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COMPARISON OF THE GROUNDWATER AND VADOSE ZONE ROADMAP PROJECTS AT HANFORD AND IDAHO

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ABSTRACT

The Department of Energy has initiated site-wide groundwater and vadose zone roadmap projects at the Hanford site in Washington and the Idaho National Engineering and Environmental Laboratory in Idaho. The Hanford project is more mature than Idaho's and is under a different regulatory environment. Most regulatory decisions regarding cleanup at Hanford are in the future so the roadmap will be used to help make or influence these decisions. At Idaho, most of the cleanup decisions have already been made and the Records of Decisions are in place. The Idaho roadmap project may identify cleanup alternatives which could beneficially impact existing regulatory decisions in addition to helping make the few remaining decisions. This paper examines the methodology and approach for both projects, how the projects are integrated with the cleanup programs, and the milestones associated with each project. It is recommended that Hanford and Idaho continue exchanging information and lessons learned. Idaho should also conduct an independent technical review of their project and engage their regulators early on during the development of the roadmap.

INTRODUCTION

In recent years the Department of Energy, through the Office of Environmental Management (EM), has placed increased emphasis on the need to more thoroughly understand the groundwater and vadose zones (GW/VZ) at our sites. Movement through the GW/VZ systems toward the accessible environment is a key mechanism for release of radioactive and hazardous constituents. Therefore, a better understanding of the transport and interactions of radioactive and hazardous materials in the subsurface is paramount to protecting the environment and the continued cleanup of our sites. This increased understanding of radioactive and hazardous constituents in the GW/VZ will lead to better programmatic decisions effecting the cleanup mission of EM.

This paper will compare and contrast the GW/VZ projects at two of the Department's largest sites -- the Hanford site in south-central Washington and the Idaho National Engineering and Environmental Laboratory (INEEL) in southeastern Idaho. [Note that Hanford refers to their project as GW/VZ integration project, whereas INEEL refers to their project as the vadose zone/groundwater (VZ/GW) project.] The GW/VZ project at Hanford was established in 1997, whereas the INEEL project was only recently initiated. As a result, the Hanford project is further developed and more mature. One fundamental difference between the two projects is the regulatory environment. Hanford developed their roadmap to address core project (fieldwork) commitments, many of which are tied to regulatory milestones. The majority of the cleanup decisions at Hanford are years out in the future. This

includes Records of Decisions (RODs) and other programmatic decisions (for example how to retrieve single shell tank waste and to dispose of immobilized low activity waste). Given this scenario at Hanford, the GW/VZ roadmap will focus the cleanup program and assist in developing the RODs, Remedial Actions (RAs) and programmatic decisions.

At INEEL there are fewer decisions to be made since most of the cleanup RODs are already in place. However, there are a few instances where the VZ/GW roadmaps will be helpful to make or influence the decision. The INEEL Environmental Restoration (ER) Program has completed the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RODs for all Waste Area Groups (WAG) with the exception of WAG 7 Operable Unit (OU) 7-13/14 (Pit 9 is currently proceeding under an Interim Action ROD), WAG 3 the Idaho Nuclear Technology Energy Center (INTEC) High-Level Waste Tank Farm, and WAG 6/10 the Site-Wide and Snake River Plain Aquifer. The VZ/GW roadmap may identify cleanup technologies or processes which could beneficially impact regulatory decisions or the selected RAs currently in place. Should this occur, the option to amend the RODs could be exercised. Moreover, for sites currently in the Remedial Investigation/Feasibility Study or ROD development phases, the information provided by the roadmap and science and technology (S&T) planning process will be required to support the evaluation of cleanup alternatives. Certainly, as the Department evaluates new cleanup alternatives for Pit 9 (OU 7-10) and the Radioactive Waste Management Complex (OU 7-13/14) at INEEL, a thorough understanding of contaminant fate and transport mechanisms through the vadose zone will be required if any alternative other than waste excavation is to be seriously considered (and, for that matter, to determine if waste excavation is truly required to protect the environment). The VZ/GW roadmap can then be used to demonstrate to regulators that there may be less costly and better ways to perform cleanup and monitoring operations. The roadmap will also be utilized for long-term monitoring/stewardship activities and will provide input to the CERCLA five-year reviews.

In particular this paper will look at three aspects of the two projects: 1) the methodology and approach for the GW/VZ roadmap projects at both sites; 2) the degree each project has been integrated with the site's cleanup program; and 3) the milestones each project is working towards. Finally, recommendations on what works best and the path forward will be presented. First a discussion of the Hanford project will be presented followed by the INEEL project.

GW/VZ PROJECT AT HANFORD

The Hanford site established the GW/VZ Integration Project in 1997 to develop the technical capability and scientific information necessary to perform site-wide assessments of the potential effects of Hanford soil and groundwater contaminants on people and ecological systems. The GW/VZ project crosscuts all the major projects at Hanford. The overall project will be accomplished over a long period of time in support of key cleanup decisions. However, near-term benefits have, and will continue to be, achieved by coordinating and focusing characterization efforts, eliminating redundancies and overlaps, developing methods to evaluate risks and impacts on a broad scale, and putting key assessment information under site configuration control. Numerous programmatic decisions, including RODs and RAs, remain to be

made and the GW/VZ roadmapping effort may aid, or at least influence, these decisions. The remaining key decisions include:

- Allowable cumulative inventory to be left in place at closure
  - Single shell tanks past leaks
  - Single shell tanks retrieval losses
  - Waste that remains in tanks after closure
  - Burial grounds RODs that provide for nonretrieval options
  - Cribs/ponds/ditches RODs that provide for nonretrieval options
- Retrieval technology/methods for single-shell tank waste
- Performance criteria of surface and subsurface barriers and other remedial actions
- Performance evaluation of Interim and Final RODs
- Use of alternative cleanup standards
- Final RODs for soil and groundwater
- Stewardship for soil and groundwater
- Land use restrictions
- National Priority List delisting

Methodology

The Hanford GW/VZ project uses a systems engineering approach and builds on existing data and experience. The project consists of six endeavors:

- Fieldwork (or Core Projects) - coordinates, integrates, and conducts fieldwork
- Integration of Information - ensures consistent interpretation and configuration control
- System Assessment Capability (SAC) - assesses the potential long-term effects of contaminants
- Science and Technology (S&T) - enhances the role of science and technology as the basis for cleanup decisions
- Public Involvement - ensures productive involvement by parties interested in Hanford's cleanup
- Expert Technical Review - ensures independent technical reviews and management oversight of the project

The Fieldwork and Integration of Information endeavors had earlier been combined under a single Integration endeavor. Now they are two separate, but closely tied, activities. The Fieldwork endeavor coordinates and optimizes vadose zone, groundwater, and Columbia River characterization and data collection. The Integration of Information endeavor ensures that the wealth of technical information and data about Hanford is well integrated, effectively managed (to ensure its integrity and quality), and easily accessible for a wide range of potential uses. Data must be available when needed, and must be maintained in a consistent and technically defensible manner. There are four areas of focus for these two endeavors: 1) management of key project interfaces; 2) coordination of characterization work; 3) standardizing data sets, conceptual models, and assessment methodologies; and 4) focusing the regulatory path.

The SAC endeavor provides the predictive tools to perform the assessments required to understand the human, environmental, cultural, socio-economic, and health effects resulting from contaminants. The results of the SAC will provide the basis for site-specific cleanup decisions about the cumulative, long-term regional impacts of the site. The results will also provide useful information for setting cleanup priorities, allocation of funding, and determining the need for additional data.

The main objective of the S&T endeavor is to provide new knowledge, data, and tools, and the understanding needed to enable the project's mission. The activities are focused on resolving key technical issues jointly with the SAC and other site projects. Five technical elements are encompassed within the S&T endeavor: chemical and radioactive inventories, vadose zone, groundwater, river, and risk. A roadmapping process is used to implement the S&T activities, and brings problem holders together with problem solvers to define problems and target solutions where S&T can be directly applied. An integrated schedule identifies the programmatic needs and when S&T solutions will be required. This allows the S&T activities to be schedule driven by the program's needs.

The Public Involvement endeavor provides effective and real-time project participation and involvement by all interested parties. Participating organizations and venues for the project include: Tribal Governments, Hanford Advisory Board, one-on-one outreach meetings, media relations, project team meetings, and working groups. This wide-spread public involvement early in the development of the "data base" leads to more readily obtained public buy-in to RODs and cleanup decisions.

The objective of the Expert Technical Review endeavor is to assure that the appropriate level of management and independent technical reviews are applied to all vadose zone, groundwater, and Columbia River work scope. An Integration Project Expert Panel has been established to provide broad oversight of the project with a focus on integration issues and relevance to DOE cleanup decisions. Also, the Department has initiated an independent technical review of the project by the National Academy of Sciences (NAS) focused on the S&T efforts and its relationship to other elements of the project and DOE needs. The NAS has reviewed Hanford's GW/VZ S&T program and will provide recommendations during the Spring of 2001 to improve the technical quality and relevance to remediation decisions. The review will assess the technical merit of the S&T work and its likely contribution to advancing scientific knowledge; the relevance and timeliness of the S&T work to remediation decisions; and the applicability of the S&T results to cleanup problems at other DOE sites along with applicability of other sites' S&T programs to Hanford.

Integration Project Expert Panel

The Integration Project Expert Panel has made numerous recommendations and identified both strong points and areas of concern with the Hanford project. Currently the Expert Panel feels the project is "headed in a reasonable direction and is making progress toward the goal of being able to conduct a comprehensive assessment." Additionally, they are pleased with the efforts of the project to balance obtaining new data while mining for the "old" data that exists. The Panel also believes the SAC is moving in the right direction to develop a defensible and comprehensive impact assessment for Hanford, however, the rate of progress towards completing the assessment is dominated by factors outside the

control of the project (i.e. budgets). To move the project forward, the Expert Panel recommends higher level of DOE management must address the barriers. The Panel is also concerned that characterization efforts have been significantly reduced and the critical path to the comprehensive impact assessment may not lie with the SAC, but in characterization.

Integration with Cleanup Program

Hanford's vadose zone, groundwater, and Columbia River characterization work is being coordinated to ensure that data collection is optimized across the site. Data collection includes work relative to defining and predicting the inventory of existing and potential radiological and chemical releases to the environment, and the collection and interpretation of data from the vadose zone, groundwater, and Columbia River. Data quality objectives, which govern how data will be collected and used, are coordinated and planned for vadose zone, groundwater, and Columbia River characterization activities. The characterization activities are often operating under multiple and sometimes overlapping regulatory requirements including Resource Conservation and Recovery Act (RCRA), CERCLA, National Environmental Policy Act (NEPA), and Nuclear Regulatory Commission (NRC) requirements. The project is working with regulators and stakeholders to reach agreement relative to Hanford's "end state," document the regulatory drivers for key cleanup decisions, identify opportunities for regulatory integration, and identify key cleanup decisions that require assessment of cumulative impacts to the regional water resources.

Milestones

The following are the key near-term milestones for the GW/VZ project:

- S&T Input and VZ transport modeling to S-SX Tank Farm Report — October 2000
- Development of Hanford Features, Events, and Processes, Phase 1 — 1st qtr FY 2001
- Virtual Library, Phase 1 — 1st qtr FY 2001
- Development of Hanford Features, Events, and Processes, Phase 2 — 2nd qtr FY 2001
- SAC Rev. 0 Modeling Output — March 2001
- Install 15 RCRA groundwater wells beginning April 1, 2000 — April 30, 2001
- Identification of SAC Rev. 1 Requirements — FY 2002

VZ/GW PROJECT AT INEEL

The INEEL Long Range Plan led to the VZ/GW roadmapping effort. An objective of the roadmap is to develop and set the S&T agenda to verify the INEEL vadose zone cleanup and ensure the long-term stewardship of the site. Another objective of the project is to gain a thorough understanding of vadose zone and groundwater flow and transport and subsurface interactions at the Radioactive Waste

Management Complex (RWMC) and WAG 7. If the Department were to decide to leave the waste in place at Pit 9, or for that matter at the entire Subsurface Disposal Area at the RWMC, INEEL would need a sufficient understanding of the VZ/GW. This will be crucial in order to convince the regulators and the public of the rationale behind the Department's decision. The RA for Pit 9 and the final ROD for WAG 7 will be dependent on this knowledge.

The mission of the roadmap is to develop a long-term strategy for S&T aligned with site programs and site operations' schedules and needs. The INEEL vadose zone roadmap will be developed to determine the gaps in current knowledge and capabilities for the INEEL vadose zone, and to ensure that ongoing and planned S&T activities will meet INEEL needs in the coming years. The roadmapping effort began with the ER program and is currently being expanded to the other programs. Recommendations will be made for integrating research and technology development with ER, Waste Management (WM), Spent Nuclear Fuel (SNF), High-Level Waste (HLW), and stewardship projects at the INEEL to more effectively achieve programmatic goals. The INEEL VZ/GW project has completed preliminary identification of the core S&T programs and the technology insertion points (points in time when cleanup programs require S&T input) necessary to support ER scheduled milestones and field activities. This information has been reviewed by other program areas such as WM and SNF and the general consensus has been that the technology needs identified will support their programs as well. Efforts are currently underway to develop the technology insertion points and integrate these with the major programmatic milestones associated with the aforementioned programs. Full integration with programmatic baselines and detailed work plans is expected to be complete in Fiscal Year 2001.

Methodology

A VZ/GW roadmap should articulate the S&T investments required to support the understanding of the VZ/GW and site decisions affecting the VZ/GW. It should also:

- clarify drivers (operations, regulations, budget, planning, decisions, and end states)
- specify critical uncertainties
- outline S&T activities to reduce uncertainties
- set S&T priorities
- establish critical path and relationships among tasks

Given these needs, the first step in the development of the site-wide vadose zone roadmap was to gather information on the roadmap process and to hold discussions with other ongoing VZ/GW roadmapping projects. Initially several documents were reviewed prior to starting the roadmap development. These included:

- Introduction to Technology Roadmapping: The Semiconductor Industry Association's Technology Roadmapping Process, 1997, Sandia National Laboratories (SNL) Report SAND97-0666.
- Fundamentals of Technology Roadmapping, 1998, SNL Business Development Dept.

- Technology Roadmapping an Overview, a presentation by McNeil Technologies for the Complex-Wide Vadose Zone Roadmapping Project, 1999.
- Applying Technology Roadmapping in Environmental Management (draft), 2000, INEEL.

INEEL is in a unique position with regard to roadmapping their S&T needs. In addition to developing their own site-wide roadmap, INEEL is leading the efforts to complete the Department's complex-wide roadmaps. INEEL has hosted several meetings and workshops on a complex-wide roadmap. In addition to DOE-ID and INEEL, participants at the workshops have included staff from the Savannah River Site, the National Laboratories (Pacific Northwest, Lawrence Livermore, Los Alamos, Sandia, Lawrence Berkeley), U.S. Geological Survey, U.S. Departments of Defense and Agriculture, the Environmental Protection Agency, and numerous experts in GW/VZ research from academia and private sector companies. At these workshops, all sites benefit from the exchange of information and lessons learned. INEEL also initiated closer communications with the Hanford GW/VZ Integration Project personnel. In April 2000, EM - Headquarters, INEEL and Bechtel BWXT Idaho, LLC (BBWI) personnel met with Hanford GW/VZ Integration Project staff to discuss the Hanford project. In addition to these discussions, the staff also attended a NAS review of the Hanford roadmap. Because the Hanford GW/VZ roadmap is in the final stages of completion and the synergism between Pacific Northwest National Laboratory (PNNL) and INEEL on vadose zone and groundwater issues, it was determined to use the Hanford roadmap as the template for the INEEL roadmap. Further discussions have been, and will continue to be, held with the Hanford roadmapping personnel as the INEEL VZ/GW roadmap is developed.

Integration with Cleanup Program

The first step in the integration of the roadmap with the site programs was completion of the "*Deficiencies in Vadose Zone Understanding at the Idaho National Engineering and Environmental Laboratory"* document in August 2000. The document was developed to identify the deficiencies in the current understanding of vadose zone flow and transport processes at the INEEL and to provide recommendations to address the deficiencies. Identified deficiencies were prioritized and grouped into seven subject areas during a workshop in October 1999. The seven subject areas were further grouped into five subject areas and science plans were developed to address the deficiencies in these five areas. A document *Science Plans to Address Deficiencies in Vadose Zone Understanding at the INEEL* (draft - September 2000) provides a discussion of the five science plan tasks. The focus of the five science plans include: (1) spatial variability, (2) characterization and monitoring, (3) flow and transport modeling and physics of flow, (4) source term, and (5) geochemistry and microbiology. The objective of the science plans is to enhance INEEL understanding of vadose zone contaminant flow and transport, to advance the ability of INEEL to conduct environmental assessments, and to support the resulting remediation. Though the deficiencies and recommendations were developed specifically for vadose zone conditions at the INEEL, they are equally applicable to most vadose zone conditions, particularly fracture rock sites in arid and semiarid regions. Recommendations will be made for integrating research and technology development with INEEL ER, WM, HLW, SNF and stewardship projects to more effectively achieve programmatic goals and will also be included in their planning process.

The degree to which INEEL needs to understand the deficiencies (data quality objectives) and the insertion points (when cleanup programs require S&T input) is achieved via an iterative process during the development of the Remedial Investigation/Feasibility Study. Science and technology-based action plans will be developed based on the deficiencies and recommendations developed in the deficiencies document. However, INEEL needs to ensure that the S&T action plans do not drive the site programs. The data needs of the site programs, identified through the roadmapping process, should drive the S&T action plans.

Milestones

The following are the proposed key near-term milestones for the project:

- Issue Draft Roadmap for Peer Review 01/15/01
- Incorporate Internal Peer Review Comments 02/16/01
- Issue Draft Roadmap for External (NAS) Review 02/21/01
- Identify Coupled Process Science Needs - VZ Fate and Transport 03/30/01
- Incorporate Initial External Review Comments 05/15/01
- Issue Rev. 0 of Roadmap 08/15/01
- Uncertainty Risk Assessment Strategy 09/30/01

In addition to the near-term milestones the INEEL project has proposed five out-year goals: 1) By 2003, INEEL will quantify the uncertainty in current groundwater concentration predictions to support development of the Subsurface Disposal Area Pits and Trenches remedial design; 2) By 2006, the unacceptable uncertainty is expected to be reduced by one-third through development of technologies, research studies, and measurement techniques. This reduction in uncertainty will support development of the INTEC tank farm soils remedial design; 3) By 2012, INEEL plans to reduce the remaining unacceptable uncertainty by another one-third to support closure of the INTEC tank farms; 4) By 2020, the remaining unacceptable uncertainty would be reduced by another one-sixth. It is expected that it will be significantly more difficult and will take longer to reduce the final third of the unacceptable uncertainty than reducing the first two-thirds; and 5) The final proposed out-year goal is to eliminate all unacceptable uncertainty (the remaining one-sixth) by 2030. This will support closure of the CERCLA Disposal Facility and allow 20 years of concentration measurements before the earliest predicted closure date for INEEL.

EVALUATION

Similarities and differences are apparent when one compares the Hanford and INEEL projects, however, this is not to say that one project or the other is the "right one". Overall, INEEL can continue to benefit from the Hanford project due to the maturity of the GW/VZ roadmapping activities at Hanford. On the other hand, the amount of progress the INEEL project has made in a relatively short period of time is impressive when compared to Hanford. This is most likely due to two factors. One is the different regulatory environments between the two sites (discussed earlier in this paper); INEEL had most of the RODs and RAs already in place whereas Hanford's are years out in the future. The second

reason is the communication and interactions INEEL has had with Hanford. INEEL has benefited from lessons learned at Hanford and the addition of key staff who previously had worked at PNNL on the Hanford project.

In addition to the different regulatory environments, there are differences in the project management organizational structure at each site. Hanford established the Groundwater/Vadose Zone Project Office within the Office of the Assistant Manager for Planning and Integration. The GW/VZ Project Office manages, coordinates, and oversees all GW/VZ activities at the Hanford site. DOE-ID has not established a stand-alone office or team with the sole responsibility of managing the site's VZ/GW efforts. Instead there appears to be a shared responsibility between the ER Division, within the Office of the Assistant Manager for EM, and the Office of Chief Scientist. The Office of Chief Scientist is clearly responsible for leading the Department's complex-wide roadmapping efforts, but is also involved with the site-wide effort of the ER Division. This relationship facilitates the ER Division's site-wide efforts of interacting and communicating with the other programs on site (WM, SNF, HLW, etc.).

The other difference between the projects is the level of funding each receives. The Hanford GW/VZ project received over $55 million in FY 2000. This includes $34 million for the core projects, or fieldwork, and $10 million from the EM Science Program. If the funding for these two activities is not included, the FY 2000 funds for the Integration Project are still in excess of $11 million. These funds are for the SAC, S&T, technical review, public involvement and integration of information. The INEEL project was funded at $400,000 in FY 2000. The FY 2000 funds were for development of the roadmap, and completion of the deficiencies document and the science plans.

There are several reasons for this cost difference. One is the relative maturity of the projects. Hanford's project has been established for a longer period and has grown over the years. Another reason for the discrepancy may be due to project organization and management, and hence how costs are reported and collected. Instead of all VZ/GW activities controlled by one office, it is possible that some costs associated with INEEL's VZ/GW project are actually incurred by another office. If INEEL incurred any costs for other "support" activities (technical review, public involvement) the project cost would be slightly higher. The most likely reason for the cost discrepancy is the mission of the project at each site. As discussed earlier Hanford is using the project to help make, or at least influence, future decisions, whereas at INEEL most of the decisions have already been made.

RECOMMENDATIONS

- Both Hanford and INEEL should continue to coordinate and share lessons learned, particularly during the early stages so INEEL can benefit from the maturity of the Hanford project.
- During FY 2001 an independent panel of prominent experts (i.e., NAS, Independent Expert, or Peer Review Panel) should begin to technically review the INEEL project.
- INEEL should engage their regulators and stakeholders (i.e., tribes and communities) early to discuss the roadmapping effort and to obtain their buy-in. Additionally, EPA Region X should be encouraged to communicate with both Hanford and INEEL so a uniform regulatory approached is achieved. However, INEEL should first gain a better understanding of the process Hanford has

used to work with regulators and stakeholders since DOE/ID staff indicated their regulators would not be supportive of the roadmapping effort as funds should only be expended on compliance activities.

- To continue to aggressively move the INEEL activities forward and obtain regulator and stakeholder buy-in, DOE/ID should seriously consider establishing a stand alone office or team to manage the VZ/GW project and manage all costs related to the project.

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REFERENCES

The information in this paper is based upon meetings and discussions with DOE and contractor staff at headquarters, Hanford and INEEL, and personal observations and experience. Also, information was obtained from presentations and reports by the Hanford Independent Expert Panel and NAS reviews. Some portions of this paper have been taken from the below references:

1. *Groundwater/Vadose Zone Integration Project Summary Description*, DOE/RL-98-48
2. *Semi-Annual Report, October 1999 - March 2000*, Hanford Site Groundwater/Vadose Zone Integration Project, May 2000
3. *Development of the INEEL Site-Wide Vadose Zone Roadmap* (Draft)
4. *Deficiencies in Vadose Zone Understanding at the Idaho National Engineering and Environmental Laboratory*, INEEL/EXT-99-00984, August 2000
5. *Science Plans to Address Deficiencies in Vadose Zone Understanding at the INEEL (Draft) INEEL/EXT-2000-01086, September 2000*