

# In Summary...

## Nuclear waste disposal programs, including the one at Yucca Mountain, should be implemented in a flexible, staged fashion



Aerial view of Yucca Mountain, Nevada (Source: DOE).

A new report from the National Academies proposes a management approach called “adaptive staging” as a promising means to develop geologic repositories for high-level waste such as the proposed repository at Yucca Mountain, Nevada. Adaptive staging is a learn-as-you-go process that enables project managers to continuously reevaluate and adjust the program in response to new knowledge and stakeholder input.

Given the impetus for staged approaches, or staging, in radioactive waste repository programs worldwide, the U.S. Department of Energy (DOE) requested that the National Academies provide advice on how to implement staging during the construction, operation, closure, and post-closure phases of a repository program. The resultant report, *One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste*, addresses staging as applied to a generic repository program with applications to the U.S. program at Yucca Mountain.

### Features of Adaptive Staging

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Every first-of-a-kind, long-term, and complex project develops in stages. With time, stages and schedules are inevitably revised in light of experience and knowledge gathered along the way. However, many national repository programs, including the U.S., have so far set rigid milestones to full-scale waste emplacement and repository closure.

The report recommends implementing adaptive staging, a flexible approach where the ultimate path to success and the end point themselves are outlined at the beginning of the program and all parties, including stakeholders, acknowledge that the program can be revised as it progresses. Adaptive staging is therefore less “error-prone” than a rigid approach and ensures that early decisions do not commit the project to a path that later proves inappropriate or unsafe. Adaptive staging also allows the current generation to manage waste using the best available knowledge without foreclosing options if future generations decide to manage waste otherwise.

A central feature of adaptive staging is a series of assessment periods, or “decision points,” when project managers actively collect and evaluate information, including stakeholder input, to develop options for the next stage of the project. At these points, managers reassess the safety of the repository, make their findings public, and engage in dialogue with affected communities and other stakeholders.

Adaptive staging is characterized by the simultaneous presence of the following seven attributes:

- **Commitment to systematic learning.** Project managers intentionally seek, are open to and learn from new knowledge and stakeholder input. Stages are designed specifically to increase available scientific, technical, societal, institutional and operational knowledge.
- **Flexibility.** Project managers are able and willing to reevaluate earlier decisions and redesign or change course when new information warrants.
- **Reversibility.** Project managers are able to abandon an earlier path and reverse the course of action to a previous stage if new information warrants.
- **Transparency.** The decision-making process and the basis for decisions are documented and accessible in real-time and plain language to all stakeholders
- **Auditability.** Documentation for the basis of decisions is complete and made available to all interested party for review purposes.
- **Integrity.** Technical results are accurately and objectively reported and all uncertainties, assumptions, and indeterminacies are identified and labeled.
- **Responsiveness.** Project managers seek and act on new information in a timely fashion.

This approach is not meant to delay the program but to allow program learning from experience. Although initial costs may be higher and waste emplacement may begin at a slower pace using adaptive staging, overall costs may be lower and completion of waste emplacement may be achieved earlier because the iterative nature of adaptive staging corrects potential problems before they become expensive and time consuming.

## Application of Adaptive Staging at Yucca Mountain

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In 2002, the U.S. Congress authorized DOE to pursue a license to build a geologic repository for high-level waste at Yucca Mountain, Nevada. DOE has set a roadmap for the stages of its repository program, projecting the beginning of waste emplacement in 2010 and the end in 2040. The report committee finds that DOE's program is characterized by the recurring tendency to propose unrealistically tight schedules and by the lack of transparency in some decision processes. In addition, major milestones in the U.S. program correspond to licensing steps with little opportunity to revise the program according to input gathered at various stages.

Consistently with adaptive staging, DOE is now considering a pilot stage to gather operational experience and to demonstrate retrievability of nuclear waste in carefully planned steps, first with non-radioactive waste and later with small amounts of radioactive waste placed in a section of the repository. The report recommends other activities that could be included in a pilot stage (see sidebar).

In order to fully implement adaptive staging as defined in the report, DOE must further shift its mindset and take specific actions including:

- Highlight the goal of ensuring safety and security at all times more prominently than the specific milestone of emplacing 70,000 metric tons of heavy metal in Yucca Mountain.
- Plan more numerous program stages than licensing steps and allow for introduction of unscheduled decision points, if new information warrants.
- Plan for sufficient buffer storage at or near the site to provide the required flexibility for repository operations, with transparency about policy implications.
- Place high priority on defining and securing funding for the monitoring, science, and technology programs with the intention of modifying and improving the program as learning progresses.

The report recommends that DOE submit to the regulator, the U.S. Nuclear Regulatory Commission, a sound repository design for the full inventory with the understanding that it can be modified as knowledge and experience are gained. This implies that the U.S. Nuclear Regulator Commission also accepts and allows sufficient flexibility in the regulatory process to allow for adaptive staging.

### Examples of recommended activities and tests for a Yucca Mountain pilot stage

- Transfer of waste from the generators to the repository, and from the repository's surface to the subsurface, while ensuring all aspects of worker safety.
- Demonstrate emplacement and retrievability of waste packages, using both simulated and radioactive waste.
- Analysis of worker exposure of radiation and industrial accident risk when handling, packaging, and emplacing waste.
- Installing backfill material as would be done to prepare for repository closure.
- Monitor the engineered barriers and adjacent natural systems in detail.

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*One Step at a Time: The Staged Development of Geologic Repositories for High-Level Radioactive Waste* is available from the National Academies Press, 500 5<sup>th</sup> Street, Washington, DC, 20001; (800) 624-6242 or <http://www.nap.edu>.