APPLICATION OF SCIENCE AND TECHNOLOGY AT HANFORD

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Abstract
The Pacific Northwest National Laboratory (PNNL) is responsible for implementing the Science and Technology (S&T) mission at Hanford while supporting the cleanup mission by delivering critical S&T to the site. In addition to a successful history for deploying technology during its long-term presence at Hanford, PNNL has made major commitments to Hanford success including technical leadership for Hanford-specific programs such as the Groundwater/Vadose Zone Integration Project, Office of River Protection, Project Hanford Technology Management, and the Tanks Safety Program, as well as key national programs that have major influence at Hanford such as the Tanks Focus Area and support to U.S. Department of Energy - Environmental Restoration and Waste Management (DOE-EM) planning. This application of S&T at Hanford is expected to reduce both cost and risk of Hanford cleanup substantially while improving public safety.

Introduction

As one of the largest sites in the DOE complex, the two primary missions of Hanford are Cleanup and Science & Technology (S&T). Pacific Northwest National Laboratory (PNNL) is responsible for implementing the Science and Technology (S&T) mission at Hanford while supporting the Cleanup mission by delivering mission- critical S&T. The application of improved approaches and technologies is expected to reduce significantly the large cost associated with U.S. Department of Energy (DOE) site cleanup. Better scientific understanding of the risks and costs associated with continued management of these wastes sites will drive decision makers to focus on the highest priority cleanup activities early on, thereby reducing both cost and risk while improving public safety.

Detailed knowledge of Hanford's S&T needs coupled with in-depth scientific and problem-solving capabilities has led to significant research programs supporting the Environmental Management Science Program (EMSP). Since program inception in 1996, PNNL has participated either as lead or co-investigator in 55 projects, providing leadership to ensure that these projects generate information of high scientific quality that is readily applicable to DOE user needs.

While this paper provides an overview of major activities at PNNL in support of Hanford cleanup, it only begins to address the hundreds of individual technology support activities being conducted to that end, many of which are being presented in other sessions at this conference.

A Successful History at Hanford

Being present at the site since 1965, PNNL possesses much of the "corporate memory" for critical decisions and actions at the site. Significant advances in science and engineering have facilitated DOE operations and reduced the costs of treating the DOE environmental legacy. PNNL provides DOE a sound, fundamental understanding of the technical issues faced in cleaning up Hanford through the experiences and lessons learned working on numerous projects such as the Defense Waste Processing Facility at Savannah River, South Carolina and the West Valley Demonstration Project at West Valley, New York.

The PNNL support to the cleanup mission at Hanford has been cyclic over the past decade as budgets for S&T and cleanup activities in general have risen and fallen, and contractors have changed several times. Consequently, the role of PNNL has historically remained secondary to the Hanford cleanup mission, and most of the laboratory's research has been focused elsewhere. Recently, we renewed our commitment to a larger role with added impact with DOE and its contractors with respect to Hanford environmental cleanup. We are now providing technical leadership for site cleanup in which PNNL leaders are committed to, and accountable for, its success. PNNL is making the kind of investments and commitments to accept direct project accountability for S&T scope.

Tanks Focus Area

The Tanks Focus Area (TFA) is a national radioactive tank waste remediation S&T program led by DOE's Richland Operations office (DOE-RL). PNNL manages the technical team, which includes representatives from five national laboratories and two DOE contractors. The TFA provides technical solutions to address the priority problems of DOE's five principal radioactive waste tank sites -- Idaho National Environmental and Engineering Laboratory, Savannah River Site, Hanford Site, Oak Ridge Reservation, and the West Valley Demonstration Project in New York.

Tank waste remediation problems represent the most costly and technically challenging environmental issue facing DOE, with a projected cleanup cost of $49 billion through 2035. The goal of TFA is to provide technical assistance and technology solutions that enable the tank sites to safely store, retrieve, and treat the radioactive waste and ultimately close DOE's waste tanks.

For example, the TFA is supporting closure of the Oak Ridge site, where all tank wastes are being consolidated into one tank farm at Melton Valley. This includes waste from Gunnite and Associated Tanks, Old Hydrofracture Tanks, Bethel Valley tanks, and numerous smaller Federal Facility Agreement tanks. The TFA was/is providing baseline retrieval technology for every tank farm under the direction of a PNNL project lead. This

includes the modified Light Duty Utility Arm, Houdini remote operated vehicle, confined sluicing end effector, gunnite scarifying end effector, borehole miner, fluidic pulse jet mixers, Russian pulsating mixer pump, Flygt mixers, pulsed air mixer, and additional waste monitoring and conditioning equipment. Most of these systems were developed and tested at PNNL facilities. Without these new "baseline" technologies, Oak Ridge would not have been able to meet their waste retrieval and consolidation compliance schedule.

Groundwater/Vadose Zone Integration Project

Beginning in FY 1998, PNNL has provided Groundwater/Vadose Zone S&T leadership to resolving issues at Hanford related to the subsurface contamination from past waste release practices and leaking high-level waste tanks. As a fully integrated partner on the Bechtel Hanford team, PNNL led a multi-laboratory team to develop a S&T plan and roadmap and identified the basic science needs required to fill gaps in understanding of processes that govern movement of contaminants in the environment. The S&T roadmap was the first site-wide roadmap in the complex. PNNL is deploying its systems assessment capability to assess cumulative effects site-wide. This capability represents a collection of models and methodologies for assessing contaminants, considering waste disposal in alternate areas, producing estimates of uncertainty, and quantifying risks and impacts of options.

This project builds on capabilities developed at PNNL during decades of characterization and treatment of the groundwater and vadose zone. In Situ Redox Manipulation technology is an example of the technologies developed under the Office of Science and Technology programs in response to a specific Hanford subsurface contamination problem. Developed to reduce the concentration of groundwater containing hazardous hexavalent chromium entering the Columbia River, this technology has advanced from laboratory analysis to deployment on the Hanford site. Treatment is accomplished by injecting a nontoxic chemical, sodium dithionite, into the aquifer through a groundwater well to create an in situ treatment zone within the contaminant plume. Multiple wells create an underground treatment zone that oxidizes the groundwater-borne chromium to a non-hazardous and less mobile species. This system has been demonstrated at three sites and is currently being deployed at the Hanford 100-D Area.

Office of River Protection

Reorganization of the Hanford Tank Waste Remediation Systems Program under the DOE Office of River Protection (ORP) in 1999 provided the right opportunity for PNNL to enhance its assistance to the site's mission to process, store, and dispose of tank waste, the largest single cleanup program on the Hanford site. A new approach to S&T management is being implemented in FY 2000 to improve the needs identification and prioritization and the direction of an integrated set of technical activities to enhance execution of the project. PNNL is responsible for this new S&T management effort, which is designed to help ensure that the life-cycle mission plan for the radioactive waste stored in 177 underground single- and double-shell tanks at the Hanford site is credible, technically defensible, and can be completed within an acceptable budget and schedule.

Ongoing interrogations of the project baseline and strategic mission analysis are generating alternatives that have the potential to reduce technical and programmatic risks, enhance cost and schedule, and/or improve safety. A risk/cost/benefit analysis of these alternatives results will result in identification of the highest priority options for further project development or implementation. Some of these proposed alternatives require the development of new scientific knowledge and technical innovations. These activities will be described and organized into an overall S&T program logic (roadmap). The roadmap will serve as the focal point for identifying and managing development activities necessary to implement an improvement to the current baseline program or to maintain the technical viability of selected alternatives to the baseline.

The PNNL Waste Disposal Integration Team is supporting the ORP mission by providing technical, regulatory, financial, and management experts with both the specific and unique expertise DOE needs to execute and manage the privatization strategy successfully, including execution of the contract with British Nuclear Fuels, Ltd. (BNFL).

Technical Support to Fluor Hanford Projects

At the start of the Project Hanford Management Contract, PNNL entered into an agreement with Fluor Hanford (FH) to co-staff the Technology Management function. The agreement set forth a collaborative approach to enhance the application of technologies to expedite cleanup. Under this contract, Fluor Hanford is responsible for Spent Nuclear Fuel activities; Waste Management activities; Nuclear Material Stabilization; River Corridor projects, which includes deactivation of several facilities adjacent to the Columbia River; and the Fast Flux Test Facility. During the last three years of this partnership, PNNL has helped the FH team deploy 45 technologies and demonstrate 30.

Today, PNNL is providing testing and technical support to resolve key issues facing the Nuclear Material Stabilization Project such as providing technical data to support the formal decision on implementing a direct oxidation method for stabilizing polycubes. PNNL is also performing a number of studies that support efforts to disposition K-Basin sludge.

PNNL staff now lead the FH Technology Management function and are helping to identify the areas of highest technical risk and uncertainty within FH projects. Working with the DOE, this FH/PNNL team has identified key technology decision points within the projects (Technology Insertion Points) and has developed a comprehensive list of S&T needs that are the basis for technology discussions with technology providers from industry and the national laboratories. The FH/PNNL partnership provides a link to technical resources available from the DOE complex and is increasing the effectiveness of the Hanford cleanup.

Tank Safety Program

For several years, PNNL has provided data and analyses necessary for the successful closure of important Hanford tank safety issues. Operating in a partnership with

Lockheed Martin Hanford Co., PNNL has generated information vital to resolution of flammable gas, ferrocyanide, criticality, and organic safety issues. Key technical capabilities in the chemistry of actual waste samples, including analytical chemistry and experimentation with simulated and actual waste samples, coupled with physics and computational modeling of tank waste behavior provide a strong technical basis for decisions.

One example is the ferrocyanide safety issue. In the early 1990s, the potential for an uncontrolled reaction due to the presence of ferrocyanide in certain high-level waste tanks brought national attention to Hanford. Consequently, PNNL staff applied a scientific basis to known waste properties and conducted tests with both simulated and actual wastes. The experiments showed that significant hydrolysis had occurred in the tanks, converting the ferrocyanide to ammonia (which decomposes slowly), carbonates, and oxides of several metals. Thus, the fuel value in the solid phase was consumed in the process. Based on this work, the DOE was able to declare this Unresolved Safety Question as "closed".

In addition, analysis of historical data and recent studies has provided an understanding of the mechanics and magnitudes of gas retention and bubble dynamics in Hanford waste tanks. This understanding of the causes of gas generation and release processes allows prediction of conditions that cause buoyant displacements and estimation of the volume of potential releases. These results allow effective preventative measures to be implemented without creating new hazards as waste is transferred.

A good example of this technology application is the successful analysis and application to the rise in surface level of flammable gas tank SY-101. . PNNL contributions have had significant impact on the path forward for the remediation of the surface level rise safety issue including the schedule, costs, and potential risks and benefits..

DOE-EM Planning

To ensure that the experience and lessons learned from participation in cleanup activities at Hanford are incorporated into DOE's corporate R&D planning, PNNL participates in important national integration activities. Examples include a role in the development of the DOE-EM Strategic Plan for S&T, and the EM Research and Development Program Plan, as well as DOE-EM integration activities such as the S&T Roadmapping and Rebaselining. These activities also ensure that Hanford gains from and adds value to waste cleanup activities at other DOE sites.