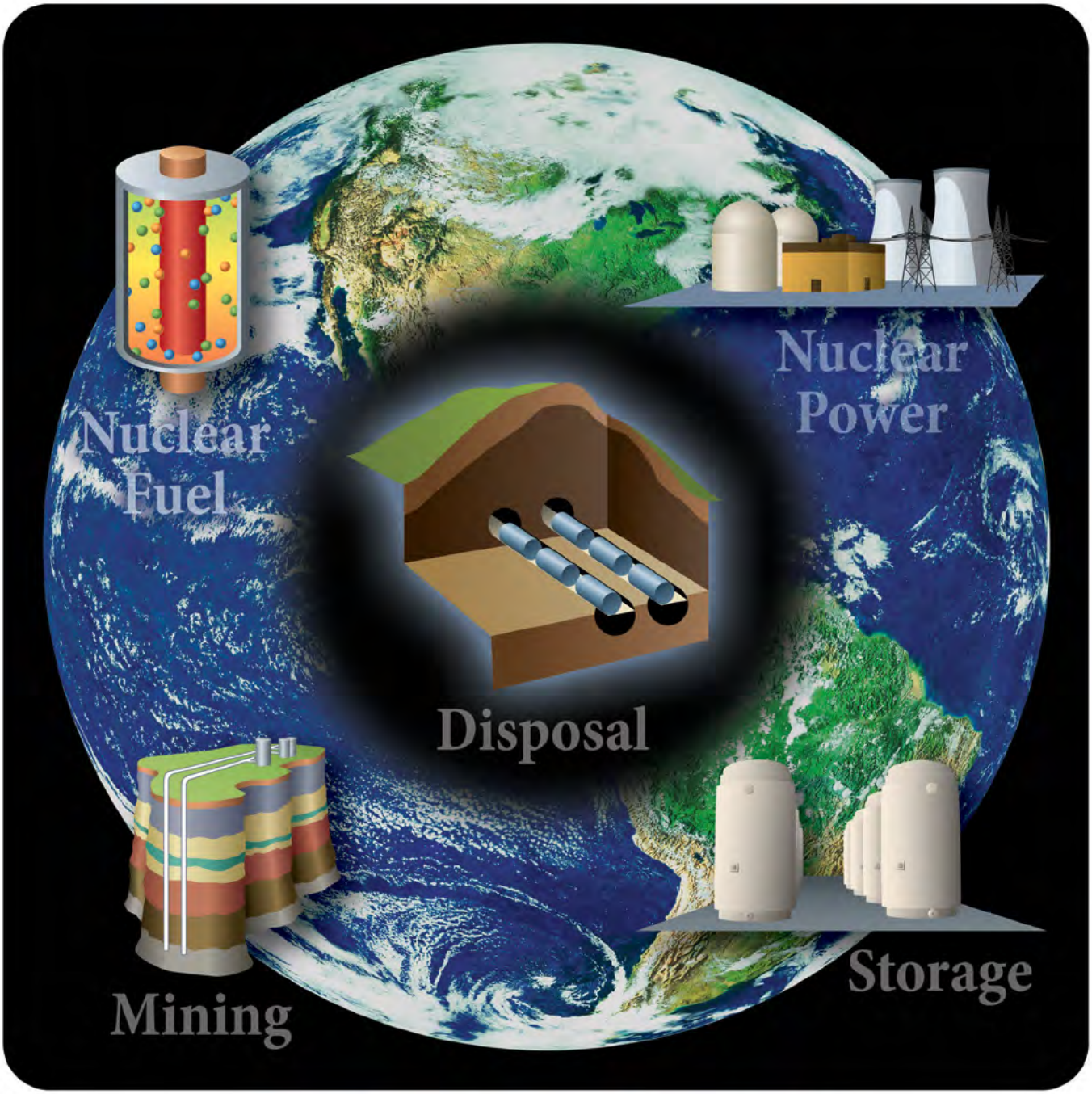
CNWRA®



SOUTHWEST RESEARCH INSTITUTE®

Southwest Research Institute®

Founded in 1947 as an independent, nonprofit research and development organization, Southwest Research Institute® provides a significant research, engineering and testing resource for industry, business and government. With nine technical divisions, SwRI® uses a multidisciplinary, integrated approach to solving complex problems in science and applied technology. The Center for Nuclear Waste Regulatory Analyses (CNWRA®) is internationally recognized for innovative solutions to complex problems in the earth, material and planetary sciences and allied engineering disciplines. The CNWRA creates multidisciplinary teams to solve client problems within a framework of risk assessment, system studies and regulatory analyses. As part of a long-held tradition, patent rights arising from sponsored research at the Institute are often assigned to the client. SwRI generally retains the rights to Institute-funded advancements.

The Center for Nuclear Waste Regulatory Analyses

The CNWRA was established in 1987 to provide independent, high quality and sustained technical assistance and research to the U.S. Nuclear Regulatory Commission (NRC). Its initial focus was on work needed to license a potential geologic repository for spent nuclear fuel and high-level radioactive waste.

D017042

For natural hazards such as volcanoes, CNWRA's hazard assessment technology identifies site conditions that cause hazards, determines forcing functions, integrates hazard information with potentially affected infrastructure, and monitors potential safety-affecting changes in natural systems.

Today, that original mission continues, although the Center's capabilities and experience have expanded significantly. With a unique range of technical expertise, computer software, laboratory facilities and field investigation experience, the CNWRA is an internationally recognized center of excellence in earth sciences and engineering. These capabilities are now used by commercial clients; by local, state, federal, and international governments and agencies; and in support of other NRC programs.

CNWRA technical expertise

- Chemical engineering
- Civil engineering
- Computational fluid dynamics
- Computer sciences
- Geochemistry and radiochemistry
- Geological engineering
- Hazard assessment
- Health physics
- Hydrology and climatology
- Material sciences and corrosion
- Mechanical engineering
- Mining engineering
- Nuclear engineering including criticality
- Performance and risk assessment
- Remote sensing
- Rock mechanics
- Structural geology
- Volcanology

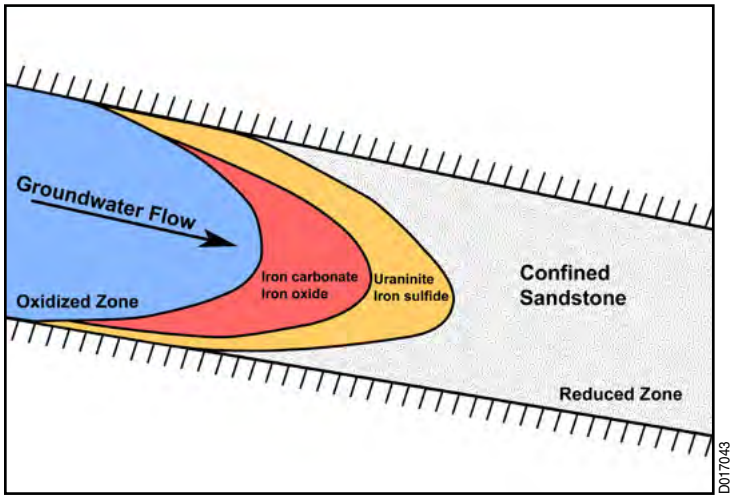
D138362

Corrosion sensors developed by CNWRA scientists detect the onset of localized corrosion, corrosion precursor events under coatings and paint films, and corrosion under alternating wet and dry conditions.

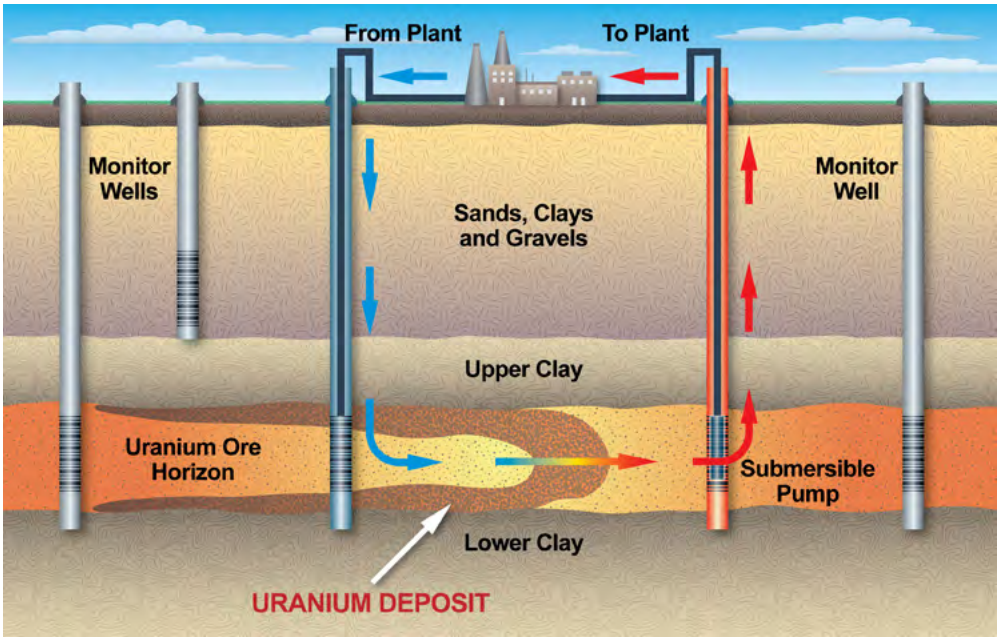
Uranium mining and processing

The CNWRA conducts technical and safety evaluations of *in-situ* leach and conventional uranium mines and associated uranium mill tailings.

CNWRA staff members have performed safety and environmental reviews for a large number of new and existing *in-situ* leach uranium recovery facilities. These reviews address the effects of construction, operation, decommissioning and reclamation while evaluating any potential environmental impacts, such as those associated with potential underground excursions of pregnant lixiviant. For conventional uranium mining and milling, CNWRA geologists have assessed mine designs and operations, tailings processing and disposal, and remediation of mill and tailings sites. Our broad-based experience includes estimating radiological doses, evaluating drying operations and planning for decontamination. CNWRA geophysics capabilities are available for site investigation and ore location.



This roll-front deposit — a uranium ore body formed at the interface of oxidizing and reducing groundwater — is one geologic setting from which uranium can be recovered. This schematic shows zoning, alteration and mineralogical changes.

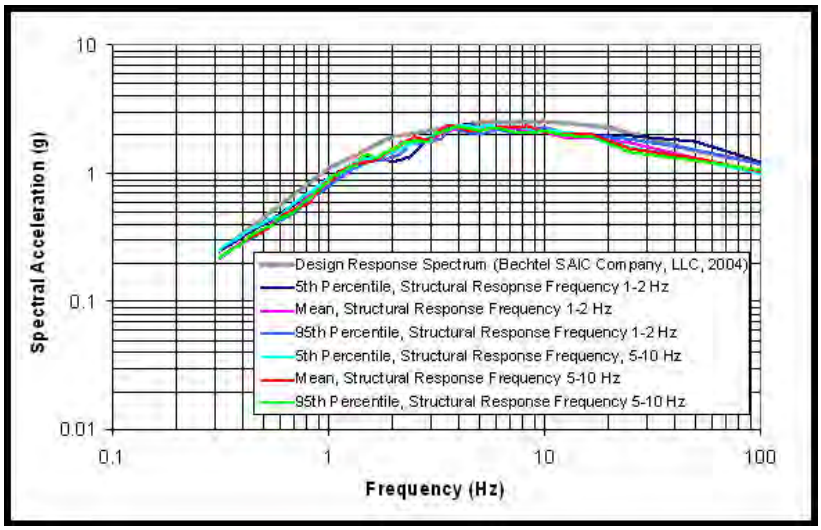


In-situ *leach (ISL) mining involves recovering minerals such as uranium through boreholes drilled into the deposit. CNWRA developed a generic environmental impact statement to identify and evaluate potential environmental consequences of constructing, operating and restoring aquifers, and decommissioning ISL facilities in the western United States.*

CNWRA scientists and engineers applied their multidisciplinary expertise in risk assessment to identity and quantify the types and consequences of accidents that can occur in uranium in-situ *leach facilities.*

Nuclear material enrichment and fuel fabrication

Scientists at the CNWRA conduct hazard assessments, perform safety reviews, analyze designs, and inspect nuclear fuel enrichment and fuel fabrication facilities. Staff members assess the safety and structural design of facilities relative to seismic, tornado and high wind hazards. CNWRA scientists have reviewed integrated safety analysis summaries of several fuel cycle facilities. Staff also has conducted onsite structural design reviews of gas centrifuge uranium enrichment facilities and performed safety reviews and analyzed the design of a mixed oxide fuel fabrication facility. The analyses used sophisticated software such as PROSHAKE®, RASCAL and LS-DYNA™. CNWRA staff also supported the NRC during Atomic Safety and Licensing Board hearings.



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CNWRA engineers evaluate the seismic design bases of structures identified as important to safety by comparing structural response curves.

Reprocessing


D017050


D017051

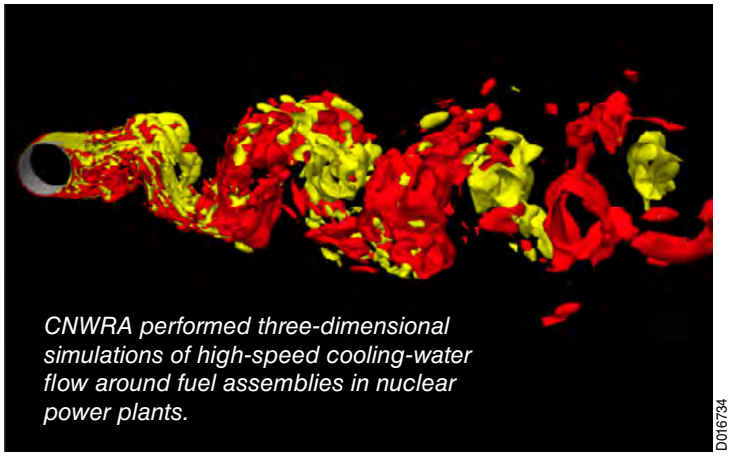
The CNWRA has the capabilities to assess process efficiency and safety, facility design and regulatory compliance of reprocessing facilities. Staff members conducted design reviews and performance assessments for vitrification plants. Existing CNWRA expertise can be expanded to meet the needs of any future reprocessing program.

Researchers and scientists at the CNWRA evaluate hazard and safety aspects of radioactive nuclear waste treatment and solidification technologies. Results were used to develop inspection and monitoring programs for radioactive tank waste remediation systems.

The Center has been evaluating the viability and safety of disposing waste incidental to reprocessing. These activities include conducting experiments on long-term stability of cementitious material, developing new software for pathways analysis, reviewing performance assessments, conducting field observations of waste disposal and calculating probabilistic biosphere dose.

CNWRA scientists are testing grout formulations to improve understanding of potential fast pathways through the grout that may allow radionuclides to be transported from the containment cells into the environment.

Nuclear power generation



CNWRA performed three-dimensional simulations of high-speed cooling-water flow around fuel assemblies in nuclear power plants.

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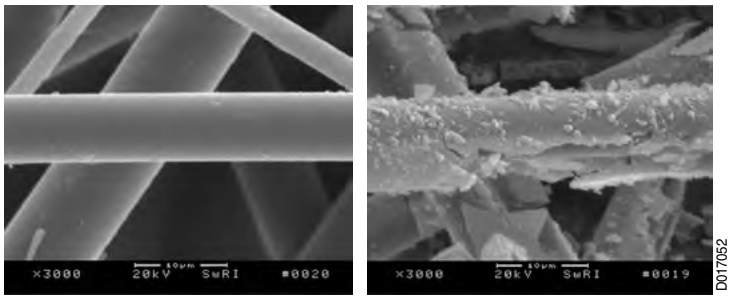


D017052

CNWRA scientists evaluated how the chemical degradation of submerged insulation materials may affect emergency cooling pumps in nuclear reactors after a loss-of-coolant accident.

From initial licensing to decommissioning, CNWRA has the capabilities to provide technical support related to testing and maintaining the two types of U.S. commercial nuclear power plants: pressurized water reactors and boiling water reactors.

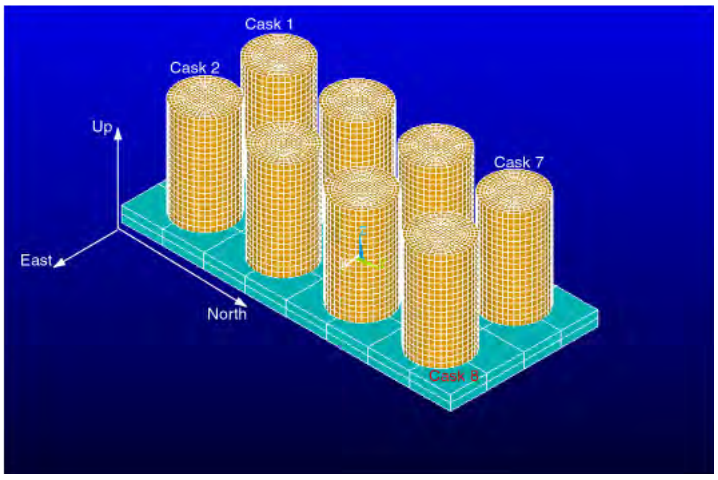
CNWRA staff members have developed and used state-of-the-art computational fluid dynamics techniques to accurately analyze steady and unsteady flow fields for a wide range of conditions and component geometries for design and safe operation of experimental reactors. These methods can be readily extended to high-temperature gas-cooled reactors, pressurized water reactors, and liquid-metal reactors.

The CNWRA analyzes impacts of loss-of-coolant accidents, especially effects on pressurized water reactor sump performance. To assess potential adverse effects, the Center evaluates thermodynamic simulation software, determines plant-specific pressurized water reactor environments and performs chemical tests to verify computational results and analyze behavior of untested materials.

Staff members support the NRC Office of Nuclear Reactor Regulation in license renewals by investigating materials aging and other issues.

Interim storage

The CNWRA developed review plans and reviewed proposed interim storage facilities to assess the safety and integrity of spent nuclear fuel storage casks and other structures and determine how these structures might be affected by natural and human-induced hazards, such as earthquakes and aircraft crashes. The CNWRA team helped the NRC license at-reactor storage facilities at nuclear power plant sites, centralized storage facilities and special purpose fuel-storage facilities.



D014629

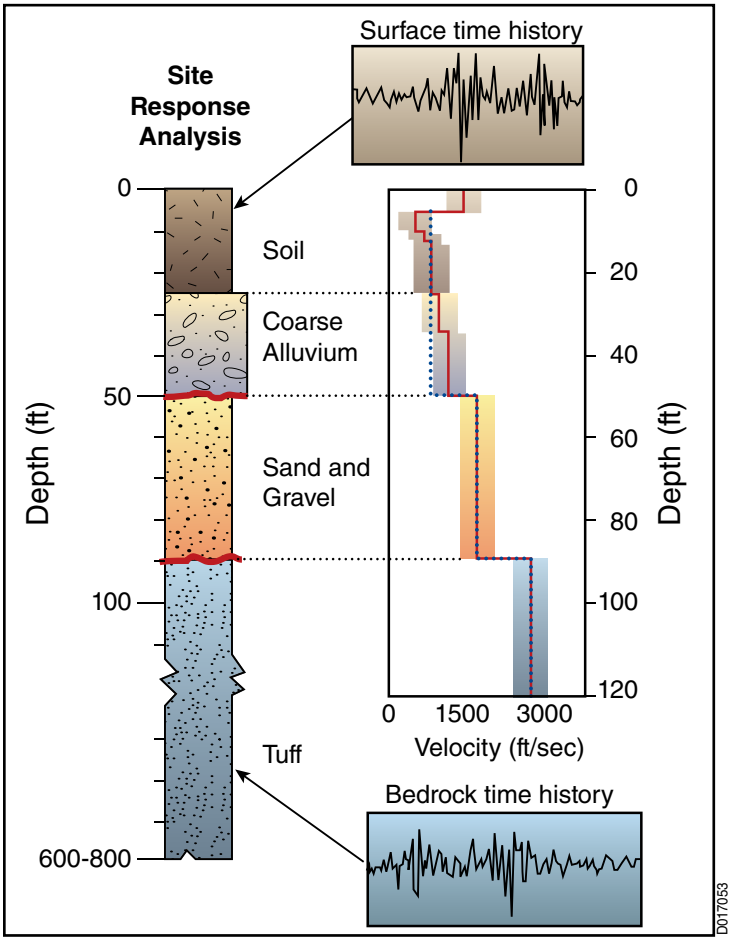
Geometrical stability of storage dry casks under earthquake conditions was evaluated using a finite element model of free-standing cylindrical casks on a concrete pad embedded in deep soil deposits and time domain soil-structure interaction analyses.

Radioactive waste disposal

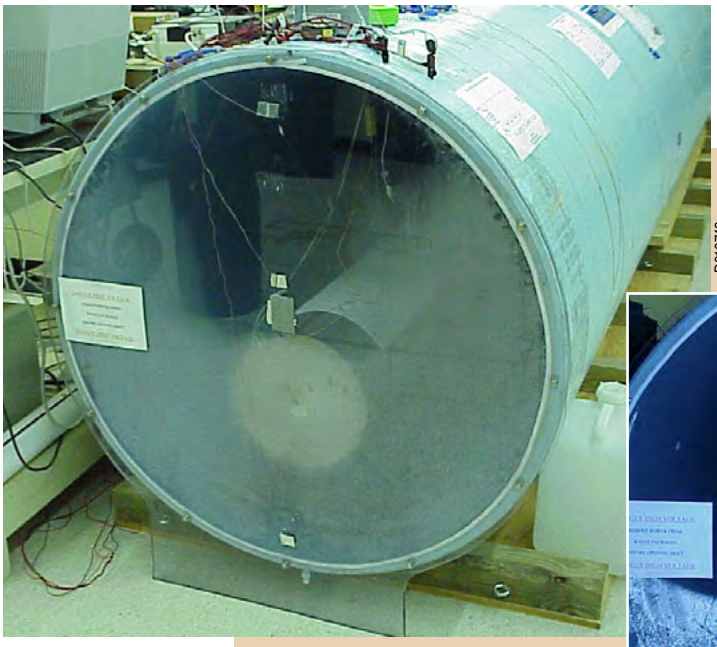
CNWRA staff members have extensive experience in management and disposal of radioactive waste. Geoscientists and engineers have worked on all phases of the proposed high-level waste repository at Yucca Mountain, Nev. Staff members also are well versed in waste disposal programs in other countries, including Canada, Finland, France, Japan, Korea and Sweden, and with international agencies, such as the Nuclear Energy Agency and the International Atomic Energy Agency.

CNWRA expertise extends from quantifying risk from natural and human-induced hazards during the relatively short operational period of a geologic repository to investigating features, events and processes that may affect repository performance for periods up to 1 million years after closure. Work encompasses laboratory studies, field investigations and numerical analyses including developing large computer models.

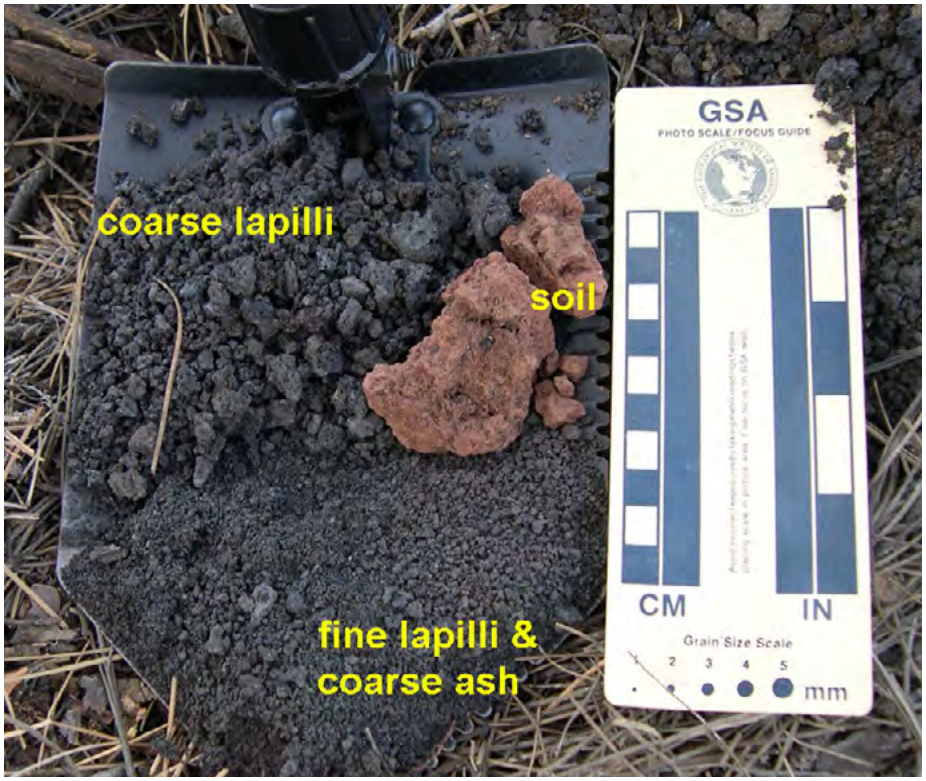
The Center team of scientists and engineers employs the best tools available in the marketplace or develops customized tools as needed to solve client problems. Some of the technologies and attendant software for waste disposal have been transferred to other industries such as oil and gas exploration and for assessing chemical facility safety.



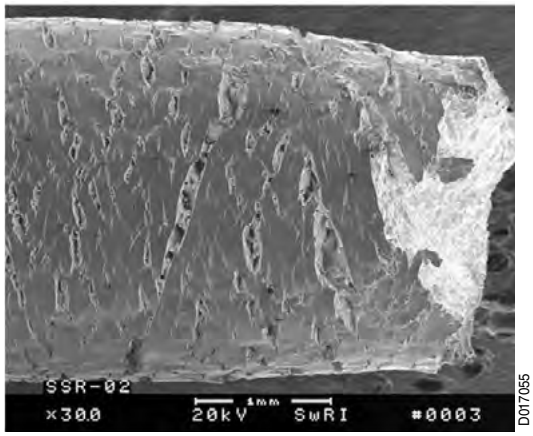
Seismic response analyses show how earthquake energy is amplified by the soils and rock layers directly beneath a site facility.



Two-phase flow experiments show zones of reduced temperature, elevated relative humidity and preferential condensation.



To determine whether radioactive materials could be transported in a potential eruption, CNWRA scientists performed field and laboratory investigations involving the volcanic ash (tephra) deposit at Sunset Crater Volcano in Arizona.

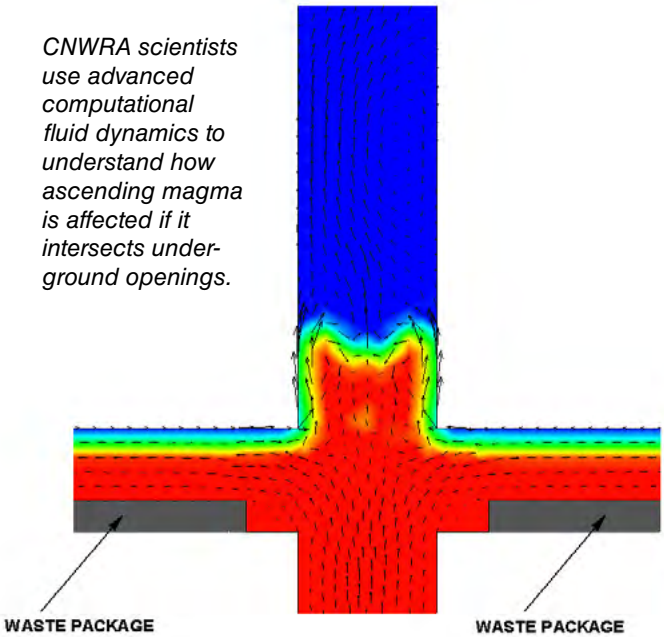


CNWRA researchers evaluated the stress corrosion cracking susceptibility of waste package materials in potential repository environments. Test results show the possibility of Alloy 22 stress corrosion cracking within a narrow range of environmental conditions and electrochemical potentials.

Combining past experience and new technologies gives the CNWRA a competitive edge in areas such as:

- Integration of geologic, hydrologic and chemical features and processes that may affect system operations
- Engineered component behavior under static and dynamic loads
- Biosphere characterization and its future evolution
- Instrumentation development and deployment
- Materials performance under varying thermal and chemical conditions
- Lifetime prediction of systems undergoing corrosion and stress corrosion cracking
- Human and environmental risk assessment for long periods and risk analysis during facility operations
- Thermodynamic modeling
- *In-situ* and real-time materials degradation inspection and monitoring
- Systematic analysis of operational safety, including potential impacts on workers and members of the public
- Integration of engineered and natural components to assess overall system safety for long time periods

CNWRA scientists use advanced computational fluid dynamics to understand how ascending magma is affected if it intersects underground openings.

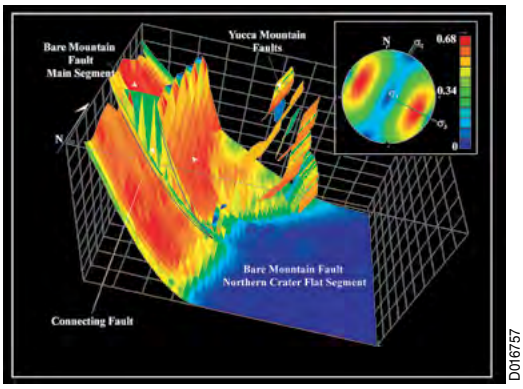


Site characterization

The CNWRA combines state-of-the-art geophysical, remote sensing and laboratory tests of site materials with subsurface investigations to conduct comprehensive, quantitative safety and performance assessments.

Techniques include electrical resistivity imaging, ground-penetrating radar and radar interferometry using synthetic aperture radar (InSAR) — a state-of-the-art technique to detect ground movement hazards. These tools and methods also are used to evaluate mineral resources, map geologic structures, evaluate water resources and examine dam stability.

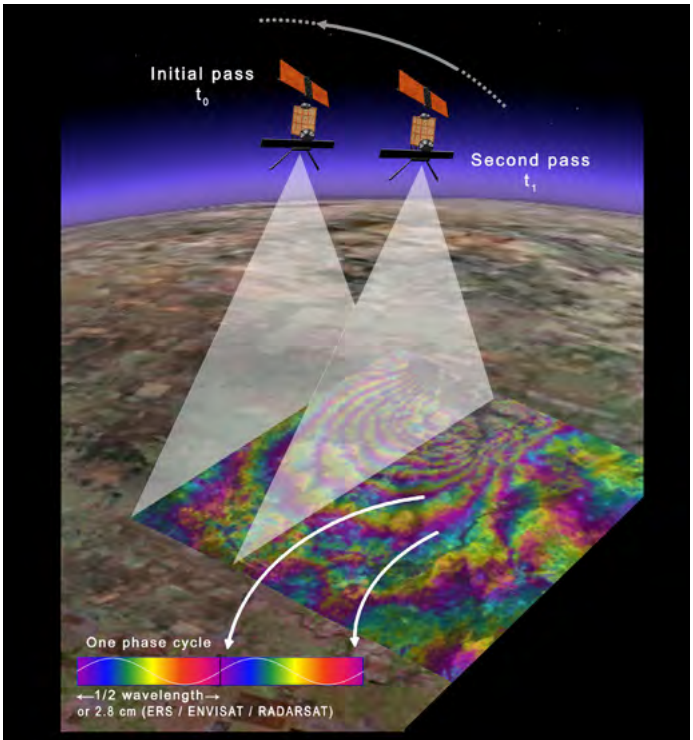
CNWRA researchers and scientists use a wide array of industry standard and custom designed and developed numerical modeling tools to assess potential hazard consequences, including codes such as PROSHAKE®, SEISM, EZFrisk™ and ABAQUS® for seismic assessments and HEC1, HEC-RES and HMR-49 for flood hazard analysis.



D016757

Using Institute-developed 3DStress® software, seismologists and geologists study the slip tendency of fault surfaces.

Through work for national and international clients, the CNWRA has developed expertise dealing with radioactively and chemically contaminated sites. By evaluating pathways and resulting exposure, scientists can recommend ways to decontaminate sites and return them to productive use.



InSAR uses the phase shift in satellite radar signals to detect ground movement. Multiple satellite passes over time create increased sensitivity and provide a finer time resolution of surface movements and their effects.

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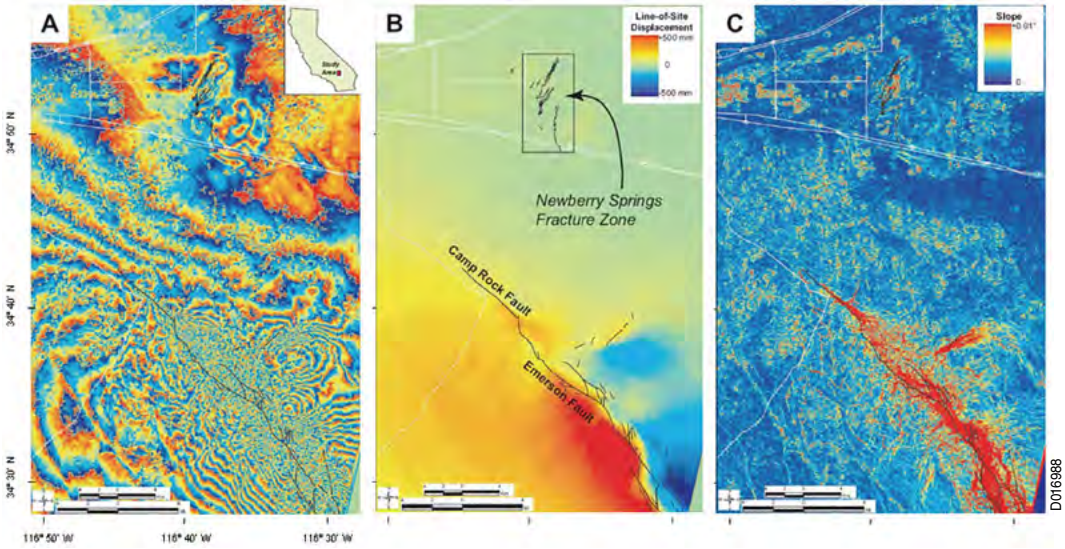


D016988

Differential interferometry (DInSAR) was used to show changes in land surface elevation. These changes are represented by (a) a coseismic radar interferogram, (b) a displacement map and (c) a displacement gradient map to identify fault ruptures.

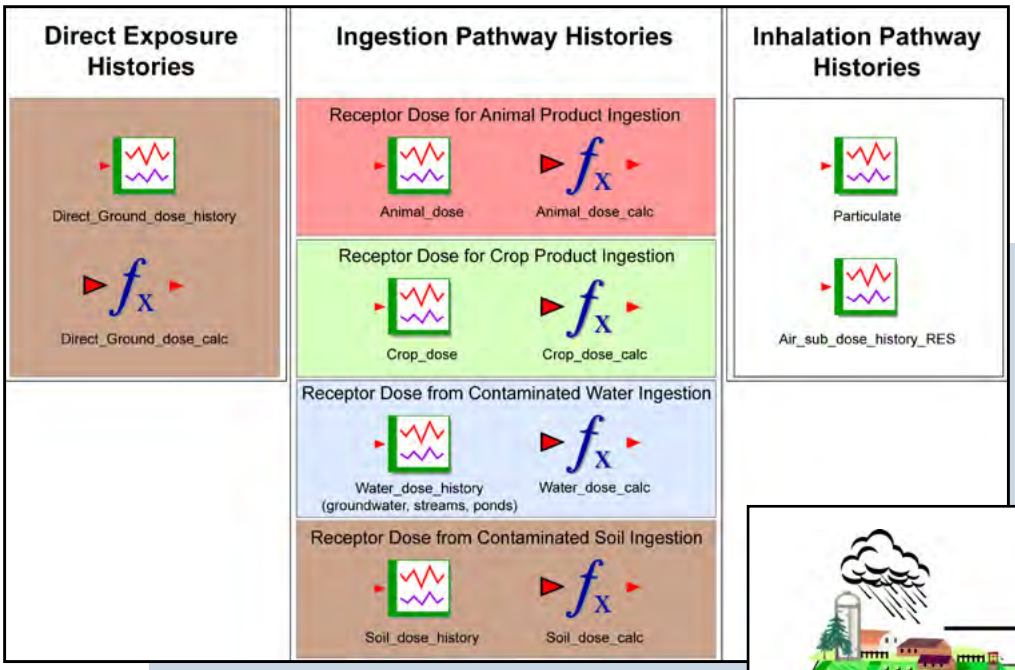
Environmental evaluations

The CNWRA has broad experience evaluating environmental impacts of existing facilities and planned future projects including sites where past practices have negatively affected the environment. CNWRA staff members can determine whether the regulatory requirements for protecting human health and safety, as well as the environment, are met.

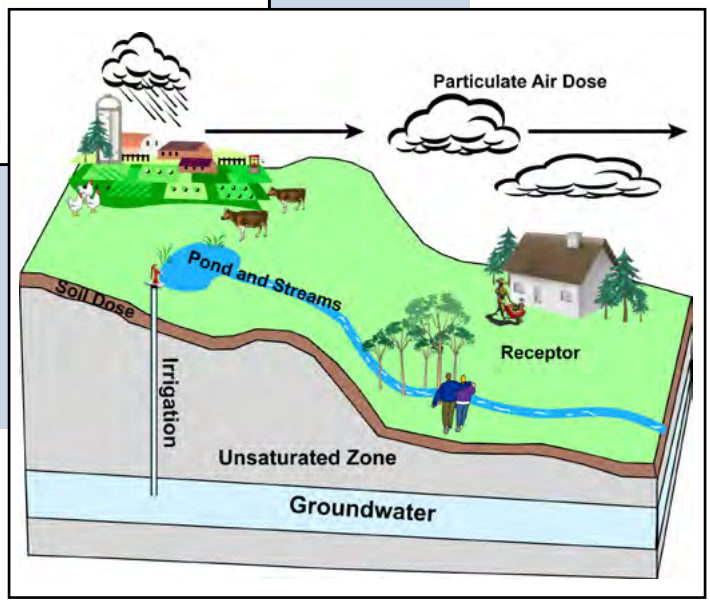
All federally funded projects in the United States must meet National Environmental Policy Act (NEPA) guidelines by considering environmental impacts. For more than 20 years, the CNWRA has helped organizations understand and implement these guidelines by offering training, document review and independent assessments to ensure compliance with NEPA standards. Staff prepares environmental assessments and environmental impact statements and conducts short-term, focused technical studies to support these environmental evaluations.

Combining past project experience and new technologies gives the CNWRA a competitive edge in areas such as:

- Comprehensive environmental impact assessments of new or existing nuclear facilities
- Development of regulatory guidance documents and site-specific regulatory review plans
- Groundwater contaminant transport and assessment to determine whether a water supply meets regulatory requirements
- Public and occupational radiological health: dose and risk assessment
- Disposal cell construction measuring cell stability, liner effectiveness and the performance of engineered covers



The CNWRA probabilistic biosphere modeling tool (BDOSE™) creates performance assessment models that evaluate potential source terms, link the different contaminant fate and transport pathways, and assess dose to potential receptors based on reasonable scenarios.



Decontaminating and decommissioning

The CNWRA performs radiological surveys and conducts pathway-dose analyses to determine appropriateness of decontamination and decommissioning of nuclear facilities.

For a major chemical company, the CNWRA used transport analysis and dose calculations to determine whether decontamination met public dose limits. In addition, staff members reviewed risk assessment and site characterization information regarding risks from U.S. Army ordnance materials.

Site decontamination and license termination programs are supported with computer models such as RESRAD and MEPAS-FRAMES. Projects at the Center have included developing clearance for low-activity solids, designing soil reuse, analyzing indoor resuspension factors, conducting multimedia environmental assessments and modeling potential doses at complex decommissioning sites.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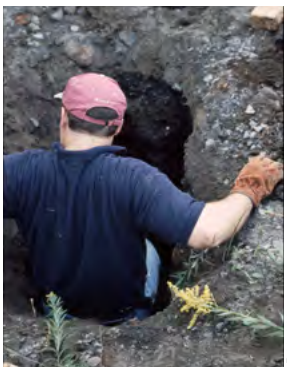
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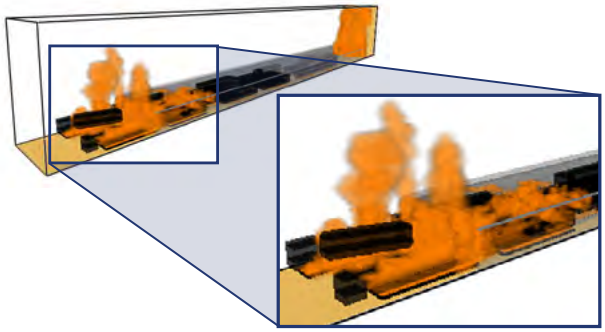
CNWRA scientists conducted field testing (left) to identify radiation hotspots for detailed sampling and characterization. Center scientists excavated a small abandoned slag pile (right) to collect fresh, unweathered samples for detailed laboratory analysis.

The CNWRA applies contaminant transport modeling to provide insights into potential contamination problems, contaminant migration, disposal cell construction and effectiveness, and the cost effectiveness of different compliance strategies.

Transportation systems and safety

Both modeling capabilities and forensic materials science were used to analyze tunnel and roadway fires. This work helped determine the performance of structural materials exposed to high-temperature fire environments.

Photo by Gene Blevins / LA Daily News.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To evaluate thermal conditions during a truck fire event, computational fluid dynamics was used to calculate gas and tunnel wall temperatures.

The CNWRA has evaluated the integrity of various canisters and designs of waste packages proposed for high-level waste transportation by truck, rail and air. Staff members are trained in using RADTRAN© software—the industry-accepted code for transportation risk assessment of radioactive materials.

Tests are performed to analyze the characteristics of transportation, aging and disposal canisters, including drop tests and numerical modeling. The information developed on structural behavior will be used directly to review representative canisters. CNWRA scientists can assess waste package performance under a variety of loading conditions.

The Center has extensively investigated the effect of transportation-related fires. Center staff has evaluated the potential performance of structural materials exposed to a high-temperature fire environment and modeled a truck accident using computational fluid dynamics software to estimate the exposure temperatures of roadway structural elements.

International programs

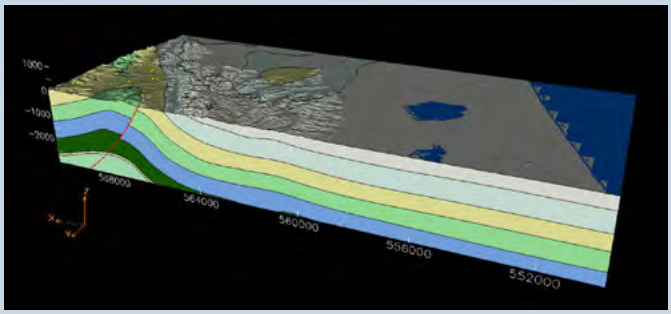
Using well-developed technologies related to radioactive waste disposal, the CNWRA has supported programs in many countries in the areas of:

- Development of regulatory framework
- Site characterization
- Detailed analyses of natural and engineered systems
- Total system performance assessment
- Environmental impact training
- Staff technical training

The CNWRA also has peer-reviewed overall national programs and subject-specific research programs on behalf of the Nuclear Energy Agency and other clients.

International clients of the CNWRA

- Atomic Energy of Canada, Ltd.
- Environment Canada
- HSK, Switzerland
- Japan National Institute for Advanced Industrial Science and Technology (AIST)
- Korean Atomic Energy Research Institute
- Swedish Nuclear Safety Inspectorate (SKI), Sweden
- Swedish Radiation Protection Institute (SSI), Sweden
- United Kingdom Department of Environment
- Other private industry clients



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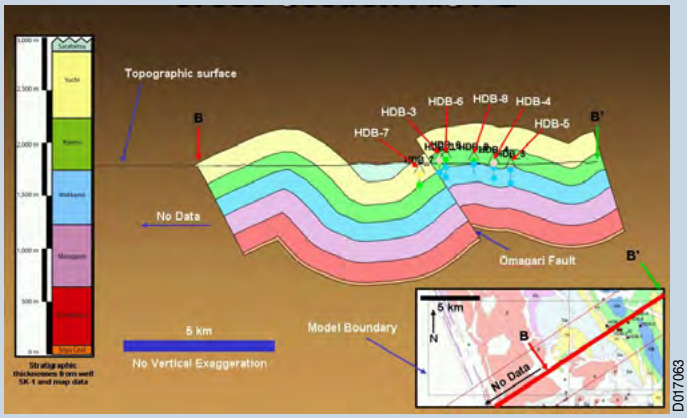

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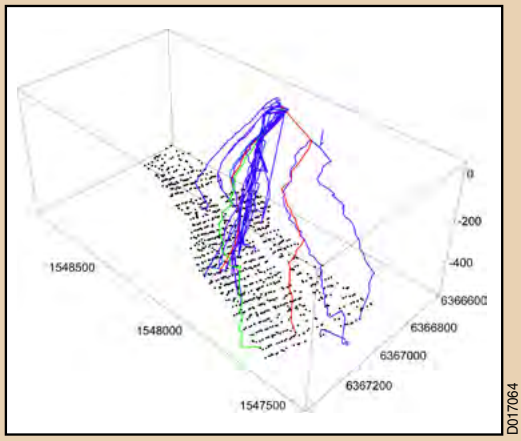
Combining cross section reconstruction with geologic framework modeling, CNWRA scientists studied the possible influences of faults on nuclear waste disposal.



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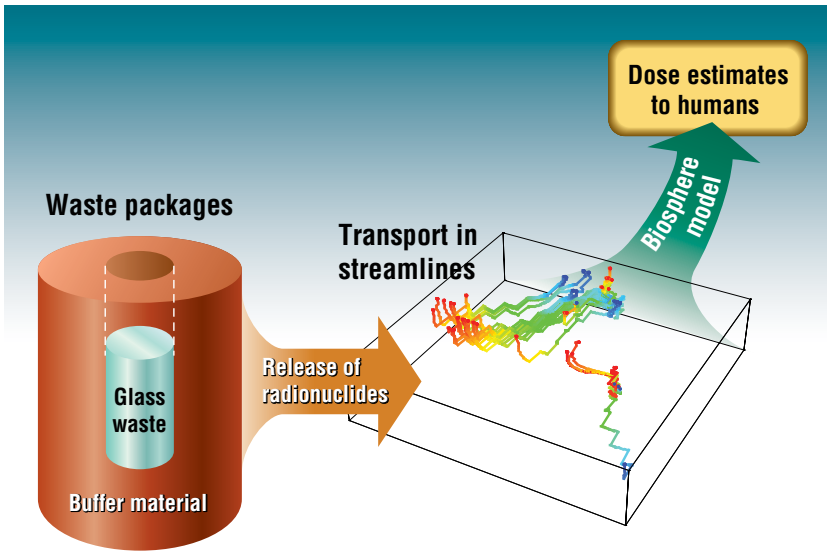
CNWRA scientists map pathways for radionuclide transport from potential geological repositories. Each pathway is color coded by calculated radionuclide discharge.



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CNWRA developed a concept for a generic performance assessment model for deep disposal of radioactive waste.

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We welcome your inquiries.
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