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Report to the Chairman and Ranking Minority Member, Subcommittee on Energy and Water Development and Related Agencies, Committee on Appropriations, House of Representatives

August 2006

NUCLEAR WASTE

DOE's Efforts to Protect the Columbia River from Contamination Could Be Further Strengthened

GAO-06-1018

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GAO Accountability·Integrity·Reliability

Highlights

Highlights of GAO-06-1018, a report to Chairman and Ranking Minority Member, Subcommittee on Energy and Water Development and Related Agencies, Committee on Appropriations, House of Representatives

Why GAO Did This Study

DOE's Hanford site in Washington State is one of the most contaminated nuclear waste sites in North America. The Columbia River flows through about 50 miles of the site. Radioactive and hazardous contamination from decades of producing nuclear materials for the nation's defense have migrated through the soil into the groundwater, which generally flows toward the river.

In November 2005, GAO reported on the potential for the Hanford site to contaminate the Columbia River. To address continuing concerns, GAO reviewed the status of DOE's efforts to (1) understand the risk to the Columbia River from Hanford site contamination and to deploy effective technologies to address contamination near the river and (2) strengthen the management of its river protection program. To assess DOE's efforts, GAO reviewed numerous reports by DOE and others, and discussed the problem with federal and state regulators and DOE officials.

What GAO Recommends

To increase the likelihood that DOE will effectively implement and sustain improvements in its program to protect the Columbia River from contamination, GAO recommends that the Secretary of Energy establish results-oriented performance measures and regular evaluations to gauge the improvements' effectiveness. DOE agreed with our recommendation.

www.gao.gov/cgi-bin/getrpt?GAO-06-1018.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Gene Aloise at (202) 512-3841 or aloisee@gao.gov.

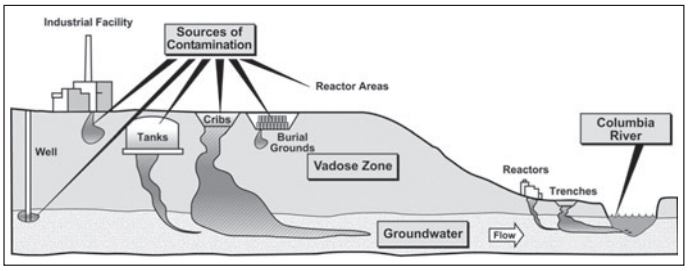
What GAO Found

The Department of Energy (DOE) is actively assessing the risk to the Columbia River from Hanford site contamination and is addressing problems with deployed river protection technologies. While DOE has extensive knowledge of contaminants that are currently in the groundwater and river, DOE knows less about contamination in the soil below the surface, known as the "vadose zone." Before proposing a cleanup approach, DOE has agreed with its regulators to take vadose zone samples in many of the contaminated areas of the site. DOE is also improving its computer simulation model that will predict future risk from the contamination, and deploying alternative technologies it believes will more effectively contain the contamination that may threaten the river.

DOE has also begun to address concerns about its management of Columbia River protection efforts, particularly the lack of integration between groundwater and vadose zone activities. In March 2006, in response to congressional committee direction, DOE proposed a new initiative to better integrate its river protection activities. The initiative included consolidating most groundwater and vadose zone characterization work under a single project; better integrating vadose zone, groundwater, and surface cleanup decisions; and improving the coordination and control over computer models used to predict movement of contamination in future years.

Initiating these management improvements is important, but it is equally important that they be implemented effectively, and past history gives some cause for concern. For example, one attempt by DOE to better integrate these activities was unsuccessful when key elements, such as putting all activities under a single project manager, failed to continue after project and other changes occurred at the site. In past GAO work, we reported that high-performing organizations sustained improvement initiatives when key elements were in place, such as clear goals, results-oriented performance measures, and evaluation strategies. Although DOE is beginning to develop a management plan for its new initiative, DOE has yet to implement some key elements, such as results-oriented performance measures and evaluations to gauge the effectiveness of its improvements, which could also help sustain the benefits of the improvements over time.

Contamination of the Columbia River from DOE's Hanford Site



Source: DOE.

Contents

Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
EPA	Environmental Protection Agency
PNNL	Pacific Northwest National Laboratory
RCRA	Resource Conservation and Recovery Act

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Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

August 28, 2006

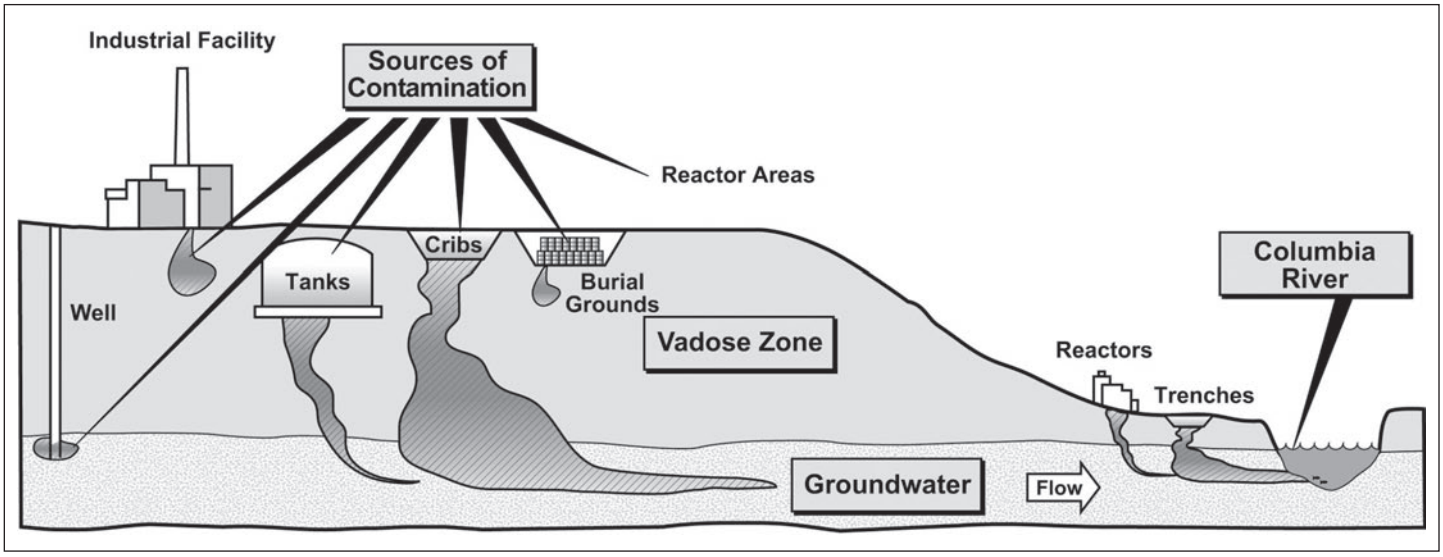
The Honorable David L. Hobson
Chairman
The Honorable Peter J. Visclosky
Ranking Minority Member
Subcommittee on Energy and Water Development
and Related Agencies
Committee on Appropriations
House of Representatives

The Department of Energy's (DOE) Hanford site in southeastern Washington State is one of the most contaminated nuclear waste sites in North America. The site occupies 586 square miles upriver from the cities of Richland, Pasco, and Kennewick, with a combined regional population of over 200,000. During Hanford's production era, beginning in 1943, nine nuclear reactors were built at the site to produce nuclear materials, especially plutonium, for the nation's defense. The site was selected, in part, because the Columbia River, the nation's second largest river by volume, flows through almost 50 miles of it; the river water was used to cool nuclear reactors and support nuclear materials processing operations. During operations from 1943 to 1989, activity at the reactors and other facilities also generated large volumes of hazardous and radioactive waste. Some of this waste was deposited directly into the ground in trenches, injection wells, or other facilities designed to allow the waste to disperse into the soil; some was packaged into drums and other containers and buried; and some was stored in 177 large underground tanks.

Over time, concern has developed about the impact of Hanford's radioactive and hazardous waste moving through the groundwater toward the Columbia River. The river is a source of hydropower production, irrigation for agriculture, and drinking water for downstream communities, as well as a major route for migrating salmon. Besides the waste intentionally discharged directly into the ground during the time of reactor operations, DOE has assumed, based on monitoring data and other techniques used to detect contamination, that 67 of the underground tanks, some burial grounds, and other waste disposal areas have also leaked contamination into the soil. Contamination could also result from accidental spills during ongoing cleanup activities. Much of this hazardous and radioactive waste can be borne by water through the soil into the

groundwater. While Hanford is a near-desert location with limited rainfall and, in many areas, thick layers of soil and rock above the groundwater, water from precipitation and other sources moves through these layers into the groundwater. The groundwater moves in the general direction of the river. In the center of the site the groundwater is more than 200 feet below the surface, but at the river the groundwater is at or near the river level. As figure 1 illustrates, the movement of this contaminated liquid through the "vadose zone"—the span of soil and rock between the surface and the groundwater beneath—can result in contamination "plumes" extending downward and outward from their sources. When these contamination plumes reach the groundwater, the contamination they contain enters the groundwater and begins flowing toward the river.

Figure 1: Sources of Contamination of the Columbia River from DOE's Hanford Site



Source: DOE.

The extent to which contamination from the Hanford site has threatened, or will threaten, the Columbia River, is not fully understood. While some contamination has already reached the river, DOE has found that it is barely detectable because the high volume of water dilutes it. DOE routinely monitors the river's water quality, which currently meets federal drinking water standards at sampling locations immediately down river from the Hanford site. However, studies also show that contamination has been found in some river life, including clams found near the shore. In addition, the rate at which contamination in the vadose zone and

groundwater may migrate to the river in future years is uncertain, and depends on the effectiveness of site cleanup activities. However, migrating contamination may continue to enter the river in the foreseeable future.

Since the early 1990s, DOE has shifted its efforts at the Hanford site from production of nuclear materials to cleaning up the contamination and other materials left over from the production era. DOE carries out its cleanup activities primarily under the requirements of two environmental laws: (1) the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA); and (2) the Resource Conservation and Recovery Act of 1976, as amended (RCRA). Milestones for completing each step of the cleanup process are specified in a legally binding agreement (commonly known as the Tri-Party Agreement) between DOE and its regulators—the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology.[1] Under the Tri-Party Agreement, DOE must complete remediation of most of the site's soil and groundwater by September 2024. DOE's goal is to complete all cleanup work at the Hanford site by 2035.

The Tri-Party Agreement incorporates the requirements of federal environmental laws and guides the process under which DOE will analyze the contamination and consider remedies, which DOE's regulators must approve.[2] First, DOE must conduct a remedial investigation, in which it carries out field sampling and laboratory analyses to determine the nature and extent of contamination. DOE is then required to conduct a feasibility study to develop and screen an initial list of remedial alternatives. After obtaining additional data, as necessary, DOE must analyze various remedial alternatives and select a preferred remedy. The determination of the preferred remedy is to be based on, among other things, whether a remedial alternative protects human health and the environment, as well as whether it attains cleanup standards that are legally applicable or otherwise relevant and appropriate, including state laws. For example, DOE and its regulators have determined that the Safe Drinking Water Act[3]

[1]Formally titled the Hanford Federal Facility Agreement and Consent Order, it was signed in May 1989 and has been amended numerous times since then.

[2]Some Hanford cleanup activities are conducted under the requirements of CERCLA, while others are conducted under RCRA. Though the terminology used to describe cleanup requirements under the two laws differs, the processes generally are functionally equivalent. In this report we use the terminology of the CERCLA program.

[3]42 U.S.C. §§ 300f — 300j-26.

provides standards for many of the contaminants in the soil and groundwater at Hanford. In addition, DOE must consider seven other criteria in selecting a remedial approach, including the cost effectiveness of the remedy, its long-term protectiveness of human health and the environment, and community acceptance. Currently, DOE is required by the Tri-Party Agreement to meet a deadline of December 2008 to select preferred remedial alternatives for 57 separate waste management areas of the site—known as operable units.[4]

After DOE selects a preferred remedial alternative, the lead regulatory agency—either EPA or the state of Washington—prepares a Record of Decision[5] that selects the final remedy. A Record of Decision generally describes, among other things, (1) the key contaminants present in the specific waste management area, (2) the contamination limits DOE must achieve for each key contaminant, (3) the time frame in which the cleanup goals will be achieved, and (4) the technologies to be used to address the contamination. In general, if contaminants remain at the site as part of the final remedy, DOE and its regulators are required to review the remedial action every 5 years to determine whether the selected treatment technology is effective in protecting human health and the environment.

DOE's cleanup program at the Hanford site is aimed, in part, at protecting the Columbia River from contamination, now and in the future. Many of the river protection activities treat contamination before it enters the vadose zone or groundwater, and we have reported on several of these activities.[6] Regarding DOE's efforts to address contamination in the vadose

[4]The Hanford site is divided into 57 different operable units. These operable units are divided into source operable units—covering areas such as contamination in buildings, soils, and burial grounds—and groundwater operable units. Forty-seven source operable units address contamination in the soils and vadose zone, and ten groundwater operable units address contamination in the groundwater. As of July 2006, field investigations for one groundwater operable unit had been completed.

[5]Under CERCLA, DOE must prepare a Record of Decision. Under RCRA, DOE prepares a Corrective Measures Study. For either, DOE generally provides the same information about extent and nature of contaminants, and proposed remedies.

[6]See, for example, GAO, *Hanford Waste Treatment Plant: Contractor and DOE Management Problems Have Led to Higher Costs, Construction Delays, and Safety Concerns*, GAO-06-602T (Washington, D.C.: Apr. 6, 2006); GAO, *Nuclear Waste: Absence of Key Management Reforms on Hanford's Cleanup Project Adds to Challenges of Achieving Cost and Schedule Goals*, GAO-04-611 (Washington, D.C.: June 9, 2004); GAO, *Nuclear Waste: Challenges to Achieving Potential Savings in DOE's High-Level Waste Cleanup Program*, GAO-03-593 (Washington, D.C.: June 17, 2003).

zone and groundwater, DOE has prioritized the work to first address threats from contaminated sites located near the river or requiring immediate action, and then address threats from contaminated sites that are farther away from the river's edge.

DOE's effort to address contamination near the river include actively removing waste, old buildings, and contaminated soil to reduce contaminants that could migrate—known as the river corridor project—and treating the groundwater to prevent contaminants from further migrating. DOE has three main approaches to treating the groundwater:

- *Pump-and-treat.* With this approach, DOE uses wells to extract contaminated groundwater, treats the groundwater in above-ground facilities, and reinjects the treated water into the ground. Since 1995, DOE has operated five pump-and-treat systems to remove strontium-90, chromium, carbon tetrachloride, and uranium from the groundwater. Four of these are intended to address near-river contamination of strontium-90 and chromium.

- *Chemical treatment.* This approach has been used in one instance. DOE uses a chemical barrier near the Columbia River to block chromium from entering the river near major salmon breeding areas.[7] The barrier consists of a 750-yard series of wells through which DOE injected a chemical into the groundwater; the chemical reacts with the chromium to change it to a less hazardous and less mobile form.

- *Natural attenuation.* This approach relies on subsurface processes such as dilution, adsorption, and chemical reactions with subsurface materials to reduce contaminant concentrations to acceptable levels. For example, a large uranium plume in the groundwater is entering the river about 4 miles above city drinking water intakes. In 1996, DOE and its regulators agreed to allow the plume to dissipate through natural attenuation.

DOE's efforts to address contamination threats that are farther from the river have involved four main types of actions:

- Characterizing the vadose zone and groundwater through sampling and other studies to help understand the risks from movement of contamination.

[7]Chromium is toxic to fish.

- Removing high-risk material from contaminated sites and/or covering the surface of the disposal area with a barrier to prevent water intrusion.

- Decommissioning (by removing or sealing) a portion of the 7,000 wells used to monitor groundwater and the vadose zone, and for other purposes, that are no longer needed. Monitoring wells are important, but they can also contribute to pollution by serving as conduits for rain, snow melt, or other liquids to flush contaminants through the vadose zone and into the groundwater.

- Reducing water intrusion from leaking pipelines and surface drainage that can drive contamination from the vadose zone to the groundwater.

DOE also monitors groundwater conditions and uses information about the nature and extent of contamination in the groundwater—and its migration toward the river—to assess current and future risks to the public and the environment. While current levels of contamination can be determined by sampling the river, soil, and groundwater, DOE uses computer models to predict how existing and future contamination from site cleanup and disposal activities will impact the river over the next 1,000 to 10,000 years.

In November 2005, we reported on the potential for Columbia River contamination from the Hanford site.[8] We discussed DOE's understanding of the sources and extent of contamination that potentially threaten the river, and the mixed results that DOE's efforts to address the contamination have achieved so far. In addition, we discussed past criticisms of DOE's program management, including a poorly organized management structure and lack of coordination among various river protection activities. Because of continuing concerns about the risks posed by the contamination and DOE's management of its river protection program, you asked us to review the status of DOE's efforts. This report addresses DOE efforts (1) to understand the risk to the Columbia River from Hanford site contamination and to deploy effective technologies to address contamination near the river, and (2) to strengthen the management of its efforts to protect the Columbia River from Hanford site contamination.

[8]GAO, *Department of Energy: Preliminary Information on the Potential for Columbia River Contamination from the Hanford Site*, GAO-06-77R (Washington, D.C.: Nov. 4, 2005).

To address these objectives, we reviewed key documents, including Hanford's 2003 Groundwater Management Plan, the 2004 Hanford Site Groundwater Strategy, and reports from the National Academy of Sciences and the DOE Inspector General.[9] We visited various groundwater protection projects at the Hanford site and discussed river contamination issues with DOE and contractor officials at Hanford. We also discussed these issues with state and federal regulators, and other stakeholders. In reviewing the data related to the groundwater and river programs, we determined they were sufficiently reliable for the purposes of our report. A more detailed description of our scope and methodology is presented in appendix I. We conducted our work from December 2005 to August 2006 in accordance with generally accepted government auditing standards.

Results in Brief

DOE has begun taking steps to better understand the risk to the Columbia River from Hanford site contamination, and to replace cleanup technologies that have proven to be ineffective in keeping the contamination from seeping into the river. To better understand the nature and extent of the potential risk of contaminating the Columbia River, DOE and its regulators agreed to do additional sampling and analysis of the Hanford site's vadose zone. While DOE and its contractors have extensive knowledge of the contaminants that are currently in the groundwater and in the river, DOE knows less about the extent and location of contaminants in the vadose zone above the groundwater. Understanding contamination in the vadose zone is important for making decisions about how best to protect the Columbia River from the contamination. To accomplish this additional investigative work, DOE has requested a 3-year delay—until 2011—to the regulatory milestone by which DOE must propose to regulators its plans for addressing the groundwater and vadose zone contamination on the Hanford site. Once DOE understands the nature and extent of contamination in the vadose zone and groundwater, it must assess the risk to the public in future years by estimating how, and where, the contamination will migrate over time. While DOE relies on sampling to determine current conditions, it uses computer simulation models to predict future conditions and estimate future risks. DOE abandoned past modeling efforts in response to criticism that the models

[9]National Academy of Sciences, *Science and Technology for Environmental Cleanup at Hanford* (Washington, D.C.: 2001); Office of Inspector General, *Groundwater Remediation Activities at Hanford*, DOE/IG-0655, (Washington, D.C.: July 22, 2004); and Office of Inspector General, *Well Decommissioning Activities at the Hanford Site*, DOE/IG-0670, (Washington, D.C.: Jan. 3, 2005).

used inconsistent assumptions, were based on data of questionable reliability and had weak quality control processes. DOE is beginning to develop a model it believes will be more reliable. DOE has also begun taking steps to replace ineffective treatment approaches in response to concerns raised by us and others, and after receiving congressional direction to make $10 million available in fiscal year 2006 to research new treatment technologies at Hanford. These steps include replacing one pump-and-treat system, improving a leaking chemical barrier, and pursuing alternatives to allowing natural processes to control uranium migration.

DOE has also begun to address management problems with its Columbia River protection efforts at the Hanford site. In March 2006, as a result of congressional direction to improve management of its river protection efforts, DOE proposed key steps intended to better coordinate and manage groundwater and vadose zone activities at the site. These steps included (1) consolidating most groundwater and vadose zone activities under a single project, (2) better coordinating decisions about groundwater cleanup with decisions about how to address vadose zone contamination, and (3) consolidating risk assessment and modeling efforts under one project. DOE has taken steps in the past to address similar management problems, but the initiative was not successfully implemented. For example, in response to our 1998 report calling for greater integration of river protection activities at the Hanford site,[10] DOE took some initial steps to better coordinate its groundwater and vadose zone efforts. However, DOE did not implement key elements, such as developing a sitewide funding baseline of all river protection efforts; other elements, such as integrating groundwater and vadose zone activities under a single project manager, were initially implemented, but DOE did not continue them after changes in project organization and contract structuring occurred at the site.

We previously reported[11] that high-performing organizations sustained management improvement initiatives when they followed a systematic,

[10]GAO, *Nuclear Waste: Understanding of Waste Migration at Hanford is Inadequate for Key Decisions*, GAO/RCED-98-80 (Washington, D.C.: March 13, 1998).

[11]See GAO, *Contract Reform: DOE Has Made Progress, but Actions Needed to Ensure Initiatives Have Improved Results*, GAO-02-798 (Washington, D.C.: Sept. 13, 2002); also, GAO, *DOE Contracting: Improved Program Management Could Help Achieve Small Business Goal*, GAO-06-501 (Washington, D.C.: April 7, 2006).

results-oriented strategy that included defining specific program objectives, developing performance measures to gauge progress, and using results-oriented outcomes to evaluate the effectiveness of the initiative. As of July 2006, DOE had begun to determine the objectives of its new integration initiative, but had not yet fully developed other aspects of a sound management plan, including developing results-oriented performance measures to gauge effectiveness and evaluating the initiative using those measures. Unless DOE takes these steps, we are concerned about its ability to sustain any improvements its new initiative may offer. The DOE Hanford Assistant Manager in charge of overseeing the new integration initiative said that the management plan for the initiative is still evolving and that future steps may include developing performance measures and evaluation strategies to gauge effectiveness.

We are recommending that the Secretary of Energy strengthen its management improvement plan by establishing results-oriented performance measures and regular evaluations to gauge the program's effectiveness and sustain benefits of the improvements over time. In commenting on a draft of this report, DOE agreed with our recommendation.

Background

Contamination from the Hanford site that may threaten the Columbia River includes (1) contamination that resulted from disposal activities during the era in which DOE produced nuclear material; (2) contamination that could occur during cleanup activities, such as from an accidental spill; and (3) possible future migration of contamination from waste that will be permanently disposed of on the Hanford site in accordance with the cleanup actions DOE and the regulators plan to use.

Contamination from production era. Contamination at Hanford resulting from plutonium production (which occurred from 1943 to 1989) that is currently migrating to the river is primarily from:[12]

[12]In addition, during Hanford's past operations, DOE and its predecessor agencies directly discharged to the river cooling water from the reactors which was contaminated with about 110 million curies of mostly short-lived radionuclides. (Radioactivity is measured in curies. One curie equals 37 billion atomic disintegrations per second.) Operations also resulted in air emissions of about 20 million curies from 1944 to 1972. The portion that went to the river is unknown. These discharges are no longer occurring.

- Intentional disposal of liquid waste and contaminated water into the ground (about 450 billion gallons).

- Leaks into the soil from waste tanks and the pipelines that connect them (between 500,000 to 1 million gallons containing about 1,000,000 curies of radioactivity).

- Contamination that has begun to migrate from solid waste (more than 710,000 cubic meters) disposed of on-site in burial grounds, pits, and other facilities.

Chemical and radioactive contamination currently affects more than 180 of the 586 square miles of the site's groundwater and large areas of the vadose zone. While there are numerous contaminants now in the vadose zone and the groundwater below, DOE believes the key contaminants in the groundwater include hazardous chemicals (such as carbon tetrachloride, chromium, nitrate, and trichloroethane) and radioactive materials (such as iodine-129, strontium-90, technetium-99, tritium, and uranium). These contaminants are of concern because of their extent, their mobility in the groundwater, and the potential health risks associated with them—at sufficient levels, some of these contaminants are toxic to humans or fish, while others are potential carcinogens.

Potential contamination from current activities. Current cleanup efforts at the Hanford site could contribute to contamination of the vadose zone and groundwater that eventually reaches the river. For example, some of the waste put into underground storage tanks as liquid has since turned into sludge or saltcake.[13] To dissolve it, more water will have to be introduced into the tanks—including tanks known to have leaked. This process may cause additional discharges into the soil.

Possible future contamination. Under DOE's cleanup plans, and with regulator approval, a large amount of contaminants will remain on-site long into the future. This contamination may be in buildings, in mostly empty underground tanks, in covered burial grounds and waste disposal areas, and in approved disposal facilities. Contaminants may leach out of these facilities in the future and join existing contamination in the vadose zone and migrate to the groundwater, where they could migrate to the river.

[13]Saltcake is a moist sand-like material, such as sodium salts, that have crystallized from the waste.

Based on groundwater sampling results, DOE reports that plumes of contamination continue to move through the vadose zone and the groundwater, and are leaching into the river. DOE estimates that about 80 square miles of groundwater under the site contains contaminants at, or above, federal drinking water standards.[14] Because the groundwater and the river are at the same relative elevation, these plumes are leaching directly into about 10 of the nearly 50 miles of river shore on the site.

DOE's Office of Groundwater and Soil Remediation under the Assistant Secretary for Environmental Management sets overall policy and oversight for groundwater and soil remediation. At the Hanford site, both the Richland Operations Office and the Office of River Protection, as well as several contractors, are involved in groundwater and vadose zone activities. The monitoring of river and shoreline conditions, and groundwater sampling, is managed by the Pacific Northwest National Laboratory (PNNL). Analysis of the samples is performed by several approved laboratories. Funding for groundwater and vadose zone activities at the site is difficult to identify due to the large number of organizations and activities involved and the structure of DOE's budget accounts. However, monitoring, characterization, well drilling and maintenance, remediation, and research activities received nearly $175 million in fiscal year 2006.

DOE is Taking Steps to Better Understand Risks to the Columbia River from Hanford and Is Replacing Ineffective Technologies near the River

DOE is taking steps to better understand the risk to the Columbia River from Hanford site contamination and to replace ineffective cleanup technologies. Specifically, DOE is addressing problems with three main aspects of its Columbia River protection efforts. First, DOE and its regulators have agreed that additional investigation of contamination in the vadose zone is needed, although doing so could delay by about 3 years the date by which DOE will propose its cleanup plans to the regulators. Second, DOE is reworking its approach to modeling the future effects of contamination on river conditions. DOE abandoned past modeling efforts in response to criticism that the models used inconsistent assumptions, were based on data of questionable reliability, and had weak quality control processes. Third, in response to concerns about the effectiveness of some of the technologies DOE had deployed to remove or contain

[14]While the groundwater at Hanford is generally not used as a source for drinking water, drinking water standards are still a common measure of the extent of contamination. EPA sets the maximum contaminant level for each contaminant allowed in water delivered to a user of any public water system. This is the federal standard for the contaminant.

contamination near the river, and with specific direction from Congress, DOE is evaluating alternative technologies that may be more effective at addressing the contamination.

DOE Has Asked to Extend Regulatory Milestones to Better Understand the Extent and Location of the Contamination in Soil above the Groundwater

While DOE has extensive knowledge of the contaminants in the river and groundwater, and the movement of contaminants in the groundwater and on or near the surface, DOE has only recently developed limited information about the extent and location of the contamination that has migrated from the surface areas into the vadose zone above the groundwater. Understanding the nature of vadose zone contamination is critical to determining the most appropriate steps to take to protect the river now, and in future years, because contaminants still in the soil may continue to migrate until they eventually reach the groundwater and the river. DOE has studied some portions of the vadose zone, such as around the underground storage tanks, where extensive contamination from leaks and spills occurred in the past. In doing so, DOE found that some contamination, including technetium-99, had migrated as far as the groundwater. DOE contractors were able to map the migration of some of these contaminants. However, DOE acknowledges that its understanding of contaminants in the vadose zone is limited in many areas of the site. For example, cribs and trenches near the underground tanks received large volumes of contaminated wastes that dispersed directly to the ground. DOE has little information on the extent and location of the contamination in those areas, according to DOE officials responsible for planning their cleanup. They also said that characterization of the lower portions of the vadose zone is difficult and expensive, and few remediation techniques have been developed or tested for removing or isolating wastes that are located deep in the vadose zone.

Understanding the extent of vadose zone contamination is critical because some contaminants still in the soil may continue to migrate until they eventually reach the groundwater and the river. Thus, understanding the type and volume of contaminants in the vadose zone and their rate of migration is essential to determining the most appropriate steps to take to protect the river now, and in future years.

After finding unexpected contaminant migration in the vadose zone at one waste disposal area known as BC cribs—a location where liquids were discharged directly into the ground—DOE agreed with its regulators that its understanding of the vadose zone was inadequate to support the development of a final cleanup remedy for that area and some others. Although DOE had originally planned to defer some of its study of the

vadose zone until after December 2008, when draft cleanup plans were due, DOE now agrees that more sampling and analysis of the vadose zone is needed to guide cleanup decisions. As a result, DOE has proposed to regulators to extend the date for submitting draft cleanup plans until 2011. DOE officials said this will allow the time needed to develop a better understanding of vadose zone conditions and to investigate potential remedies.

DOE Is Reworking Efforts to Estimate Risks from the Movement of Contamination toward the River

In response to the discovery that its previous models to estimate the future risks of the movement of contamination toward the river were based on data of questionable reliability, DOE has begun reworking these efforts. While DOE relies on sampling to determine current conditions, it uses computer simulation models to predict future conditions and estimate future risks. In 1998, DOE groundwater program officials said DOE concluded from its simulation models that the migration was slow enough that the contaminants included in the study would not exceed their limits for 1,000 years into the future. However, DOE was concerned about the completeness of the model and began an effort, known as the System Assessment Capability, to develop a more comprehensive model. This $16 million, 8-year effort was cancelled when, in the course of a lawsuit over Hanford's disposal plans,[15] several quality assurance problems were found, including discrepancies in the data. DOE abandoned the past modeling efforts in response to criticisms that the models used inconsistent assumptions, were based on data of questionable reliability, and had weak quality control processes. In January 2006, DOE and Washington State settled the lawsuit. In the settlement agreement, DOE agreed to re-analyze and update its study of the cleanup's effect on groundwater. In addition, DOE agreed to consolidate two studies of the cleanup's effects on groundwater into a single, integrated study.

DOE Is Considering New Treatment Technologies to Replace Those That Have Not Kept Contamination from Entering the River

Both DOE and its regulators have determined that the results of all three of DOE's approaches to treating groundwater—pump-and-treat, chemical treatment, and natural attenuation—are not fully satisfactory. Specifically:

- *Pump-and-treat*. In a 2004 report, the DOE Inspector General concluded that the pump-and-treat system to remove strontium-90 was ineffective and that the other four pump-and-treat systems have had mixed results.

[15]*Washington v. Bodman*, Civ.A. No. 2:03-cv-05018-AAM (E.D. Wash. filed Mar. 4, 2003).

However, Hanford's acting groundwater project manager told us that four of the five pump-and-treat systems at the Hanford site meet the remedial objectives agreed to with Hanford's regulators. The official acknowledged that the system to remove strontium-90 was largely ineffective and that DOE had been trying to obtain permission from the regulators to turn it off. Both DOE and the regulators told us that the regulators refused to allow the system to be turned off, however, until a more effective remedy was found. In March 2006, after spending about $16 million since 1996 to install and operate the system, DOE turned the system off with the regulators' permission, and began testing a chemical barrier to prevent the strontium-90 from entering the river.

- *Chemical treatment.* In 2004, DOE reported that, based on groundwater samples, the chemical barrier for chromium was not fully effective, and that the hazardous form of chromium was detected beyond the barrier and close to the river. DOE is currently testing alternative approaches to improve the barrier.

- *Natural attenuation.* According to monitoring well data, DOE's reliance on natural attenuation to dissipate a uranium plume near the city of Richland was ineffective and has not controlled the migration of uranium to the river. The plume has not dissipated in the 10-year period since the natural attenuation strategy was adopted. DOE is currently investigating the plume, testing chemical barriers, and exploring other ways to mitigate the problem.

In the conference report accompanying the fiscal year 2006 Energy and Water Development Appropriations Act, the conferees directed DOE to make $10 million available to analyze and identify new technologies to address contaminant migration to the Columbia River.[16] DOE convened a study group to identify potential technologies and determine how best to allocate the funds to support them. According to DOE's groundwater project manager, if the technologies tested are successful, DOE will seek funds to expand the systems to fully address these problems. DOE is testing the following:

- To address problems with pump-and-treat systems, DOE is testing new approaches to containing strontium-90 and chromium. To contain the strontium, DOE is testing two techniques: (1) using a chemical to bind the strontium to the soil until it decays, which would prevent it from leaching

[16]H.R. Rep. No. 109-275, at 172 (2005).

into the river; and (2) planting willow bushes near shore to capture the strontium in the plants, which can be harvested to dispose of the strontium. For chromium removal, DOE has adopted a "systems approach" which includes combining source removal, pump-and-treat system expansion, and barrier repairs according to DOE's groundwater project manager. DOE is also planning to test an improvement to the pump-and-treat system. The test system will use an electric field to remove the chromium from the groundwater extracted by several of the existing wells. If it succeeds, DOE's project manager said, they will expand the pump-and-treat system to include this technology.

- To address problems with the chromium barrier near the river, DOE plans to inject chemicals through the wells used to create the barrier to help convert the chromium to a less toxic and less mobile form.

- To address problems with using natural attenuation to dissipate the uranium plume near the city of Richland, DOE is testing whether injecting a chemical called polyphosphate can help prevent the uranium from migrating to the river.

In addition to these activities, DOE plans to research methods to better understand the existing carbon tetrachloride plume in the center of the site.

DOE Has Begun To Address Management Weaknesses but Can Further Strengthen Its Management Plan

DOE has begun to address management problems with its Columbia River protection efforts at the Hanford site by proposing management improvements to better oversee and coordinate its groundwater and vadose zone activities. Although those steps are important and needed, we are concerned about DOE's ability to sustain any improvements made. Similar efforts in the past failed. In our previous work, we reported that leading organizations use a systematic, results-oriented plan to sustain management improvement initiatives. Such a plan incorporates key elements, such as clear goals, performance measures to gauge progress toward those goals, and an evaluation strategy to help ensure the initiative is effective. Although DOE is beginning to develop a plan for its new integration initiative, it has yet to implement key elements, such as performance measures or an evaluation strategy. These tools could help measure effectiveness and sustain the benefits of the initiative over time.

DOE Is Taking Steps to Improve River Protection Management and Oversight

DOE is beginning to address longstanding concerns about the management and oversight of its Columbia River protection efforts at the Hanford site. In November 2005, we reported that DOE's river protection efforts continued to be fragmented among two DOE site operations offices and several site contractors.[17] We raised concerns that the potential existed for duplication, gaps, and inefficiencies. Subsequently, in the November 2005 conference report accompanying the Fiscal Year 2006 Energy and Water Development Appropriations Act,[18] the conference committee cited these continuing management and organization problems and directed DOE to study how to better integrate its river protection efforts. In response to the congressional direction, in March 2006, DOE's Assistant Secretary for Environmental Management developed a new plan to better integrate Hanford's river protection, vadose zone, and groundwater efforts. Specifically, DOE's new integration initiative would:

- **Consolidate most groundwater and vadose zone characterization and cleanup activities under a single project**. At the time of the congressional direction, two DOE offices and three main contractors on-site were collectively responsible for characterizing and cleaning up vadose zone and groundwater contamination.[19] The Office of River Protection and its contractor, CH2M Hill Hanford Group, were responsible for characterizing and addressing contamination of the vadose zone in tank farms—areas where tanks containing radioactive liquid waste are buried. The Richland Operations Office and its contractors, Fluor Hanford and Washington Closure Hanford, were responsible for vadose zone characterization in the central plateau area of the site and along the river corridor, respectively. In addition, Fluor Hanford was responsible for groundwater activities in all areas of the site. Within Fluor Hanford, responsibility for cleanup of the groundwater and vadose zone was divided between two different projects with the project handling vadose zone issues also responsible for addressing removal of old buildings and burial grounds.

[17]GAO, *Department of Energy: Preliminary Information on the Potential for Columbia River Contamination from the Hanford Site*, GAO-06-77R (Washington, D.C.: Nov. 4, 2005).

[18]H.R. Rep. No. 109-275, at 172 (2005).

[19]In addition, DOE's PNNL was responsible for support activities, such as science and technology development and groundwater monitoring activities.

To better coordinate vadose zone and groundwater characterization and cleanup activities, DOE's new integration initiative proposed consolidating most of this work under a single project managed and coordinated by Fluor Hanford. To do so, DOE planned to modify existing contracts with the affected contractors to reflect this reorganization. In June 2006, the Office of River Protection and the Richland Operations Office issued a *Plan of Action for Hanford Groundwater and Vadose Zone Integration Improvements*. It identified general activities and areas of responsibility that the Fluor Hanford and CH2M Hill Hanford Group contractors would be responsible for under the new initiative. As of the end of July 2006, DOE was negotiating the details of this reorganization of responsibilities with the contractors and anticipated having the contracts modified to reflect the changes by October 1, 2006.

- **Better integrate vadose zone, groundwater, and waste disposal site cleanup decisions**. DOE acknowledged that decisions about when and how to address vadose zone and groundwater contamination were not always well coordinated, and they generally were not coordinated with decisions about when and how to address the source contamination in a waste disposal site located above the vadose zone and groundwater. For example, initial plans for cleanup decisions of the surface areas in the Central Plateau were not necessarily linked to the plans for the underlying groundwater units, according to DOE's groundwater project manager.

  To better integrate vadose zone, groundwater, and waste disposal site cleanup decisions, DOE proposed to implement a new strategy by the end of fiscal year 2006 and to work with regulators to better align regulatory milestone dates for making cleanup decisions about waste sites, the vadose zone, and the groundwater. DOE's new strategy includes plans to transfer most vadose zone characterization activities into the groundwater program.

- **Consolidate responsibility for modeling the movement of contaminants through the vadose zone and groundwater to estimate the potential current and future health risks**. DOE has acknowledged that inconsistencies and reliability problems existed in the modeling of how contaminants move through the vadose zone and groundwater, and how the environmental risks associated with those contaminants were estimated. A DOE team reviewing the data quality issues and the modeling effort found that, in addition to issues of the reliability of data used in the models, various modeling efforts under way were based on different assumptions, and information about

contamination movement was not always correctly transferred to other models.

To address these problems, DOE proposed to more closely coordinate modeling and risk assessment activities at the site and strengthen control over model design so that a common set of databases and assumptions were being used for decision making. The groundwater project would have configuration control over any models used so that any changes to databases and models assumptions would require approval by the groundwater project before users could implement them.

In addition to these management improvement efforts at the Hanford site, in May 2006, DOE also established a new Office of Groundwater and Soil Remediation to improve headquarters' oversight on issues dealing with soil and groundwater contamination across the DOE complex. The office is tasked with reviewing all soil and groundwater remedies at DOE sites, helping to develop technologies to solve groundwater and soil contamination problems at different DOE sites, and generally overseeing DOE policy and assessments regarding vadose zone and groundwater cleanup.

DOE Has Not Fully Implemented a Management Plan to Ensure Improvements Will Be Sustained

Given past problems fully implementing and sustaining improvements to the management of DOE's Columbia River protection efforts at the Hanford site, it is uncertain whether any improvements that result from DOE's new integration initiative will be sustained. In 1998, we reported that DOE lacked a comprehensive and integrated groundwater and vadose zone program,[20] and recommended that DOE implement an integrated strategy that defined measurable performance goals, clearly defined leadership roles, and established accountability for meeting those goals.

In response to our 1998 report, DOE proposed an integrated management plan to coordinate groundwater and vadose zone work.[21] To accomplish this, DOE assigned a single DOE Assistant Manager in the Richland

[20]GAO, *Nuclear Waste: Understanding of Waste Migration at Hanford is Inadequate for Key Decisions*, GAO/RCED-98-80 (Washington, D.C.: March 13, 1998).

[21]We have also previously reported about lack of integration among DOE river protection efforts. For example, in 1992, we reported that DOE lacked coordination in its efforts to monitor and characterize contamination in the vadose zone. See GAO, *Nuclear Waste: Improvements Needed in Monitoring Contaminants in Hanford Soils*, GAO/RCED-92-149 (Washington, D.C.: July 6, 1992).

Operations Office to coordinate all groundwater and vadose zone work at the Hanford site. Because DOE's other site office, the Office of River Protection, and several contractors at the site also carried out groundwater and vadose zone cleanup, DOE made the Assistant Manager responsible for ensuring that all groundwater and vadose zone activities were integrated into a single planning effort. This "Integration Project" included developing a sitewide approach to project planning, funding, and information management, and co-locating contractor staff working on the project to improve coordination. In addition, the project included improving coordination of efforts to develop science and technology to address contamination in the vadose zone and groundwater.

Despite these proposed changes, DOE was unable to effectively implement the improvements it planned to make. For example, according to a site official at Hanford who oversaw the initial integration effort, DOE did not implement key elements of the plan, such as establishing a sitewide funding profile for all groundwater and vadose zone activities. DOE implemented other elements of the plan but did not sustain them when changes, such as how projects were organized and contracts were structured, occurred at the site. For example, coordinating all activities through a single federal project manager faltered as site offices were reorganized and responsibilities were distributed among three federal project directors. The DOE official from the Hanford groundwater program attributes the lack of coordination of groundwater and vadose zone efforts to redefining project activities, which resulted in groundwater and vadose zone activities being managed as separate projects and changes in the structure of site contracts, which resulted in scopes of work being organized and assigned differently. A 2001 National Academy of Sciences review of DOE's groundwater science and technology activities noted that DOE's integration efforts had been superimposed over several already existing cleanup projects without establishing a clear line of responsibility for results. The National Academy said that this left the program operating in an unstable environment.[22]

To increase the chances of success for DOE's current improvement initiative, we assessed DOE's management of its new integration initiative against model practices used by organizations that successfully sustained improvement initiatives. We previously reported that in high-performing

[22]National Academy of Sciences, *Science and Technology for Environmental Cleanup at Hanford* (Washington, D.C.: 2001).

organizations, management improvement initiatives are sustained by using a systematic, results-oriented plan that incorporates a rigorous measurement of progress.[23] Such a plan typically included the following steps: (1) defining clear program goals for the initiative—important because it focuses an organization's efforts on achieving specific outcomes and allows as assessment of future performance against those goals; (2) developing an implementation strategy that sets milestones and establishes individual responsibilities—important because it establishes accountability for achieving the initiative's goals; (3) establishing results-oriented performance measures—important because it allows organizations to measure progress toward achieving their goals; and (4) using results-oriented data to evaluate the effectiveness of the initiative and make additional changes where warranted—important because periodic evaluations can reveal systemic problems and promote continuous program improvement over the long term.

As of July 2006, DOE had implemented two components and not implemented other management components to help ensure that it could sustain any improvements resulting from its new integration initiative. For example, in putting forward its plan to Congress, DOE described a general goal of its new integration initiative as better coordination of Hanford's groundwater and vadose zone cleanup activities in order to achieve greater protection of the Columbia River. DOE also outlined steps it would take toward its goal, such as (1) consolidating site modeling and risk assessments; (2) consolidating river protection efforts under a single project; and (3) integrating soil and groundwater cleanup decisions. In going forward, DOE could further refine its goals to include measurable steps to achieving its overall goal of protecting the river. For example, a more measurable goal would be the reduction of contamination reaching the river or ensuring duplication of efforts is reduced in order to better protect the Columbia River.

DOE had established general milestones and individual responsibilities for implementing its new integration initiative. For example, DOE's plan of action sets 16 milestones by September 2006 by which various initial steps are to be taken. DOE also reported that five of these actions, including

[23]See GAO, *Contract Reform: DOE Has Made Progress, but Actions Needed to Ensure Initiatives Have Improved Results*, GAO-02-798 (Washington, D.C.: Sept. 13, 2002); also, GAO, *DOE Contracting: Improved Program Management Could Help Achieve Small Business Goal*, GAO-06-501 (Washington, D.C.: Apr. 7, 2006).

making staff assignments and establishing an integrated project team, had been completed.

DOE has not established results-oriented measures to gauge the progress of its integrated management initiative. In outlining the steps it will take under its plan, DOE has generally concentrated on establishing relationships and moving work-scope between various DOE offices and contractors, and not on outcomes, such as reducing redundancies or gaps in river protection efforts. Without clear results-oriented performance measures to gauge progress, problems that occur under a fragmented management structure could be masked and allowed to continue under DOE's integration plan. Translating the general goal of "better integration" and "protection of the river" into a more specific goal, such as reducing duplicative efforts, would help DOE identify ways it could measure results and, therefore, gauge progress toward the goals of its integration initiative.

Finally, DOE has not yet identified an evaluation strategy to determine whether the steps it is taking are effective and are being sustained. Without an evaluation strategy based on clear goals and results-oriented measures, DOE will not have the results-oriented data necessary to objectively evaluate progress and implement corrective actions as needed.

Although DOE is still working to define and implement its integration initiative, fully developing and putting in place key elements outlined above could help ensure that any program improvements are sustained in the future. DOE's Hanford Assistant Manager in charge of overseeing the latest management improvements for the river protection program said that, beyond outlining broad goals and setting the framework for roles and responsibilities, DOE had not yet fully developed a project execution plan for the new initiative. He said that the management plan is still evolving and that future steps may include more clearly defining performance measures and strategies for evaluating the initiative's effectiveness.

Conclusions

DOE is involved in a lengthy process to identify and address potential threats to the Columbia River from contamination in the soil and groundwater at the Hanford site. This requires a good understanding of the risks to the river and an effective management strategy for addressing those risks. Over the years, we and others have raised concerns about DOE's efforts to understand the nature and extent of the contamination and how best to manage the efforts to prevent contamination from seeping into the river. In recent months, DOE has taken several steps to gain a better understanding of the risks from the contamination as well as to

improve its management of the program and integration of activities. While these steps are encouraging, DOE has not yet decided whether to put in place elements of a management plan that could help ensure potential benefits of these improvements will be continued, even when organizational and contract changes occur at the site. Such a management plan should include developing results-oriented performance measures, using the measures to determine progress toward objectives, and making changes as necessary.

Recommendation for Executive Action

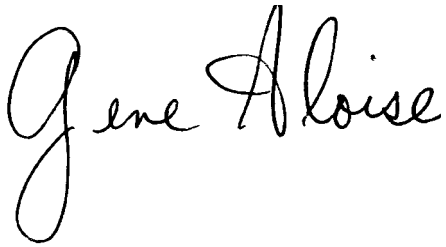
To increase the likelihood that DOE will effectively implement and sustain improvements in its program to protect the Columbia River from contamination at the Hanford site, we recommend that the Secretary of Energy strengthen the management improvement plan by establishing results-oriented performance measures and regular evaluations to gauge the program's effectiveness.

Agency Comments and Our Evaluation

We provided a draft of this report to DOE for its review and comment. In a letter from DOE's Principal Deputy Assistant Secretary for Environmental Management, DOE agreed with the report's findings and fully endorsed the recommendation to adopt results-oriented performance measures and regular evaluations of the river protection program. DOE acknowledged that performance measures and regular evaluations are a fundamental and integral component of sound project management practice and said that it would incorporate them into the project. The full text of DOE's comments is presented in appendix II.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days after the date of this report. At that time, we will send copies of this report to other interested congressional committees and to the Secretary of Energy. Copies will be made available to others on request. In addition, this report will be available at no charge on our Web site at http://www.gao.gov.

If you or your staff have any questions on this report, please contact me at (202) 512-3841 or by e-mail at aloisee@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Other staff contributing to this report are listed in appendix III.



Gene Aloise
Director, Natural Resources and Environment

Appendix I: Scope and Methodology

To understand the risk to the Columbia River from Hanford site contamination, we reviewed risk assessments, groundwater, vadose zone, and river monitoring reports by the Department of Energy (DOE), DOE's Office of Inspector General, DOE contractors including the Pacific Northwest National Laboratory, and various outside groups such as the National Academy of Sciences. We interviewed DOE officials at both headquarters and the Hanford site, as well as contractor staff at Hanford, to obtain information on the distribution of contamination at Hanford and the steps being taken to better understand it. To understand DOE's approach to the vadose zone, we primarily reviewed our 1998 report, as well as documents prepared by DOE and its staff in response to that report. We also reviewed documents DOE submitted to regulators related to changing Tri-Party Agreement milestones; the documents were to be used for preparing initial drafts of plans for all remaining contaminated areas. We discussed the proposed change to the December 2008 Tri-Party Agreement milestone with DOE officials and regulators. In reviewing DOE's efforts to determine the extent of risk of future damage to the river from contamination, we reviewed documents related to DOE's sitewide modeling effort and legal documents related to this modeling effort. We discussed these modeling efforts with DOE officials, contractors, and regulators.

In assessing DOE's efforts to deploy effective technologies to address contamination near the river, we visited the sites of existing and planned cleanup efforts. We discussed current existing projects with DOE officials, contractor staff, regulators, and stakeholders, and reviewed reports prepared for DOE and others. To assess technology plans developed by DOE to use $10 million of funds earmarked for fiscal year 2006, we attended DOE screening panels, reviewed reports prepared by DOE and others, and discussed the efforts with DOE regulators.

To review DOE efforts to strengthen the management of its river protection efforts, we reviewed DOE's past and current management plans. We obtained DOE's recent integration initiative proposals, including its proposal to Congress in March 2006 and its subsequent Memorandum of Agreement and Plan of Action. We discussed DOE's approach with headquarters and site officials. We reviewed previous work in which we documented strategies used by high-performing organizations to implement improvement initiatives. We reviewed DOE's proposed integration initiative and compared it to key elements of these strategies. We also discussed DOE's plans to implement its strategy with knowledgeable site officials.

In reviewing the management of DOE programs related to groundwater and river protection, we reviewed DOE efforts to assure that contamination levels were accurately reported; we also interviewed regulators, DOE officials, and contractors regarding data reliability. While we did not independently test the contaminant data, we reviewed controls over how the data were obtained and tested, visited sampling locations and discussed sampling methods with key staff, and reviewed other relevant information to determine that the data were sufficiently reliable for the purposes of our report. We conducted our work from December 2005 to August 2006 in accordance with generally accepted government auditing standards.

Appendix II: Comments from the Department of Energy

Department of Energy
Washington, DC 20585

August 18,2006

Mr. Gene Aloise
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Aloise:

The Department of Energy (DOE) has reviewed the draft report entitled "Nuclear Waste - DOE's Efforts to Protect the Columbia River from Contamination Could Be Further Strengthened." We find the report to be generally accurate, and we fully endorse the single recommendation offered by the U.S. Government Accountability Office (GAO). The GAO recommendation states:

> "To increase the likelihood that DOE will effectively implement and sustain improvements in its program to protect the Columbia River from contamination, GAO recommends that the Secretary of Energy establish results-oriented performance measures and regular evaluations to gauge the program's effectiveness."

We appreciate the thoroughness and professionalism that the GAO team exhibited throughout the conduct of this audit. The team has made every effort to be accurate in their report and has interacted with DOE staff throughout the process to ensure the report has value.

In response to Conference Report (109-275) that accompanied the Fiscal Year 2006 Energy and Water Development Appropriations Act (P.L. 109-103), I submitted a March 29, 2006, Report to Congress that outlines DOE's proposal to:

1. Consolidate modeling and risk assessment work for the Hanford site;
2. Consolidate all groundwater and vadose zone activities under the Groundwater Remediation Project; and
3. Integrate groundwater, vadose zone, and source area cleanup decisions.

The report identified specific actions and schedules for implementation. The GAO correctly identified that this report did not include specific results-oriented performance measures and regular evaluations to gauge the improvements' effectiveness. We agree that such measures and evaluations are a fundamental and integral component of sound project management practice and the development and implementation of such measures and evaluations will strengthen and ensure DOE's plans to protect the Columbia River. Therefore,

DOE will incorporate the actions identified in the aforementioned March 29, 2006, Report to Congress into our project baseline, including appropriate specific results-oriented performance measures. We will also be performing periodic evaluations to gauge the improvements' effectiveness.

If you have any questions, please call me at (202) 586-7709 or Mr. Mark A. Gilbertson, Deputy Assistant Secretary for Engineering and Technology, at (202) 586-0755.

Sincerely,

Charles E. Anderson (Acting for)
Assistant Secretary for
Environmental Management

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Gene Aloise, (202) 512-3841

Staff Acknowledgments

In addition to the contact named above, Bill Swick, Assistant Director; Chris Abraham; Doreen Feldman; Nancy Kintner-Meyer; Jeffrey Larson; Omari Norman; Alison O'Neill; Thomas Perry; and Stan Stenersen made significant contributions to this report. Others who made important contributions included Mark Braza, Doreen Eng, and Mehrzad Nadji.

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