SCIENCE FOR ENVIRONMENTAL CLEANUP: OVERVIEW

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ABSTRACT

The focus of this session at Waste Management '04 is on scientific contributions to cleanup of the nuclear weapons complex. This opening talk provides a brief overview of the cleanup challenges and how scientific research is helping to address them. The following presentations provide specific examples of contributions from a range of science disciplines.

INTRODUCTION

The Department of Energy (DOE) is responsible for remediating waste and environmental contamination from the nation's nuclear weapons programs that began with the Manhattan Project and continued through the Cold War. To consolidate and enhance its remediation activities, DOE established its Office of Environmental Management in 1989. The "cleanup" program being carried out by this office could ultimately entail more time and expense than weapons production itself.

The importance of science to DOE's cleanup mission has been widely acknowledged. In 1996, the U.S. Congress, recognizing that DOE was not providing sufficient attention and resources to scientific research, established the Environmental Management (EM) Science Program. This mission-directed research program was established to "stimulate the required basic research, development and demonstration efforts to seek new and innovative cleanup methods to replace current conventional approaches which are often costly and ineffective" [1].

The EM Science Program was initially housed within the Office of Environmental Management. It was moved to the Office of Science in 2003 as part of a broader effort to refocus the Office of Environmental Management on its core cleanup mission. The EM Science Program is now allied with three other research programs (Natural and Accelerated Bioremediation Research Program, Environmental Molecular Sciences Laboratory, and Savannah River Ecology Laboratory) in the newly established Environmental Remediation Sciences Division. These programs collectively represent a $100+ million annual investment in environmental research.

BACKGROUND ON THE CLEANUP PROGRAM

The nuclear weapons complex consists of some 5,000 facilities at 16 major sites and 100 smaller sites, ranging from uranium mills to weapons assembly and testing facilities. The largest and most contaminated sites in the weapons complex are the so-called "production" sites: Hanford, Washington; Idaho National Engineering and Environmental Laboratory; Oak Ridge, Tennessee; and Savannah River, South Carolina. Nuclear materials (enriched uranium, plutonium, and tritium) were produced at these sites for use in nuclear weapons, naval fuel, and civilian nuclear applications. Most of the expenditures for environmental cleanup—now estimated to exceed $200 billion—will likely be made at these sites.

The production of nuclear materials generated huge quantities of waste [2, 3]. Some of this waste was intentionally discharged into the environment, especially during the mid- to late-1940s, or was inadvertently released. These discharges have contaminated large volumes of soil and groundwater. Large quantities of waste remain in storage and are potential sources of future contamination.

"Cleanup" of DOE sites involves meeting agreed-to schedules and milestones for remediating waste and environmental contamination rather than ensuring their complete removal. DOE began negotiating legally enforceable cleanup schedules and milestones with its regulators even before it had an adequate understanding of the environmental contamination at its sites—or its scientific and technical capabilities to perform site cleanup. The cleanup program now operates under about 70 separate agreements with more than 7,000 schedule milestones. Many of these milestones have been missed or renegotiated as costs and technical barriers became insurmountable.

Because of its focus on meeting schedules and milestones, the cleanup program is sometimes accused of being resistant to incorporating new ideas and approaches, especially if they result in changes to the cleanup "baselines." This charge is not borne out by experience or the talks at this session, however. In fact, DOE has recently indicated that it is willing to consider new cleanup approaches that would substantially reduce risks, costs, and schedules, even if that requires substantial changes to its baselines.

RESEARCH CONTRIBUTIONS

The programs within the Environmental Remediation Science Division support fundamental research designed to address real-world problems. The programs attract high-quality researchers, primarily from national laboratories and universities, who may not be well acquainted with DOE's contamination problems or science needs. These research programs have developed some innovative mechanisms for connecting researchers with the problems and problem holders at DOE's contaminated sites:

- At the request of the EM Science Program, the National Research Council has developed a series of reports [4-9] that frame the cleanup challenges. These reports also have been used by EM Science Program staff to develop proposal solicitations and organize proposal reviews.
- The EM Science Program has sponsored a series of workshops that bring together researchers with "problem holders" (i.e., DOE managers and cleanup contractors) at DOE sites. These workshops help researchers to better understand site needs and develop proposals for research that can have an impact on cleanup activities. Once projects are underway, the workshops provide a forum for discussion of research results.
- The Natural and Accelerated Bioremediation Research Program has established a research station at the Oak Ridge site where researchers can perform field studies in a real-world environment.

There are many measures of success for a research project, depending on one's perspective. The traditional measure of success in the scientific community is the project's impact on advancing the state of knowledge through publication in the scientific literature and training of students and postdocs. From the perspective of the cleanup program, however, the success of a research project is judged primarily on its impact on reducing risks (to workers, the public, or environment), costs, and schedules. The research programs within the Environmental Remediation Sciences Division strive to support projects that have the potential to advance scientific knowledge and the cleanup effort.

Many research projects supported by the EM Science Program and its sister programs have had near-term impacts on cleanup plans and schedules. Such projects tend to focus on problems that are "ripe" for attention, and they produce results in time for making cleanup decisions. Problems may be ripe for many reasons—for example, because they influence near-term cleanup milestones or records of decision, or they involve technical impediments in current waste management or remediation efforts. While such projects often have a narrow, more applied focus, this is not always the case. For example, research projects that focus on improving the understanding of fundamental environmental processes for contaminant migration in the environment are having a substantial impact on decisions concerning "how clean is clean enough" at some DOE sites.

LOOKING AHEAD

An initial but unspoken assumption of DOE's cleanup program at its inception was that many sites would be remediated to standards that would allow for their unrestricted release. By the mid 1990s, the program had begun to retreat from this assumption as the cost and technical difficulties of achieving substantially complete cleanup became apparent [10]. DOE now estimates that more than 100 sites will contain residual contamination once its cleanup program is completed [11].

DOE is now promoting the use of "risk-based end states" as the basis for decision making on what and how much clean up is required [12]. DOE believes that this approach will allow cleanup efforts to be accelerated and resources to be focused on those waste and contamination problems that pose the greatest hazards to workers, the public, and the environment. The unstated implication of this approach is that waste and contamination that does not pose a substantial hazard will be left in place—a prospect that does not sit well with many stakeholders and has led to lawsuits.

The use of risk-based end states will require the development of methods for risk estimation using, for example, site-wide performance assessments.[a] The development of reliable assessments will require an improved understanding of waste and contaminant behavior over long time periods, both for natural and engineered environments. The Environmental Remediation Science Division's programs can play an important role in providing this understanding.

As noted elsewhere in this paper, DOE's cleanup program is being refocused on those activities that are related directly to its mission. Scientific research is seen as perhaps a necessary but subsidiary activity. Nevertheless, continued advances in science and the technology it begets are surely essential to the long-term success of the cleanup effort, which will last for at least another two decades. The continued direct engagement by the research community with problems and the problem holders at DOE sites is essential to ensure that science continues to have a positive, significant impact on the cleanup and increasingly important stewardship missions at DOE.

REFERENCES

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FOOTNOTES

a. For example, the System Assessment Capability (SAC) at Hanford is a site-wide performance assessment model. A description of the SAC is provided in the National Research Council report "Science and Technology for Environmental Cleanup at Hanford" (http://books.nap.edu/catalog/10220.html) and is also described on the Hanford web site (http://www.hanford.gov/cp/gpp/modeling/sac.cfm).