Substantial progress has been made on environmental remediation efforts at Hanford. The scope of work includes planning, managing, integrating, and executing a range of activities to clean up groundwater, contaminated soils, and inactive nuclear facilities.

Dedicated to Cleanup

Environmental Remediation at Hanford

By Todd A. Nelson

Cleanup progress is being made on the world's largest environmental restoration project. At the U.S. Department of Energy's 560-square-mile Hanford Site, contaminated soil cleanup along the Columbia River is nearly 30 percent complete. More than 150 facilities have been decontaminated or decommissioned. More than 220 individual waste sites have been cleaned up to regulatory standards. And one of Hanford's nine surplus plutonium reactors has been placed into interim safe storage, or cocooned, and work accelerated on four more.

The work is being by the DOE's Environmental Restoration Contractor (ERC) team, led by Bechtel Hanford Inc., and its selected subcontractors, Eberline Services Hanford Inc. and CH2M Hill Hanford Inc. The DOE Richland Operations Office selected the Bechtel Hanford team in 1994 to manage Hanford's Environmental Restoration Project, one of the first contracts in the United States dedicated solely to cleaning up wastes from decades of nuclear weapons production.

The scope of work for the ERC team includes planning, managing, integrating, and executing a range of activities to clean up groundwater, contaminated soils, and inactive nuclear facilities at Hanford. Activities include groundwater/vadose zone integration and groundwater management, reactors and facilities decontamination and decommissioning, and surveillance/maintenance and transition, in addition to remedial action and waste disposal.

The cleanup task at Hanford is enormous. From 1943 through 1964, the federal government constructed and operated nine nuclear reactors, along with research laboratories, and facilities for reactor fuel fabrication, spent-fuel storage and processing, and waste handling and disposal. Included in the construction program were hundreds of support buildings and facilities, such as offices, warehouses, water treatment, sewage and central heating plants, and more.

Hanford's early years included the construction of underground single-shelled tanks to hold high-level liquid waste generated during the processing of spent reactor fuel for its plutonium. Later years also included the construction of 1-million-gallon double-shelled tanks. There are 177 underground tanks at Hanford today, 67 of which are known to have leaked at least 1 million gal into the soil and groundwater.

Each waste site that is cleaned up at Hanford is returned to its original contour and revegetated. Backfill material is brought in and native grasses are planted as groundcover.

In 1989, the DOE, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology signed what has become known as the Tri-Party Agreement. This legally enforceable consent decree sets schedules and milestones for the cleanup of Hanford. The DOE and its contractors also provide opportunities for stakeholders to help make important cleanup decisions through a comprehensive public involvement process.

Since that time, substantial progress has been made on remediation efforts at Hanford. Although some of the site's cleanup efforts present significant challenges, others are more straightforward.

Nearly 3 million tons of contaminated soil and debris have been disposed of safely at Hanford's ERDF, one of the most efficient in the nation, according to the GAO. The facility has a planned operating capacity of 10 million tons and can be expanded if required.

The early reactors used "once-through cooling"; i.e., water was taken directly from the river to cool the reactor core, where it came in direct contact with fuel elements, which occasionally would fail.

Environmental Restoration Disposal Facility

A critical component in efficiently managing the work and the costs of remediation on the Hanford Site has been the availability of the Environmental Restoration Disposal Facility (ERDF), a massive, engineered disposal facility in which low-level and mixed low-level wastes from Hanford cleanup are disposed.

The facility is located on Hanford's central plateau, miles away from the Columbia River. It is owned by the DOE, managed by Bechtel Hanford, and operated under contract to Bechtel by Duratek Federal Services of Hanford. ERDF was opened on July 1, 1996, three months ahead of schedule and $80 million under budget.

The ERDF was the first of its kind to be built within the DOE complex. Remedial Action and Waste Disposal Project personnel are sharing their operating experience and lessons learned with other interested people—inside and outside of the DOE.

Vern Dronen, Bechtel Hanford's project manager for Remedial Action and Waste Disposal, says direct management of ERDF is key to working efficiently. "The ability to manage waste from site excavation to disposal in ERDF is critical to keeping cleanup costs as low as possible," Dronen said. "We are continually looking for ways to safely lower the costs of disposing of each cubic meter of waste."

In fact, at a life-cycle disposal cost of $63 per cubic meter, ERDF is the most cost-effective of DOE's existing or planned Comprehensive Environmental Response, Compensation, and Liability Act facilities for low-level and mixed waste, according to the U.S. General Accounting Office (GAO).

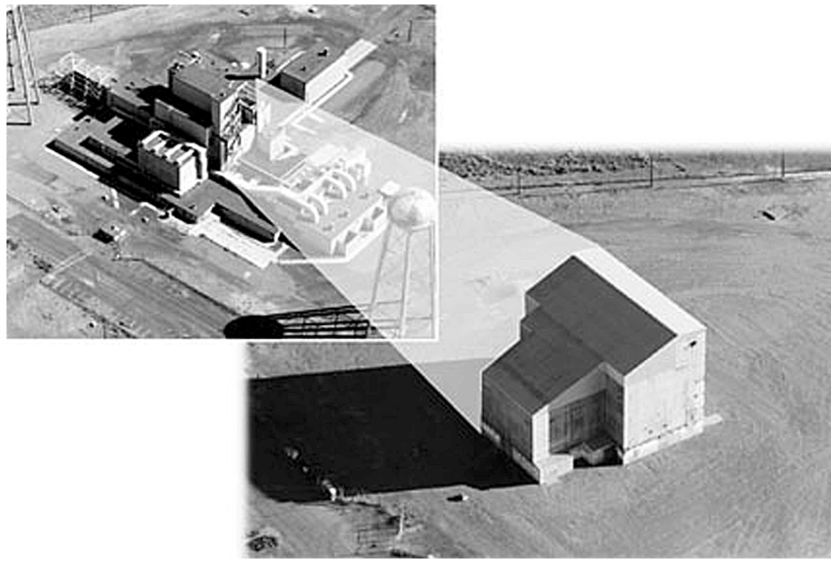
The ERDF is designed to be a series of disposal cells that can be expanded as required to meet Hanford's disposal needs without interrupting operations. Current operational capacity of the four existing cells is 5.2 million tons. Construction was completed on cells three and four in 1999, and an interim cover was placed on portions of cells one and two. Planned capacity for ERDF is 10 million tons, with the option to further increase capacity if required.

Most of the contaminated soil and materials placed in ERDF come from cleanup sites along the Columbia River, most of which were contaminated with liquid radioactive wastes during Hanford operations. They include sites near the former plutonium production reactors and waste disposal sites and burial grounds north of the city of Richland.

Since the first wastes were disposed of in ERDF in 1996, drivers hauling material to the facility have made 152 000 trips and logged 5 million miles without an at-fault accident. Nearly 3000 tons of materials are disposed of in ERDF each day. By the end of fiscal year 2001, more than 3 million tons of contaminated material—30 percent of the estimated total—will have been moved away from the Columbia River and safely disposed of in ERDF.

Surplus Reactors

Construction debris from the old plutonium production reactors account for part of the material buried at ERDF. Of the nine existing reactors, one has been placed in interim safe storage—a process called



In 1998, Hanford's restoration team completed work to place C Reactor in interim safe storage for up to 75 years. Work is under way on four more reactors. When finished with the task, called cocooning, the original footprint of the facility and surrounding structures is reduced 81 percent.

Demolition began in February at Hanford's fourth plutonium production reactor to undergo the cocooning process and should be completed in fiscal year 2003. In the background is DR Reactor, where cocooning is 85 percent complete. The final step in the DR Reactor cocooning process is to install a new roof over the entire structure, which should be completed in fiscal year 2002. Hanford is home to nine surplus plutonium production reactors.

cocooning—and work on four others has been accelerated. (See "The 'Cocooning' of C Reactor: A Hanford Success Story," *Radwaste Magazine*, Sept./Oct. 1999, p. 29.)

Cocooning involves removing everything at a reactor site except the reactor core and the surrounding 4-foot-thick concrete shield walls. All openings in the shield walls are sealed, and a new roof is placed on the remaining structure. The plan is to cocoon each reactor core for up to 75 years. That will give radiation levels time to decay to manageable levels and decision-makers time to devise a permanent disposal plan.

One reactor, C Reactor, was placed in interim safe storage in 1998. Currently, DR Reactor is 85 percent finished and will be completed in 2002. The F Reactor is 72 percent finished and will be completed in 2003. The D and H Reactors are 21 and 5 percent finished and will be completed in 2003 and 2004, respectively, provided required funding is received. Work on KW and KE Reactors will begin after spent fuel is removed from the storage basins.

Each reactor and its support facilities yield tons of demolition debris that is disposed of at ERDF or recycled, reused, or sold as scrap. For example, during the cocooning of C Reactor, the ERC team recycled 400 tons of steel, 2.5 tons of nonferrous material, 40 tons of lead, and 1 gal of mercury. Much of the uncontaminated wood was sent to the city of Richland landfill for composting.

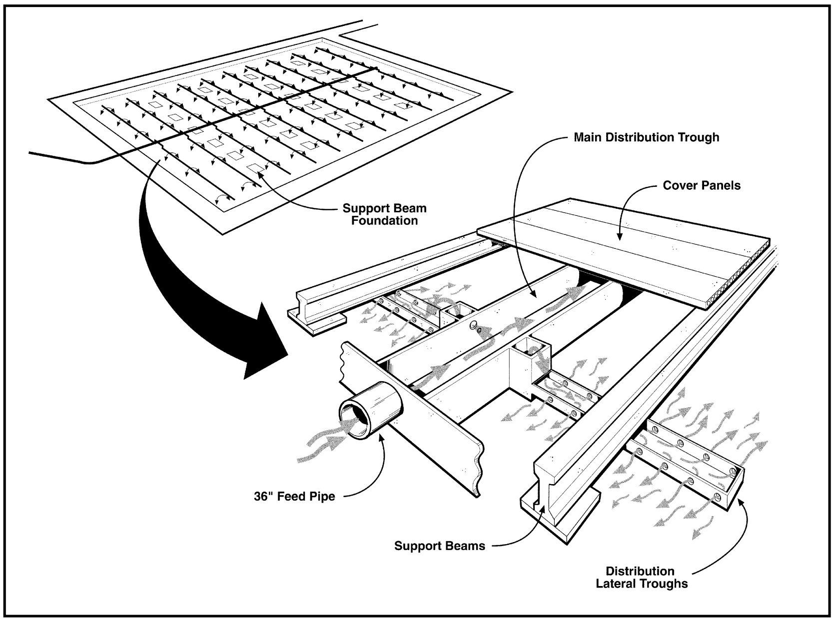
In addition, a total of 215 000 gal of water was shipped to the Effluent Treatment Facility for disposal, including rainwater that leaked into C Reactor and water used for dust control.

Two reactors are not scheduled to be cocooned. The world's first full-scale nuclear reactor, B Reactor, is being preserved for possible use as a museum. The N Reactor had not been shut down when the Tri-Party Agreement was signed and is not scheduled yet for demolition. However, auxiliary facilities are being torn down, and the site is being readied for eventual demolition and site remediation.

Reactor Effluent Piping

Reactor effluent piping excavation is a major undertaking and a major contributor of waste to ERDF. The effluent piping carried cooling water from the reactor core. The early reactors used "once-through cooling"; i.e., water was taken directly from the river to cool the reactor core, where it came in direct contact with fuel

More than 17 000 ft of reactor effluent piping was removed from D and DR Reactors. Major challenges in excavating the 60-in.-diameter piping included containing contamination-bearing rust from inside the pipe and asbestos cladding from the outside.



N Reactor cooling water was released to the soil through cribs. The water entered the 116-N-3 crib through a 36-in. feed pipe and was distributed over 1.3 acres of soil via a central distribution trough and a series of lateral troughs.

elements, which occasionally would fail. This cooling water then would be returned to the river via settling ponds or released to cribs and trenches where it percolated through the sandy soil.

Over the years, the effluent pipelines would develop leaks. The pipelines, trenches, cribs, and contaminated soil make up a major source of radioactive and hazardous material for disposal.

One of the most complicated effluent remediation projects involves N Reactor. It was the last of Hanford's nine plutonium production reactors to be built and the last to be shut down. Because it was shut down only 12 years ago, in 1989, radiation levels have not had nearly as much time to decay as they have at other reactor sites, the last of which was closed in the early 1970s.

Remediating the N Reactor trenches and cribs is particularly challenging. There, ERC team members are working with some of the most radioactive materials and debris yet encountered. After nearly two years of planning, Foster Wheeler Environmental Corp. workers were able to remove 420 concrete and rebar panels off the 116-N-3 crib in the N Area. Each panel weighs 6.5 tons. The panels covered a liquid distribution system and soil where water from N Reactor's cooling system was released. The distribution system and soil were contaminated with cobalt, cesium, strontium, and plutonium. Radiation levels at the soil surface were as high as 500 millirems per hour.

"We studied the engineering and dynamics of this project for nearly two years to develop a plan that would limit worker exposure to the lowest, reasonably achievable level," said Rick Donahoe, Bechtel Hanford task leader for the project. The company ended up placing 2 ft of slightly contaminated soil over the crib soil surface to provide added shielding for workers. A total of 7 ft of soil will be excavated and packaged for disposal at ERDF–2 ft of slightly contaminated fill and 5 ft of more highly contaminated crib soil.

Demolition of the effluent distributed system required additional care. The main distribution trough was filled with grout and sprayed with a plyurea elastomer material to fix contaminants to the trough. It was broken up into smaller pieces, or "rubblized," in place, then packaged and shipped to ERDF for disposal.

When completed, an estimated 2 000 tons of contaminated soil and debris will have been removed from the 116-N-3 trench and pipeline, as well as adjacent contamination plumes in the soil. Remediation will begin on a similar trench and crib in fiscal year 2002.

618-4 Burial Ground

Cleaning up old waste sites can yield unexpected results. In February

1998, remediation efforts were under way at the 618-4 Burial Ground in Hanford's 300 Area when the ERC team began unearthing unidentified barrels. The only marking on some of the drums—D38—was unfamiliar to project staff. A retired Hanford worker said the marking had been used to identify depleted uranium shavings and that the material was potentially pyrophoric. Before disposal, the shavings had been immersed in various oils—some containing Resource Conservation and Recovery Act–listed metals, organics, and polychlorinated biphenyls (PCBs)—to prevent them from igniting. PCBs were commonly used in transformer oil before it was banned as a carcinogen.

A total of 338 drums were unearthed from February 6–April 2, 1998. Field observations suggest that as many as 1200 additional drums could remain buried within the site. Of the 338 drums unearthed, 260 contained depleted uranium shavings. The other 78 contained uranium oxide powder, which is not pyrophoric. Of the 260 drums containing shavings, varying amounts of oil had leaked out of 149 of them. They were stabilized without incident by reimmersing the shavings in mineral oil.

Depleted uranium is less radioactive than uranium ore, but it contains enough radioactivity to be considered a health hazard should it burn. It was most likely the by-product of processes used to make fuel for plutonium production reactors. However, there are no existing records to identify the source of the material.

Lead contamination was found in some of the barrels containing uranium oxide. The lead-contaminated material will require stabilization with cement before it can be disposed of at the ERDF. The uncontaminated uranium oxide will be macroencapsulated and disposed of at ERDF in the summer of 2001. Also unearthed at the site were additional quantities of soil contaminated with lead and barium, which will be safely treated and disposed of at ERDF.

Discussions are still under way between the DOE and regulators as to the final disposition of the depleted uranium. However, it appears that any disposal option will involve some sort of onsite or offsite vitrification.

Remediation of Hanford's 116-N-3 crib has been a major challenge. The restoration team spent nearly two years in planning the work to limit worker radiation exposure to as low as reasonably achievable. Before protective measures were implemented, radiation levels at the soil surface were as high as 500 mrem/h.

Twice a month, Bechtel Hanford waste transportation specialists and radiological control technicians monitor 338 drums containing uranium oxide or depleted uranium shavings covered in oil. The barrels were discovered at the 618-4 Burial Ground north of Hanford's 300 Area in 1998. Project staff are developing a plan for the safe disposal of about 1200 more barrels that they believe are buried at the site.

Wildlife Habitat

Each waste site that is cleaned up at Hanford is returned to its original contour and revegetated. Backfill material is brought in and native grasses are planted as groundcover. To provide clean backfill material, Hanford has several dozen gravel and "borrow" pits. Most have been in existence since the early days of the Hanford Site. Others were established near the remediated sites to reduce transportation costs. Borrow pits will also be revegetated when they are no longer needed.

One pit near Hanford's B and C Reactors has been in existence since construction started on B Reactor in 1944. It is being used for clean fill at both reactor sites.

Field personnel push geoprobe rods into the soil before performing gamma-ray logging. The Environmental Restoration Project team avoided nearly $20 million in cleanup costs by using the system to distinguish between natural and man-made gamma-emitting materials in the soil.

Removal of strontium-90 from sites along the Columbia River and carbon tetrachloride from an area on Hanford's central plateau are examples where new technologies are needed.

When backfill work is completed at B/C Reactors in 2004, nearly 1 million tons of material will have been removed from the borrow pit. However, as ERC workers were removing material, they decided to take advantage of its proximity to groundwater and sculpt a wetland in part of the pit.

"Since we would be removing soil and rock from the pit anyway, we decided to do it in a planned fashion and create a wetland in the area," said Bechtel Hanford's Alvin Langstaff. "We were able to significantly enhance the appearance of the gravel pit and create a sizeable wetland at no additional cost to the government and taxpayers."

They created a 1.5-acre wetland and planted willow, cottonwood, and locust saplings. With an average annual rainfall of about 7 inches, the new wetland will provide needed habitat for wildlife in the Hanford desert. ERC staff are looking for opportunities to add value to other sites as well. (See "Creating a Desert Oasis: Hanford Gravel Pit Converted to Wetland," *Radwaste Solutions*, Jan./Feb. 2001, p. 28.)

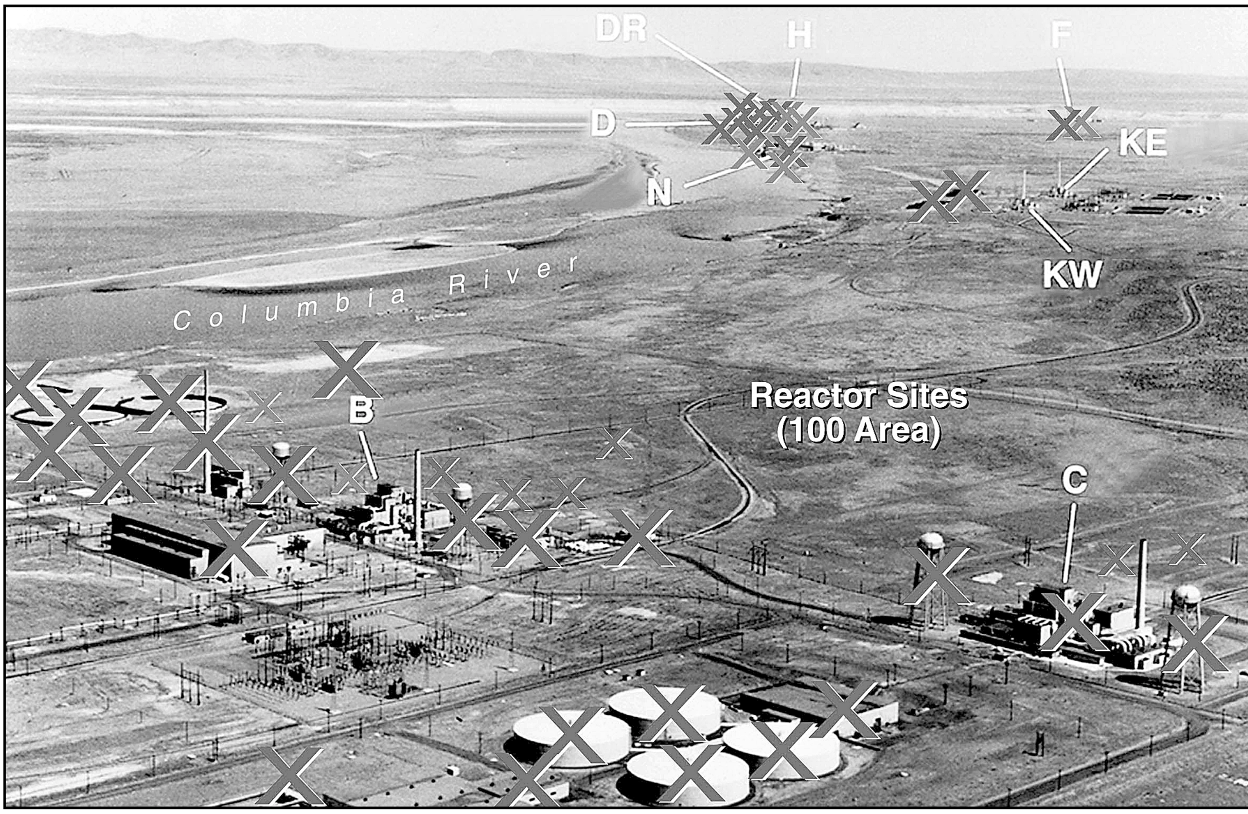
Leader in Pollution Prevention and Waste Minimization

Increased efficiencies, greater value for money spent, and avoided costs all lead to savings that can be plowed back into cleanup efforts. Creating value out of waste or surplus material is one of the goals of the ERC team's pollution prevention and waste minimization efforts. For example, last year the DOE recognized the ERC team for reducing waste by more than 300 000 tons and avoiding costs of nearly $50 million in 1999 through aggressively pursuing pollution prevention and waste minimization activities.

Also in 1999, the DOE's Environmental Restoration team at Hanford implemented the largest source reduction project in the DOE complex. It involved extensive evaluation of 417 waste sites. As a result, 348 sites were reclassified, enabling the ERC team to reduce the amount of low-level radioactive waste requiring treatment by nearly 65 000 cubic yards and avoiding costs of more than $36 million. This single effort reduced more waste than did all of the combined source reduction projects throughout the DOE complex.

In some cases, new technologies are used to help minimize the amount of waste requiring disposal. An example is use of a small-diameter geophysical logging system. This technology uses a probe inside a small-diameter tube to measure and distinguish between naturally occurring and man-made gamma radiation in the soil. It is less expensive and faster than other methods.

Under contract to Bechtel Hanford, employees of CH2M Hill Hanford, Three Rivers Scientific, and Northwest Geophysics developed the system from existing equipment and technology. It was recently used at a coal ash pit near Hanford's defunct F Reactor. Analysis of samples confirmed that nearly 200 000 tons of soil did not have to be treated as contaminated waste, avoiding more than $20 million in disposal costs.



Since beginning work on Hanford's Environmental Restoration Project, the Bechtel Hanford–led team has cleaned up 219 waste sites to regulatory standards, decontaminated and decommissioned more than 150 facilities, decommissioned 185 groundwater monitoring wells, cocooned one reactor, and is significantly ahead of schedule on four more.

Critical Need for New Technology

It's easy to underestimate the role technology plays in progress made by the ERC team on Hanford cleanup. After all, much of the work involves commonplace excavation and hauling. However, cleanup efforts on the Environmental Restoration Project pose more than just a few technological challenges. Existing technologies are used to meet some of them; in other cases, new technologies must be developed.

Removal of strontium-90 from sites along the Columbia River and carbon tetrachloride from an area on Hanford's central plateau are examples where new technologies are needed. The strontium-90 was discharged to the soil during N Reactor operations. Carbon tetrachloride was widely used as a solvent in chemical processes at Hanford and then discharged to the soil.

"We continue to pump and treat the strontium-containing groundwater for near-term containment, but it's not the permanent solution," said Michael Graham, manager of Bechtel Hanford's Groundwater/Vadose Zone Integration Project. "With carbon tetrachloride, as with other issues, we're taking small steps where we can." Such steps, he explained, include placing carbon filters on wellheads to trap airborne carbon tetrachloride. "It's an example of doing what we can with what we've got until we can develop something better," said Graham.

The DOE and its contractors are hoping new and better technologies will emerge as a result of the DOE's annual publication of science and technology needs at Hanford. "We evaluate hundreds of technologies a year for possible use," said Jerry White, senior technology representative for Bechtel Hanford. "We need to ensure they are appropriate for the problem at hand."

Graham said an annual technology needs assessment is important. "There are cleanup problems at Hanford for which we have no technological solution," he said. "We have to anticipate that an unidentified technology will become available at some future date and insert it into the schedule. These technology insertion points are crucial to meeting our cleanup milestones with the EPA and State of Washington."

Outlook for the Future

Hanford's Environmental Restoration Contract expires on June 30, 2002. The contract will be rebid as a river corridor contract. It is part of the DOE Richland Operations Office Manager Keith Klein's vision to accelerate cleanup of the Columbia River corridor by moving all contaminated materials to Hanford's central plateau by 2012. That goal would be impossible if not for the significant progress made on site cleanup to date. The DOE, regulators, and the public agree: Momentum on Hanford cleanup must continue. ■

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