U.S. Department of Energy
Office of Inspector General
Office of Audit Services

Audit Report

Groundwater Remediation Activities at Hanford

DOE/IG-0655

July 2004

Department of Energy

Washington, DC 20585

July 22, 2004

MEMORANDUM FOR THE SECRETARY

FROM: Gregory H. Friedman
Inspector General

SUBJECT: INFORMATION: Audit Report on "Groundwater Remediation Activities at Hanford"

BACKGROUND

Fifty years of defense production has resulted in significant subsurface contamination at the Department of Energy's Hanford Site. An estimated 450 billion gallons of liquid waste, some containing radionuclides and hazardous chemicals, have been released to the ground at Hanford since 1944. Much of the contamination remains above the groundwater in the vadose zone, the region between the land surface and underlying groundwater, but some has reached Hanford's groundwater. The Richland Operations Office estimated that 80 square miles of Hanford's groundwater had contaminant levels greater than Federal and State drinking water standards. Although groundwater at Hanford is not a primary source of drinking water, it does eventually flow into the Columbia River, a major drinking water source for a significant section of the Northwest.

The goals of current groundwater remediation activities at Hanford are to minimize the adverse impact to groundwater from contaminants, protect the Columbia River, and restore groundwater beneath the site to drinking water standards. In an effort to meet these goals, five pump-and-treat systems were installed at Hanford in 1995 as interim groundwater remediation measures. These systems are designed to pump contaminated groundwater out of the subsurface, treat the groundwater to remove contamination, and return the clean water to the subsurface. The objective of our audit was to determine if pump-and-treat systems were effective at remediating the Hanford Site's groundwater.

RESULTS OF AUDIT

The audit disclosed that the Department had not made significant progress in its efforts to remediate Hanford's groundwater and that pump-and-treat systems installed for this purpose have been largely ineffective. Specifically, contaminants have been:

- Bonding with sediments in the groundwater making them difficult to extract and treat;
- Migrating through the groundwater leaving the wells improperly positioned;

- Continuing to taint the groundwater through untreated sources; and,

- Leaching directly into the Columbia River without being processed.

In addition, Richland plans to install surface barriers as a final remediation action for groundwater in certain areas of the site. Based on concerns expressed by stakeholders and a yet undefined "end-state" for groundwater at Hanford, such barriers may be inappropriate.

Several factors have inhibited the implementation of an effective groundwater program at Hanford. In particular, Richland has not initiated discussion with regulators on an acceptable end-state for groundwater, Records of Decision requiring the operation of the pump-and-treat systems have not been modified, and the development and deployment of new remediation technologies has not been emphasized. As a result, Richland risks the further contamination of groundwater and the continued expenditure of funds on a largely ineffective technology. Also, more than $230 million is scheduled to be spent on surface barriers that may be inconsistent with the end-state developed for Hanford's groundwater.

At the close of our audit, we were informed that the Office of Environmental Management, in conjunction with the Army Corps of Engineers, had recently undertaken an independent technical review of the groundwater remediation program at Hanford. The results of that review, in conjunction with the recommendations contained in this report, should be beneficial in identifying specific steps necessary to improve the groundwater remediation program.

MANAGEMENT REACTION

The Assistant Secretary for Environmental Management (EM) generally concurred with the recommendations and stated that the recommendations are consistent with the Department's current actions. EM's comments are summarized beginning on page 4 of the report and are included as Appendix 3.

Attachment

cc: Deputy Secretary
Under Secretary for Energy, Science and Environment
Acting Assistant Secretary for Environmental Management

REPORT ON GROUNDWATER REMEDIATION ACTIVITIES AT HANFORD

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Groundwater Remediation Activities

The audit disclosed that the Department of Energy (Energy) has not made significant progress in its efforts to remediate the Hanford Site's (Hanford) groundwater and that the pump-and-treat systems installed for this purpose have been largely ineffective. In addition, the Richland Operations Office (Richland) plans to install surface barriers as a final remediation action for groundwater in certain areas of the site. However, this action may be inappropriate because an "end-state" has yet to be defined for groundwater at Hanford.

Pump-and-Treat Systems

In 1995, as part of an agreement with the U.S. Environmental Protection Agency and the Washington State Department of Ecology, Richland installed five pump-and-treat systems to treat radiological and chemical contaminants in the groundwater. Since that time, none of the five systems have made significant progress in remediating groundwater. Despite the limited results, the systems continue to operate.

The first pump-and-treat system, originally installed to remove strontium-90 from the groundwater, was constructed in Hanford's 100-N Area. From 1995 to 2002, the pump-and-treat system removed only 1.3 curies of strontium-90. Over the same time period, 319.3 curies of the contaminant naturally decayed in the groundwater. Prior to its installation, an independent expert panel determined that significant reductions in concentrations of strontium-90 using a pump-and-treat system would be difficult to obtain. Specifically, they found that strontium-90 is particularly difficult to treat because the contaminant bonds with sediments in the groundwater making it hard to extract. While the treatment of the strontium-90 has resulted in little progress, the "pump" portion of the system may have been useful in keeping the strontium-90 away from the Columbia River, a key protective goal of the Interim Remedial Action Record of Decision (ROD) for this area.

A second pump-and-treat system, designed to remediate groundwater contaminated with carbon tetrachloride, is also not operating effectively. Since this system first became operational in 1995, the contaminant it was designed to mitigate has migrated away from the treatment zone. As a result, the wells are no longer properly positioned to capture the highest concentration of contamination. Further, a significant amount of carbon tetrachloride still remains in the groundwater and the vadose zone. The source of this contamination is unknown. As acknowledged in *Hanford's Groundwater Management Plan* (Groundwater Plan),

dated 2003, years of pump-and-treat operations have produced little change in groundwater concentrations of carbon tetrachloride.

Another pump-and-treat system, designed to remediate groundwater contaminated with uranium and technetium-99, has achieved mixed results. Due to the fact that technetium-99 is a highly mobile radioactive contaminant, it appears the pump-and-treat system may effectively remediate this contaminant. However, uranium, much like strontium-90, binds to sediments in the groundwater making it difficult to extract, and the pump-and-treat system has not been effective at removing it.

Finally, two other pump-and-treat systems, designed to remediate groundwater contaminated with chromium in the 100-Area, have also not been entirely successful. According to the Groundwater Plan, one of these systems will experience marginal success until the primary sources responsible for the chromium contamination are remediated. Further, the other 100-Area pump-and-treat system may not be entirely effective. Even though Richland considers this system their most successful pump-and-treat operation and expects to reach the remedial action objective by 2006, it may not be preventing or slowing the migration of contaminated groundwater to the Columbia River. According to the *Calendar Year 2002 Annual Summary Report for the 100-HR-3, 100-KR-4, and 100-NR-2 Operable Unit Pump-and-Treat Operations*, contaminant concentrations are increasing in monitoring wells close to the Columbia River, outside the expanded capture zone of the system.

The National Research Council (Council) had similar findings related to the pump-and-treat systems used at many Departmental sites. They reported that, of the 77 contaminated sites using pump-and-treat systems, only 8 had achieved cleanup goals. Richland acknowledged problems comparable to those reported by the Council in its *2001 Hanford Site Cleanup Challenges and Opportunities for Science and Technology*; and, specifically, that pump-and-treat systems have not been entirely effective at reducing contamination levels in the groundwater to regulatory limits. Further, the report stated that indefinite operation of existing pump-and-treat systems adds costs to the program while providing only limited benefits.

Surface Barriers

Richland has developed plans to install surface barriers as a final remediation action for groundwater in certain areas of the site. A surface barrier is a cap consisting of layers such as sand, gravel, and soil designed to reduce or eliminate leaching of contamination to groundwater. Richland has provided incentives to one of its contractors to install the surface barriers at two of the four high-risk waste sites because it considers this an appropriate end-state for the groundwater beneath these waste sites and plans to monitor these areas once the barriers are installed. However, regulators were not consulted prior to the decision being made and have not agreed at this time that surface barriers are an appropriate end-state. Additionally, stakeholders have expressed concern that the Department's surface barrier plans represent only a partial solution for near surface contaminants and do not provide a remedy for deep vadose zone contamination.

Replacement Technology and Incentives

Several factors have contributed to the lack of significant progress in remediating contaminated groundwater at Hanford. Despite the requirements of Departmental Policy 455.1, *Use of Risk-Based End Sates*, the Department has not moved to formulate risk-based end-states with the cooperation of regulators, affected governments, Tribal nations, and other stakeholders. Current unsuccessful efforts to remediate the groundwater will likely continue unless Richland initiates the discussions with the regulators with a view toward developing an acceptable end-state for the groundwater. Similarly, RODs between the Department, the U.S. Environmental Protection Agency, and the Washington State Department of Ecology currently require Richland to continue to operate the pump-and-treat systems until they are modified through negotiations.

In addition, new technologies have not been developed to achieve groundwater remediation requirements at a reasonable cost. The *Hanford Site Cleanup Challenges and Opportunities for Science and Technology* concluded that developing innovative groundwater remediation technologies and solutions represent an urgent cleanup challenge and a key science and technology need for the site. Likewise, the Council reported that new technologies are needed to enable the Department to achieve groundwater remediation requirements at a reasonable cost. The Council added that the Department faces the challenge of cleaning up significant amounts of contaminated groundwater and soil with only baseline

technologies that are not adequate for the job. Stakeholders and regulators also agree that groundwater remediation advances are urgently needed.

Despite the recognition that more effective technologies are needed, there has not been an emphasis on developing and deploying new groundwater technologies. The Environmental Management Science Program (Science Program) has traditionally funded research in subsurface sciences, which included work in the vadose zone and groundwater. However, the Science Program was transferred from the Office of Environmental Management (EM) to the Office of Science in Fiscal Year 2003. The Office of Science has historically been involved only in basic research, rather than the deployment of new technologies. According to the Office of Core Technical Group within EM, the type of technologies needed to solve groundwater contamination issues will require significant efforts beyond the current scope of the Office of Science's basic research grants. In addition, officials in the Office of Science indicated that the budget for the Science Program is declining.

Public Health Risks and Costs

As a result, Richland continues to expend funds on technology methods that have been demonstrated to be largely ineffective. The Department has spent more than $85 million over the last eight years and will continue to spend approximately $8 million a year to operate pump-and-treat systems that are not effectively remediating Hanford's groundwater. Also, more than $230 million is scheduled to be expended on surface barriers that may be inconsistent with a yet to be determined end-state for Hanford's groundwater. The costs to operate these interim systems will continue until an end-state is established and a final remediation technology is identified. Lastly, until a final groundwater remediation technology is identified, Richland lacks a firm cost estimate for final remediation and closure of the Hanford Site.

RECOMMENDATIONS

We recommend that the Assistant Secretary for Environmental Management:

1. Direct Richland to initiate discussions with regulators and stakeholders to establish an end-state for Hanford's groundwater;

2. In coordination with regulators and stakeholders, initiate actions to shut down the ineffective portion of the strontium-90 pump-and-treat system;

3. Suspend plans and associated contractor incentives to install surface barriers until end-states for groundwater have been established;

4. Establish operational goals for the remaining four pump-and-treat systems consistent with an established end-state for groundwater; and,

5. Work with the Office of Science to provide solutions for developing and ultimately deploying new groundwater remediation technologies.

MANAGEMENT REACTION

The Assistant Secretary for Environmental Management (EM) generally concurred with the recommendations and stated that many of the recommendations are consistent with the Department's current actions. Regarding recommendation 3, EM stated that, while there are no current plans to install surface barriers, any future plans or incentives for contractor installed groundwater contamination barriers will be consistent with the established groundwater end-state and will be fully evaluated as part of the CERCLA and RCRA process.

AUDITOR COMMENTS

We consider management's comments, included in their entirety in Appendix 3, to be responsive to the report's recommendations.

Although EM indicated that there were no current plans to install surface barriers specifically for groundwater remediation, we noted that incentives were already in place to install other surface barriers that may be inconsistent with end-states.

Appendix 1

OBJECTIVE

The objective of the audit was to determine if pump-and-treat systems were effective at remediating the Hanford Site's groundwater.

SCOPE

We conducted the audit from September 2003 to April 2004, at the Hanford Site in Richland, Washington. The scope of the audit covered the Department's pump-and-treat groundwater remediation systems and plans to install surface barriers.

METHODOLOGY

To accomplish the audit objective, we:

- Obtained and reviewed planning documents for Groundwater Protection Program activities;
- Researched Federal and Departmental regulations;
- Reviewed findings from prior audit reports regarding the Groundwater Protection Program;
- Reviewed the Fluor Hanford, Inc. contract with the Richland Operations Office;
- Assessed internal controls and performance measures established under the *Government Performance and Results Act of 1993*; and,
- Interviewed key personnel in the Richland Operations Office, Office of Science, and the Office of Environmental Management.

The audit was conducted in accordance with generally accepted Government auditing standards for performance audits and included tests of internal controls and compliance with laws and regulations to the extent necessary to satisfy the audit objective. We assessed internal controls established under the Government Performance and Results Act of 1993 related to Richland's Groundwater Protection Program activities at the Hanford Site. Because our review was limited, it would not necessarily have disclosed all internal control deficiencies that may have existed at the time of our audit. We did not conduct a reliability assessment of computer-processed data because we did not consider such data critical to achieving our audit objective. Management waived the exit conference.

PRIOR AUDIT REPORTS

Office of Inspector General Reports

- *Groundwater Monitoring Activities at Department of Energy Facilities* (DOE/IG-0461, February 2000). The audit disclosed that some Departmental sites had not adopted innovative technologies and approaches to groundwater monitoring. Groundwater monitoring activities were not being conducted as economically as possible. As a result, opportunities to reduce operating costs by about $3.6 million annually and to improve groundwater monitoring efficiencies were not realized.

- *Audit of Groundwater Monitoring at Hanford* (WR-B-97-03, November 1996). The audit showed that while Richland's groundwater monitoring program was mission essential, it was not performed at the least cost to the Department. Work performed by the three principle contractors overlapped, resulting in duplicative groundwater monitoring activities. Because of duplicative efforts, the Department spent at least $700,000 in Fiscal Years 1995 and 1996 more than it should have and could save at least $500,000 annually by implementing action to ensure coordination of contractor's work for Hanford groundwater monitoring.

- *Groundwater Remediation Plans at the Savannah River Site* (ER-B-96-02, June 1996). The audit found that the Savannah River Operations Office entered into several agreements with Federal and State regulators to decrease groundwater contamination to levels that would allow a hypothetical future resident to someday live above and drink the groundwater. Basing the agreements on drinking water standards was unreasonable because no one will likely live above these areas or drink the groundwater. Drinking water standards were included in the planning process because Savannah River had not developed a Land Use Plan that would permit rational decision making for the entire site. Consequently, Savannah River may continue to pursue expensive remediation projects for longer than would be necessary to protect human health and the environment under less stringent scenarios.

National Academy of Sciences Reports

- *Groundwater and Soil Cleanup: Improving Management of Persistent Contaminants* (report number 0309065496; 1999). Assessing DOE's groundwater and soil cleanup progress is difficult due to data limitations, conflicting terminology, and lack of an agreed-upon metric for measuring success. Pump-and-treat systems, the conventional method for cleaning up contaminated groundwater, are often ineffective in restoring contaminated groundwater to regulatory standards. Recent DOE budget projections have indicated that most groundwater at DOE sites will not be cleaned up; however, federal law requires groundwater cleanup, and political pressure to meet the Federal requirements continues. Further, effective technologies for treating many common groundwater and soil contaminants at DOE facilities do not exist. Adequate funding for groundwater science and technology is not being provided.

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United States Government **Department of Energy**

Memorandum

DATE: June 29, 2004

REPLY TO ATTN OF: EM-21 (Paul Beam, 301-903-8133)

SUBJECT: Response to Office of Inspector General on Draft Report on Ground Water Remediation Activities at Hanford

TO: Rickey R. Hass, Assistant Inspector General for Audit Services, Office of Inspector General

Thank you for your draft report on ground water remediation activities at Hanford dated May 27, 2004. Your comments will be helpful in effective completion of ground water remediation activities at the site. Attached are specific comments on the draft report for your consideration in development of the final report.

Many of your recommendations are consistent with our current actions, and I offer the following summary comments to the draft report numbered recommendations:

1. Direct Richland to initiate discussions with regulators and stakeholders to establish an end-state of Hanford's groundwater.

   Agree: Discussions with regulators and stakeholders are necessary to establish an end-state for ground water at Hanford. However, an end-state for ground water must be consistent with the end-state for the site. In accordance with the Department of Energy's (DOE) policy on Risk Based End States (RBES), DOE-Richland (RL) initiated end-state discussion with regulators and stakeholders in January 2004 and is continuing discussions to establish a RBES vision for the entire site. Once that vision is completed, ground water remediation decisions will be developed with the regulators as part of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) process.

2. In coordination with regulators and stakeholders, initiate actions to shut down the ineffective portion of the strontium-90 pump-and-treat system.

   Agree: The strontium-90 pump and treat system has not been effective. This system was installed to comply with a formal order from the Washington State Department of Ecology. In accordance with the current interim Record of Decision (ROD), the Office of Environmental Management (EM) will begin a treatability study for the alternatives this fall which will include suspending the pump-and-treat operations and implementing a field scale demonstration of the alternatives to pump-and-treat.

Operational goals for the remaining pump-and-treat systems, if part of a final remediation strategy, will be consistent with the established ground water end-state being developed as a part of the RBES development for Hanford.

3. Suspend plans and associated contractor incentives to install surface barriers until end-states for groundwater have been established.

   Partially Agree: While there are no current plans to install surface barriers, barriers discussed in the Office of Inspector General's draft report are likely to be part of the overall strategy for dealing with the waste sites on the Central Plateau and will be consistent with the ground water end-state established for the site. As such, any future plans and incentives for contractor installed ground water contamination barriers will be consistent with the established ground water end-state and will be fully evaluated as part of the CERCLA and RCRA process.

4. Establish operational goals for the remaining four pump-and-treat systems consistent with established end-state for groundwater.

   Agree: See response to recommendation 2.

5. Work with the Office of Science to provide solutions for developing and ultimately deploying new groundwater remediation technologies

   Agree: As part of the Ground Water Protection Project, considerable effort has been expended in technology development efforts to evaluate alternative remediation technologies and the characteristics and mobility of the contaminants of concern (carbon tetrachloride, technetium 99, uranium and chromium) so that effective and well-founded end-state decisions can be made for remediating the ground water. EM has and will continue to pursue development and deployment of new ground water remediation technologies with the Office of Science.

If you have any further questions, please call me at (202) 586-7709 or Mr. Eugene C. Schmitt, Deputy Assistant Secretary for Environmental Cleanup and Acceleration, at (202) 586-0755.

Jessie Hill Roberson
Assistant Secretary for
Environmental Management

Attachment

cc: Joni Boone, EM-33

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