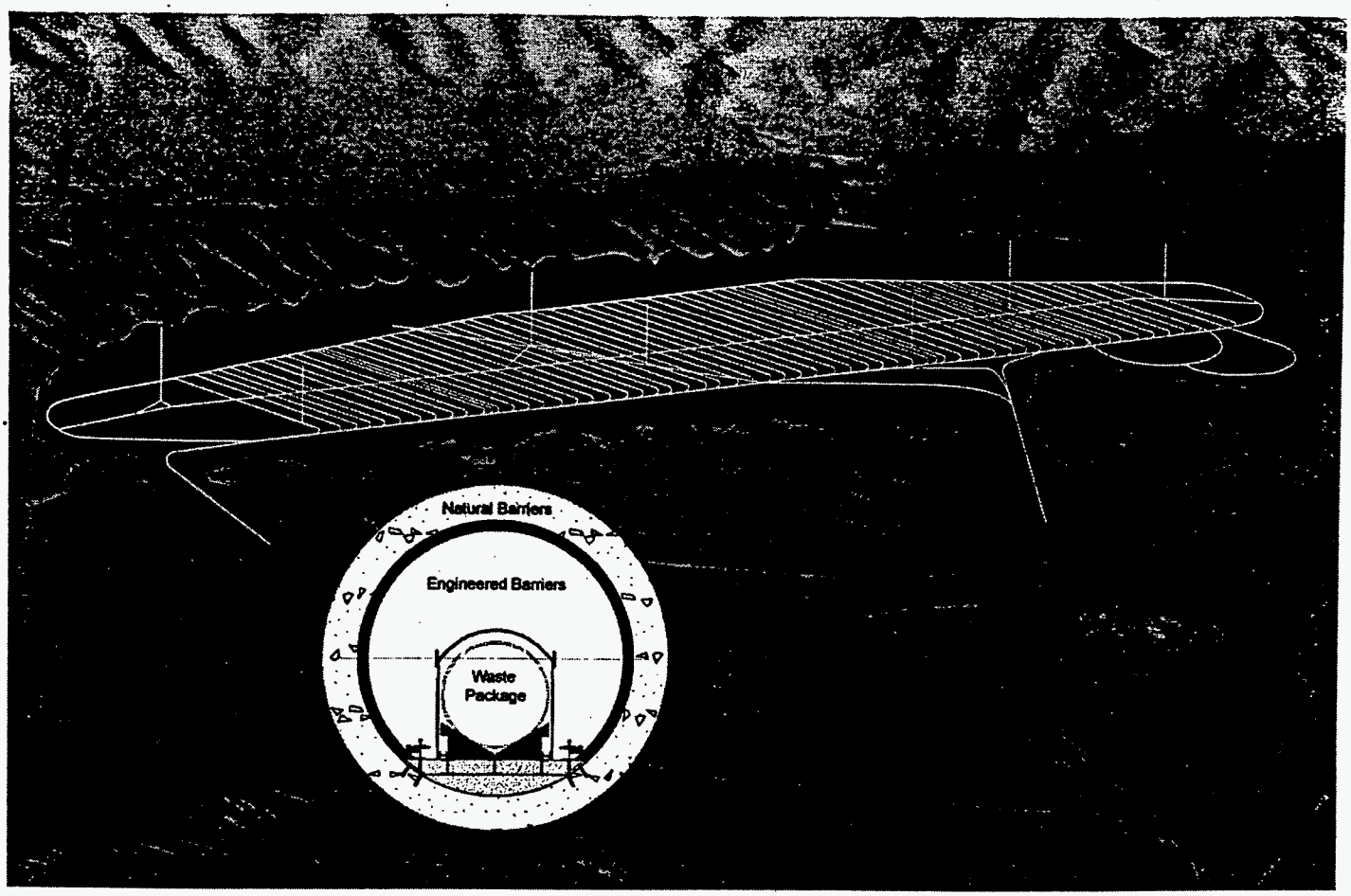
The engineering, or technological measures, that would be built into a repository at Yucca Mountain would help ensure that health and safety standards are maintained even if some components of the natural system do not perform as expected for the first 10,000 years of repository operation.

Natural barriers act together to slow movement of radioactive particles

The dry, desert climate at Yucca Mountain is an important natural barrier to radionuclide movement, as are the low levels of rainfall in the area. Any radioactive particles that have the potential to move out of a repository will most likely do so in water. But the Yucca Mountain area receives less than seven inches of rainfall or snow each year. Most of this moisture flows off the surface of the mountain or evaporates before seeping into the rock. Only very small amounts of moisture ever reach the repository level at all.

Another important natural barrier can be found in the rock and minerals at Yucca Mountain. With few exceptions, water moves very slowly through this rock. In most instances, it would take thousands of years for the small amounts of water reaching the repository level to soak through to the water table situated hundreds of feet below the potential repository. Some minerals within the rock actually strain radioactive particles from contaminated water, holding them in place in the rock. Those particles that do reach the water table would disperse in a larger volume of water. The radioactive particles must then be transported more than 12 miles through the rock in the underground water before the particles would reach an area where the water



If a repository were to be built at Yucca Mountain, it would be approximately 300 meters (1,000 feet) below the top of the mountain. A series of man-made barriers would be in place to work with the natural system of the mountain to protect the health and safety of the public.

could be used by anyone. In such concentrations as are likely to exist, these particles are unlikely to harm anyone using the groundwater.

These natural features would help limit opportunities for water to contact and dissolve the spent nuclear fuel and high-level radioactive waste contained within a repository. Together they would make it difficult for any waste that may dissolve in water over the thousands of years of the repository's lifetime to move into areas where people live. The site itself would protect an underground repository against those disruptive natural events and processes that could affect a surface storage facility. The repository would be approximately 300 meters (1,000 feet) below the top of Yucca Mountain. The rock above the repository would protect it against the effects of extreme weather, climate change, erosion, and other potential hazards.

Engineered barriers contribute to defense in depth

By itself, the mountain would provide a high degree of protection to the public. Nevertheless, scientists have devised a series of man-made, or engineered, barriers to augment the natural system. Corrosion-resistant waste packages, disposal tunnels excavated away from possible entry points for moisture, water-resistant drip shields placed over the waste packages, and other design com-

ponents will increase the repository's inherent ability to contain and isolate its radioactive contents.

The repository tunnels are an important engineered barrier to potential radioactive releases. The tunnels would be arranged so that any water that does enter them can drain, by gravity, out of the drifts and away from any others. Other measures, such as drain-holes, could assist in diverting water.

The spent nuclear fuel and high-level radioactive waste would be contained in waste packages designed to last for thousands of years. Under the current design the waste packages would consist of two metal cylinders, one nested within the other. The inner cylinder would be five centimeters (two inches) of stainless steel. It would provide structural strength for the waste package. The outer cylinder would be two centimeters (about one inch) of a nickel alloy highly resistant to corrosion.

Inside their disposal tunnels, the waste packages would be equipped with drip shields. These are sheets of corrosion-resistant metal designed to protect the packages from seeping or dripping water. The metal used to make these shields would be different than the metals used to make the waste package. This means that there is no need to depend upon the durability of only one metal. These shields are not a key or vital component of the repository. They are intended as a redundancy — an additional safeguard designed to give added protection to the waste packages.

The waste packages themselves will be placed on stands. Their purpose is to present yet another barrier to contact with water. The stands keep the waste packages off the floor so that any water that pools on the tunnel floor would not touch the waste packages.

Natural and engineered barriers work together to provide necessary protection

When designing disposal systems intended to last longer than recorded human history, scientists and engineers must consider the possibility that one or more barriers, natural or engineered, could fail to perform as expected. Waste packages may fail earlier than envisioned due to hidden defects. Alternatively, more water than expected could eventually seep into the drifts. Fortunately, no single barrier, natural or man-made, would have to sustain the safety of the repository single-handedly. Each of the barriers present, whether primary or intended as an additional safeguard, would work as a system designed to maintain the public's safety.

U.S. Department of Energy
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