Sandia National Laboratories

Energy, Climate, & Infrastructure Security

Advances in Performance Assessment

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Sandia National Laboratories originated an innovative approach to determining the safety of geologic repositories for radioactive waste disposal called "performance assessment" (PA).

Introduction

Researchers at Sandia National Laboratories originated an innovative approach to determining the safety of geologic repositories for radioactive waste disposal called "performance assessment", PA. The discipline of PA continues to advance within the Defense Waste Management Programs as computing capabilities advance and as the discipline is used in an expanding portfolio of applications both nationally and internationally.

Example of Geologic Instability Via a Large Fracture in the Earth's Crust

Do Radioactive Waste Disposal Options Assure Safety for Generations to Come?

The overwhelming concern associated with disposal of radioactive wastes is public safety, not just for current generations, but for the generations to come. Even as the nuclear era was dawning, scientists realized that the materials they were harnessing for the benefit of our Nation posed a significant threat to public safety, both the material itself and the waste material produced. That waste material in many cases is highly radioactive (alpha, beta and gamma radiation) and portions will remain radioactive for millions of years. These waste characteristics have driven researchers to explore disposal options that will completely isolate highly radioactive, long-lived wastes from the public for tens of thousands, maybe even millions, of years. Thus, the concept of deep geologic waste disposal was born.

Relying on Geologic Systems for Waste Isolation Introduces Uncertainty

Geologic systems, like biological systems, are highly complex. They follow the rules of nature (physics, chemistry, and biology), but they are heterogeneous, so that behavior noted in one location may not be repeated a mile away. Geologic systems also evolve very slowly, over millennia, making them difficult to study within human lifetimes. This aspect of geologic disposal introduces uncertainty into estimates of the behavior of geologic systems. This is called Epistemic uncertainty. Subjective (epistemic) uncertainty arises from a lack of knowledge about parameters assumed to have fixed values in a calculation.

Human Behavior into the Future is Also Uncertain

While a certain degree of confidence can be placed on the activities of humans in the very near term, how mankind will evolve and how humans will behave even one hundred years from now is uncertain. But, assuring that radioactive waste is isolated into the future requires suppositions about the likelihood of future events. The uncertainty about the likelihood of future events is called Aleatory uncertainty. Stochastic (aleatory) uncertainty arises from a lack of knowledge about future events.

Sandia National Laboratories Adopts a Probabilistic Approach

Largely because of considerable expertise in Probabilistic Risk Assessment (PRA), Sandia National Laboratories recognized the two types of uncertainties inherent in investigations of the safety of a geologic disposal system and developed a probabilistic approach for addressing these uncertainties called Performance Assessment (PA). Performance assessment moved safety evaluations for radioactive waste disposal from a deterministic realm to a probabilistic perspective. Today Sandia's Defense Waste Management

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Programs in Carlsbad, NM maintains a balanced multidisciplinary team with experts spanning all relevant disciplines that contribute to the advancement of PA for a variety of deep geologic disposal systems. This team of scientists, engineers, and mathematicians provides scientific advice to decision makers who are examining the merits of deep geologic disposal for radioactive waste. They also endeavor to expand the application of PA to other waste disposal problems that need to take uncertainties into consideration.

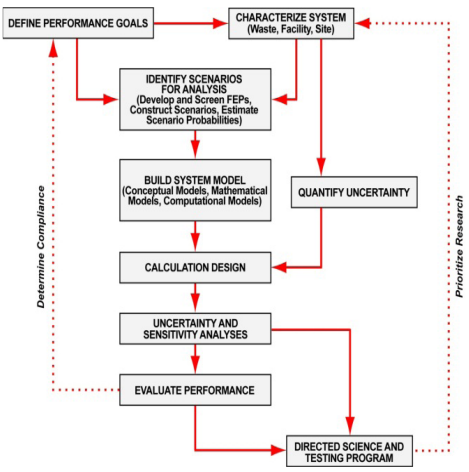
Performance Assessment Is the Foundation for Science-based Decision Making

Starting with an assessment of the feasibility of disposal of high-level radioactive waste in the seabed, Sandia National Laboratories has assisted our Nation's leaders in making science-based decisions through PA. This seabed project was sponsored by the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (1976-1988). Sandia had lead responsibility for PA for the international project and was a key participant in the feasibility evaluation.

Sandia performed iterative PAs for the WIPP between 1989 and 1992. Each of these preliminary PAs included sensitivity analyses identifying parameters with the greatest impact on system-level performance. Results of these PAs were delivered to the Department of Energy (DOE) and were used to guide experimental and design activities. Sandia was able to quantify the effect of all proposed technical activities, including experimental research and design alternatives, on the likelihood of achieving compliance with applicable EPA regulations for long-term repository performance. The DOE was able to select an optimal combination of activities to achieve a defensible compliance certification application within the allowable time.

Sandia conducted PAs since 1989 to advise the DOE on the suitability of the Greater Confinement Disposal (GCD) facility on the Nevada Test Site. PAs for the GCD have evaluated the capability of the site to meet EPA standards for the disposal of transuranic waste.

Sandia used PA between 1993 and 1998 to evaluate alternative disposal options for high-level radioactive waste and spent fuel stored at the INEEL and the Hanford Reservation. The purpose of the studies was to assess the likelihood that hypothetical disposal sites could comply with applicable long-term regulations. Performance assessments used data from actual sites as analogs for the hypothetical sites. Sites considered included a bedded salt site (using WIPP as an analog), a granite site (using generic data and site specific data from the Lac Du Bonnet site in Canada as an analog), and a tuff site (using Yucca Mountain as an analog).



Performance Assessment Methodology Developed at Sandia National Laboratories

Sandia played a key role in designing total system performance assessment (TSPA) methodology for the Yucca Mountain Site Characterization Plan in 1988, and completed iterative preliminary TSPAs for the site in 1990, 1991, and 1993. Beginning in 1995, Sandia partnered with Duke Engineering and Services in the Civilian Radioactive Waste Management System Management and Operating Contractor's Performance Assessment Department, and played a key role in the 1995 preliminary TSPA and TSPAs to support the 1998 Viability Assessment and 2000 Site Characterization Consideration Report.

Advancing the State-of-the Art

Today, researchers in the Defense Waste Management Programs are migrating the WIPP PA system to a state-of the art computing platform. They are evaluating the WIPP PA model components to determine how they can contribute to a generic disposal system computing model.

Publications

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Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant. 1996. DOE/CAO-1996-2184. U.S. Department of Energy, Waste Isolation Pilot Plant Carlsbad Area Office. Carlsbad, NM.

Summary of the total system performance assessment for Yucca Mountain license application. C. W. Hansen, et. al. Sandia National Laboratories, Albuquerque, NM. SAND2010-3754C.

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