DISCOVERY IN ACTION

Pacific Northwest National Laboratory builds upon its Hanford history and heritage to focus its nuclear science and technology capabilities on current challenges such as cleaning up contaminated sites, safe and secure storage of spent nuclear fuel, next-generation nuclear energy and preventing the trafficking of illicit nuclear materials. In 1967, researchers were continuing the fundamental scientific and technical work that provided the basis for the design, fabrication and reprocessing of weapons grade nuclear fuels (left). Also in the mid-1960s, researchers devised a computer code, called COBRA for Coolant Boiling in Rod Arrays, which allowed for three-dimensional, multiphase hydrothermal modeling of reactor and other complex systems (right).

Nuclear knowledge for the nation

This is the tenth of a 12-part series that features some of the scientific challenges PNNL has tackled over its 50-year history and highlights its vision for the future. PNNL is one of 10 national laboratories overseen by the U.S. Department of Energy's Office of Science and has been managed by Battelle since its inception in 1965. Through this enduring partnership—and by working closely with sponsors and collaborators—PNNL builds upon its legacy to advance science and solutions that improve the lives of Tri-Citians and people around the world. This edition focuses on PNNL's capabilities and experience in nuclear science and nuclear safety and how they have been applied to energy, national security and environmental challenges over the decades.

PACIFIC NORTHWEST
NATIONAL LABORATORY

The diverse research portfolio of the U.S. Department of Energy's Pacific Northwest National Laboratory builds upon PNNL's history and heritage in nuclear science and nuclear safety.

For example, PNNL invented a technology to turn radioactive waste into glass for safe long-term storage. Its researchers came up with a computing code that allows a clear view of subsurface contaminants at Hanford's radioactive waste storage tanks despite metal objects that interfere with conventional imaging methods. They are helping determine whether existing nuclear plants can continue operating safely. And they develop technologies to prevent nuclear materials from being smuggled across international borders.

"The world-class nuclear expertise that we have developed while supporting DOE's nuclear mission over 50 years has positioned PNNL to address today's nuclear challenges in advanced reactor design and waste processing, plus nuclear materials and process science," said Jud Virden, associate laboratory director for energy and environment.

In 1965, Battelle was awarded the contract to manage what was then the Hanford Labs. Today, the multi-program national lab is no longer part of Hanford, but continues to draw upon its long-standing capabilities in actinide chemistry, radionuclide detection and nuclear safety.

"Our scientists and engineers deliver scientifically defensible solutions—saving taxpayers millions of dollars—for cleaning up contaminated sites, producing safe and efficient nuclear energy, and detecting and deterring the transport of nuclear materials," Virden said.

Helping Hanford

Nearly 30 years after plutonium production ended at Hanford, cleaning up the radioactive and chemically hazardous waste generated by those processes remains one of the nation's largest environmental challenges.

Various forms of waste, which have changed over time, are stored in facilities well beyond their planned lifetimes. PNNL applies its specialized expertise to support cleanup of Hanford's tank farms and deployment of the waste treatment plant under construction today.

In the 1970s, even before the cleanup mission, PNNL researchers developed a technology for incorporating high-level radioactive waste in a stable glass form suitable for permanent geologic disposal. The technology was deployed at Hanford, the West Valley nuclear site in New York and the Savannah River Site in South Carolina.

By expanding the understanding of the fundamental processes controlling environmental contamination and waste behavior, researchers are building a foundation to reduce the cost and risk of legacy waste cleanup at contaminated sites. They are developing a predictive understanding of system performance involving tank waste processing, immobilization and disposal; environmental remediation; and site closure. Their leadership in subsurface science is helping protect the soil and groundwater along the Columbia River. But PNNL's nuclear science and technology reaches far beyond Hanford.

Containing Chernobyl

After the Chernobyl Nuclear Power Plant accident in Ukraine in 1986, PNNL researchers were assigned to lead the collection and maintenance of information on the accident, including analyzing radiation levels after the plume arrived in the United States and collecting air samples using research aircraft.

PNNL also helped develop the 1997 Shelter Implementation Plan, outlining how to solve the technical problems left by the reactor core meltdown. While the damaged reactor core was quickly protected to reduce immediate risks, PNNL staff members—including several who relocated to Ukraine—supported the planning, design and construction of a complex, long-term confinement structure. The gigantic arch structure is being constructed 650 yards away and then rolled into place over the reactor. It will keep radioactive material from escaping and allow the old reactor to be dismantled safely.

Improving international safety

In the 1990s, PNNL provided technical leadership to an international effort to reduce risks at Soviet-designed nuclear reactors. Led by DOE and working cooperatively with nine host nations, other national labs and U.S. businesses, PNNL helped correct major safety deficiencies and establish self-sustaining nuclear safety infrastructures, mostly in the former Soviet Union. For about 10 years, the International Nuclear Safety Program focused on 21 nuclear plants with 65 operating reactors.

Following Fukushima

After the 2011 earthquake and resulting tsunami led to a nuclear power accident in Fukushima, Japan, PNNL-developed technology for ultra-trace detection was immediately put to work to provide technical readings for Japanese leaders managing the crisis. The same equipment detected the first signals of nuclear fallout when it made its way to the atmosphere over the United States and helped determine the nature and magnitude of the release.

PNNL still supports response and recovery efforts at Fukushima, drawing upon Hanford cleanup experience to address Japan's most pressing challenges in reactor recovery and environmental remediation. PNNL also is helping the U.S. Nuclear Regulatory Commission (NRC) assess the implications of the Fukushima accident for U.S. nuclear power plants.

Powering the future

The 99 nuclear power plant reactors in the United States—many built more than 35 years ago—produce nearly 20 percent of the nation's electricity.

For three decades, PNNL has provided technical support to the NRC in its mission to ensure these plants can continue to operate safely and reliably, including the license renewal process. Already, 74 plants have received 20-year license extensions, 10 have applications pending and more are expected.

PNNL experts also supported the NRC in the environmental and safety reviews that cleared the path for the first construction of new power plants in the U.S. in more than 30 years.

PNNL conducts fundamental research and development across the full nuclear fuel cycle. This includes materials science that supports the safe operation of reactors and storage and transportation of spent fuel. Researchers also explore and assess new processes for recycling spent fuel, the safety performance of spent fuel repository concepts, and technologies for the next generation of safer, more economical reactors.

Supporting global and national security

Building on its nuclear expertise, PNNL has a strong history and extensive experience in proliferation prevention. In the 1990s, PNNL was advising the Russian government on security improvements in weapons production facilities as part of DOE's Materials, Protection, Control and Accountability Program.

PNNL also develops technologies to detect trace levels of radioactivity that could be evidence of nuclear explosions around the world.

In support of the National Nuclear Security Administration's global nuclear security goals, PNNL researchers develop, integrate and test radiation methods and technologies for identifying weapons of mass destruction and terrorist activities and for supporting international treaties and agreements.

PNNL supports the Department of Homeland Security and U.S. Customs and Border Protection in protecting the U.S. borders by preventing terrorist weapons, including weapons of mass destruction, from entering our country. Working closely with these sponsors, PNNL played a key role in installing and deploying radiation portal monitors that can detect radiation emanating from nuclear devices, dirty bombs, special nuclear materials, natural sources and isotopes commonly used in medicine and industry.

Addressing scientific challenges

PNNL is advancing nuclear science for a stronger nation. Recent efforts focus on understanding, harnessing and exploiting the chemistry that controls interfacial processes in radioactive material and radiation environments.

"These efforts build upon our 50-year history," said Tony Peurrung, associate laboratory director for national security. "And through them we are paving the way for solutions in environmental cleanup, safe and secure storage of spent nuclear fuel, the next-generation of energy production, and preventing the trafficking of illicit nuclear materials."

Owned by the U.S. Department of Energy; operated by Battelle; and supported by academic, industrial and governmental collaborators, Pacific Northwest National Laboratory is celebrating 50 years of inspiring and enabling the world to live prosperously, safely and securely. Interdisciplinary teams at PNNL address many of America's most pressing issues in energy, the environment and national security through advances in basic and applied science. With an annual budget of about $1 billion and nearly 4,300 staff members, Battelle is the largest employer in the Tri-Cities.

Learn more about PNNL at **www.pnnl.gov** and through stories to commemorate 50 years of scientific discovery contributed by employees, retirees and the community at **www.celebrate.pnnl.gov**.

In the late 1990s, PNNL developed the Automated Radioxenon Sampler-Analyzer, or ARSA, which analyzes air samples for radioactive xenon, or radioxenon, that seeps from underground nuclear explosions and could be used to detect nuclear testing. PNNL nuclear radiation detection technologies such as this were able to detect the radioactive isotope xenon-133 entering the continental United States on March 16, 2011, following the release from the Fukushima nuclear reactors in Japan a few days earlier.

PNNL has developed and deployed vitrification technologies to encapsulate nuclear waste in glass for safe and long-term disposal. Here, researchers are analyzing the performance of glass used in waste treatment. PNNL is testing, evaluating and providing engineering support and regulatory guidance to aid the development of a bulk vitrification for converting Hanford low-activity tank waste into a stable waste for suitable for disposal.

PNNL maintains two research facilities in Richland dedicated to nuclear science. Shown here is the Radiochemical Processing Laboratory, one of only two DOE Office of Science Hazard Category 2 Non-Reactor Nuclear Facilities designed for multi-disciplinary nuclear materials research and development. The other facility is part of EMSL, a DOE national user facility known also as the Environmental Molecular Sciences Laboratory, which gives the research community access to instruments and capabilities to deepen the understanding of the chemical fate and transport of nuclides on land and below the surface.