



DECOMMISSIONING NUCLEAR FACILITIES

PNNL Resolves Environmental Challenges Through Expertise in Environmental Assessments, Sampling, Analysis, Modeling, and a Decision-Support Toolbox

ENVIRONMENTAL FRAMEWORK

Pacific Northwest National Laboratory (PNNL) has provided technical support to the U.S. Nuclear Regulatory Commission (NRC) for nearly 50 years. With over 240 scientists, engineers, and professional staff supporting a comprehensive suite of scientific- and risk-based environmental capabilities, PNNL is committed to resolving challenges associated with decommissioning nuclear facilities, including safely removing a facility or site from service, terminating the NRC license, and releasing property for restricted or unrestricted use.

In support of those decommissioning activities, PNNL can:

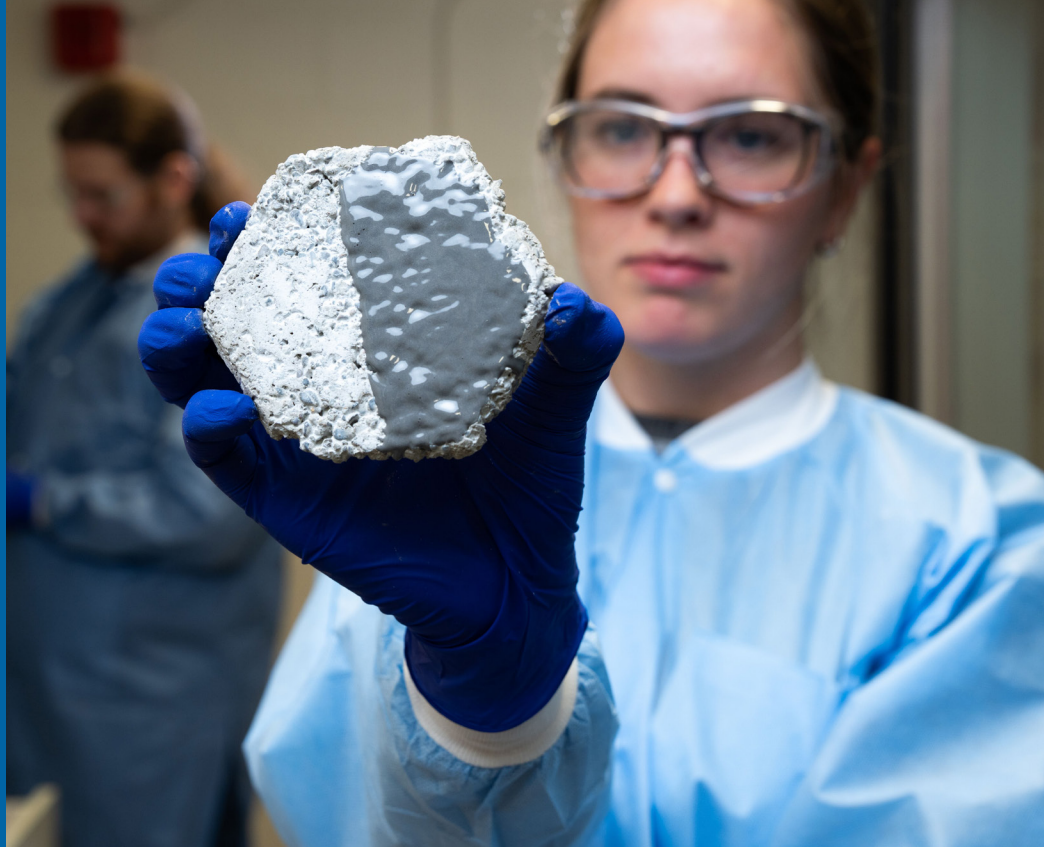
- ▶ Provide the scientific basis to establish compliance with regulatory requirements under Title 10 of the Code of Federal Regulations (CFR) 20 Subpart E: Radiological Criteria for License Termination.
- ▶ Establish and adhere to a structured, integrated environmental framework for decommissioning activities and site closure objectives.
- ▶ Satisfy requirements for independent verification as applied to the process of releasing, or accounting for the release of, facilities or properties under radiological controls.
- ▶ Actively manage real or perceived organizational conflicts of interest through established and vetted processes in the delivery of impartial, technically sound, and objective performance requirements.



TECHNICAL GUIDANCE AND PROGRAM DEVELOPMENT

PNNL has a legacy of understanding the potential impacts of contaminants of concern on human health and the environment. Working in collaboration with federal clients and regulators, PNNL has developed and implemented processes and programs specifically for sampling, characterizing, and remediating soils and sediments, surface water and groundwater, air and dispersive contaminants, facilities, and construction materials, including:

- ▷ Technical guidance, methodologies, standards (e.g., ASTM), and templates.
- ▷ Program planning, data sufficiency, and data-quality objective process evaluations.
- ▷ Sampling, characterizing, and affixing of contaminants.
- ▷ Modeling and decision support including predictive and remedial analytics.
- ▷ Records management for administrative record and document control.
- ▷ Quality assurance compliance through Department of Energy Order 414.1D and ASME NQA-1-2012.



SAMPLING AND ANALYSIS

PNNL maintains and operates state-of-the-art facilities that enable integrated, cross-disciplinary characterization, remediation, and containment or fixation of contaminants across all environmental matrices. With expertise in metals and radionuclide analysis, biogeochemical interactions, and co-contaminated complexes, PNNL's analytic capabilities are exemplified as follows:

- ▶ Provides established proficiencies in environmental sampling and in analyzing soils and sediments, surface water and groundwater, air, biota, vegetation, and construction materials (e.g., concrete, asphalt, and drywall).
- ▶ Offers field and fixed laboratory equipment supporting detection in a range of radiological conditions, detectable activity and sensitivities, and matrices.
- ▶ Utilizes and stewards alpha, beta, and gamma detectors, isotopic analysis, inductively coupled plasma mass spectrometry, x-ray fluorescence, x-ray absorption spectroscopy, and x-ray diffraction.
- ▶ Evaluates fixative spray technologies and standard testing recommendations.
- ▶ Participates in the Department of Energy's Analytic Services Program.
- ▶ Maintains laboratory testing credentials as Mixed Analyte Performance Evaluation Program (MAPEP) qualified.
- ▶ Ensures compliance with laboratory quality assurance and quality control programs for traceability, procedure and methods development, and analysis.



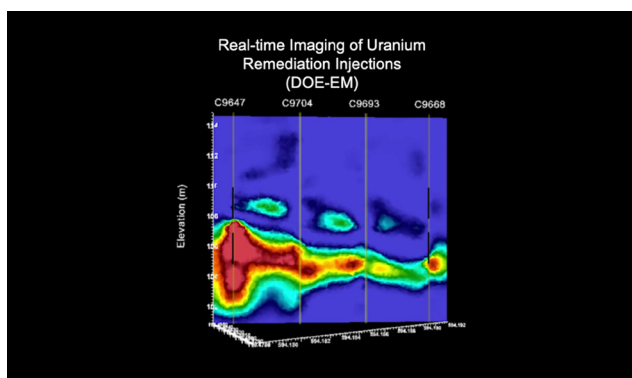
MODELING AND DECISION-SUPPORT TOOLBOX

Complemented by dedicated institutional computing resources, PNNL's modeling and predictive analytic capabilities enable risk, safety, and human-health informed decision-making when designing, evaluating, and implementing environmental sampling, analysis, and remediation plans. Modeling capabilities and established decision-support tools include the following:

- ▶ Workflow development for data curation through probabilistic decision-making.
- ▶ Optimization of experimental designs related to deactivation and decommissioning (D&D) and environmental management.
- ▶ AI/machine learning and data science: exploratory data analysis, visual analytics, data quality objectives (DQO), data quality assessment (DQA), and multi-modal data fusion and analytics to combine imagery and sensor data for AI/machine learning and statistical methodologies in D&D.
- ▶ Visual Sample Plan (VSP): Developed by PNNL, VSP combines site, building, and sample location visualization capabilities with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)-specific strategies for optimal sampling design and statistical analysis. <https://www.pnnl.gov/projects/visual-sample-plan>
- ▶ GENII: This set of PNNL-developed computer programs can be used to estimate radionuclide concentrations in the environment and the dose/risk to humans and biota. GENII's model evaluates factors including acute or chronic exposures, releases to surface water or the atmosphere, and initial contamination conditions. <https://www.pnnl.gov/projects/earth/genii>
- ▶ Subsurface Transport Over Multiple Phases (STOMP): STOMP is a computational tool for simulating groundwater flow and contaminant transport phenomena for multidimensional analysis of sites with radioactive and other contaminants. <https://www.pnnl.gov/projects/stomp>
- ▶ Advanced Simulation Capability for Environmental Management (ASCEM): ASCEM is a modular and open-source high-performance computing tool informing integrated approaches to modeling and site characterization for standardized assessments of performance and risk for site cleanup and closure activities.
- ▶ PFLOTRAN: This open-source, multiphysics subsurface flow and reactive transport code solves a system of generally nonlinear partial differential equations describing multiphase,

multicomponent, and multiscale reactive flow and transport in porous materials. The PFLOTRAN code is designed to run on massively parallel computing architectures as well as workstations and laptops. www.pflotran.org

- ▶ E4D: E4D is a geophysical assessment and computation geophysics modeling tool used to describe spatially relevant subsurface information, improve geophysical characterization of subsurface features and contaminant transport, and monitor and predict temporal changes. <https://www.pnnl.gov/projects/e4d>



INTEGRATED PROGRAM EXECUTION

PNNL has actively participated in the development of more than 70 NUREGs/Regulatory Guides/Contractor Reports addressing safety, cost, environmental, and radiological characterization requirements for decommissioning nuclear facilities. Our capabilities have been, or may be used, to develop or support the following:

- ▶ Provide subject-matter expertise in the development and execution of regulations and guidance for decommissioning activities.
- ▶ Conduct research to develop data, techniques, and models to assess human/environmental health risks associated with site closure activities.
- ▶ Review applications for license termination, license termination plans, and license amendment requests in accordance with NRC regulations and requirements.
- ▶ Participate in inspections, audits, and review of site survey reports.
- ▶ Conduct independent confirmatory analyses of site surveys including sampling, analysis, and monitoring methodologies and results.
- ▶ Develop environmental assessments and environmental impact statements in support of NRC decommissioning activities.
- ▶ Organize and support public meetings and manage public comments.



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