HANFORD SITE INTEGRATION PROJECT APPROACH TO SCIENCE AND TECHNOLOGY THROUGH ROADMAPPING

Dr. Michael J. Graham, Bechtel Hanford, Inc.
Mr. John G. Morse, Department of Energy, Richland Operations
Mr. Mark D. Freshley, Pacific Northwest National Laboratory

ABSTRACT

The U.S. Department of Energy's (DOE) Hanford Site was established during World War II to produce plutonium for the U.S. Army Corps of Engineers' Manhattan Project. From 1944 through the end of the Cold War, nine plutonium production reactors, along with nuclear fuel fabrication and processing facilities, were built and operated at the Site. The 560-square-mile site is located in southeastern Washington state.

During Hanford's 45 years of plutonium production, huge amounts of chemical and radioactive waste were produced. Much of this waste has found its way into the soil, groundwater, and the adjacent Columbia River. Nearly 54 million gallons of high-level radioactive and chemical wastes remain in 177 aging underground storage tanks – 67 of which have leaked more than one million gallons of waste to the adjoining soil and groundwater. In addition, more than 400 billion gallons of waste were disposed directly to the soil and groundwater.

Hanford's focus is now on environmental cleanup. There are more than 1,500 waste sites at Hanford – ranging from small areas of surface contamination to the underground storage tanks.

In late 1997, the DOE, in conjunction with its Environmental Restoration Contractor, Bechtel Hanford, Inc. (BHI), began development of a new, coordinated cleanup project for Hanford – the Groundwater/Vadose Zone Integration Project. In addition to a strong commitment to science and technology through a formal roadmap process, the Integration Project applies rigorous independent technical reviews to its work, and engages a diverse group of local and regional stakeholders.

INTRODUCTION

The Hanford Site was established during World War II to produce plutonium for the U.S. Army Corps of Engineers' Manhattan Project. From 1944 through the end of the Cold War, nine plutonium production reactors, along with nuclear fuel fabrication and processing facilities, were built and operated at the site. Hanford is now focused on management and cleanup of the legacy wastes from those days. The 560-square-mile site is located in southeastern Washington state. (Figure 1)

The DOE established the Hanford Groundwater/Vadose Zone Integration Project (Integration Project) in late 1997 to provide further assurance that cleanup actions and decisions at Hanford are protective of the Columbia River (1). Dr. Ernest J. Moniz, Undersecretary of Energy, directed the Integration Project to be science-based, including strong participation from national laboratories, incorporate rigorous technical reviews, and engaging diverse stakeholders in a meaningful way. In this way the Integration Project provides the technical and scientific basis required to inform and influence important Hanford Site cleanup decisions. These decisions must be supported by the regulators (the Washington State Department of Ecology, and the U.S. Environmental Protection Agency, Region 10), and will continue to require stakeholder support and technical defensibility.

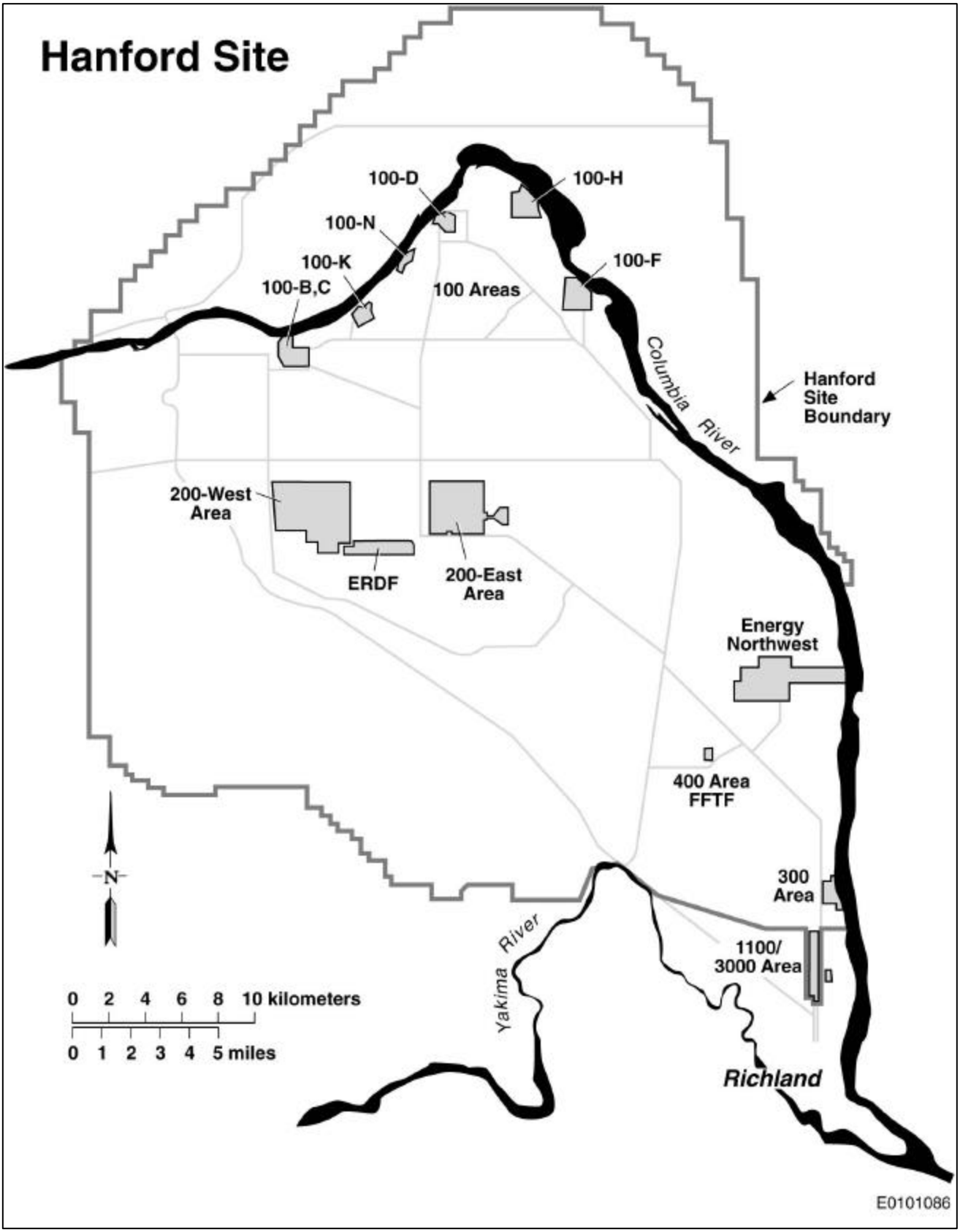

Fig. 1. Hanford Site Map

Important decisions that the Integration Project will inform and influence include the following:

- Waste retrieval from single- and double-shell tanks, as well as final closure of those tanks.
- Remediation of 200 Area's (Hanford's Central Plateau) nearly 800 waste sites.
- Final Hanford closure and end-state plans and projections.
- Interim actions to protect groundwater.
- Operational practices to further protect water resources and the Columbia River.

BACKGROUND

At Hanford, as with most complex waste management and cleanup endeavors, there are multiple projects and organizations responsible for various aspects of the overall site mission. Projects whose primary scope involves environmental characterization and monitoring, or risk and performance assessments are termed **core projects**. Examples of Hanford's core projects include:

- Site-Wide Groundwater Monitoring and Modeling
- Tank Farm Vadose Zone Characterization (Assessment of past leaks from single-shell tanks)
- 200 Area Soil Site Remediation (Assessment of past-practice soil sites)
- Immobilized Low-Activity Waste Performance Assessment (Performance assessment to support future disposal of low-activity glass from the planned vitrification of Hanford's tank wastes.)

The Integration Project, by teaming with these core projects, has created a coordinated and cohesive approach to this scope of work. The Integration Project also added elements that were either lacking or under emphasized (e.g. Science & Technology). The result is an integrated site-wide strategic approach that is effectively focused on Hanford's most pressing near- and long-term cleanup priorities. The Integration Project approach to addressing these priorities is as follows:

Site-wide integration of vadose zone characterization, assessments, modeling, and monitoring.

- Duplication of effort and overlaps between Hanford's multiple projects and contractors have been eliminated.
- Critical data gaps have been identified and prioritized for additional characterization work.
- Procedures and methods are in place to formally track and address technical issues.
- A framework is being developed and tested to provide consistency and completeness in conceptual models.

Develop the **capability to assess** the cumulative long-term impact of Hanford-derived contaminants on the Columbia River and the Pacific Northwest.

- The System Assessment Capability (SAC) has been developed to provide integrated site-wide assessments (2). The assessments of individual cleanup actions are still required and may indicate that the individual risks or impacts are acceptable, but the cumulative impact of the entire waste management disposal system needs to be evaluated.
- The SAC is analyzing the current Hanford Site cleanup plan. Predictions for the state of key chemicals and radionuclides and their potential impacts through the year 3050 (1000 years after the end of the current cleanup mission) are slated for the summer of 2001.

Apply **science and technology** (S&T) to critical Hanford vadose zone, groundwater, and Columbia River needs.

- A Hanford site-wide S&T roadmap has been implemented to fill critical gaps in the technical baseline. Roadmap tasks are focused on understanding and quantifying the inventory of contaminants discharged to the vadose zone from past waste management practices, subsurface flow and transport processes - with emphasis on the interfaces (e.g., vadose zone/groundwater/river), and biological uptake and elimination in aquatic organisms in the Columbia River.
- The S&T roadmap also focuses tasks to develop and test advanced vadose zone characterization and monitoring tools, and to develop and utilize advanced computational methodologies.

From its inception, the Integration Project has striven to provide meaningful **public involvement.** The project's success hinged on providing key regional stakeholders, Tribal Nations, regulators (State of Washington and U.S. Environmental Protection Agency), and the state of Oregon with an understanding of the project and their ability to provide input into the decision-making process.

- Bi-monthly open project update meetings are held for all interested parties.
- A semi-annual report on the project is prepared to provide members of Congress and other stakeholders with an in-depth look at the Integration Project.
- Focus sessions with individual stakeholder groups and Tribal Nations are conducted routinely by project managers and technical experts.
- An Integration Project web site *(http://www.bhi-erc.com/vadose)* provides an overview of the project and its current activities.
- All peer review meetings and workshops are open with scheduled times for input from regulators, stakeholders, and Tribal Nations

Establish multi-tiered management and **technical reviews** for all Hanford vadose zone, groundwater, and Columbia River work.

- The Integration Project Expert Panel (IPEP) was established in 1998 to provide independent management and technical review. The continuing 8-member IPEP has expertise in environmental management, geophysics, ecological health, radiochemistry, and hydrology. The tenth full-panel meeting is scheduled for April 2001.
- DOE Headquarters (DOE-HQ) requested a review of the S&T activities and their relevance to Hanford Site decisions by a 15-member National Academy of Sciences (NAS) committee. The NAS initiated their review during fiscal year (FY) 2000, and will complete their review in the spring of 2001.

S&T ROADMAP DEVELOPMENT AND IMPLEMENTATION

The first comprehensive S&T roadmap produced for a major DOE site-wide project was developed in support of the Integration Project. Both the Hanford DOE/contractor team and Undersecretary Moniz determined that a project-level roadmap was integral to development of an effective management and planning strategy for the Integration Project.

The Integration Project's S&T roadmap was developed during FY98-99, with review and evaluation by DOE and key Hanford regulators and stakeholders. It was then released in December 1998 for an extended comment period, and ultimately published as Rev. 0 in June 1999 (3). It has since helped guide decisions for the Integration Project, as well as new investments in S&T. The S&T roadmap describes the products on a schedule documenting linkages to Hanford Site projects receiving S&T input (Figure 2). In Figure 2, "up" triangles depict a S&T product that provides input to a core project; "down" triangles show a S&T product that feeds into the SAC. The roadmap documents S&T activities within each technical element (inventory, vadose zone, groundwater, Columbia River, and risk assessment). It also provides a brief definition of each product, including project linkages and interactions, identification of the customer for the S&T product, and both startup and delivery dates. The document also includes a summary of budgets estimated for planning and executing the S&T activities.

The Integration Project uses the S&T roadmap as input to developing detailed work plans each fiscal year. Rev. 0 of the roadmap provided the basis for defining the FY00 scope of work for the Integration Project S&T, and was used to influence a call for proposals by the DOE Environmental Management Science Program (EMSP).

The EMSP is administered through the DOE Office of Science and Technology, and invests in basic and applied science. During FY99, the EMSP awarded 31 new grants (worth $25M in work scope over three years) that were directed at vadose zone problems. The principal investigators participating in these projects are from across the DOE complex, as well as universities and private industry. During November 1999, the Integration Project held an orientation workshop for the successful EMSP investigators to link their efforts with research efforts at the Hanford Site. The Integration Project continues to interact with the EMSP principal investigators to incorporate their research results into scientific investigations supporting remediation actions at the Hanford Site. A second EMSP principal investigator workshop was held in November 2000, with over 100 participants from EMSP projects, Integration Project staff, and contractors for other Hanford projects. Workshop papers are posted on the Integration Project website *(http://www.bhi-erc.com/vadose).*

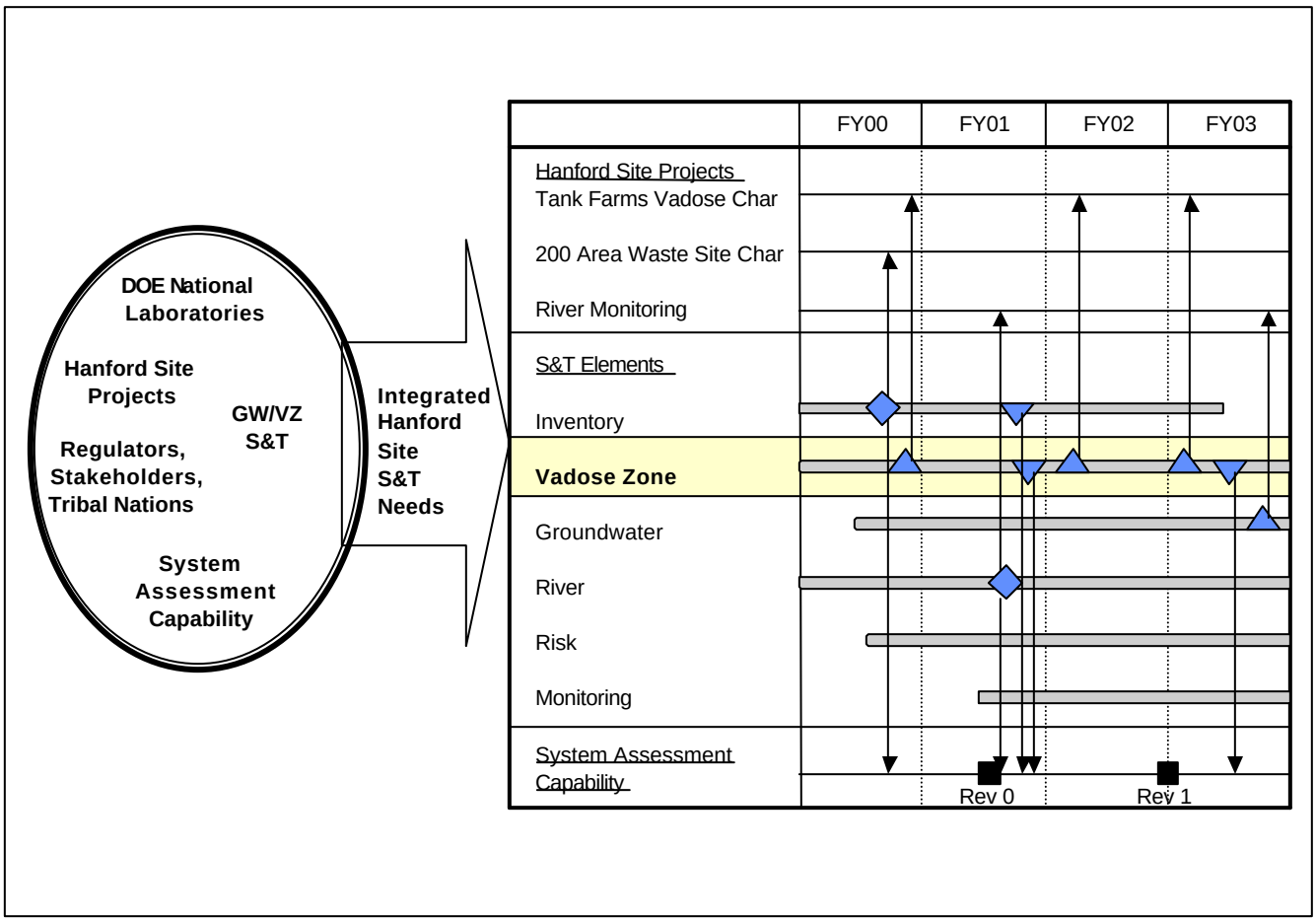

Fig. 2. Science & Technology Roadmap

During FY00, the S&T roadmap was revised (Rev. 1) to include the risk technical element and incorporate the FY99 EMSP awards (4). The activities and outcomes were revised to match changes in Hanford Site project strategies and schedules. The FY01 work scope includes the following activities:

- Develop mass-balanced soil waste inventories for the SAC, and reconcile the inventory estimates with field characterization data.
- Complete scientific studies of samples from beneath several of the high-level waste tank farms that are suspected of having contaminated groundwater, and provide S&T input to final characterization reports.
- Perform vadose zone transport field experiment with high salt tracer and analyze the results, including evaluation of advanced characterization technologies suitable for the Hanford vadose zone.
- Complete analyses of groundwater/river interactions at key locations along the Columbia River to develop dilution models for the SAC.
- Initiate laboratory studies of biological uptake and elimination in aquatic organisms exposed to key Hanford contaminants in the Columbia River.

For the Integration Project S&T activity to have an impact, it must deliver correct scientific and technical information in a timely manner that allows the information to be used by other Integration Project tasks and the core projects. The linkages are based on S&T needs identified in the process of developing the roadmap, and through ongoing teamwork.

BENEFITS OF THE S&T ROADMAP PROCESS

The Integration Project's S&T roadmap has provided a number of significant benefits to the project as noted below:

- Organization of project S&T needs and strategies into a coherent and systems-oriented process that can be effectively understood, defended and managed.
- Justification for and understanding of the timing of actions and the need for sequencing of S&T actions.
- Enabling an understanding of the benefits of starting long-term science activities, with the ability to prioritize long-term vs. short-term activities.
- Identifying and justifying budget priorities and rankings of proposed S&T tasks.
- Identifying redundancies, overlaps and gaps relative to scientific knowledge and needed technologies.
- Allowing the Hanford Site to develop improved ties between the Integration Project and similar projects at other DOE sites, thus achieving multiple-site benefits from Integration Project S&T activities.
- Allowing the Integration Project to be more outcome-oriented relative to S&T activities (e.g. S&T activities could be focused on resolving issues identified in the roadmap).
- Promoting better collaboration between project team members and scientists, and enhancing their ability to work together and develop an integrated approach to S&T in support of the Integration Project.
- Promoting up-front and positive engagement of scientists. As a result, scientists can better understand how to focus their studies to produce a product (scientific knowledge or new technology) that would actually be utilized by a project.

EARLY S&T ROADMAP SUCCESSES

The S&T roadmap, as a planning and management tool, provides benefits only if it is implemented. As stated by the IPEP in November 1998: "planning is not progress, it is only the prelude to progress."

FY00 marked the beginning of implementation of the S&T roadmap defined for the inventory, vadose zone, groundwater, and Columbia River technical elements. New tasks were created to 1) develop soil waste site inventory estimates; 2) conduct scientific investigations at representative soil waste sites; 3) perform vadose zone transport field experiments; 4) develop and apply advanced multiphase reactive transport numerical models; and 5) investigate and improve conceptual and numerical models of the groundwater/river interface. Specifically, the following early successes and impacts have been realized from the S&T roadmap.

- The S&T roadmap was the basis for the FY99 new EMSP call for research proposals. Researchers were able to access the roadmap via the Internet and focus their efforts on the technical issues and data gaps identified. The proposal evaluators were more readily able to evaluate the relevance of the proposals to the true problems in the field. EMSP Principal Investigators were convened in a workshop after awarding the research grants. Using the S&T roadmap, they were able to see how they fit into the solution, as well as the relationships between and among the research efforts.
- The S&T roadmap was used to capture and integrate the Site Technology Coordination Group Science and Technology needs for the project. Having the S&T roadmap in place not

only simplified the process of developing the S&T needs, but also provided assurance that these needs would be directly related to the identified problems and data gaps.

- The Soil Inventory Task completed development of a computer model to derive waste inventories and uncertainties for contaminated soil sites on Hanford's Central Plateau. Estimates for nine waste streams were completed (four were planned to be developed). These estimates reconstruct inventories of radionuclides and chemicals discharged to soil waste sites. They also capture the associated uncertainty, based on process knowledge, to estimate the volume, amount, and location of chemical and radionuclide inventories in the soil sites.
- The soil inventory team was diverted during August/September 2000 to fill critical gaps in tank leak inventory estimates for tank farm vadose zone core project and for SAC. Utilizing the approach and models developed for soil sites, inventory estimates for past leaks from single shell-tanks were calculated.
- The Field Investigations at Representative Sites Task performed laboratory studies on core materials collected as part of field investigations at single-shell tank leak sites. The scope of this task includes: 1) determining mineralogical association and sorption reversibility of technetium and cesium; 2) determining whether new mineral phases have resulted from the high temperatures associated with leaks from these boiling waste tanks; 3) investigating high aluminum, caustic waste/sediment interaction; and 4) establishing the impact of high salinity/caustic waste solutions on soil hydraulic properties. This scientific information is being utilized in an ongoing risk analysis and evaluation of corrective actions.
- The Vadose Zone Transport Field Study Task completed the first field experiment in the 200-East Area involving injection of 40,000 liters of uncontaminated water with a sodium bromide tracer. Nine different characterization methods were deployed in the field experiment. Reports are posted on the project web site at: h*ttp://etd.pnl.gov:2080/vadose/contrepts.htm*
- The Groundwater/River Interface Task completed conceptual and numerical model development of the groundwater/river interface at Hanford's 100H Area. Animations have been developed based on simulations of the groundwater/river interface.

CHALLENGES

The premise of a roadmap is that it represents a process in which problem holders come together with problem solvers to define problems and establish a path to resolution. At Hanford, problem holders are represented by the DOE, Tribal Nations, regulators, stakeholders, and remediation contractors. The problem solvers are the scientists and engineers from the national laboratories and universities. All of these groups participated in workshops to define the roadmap. The difficulty, however, comes with defining the specific work activities during planning for each fiscal year, and getting the users of the S&T results to agree that the results would be useful. The S&T effort has met with varying degrees of acceptance by the problem holders.

The S&T roadmap identified more work scope than the project had funding for, so prioritization of S&T investments was required. The Integration Project prioritized S&T work activities through a structured process involving project scientists and engineers, representatives of other Hanford Site projects linked with the Integration Project, and representatives of the DOE. Balancing long-term efforts (such as S&T) with near-term compliance-driven actions is inherently difficult. Some of the S&T plans could not be initiated given funding constraints. The prioritization of continuing the existing S&T tasks as planned, versus initiation of new S&T tasks, is an ongoing challenge. Insights from the NAS review and the oversight of the IPEP will be used in revising future S&T priorities.

CONCLUSIONS

Science and Technology is an integral part of Hanford's Integration Project. The roadmap facilitates the definition and management of S&T as a **project**. There is consensus on the focus; the outcomes and timing are understood by both the developers and the users. As a result, a broad range of scientific knowledge and expertise is being applied to solve problems at the Hanford Site through partnerships with DOE national laboratories and private industry.

REFERENCES

1. DOE, 1999a, U.S. Department of Energy. *Groundwater/Vadose Zone Integration Project Summary Description*. DOE/RL-98-48, Vol. I, Rev. 0, U.S. Department of Energy, Richland Operations, Richland, Washington.
2. BHI, 2000, Bechtel Hanford, Inc. *Groundwater/Vadose Zone Integration Project System Assessment Capability (Revision 0) Assessment Description, Requirements, Software Design, and Test Plan*. BHI-01365, Draft A, Bechtel Hanford, Inc, Richland, Washington.
3. DOE, 1999b, U.S. Department of Energy. *Groundwater/Vadose Zone Integration Project Science and Technology Summary Description*. DOE/RL-98-48, Vol. III, Rev. 0, U.S. Department of Energy, Richland Operations, Richland, Washington.
4. DOE, 2000, U.S. Department of Energy. *Groundwater/Vadose Zone Integration Project Science and Technology Summary Description*. DOE/RL-98-48, Vol. III, Rev. 1, U.S. Department of Energy, Richland Operations, Richland, Washington.