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Report to the Chairman, Environment, Energy, and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

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NUCLEAR WASTE

Hanford Tank Waste Program Needs Cost, Schedule, and Management Changes

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GAO
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Resources, Community, and
Economic Development Division

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March 8, 1993

The Honorable Mike Synar
Chairman, Environment, Energy, and
Natural Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

As you requested, this report presents the current status of the Hanford waste vitrification plant and its supporting facilities and identifies technical and other issues that may affect Hanford's high-level waste disposal program—referred to as the Tank Waste Remediation System (TWRS). The Department of Energy initiated efforts to end the interim storage of the high-level radioactive waste at the Hanford Site by transforming the part of the waste that was highly radioactive into a more stable glass form—a process known as vitrification—and shipping it to a geologic repository for permanent disposal. We are recommending that the Secretary of Energy postpone construction of the Hanford Site vitrification plant, renegotiate the milestones agreed to in the May 1989 Federal Facility Agreement and Consent Order, and improve management of the TWRS program.

As arranged with your office, unless you publicly announce its contents earlier, we will make no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies to the Secretary of Energy and the Director, Office of Management and Budget. We will also make copies available to others on request.

This work was performed under the direction of Victor S. Rezendes, Director, Energy and Science Issues, who can be reached on (202) 512-3841 if you or your staff have any questions. Other major contributors to this report are listed in appendix I.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Since the 1970s the Department of Energy (DOE) has been developing a program to dispose of 61 million gallons of highly radioactive waste stored in 177 single-shell and double-shell underground tanks at its Hanford Site in Washington State. Sixty-seven tanks are known to or are assumed to have leaked waste into the ground, and 53 tanks contain waste that is potentially explosive or has other safety problems. The Chairman of the Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked GAO to examine the technical problems associated with DOE's Tank Waste Remediation System (TWRS) program for disposing of this waste and evaluate the program's cost, schedule, and management.

Background

In order to develop appropriate ways to retrieve the waste from the tanks and treat it, the waste must first be sampled and analyzed to determine its contents—a step called characterization. After retrieving the waste, DOE plans to separate it into high-level and low-level radioactive portions in a step called pretreatment. DOE plans to vitrify Hanford's high-level waste—that is, convert it into a glass-like product that can be poured into steel canisters to harden—for eventual shipment to a permanent underground repository. DOE plans to convert the low-level waste into a cement-like product called grout and dispose of it permanently in about 240 large underground concrete vaults.

DOE's original plan called for retrieving and treating the relatively well-defined waste in Hanford's 28 double-shell tanks before addressing the more poorly understood waste in the 149 single-shell tanks. The milestones for this plan are contained in a Tri-Party Agreement, which was signed by DOE, the Environmental Protection Agency (EPA), and the Washington State Department of Ecology in May 1989. After the agreement was signed, technical and environmental problems were found with DOE's original plan. For example, GAO concluded that the 47-year-old B Plant, which DOE intended to convert into a pretreatment facility, was not a viable option because it would not meet environmental regulations. In light of problems with the original plan, DOE established the TWRS program in December 1991 to treat waste from both types of tanks at the same time. DOE announced that in March 1993 it would make final decisions on how the new program would proceed.

Results in Brief

Major technical problems exist in all key steps of the TWRS program. Specifically, DOE has not determined how many samples it will ultimately

need for characterization and lacks adequate facilities for analyzing the samples within existing milestones. DOE has not fully determined or tested its approach for retrieving the different wastes to be treated and is basing its pretreatment plans on untested technology. Even if DOE surmounts these obstacles, two obstacles remain: (1) the vitrification plant, as currently designed, may not be large enough to treat all of the high-level waste in a reasonable time frame and (2) the technical feasibility of DOE's approach to dispose of low-level waste has yet to be demonstrated.

In addition to technical uncertainties, questions also exist about the program's cost, schedule, and management. DOE's program cost estimates substantially exceed earlier estimates and are unreliable. In 1988 DOE estimated that disposing of tank wastes could cost as much as $14 billion; according to 1992 internal estimates, the cost could amount to nearly $50 billion. DOE continues to work against Tri-Party Agreement milestones for the vitrification plant and other facilities that have been made obsolete by program changes and technical problems. As a result, DOE does not have an accurate schedule of how and when it can cost-effectively treat Hanford's tank wastes. Continued adherence to the current Tri-Party Agreement schedule may result not in timely completion of the program, but in the construction of facilities that are not cost-effective or do not work. Finally, DOE's fragmented management approach has contributed to program problems. For example, program elements that affect other elements, such as waste characterization, have received less funding, resulting in delays.

Principal Findings

Data and Facilities for Characterization Are Limited

The Tri-Party Agreement requires DOE to analyze 309 samples from the 149 single-shell tanks (essentially 2 samples per tank) by 1998. Currently, DOE is several years behind schedule. Even if DOE can extract the samples on schedule, it lacks sufficient facilities to analyze them all within existing milestones. Furthermore, officials from Westinghouse (DOE's site contractor) said that as many as 14 samples per tank may be needed. If DOE plans its treatment facilities using only limited knowledge about the tanks' contents, it risks future changes that would involve both substantial cost increases and schedule delays.

Retrieval and Pretreatment Uncertainties Could Cause Delays

Techniques for retrieving and pretreating Hanford's tank wastes are largely in the conceptual stage of development. DOE faces numerous problems in developing retrieval methods, such as avoiding damage to aging tanks and releasing more waste into the ground. Furthermore, DOE's current planned processes for pretreatment have never been fully tested. Consequently, construction of new pretreatment facilities has been delayed about 2 years. As a result, if the vitrification plant begins operations in December 1999, as the Tri-Party Agreement requires, the amount of pretreated waste may be insufficient to operate the plant on a continuous basis. To maintain an idle vitrification plant could cost about $115 million annually.

Treatment Approaches Are Not Fully Defined

The planned vitrification plant was designed only for treating high-level waste from the double-shell tanks. Its design capacity assumes that untested pretreatment technology for reducing the volume of high-level waste will be available. Under this assumption, DOE estimates that it will take about 40 years to treat all single-shell and double-shell tank wastes. If this pretreatment technology is not successful, the current vitrification plant's design capacity would mean that it could take well over 100 years to treat the wastes from both kinds of tanks. As part of the reevaluation scheduled to end in March 1993, DOE is examining 22 other options for treating high-level waste, including building a much larger vitrification plant or using other approaches that would not require vitrification. However, DOE is moving ahead with design and site work for the vitrification plant before these uncertainties are resolved and before a complete design package is prepared. Actual construction of the building is scheduled to start in March 1993. Use of a similar "fast track" approach at DOE's Savannah River vitrification facility contributed to a plant that is still not operating, is about $1 billion over budget, and is 5 years behind schedule.

DOE's plans to dispose of low-level waste may not be acceptable to regulators. The state's Department of Ecology argues that the waste contains high-activity, long-lived constituents, such as technetium 99 and iodine 129, that are difficult to immobilize and will leak into the environment before half of their radioactivity has decayed. The Nuclear Regulatory Commission is reviewing this issue but has not stated when it will render a decision. In the meantime, the schedule to dispose of this waste has slipped about 3 years, and DOE has delayed further grouting of low-level waste until late 1993.

The Program's Cost, Schedule, and Management Need Attention

DOE has not developed a reliable estimate of the program's cost. However, the limited information available indicates that costs have grown considerably. According to estimates DOE developed in 1988, the cost of disposing of double-shell and single-shell tank wastes ranged from about $4 billion to $14 billion. Recent internal documents stated that the tank waste disposal program's cost could amount to nearly $50 billion. However, DOE officials told GAO that this estimate is highly uncertain.

DOE's program schedule, which is based on the Tri-Party Agreement milestones, is no longer realistic because the agreement has not been revised to reflect recent program changes and technical problems. For example, the milestone for completing the vitrification plant—December 1999—was based on the expectation that the plant would treat only double-shell tank waste. On the basis of its current design capacity, the plant could not vitrify all tank wastes until about 2038—20 years beyond scheduled closure of the single-shell tanks. Consequently, DOE does not have an accurate schedule of how and when it can cost-effectively treat Hanford's tank wastes. Strict adherence to the milestones could result in spending money on facilities that are not cost-effective, just to meet milestones.

DOE's fragmented management approach has contributed to program problems. DOE has managed the program elements as separate projects with separate funding priorities. As a result, some program elements that affect other elements, such as waste characterization, have received relatively less funding, resulting in delays in technology development. While DOE has recognized these problems, it has not yet fully resolved them.

Recommendations

GAO is recommending that the Secretary of Energy (1) seek concurrence of EPA and the Department of Ecology to postpone construction of the vitrification plant until a final decision is made on how high-level waste will be immobilized; (2) complete the design of the plant before beginning construction; (3) develop a reliable cost estimate for the TWRS program; and (4) renegotiate the Tri-Party Agreement with the Department of Ecology and EPA to establish a comprehensive and realistic schedule for all elements of Hanford's TWRS program. GAO also makes recommendations about improving the program's management.

Agency Comments

As requested, GAO did not obtain written agency comments on this report. GAO discussed the facts presented in the report with the Director, Hanford Program Office at DOE headquarters, and with Richland Field Office officials responsible for managing the program and incorporated their views where appropriate. While they agreed that there are many uncertainties associated with the program's technology, cost, and schedule, they stated that these are being considered during the 15-month evaluation, which is scheduled to end March 31, 1993. If the results of the evaluation indicate that significant changes in the Tri-Party Agreement are needed, DOE officials told GAO that they will propose such changes.

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Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE	Department of Energy
EPA	Environmental Protection Agency
NCAW	neutralized current acid waste
RCRA	Resource, Conservation, and Recovery Act of 1976
TPA	Tri-Party Agreement
TRUEX	Transuranic extraction
TWRS	Tank Waste Remediation System

Introduction

The Department of Energy's (DOE) Hanford Site in southeastern Washington State was established in 1943 to produce nuclear materials for the nation's defense. Production of these materials resulted in radioactive waste that has been temporarily stored in underground tanks beginning nearly 5 decades ago. In the 1970s DOE began developing plans to end the interim storage of this waste by transforming the part that was highly radioactive into a more stable glass form—a process known as vitrification—and shipping it to a geologic repository for permanent disposal. DOE planned to convert the less radioactive portion of the waste into a cement-like product called grout and dispose of it permanently on-site in large vaults. DOE's schedule for disposing of the waste is contained in an agreement signed by DOE, the state of Washington, and the Environmental Protection Agency (EPA) in May 1989. This agreement called for starting vitrification by December 1999. DOE's approach to dealing with the waste is called the Tank Waste Remediation System (TWRS) program, which DOE established in December 1991.

High-Level Radioactive Waste and the Vitrification Process

Hanford's high-level radioactive wastes are contained mainly in 177 underground storage tanks built between 1943 and 1986. These tanks range in capacity from 55,000 gallons to more than 1 million gallons. All together, the tanks contain about 61 million gallons of waste—about 63 percent of DOE's total high-level waste volume and about 37 percent of its radioactivity.

Hanford's waste storage tanks are of two basic types. The oldest 149 tanks, containing about 36 million gallons of highly radioactive waste, are "single-shell" tanks that have a single-layer steel wall encased inside a concrete shell. Sixty-seven of these tanks are known to or are assumed to have leaked radioactive materials into the surrounding soil, and DOE is concerned that at least 48 single-shell tanks contain wastes that are potentially explosive or have other safety problems.[1] The newest 28 tanks, containing about 25 million gallons of waste, are "double-shell" tanks with walls that include two steel layers rather than one. As of December 1992, no leaks have been detected in double-shell tanks, but the wastes in six of them are also potentially explosive.

The waste inside the tanks has taken four main forms: sludge, saltcake, slurry, and liquid:

[1]We have reported on leaks from single-shell tanks and on potentially explosive tanks in earlier reports. See Related GAO Products.

- Sludge, which has settled on the bottom of the tanks, consists of iron, aluminum, and other insoluble components. The principal radioactive elements are strontium, plutonium, and americium.
- Saltcake, which is sometimes layered over the sludge, is a solid consisting mainly of sodium salts. A major radioactive element is cesium.
- Slurry is a combination of liquid and suspended solid waste. Its major radioactive components include cesium, strontium, and transuranic wastes[2] containing components such as plutonium, neptunium, americium, and curium.
- Liquid, also called supernate, is located at the top of these other waste forms. Like saltcake, its main component is sodium salts and a major radioactive element is cesium.

DOE's approach to cleaning up the single- and double-shell tanks' high-level waste involves five basic steps, which can be summarized as follows:

- Characterization involves the determination of the specific physical, chemical, and radiological components of the wastes in each tank. This step is important because DOE's current information about tank wastes is incomplete. Some of the waste was placed in the tanks with little or no documentation of its makeup, and some tanks contain a complex mixture of unknown waste constituents. Detailed knowledge of tank contents is needed to determine how to resolve tank safety issues as well as how to retrieve, pretreat, and treat the wastes. To characterize the waste DOE plans to analyze samples drawn from each tank.
- Retrieval is the removal of the waste from the tanks by pumping or other means and its transfer to treatment facilities. Because the waste exists in liquid, solid, and other forms, certain steps may be needed to turn the waste into a form that will allow the pumping to take place. Solid waste that cannot be pumped from many of the single-shell tanks may have to be extracted with specially designed robotic arms.
- Pretreatment is the separation of the high-level fraction of the waste from the low-level fraction and from other nonradioactive elements, such as aluminum, organic compounds, and salts. This step is desirable because it decreases the amount of high-level waste that must be vitrified. The remaining low-level waste can then be treated and disposed of less expensively.
- Treatment involves the immobilization of the waste. DOE plans to vitrify the high-level fraction of the waste separated during pretreatment by mixing it with a glass-forming material and melting the mixture into glass.

[2]Transuranic wastes are man-made radioactive elements produced from uranium during nuclear reactor operations. All transuranic wastes contain radioactive elements that have an atomic number greater than uranium.

As planned, the molten glass will be poured into stainless steel canisters to harden; each container is about 2 feet in diameter and 10 feet tall. DOE plans to immobilize the remaining low-level fraction of the waste by mixing it with cement, flyash, and other materials so that it will harden into a cement-like substance called grout.

- Disposal involves the final emplacement of the immobilized waste so as to ensure isolation from the surrounding environment until it is no longer dangerously radioactive. DOE plans to temporarily store the canisters containing the high-level fraction of the waste at the Hanford Site until an underground repository is ready to receive them permanently. It will dispose of the low-level fraction of the waste in large, underground concrete vaults at the Hanford Site; each vault will hold about 1.4 million gallons of grout.

Tri-Party Agreement Established a Schedule for Dealing With Tank Wastes

In May 1989 DOE, Washington State's Department of Ecology, and EPA signed the Hanford Federal Facility Agreement and Consent Order, commonly referred to as the Tri-Party Agreement. This agreement was a comprehensive effort to bring the Hanford Site into compliance with the Resource, Conservation, and Recovery Act of 1976, as amended (RCRA), the Washington State Administrative Code, and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA).[3] The agreement is structured as a series of cleanup milestones, both for the tank waste remediation and for other environmental restoration activities at the Hanford Site. The milestones are legally binding unless all three parties agree to modify them. Among other things, the agreement called for starting waste treatment operations at the vitrification plant by December 1999.

DOE's original cleanup plan for the Hanford storage tanks was to (1) proceed with disposal activities for the 25 million gallons of double-shell tank waste and (2) defer a decision on disposal of the 36 million gallons of single-shell tank waste until 2003, when additional development and evaluation of waste retrieval and disposal methods could be completed. An essential element of the process for disposing of the double-shell tank waste was the use of an existing Hanford facility—the B Plant—to pretreat the wastes.[4] Concerns about the use of B Plant for

[3]RCRA applies primarily to active waste sites, CERCLA to inactive ones. RCRA and CERCLA place regulatory authority for cleanup with EPA at the federal level and with a designated state agency at the state level—in this case, Washington's Department of Ecology.

[4]B Plant is a 47-year-old facility that was originally used to recover plutonium for nuclear weapons. DOE began upgrading the plant in 1983 for pretreatment purposes.

pretreatment, among other factors, led DOE to re-examine the waste disposal approach it had originally proposed. One concern, for example, was that B Plant did not meet RCRA requirements for double containment for piping and liners for cells that handle hazardous waste. The B Plant had single-walled steel pipes embedded in concrete walls and unlined cells that did not meet this requirement. In June 1991 we concluded that B Plant was not a viable option for pretreating high-level radioactive tank wastes.[5] In October 1991 DOE and the Westinghouse Hanford Company, DOE's main contractor for operating the Hanford Site, issued reports stating, among other things, that B Plant should not be used for pretreatment purposes and that both single-shell and double-shell tank wastes be incorporated into a single waste-disposal program.

After consultation with EPA and Washington State's Department of Ecology and concurrence that an integrated approach was needed, DOE decided on a new strategy—the TWRS program—for the disposal of Hanford Site tank wastes. The Secretary of Energy formally announced the new program in December 1991. TWRS includes all programs, projects, and activities for receiving, pretreating, treating, and disposing of all tank wastes in both the single-shell and double-shell tanks located on the Hanford Site.[6] At the Secretary's request, the resolution of tank safety issues, such as the possibility of explosions, has been given the highest priority in the TWRS program.

In January 1992 DOE Richland began a 15-month evaluation to make program, design, and schedule decisions necessary to execute the many activities included under TWRS. However, because the Tri-Party Agreement milestones are legally binding, DOE is continuing to perform all actions necessary to comply with near-term milestones contained in the agreement. If the results of the evaluation, which is expected to end on March 31, 1993, indicate that significant changes in the Tri-Party Agreement are needed to execute the TWRS program, DOE officials told us that they plan to propose such changes.

Objectives, Scope, and Methodology

The Chairman of the Environment, Energy, and Natural Resources Subcommittee, House Committee on Government Operations, asked us to examine the technical uncertainties associated with Hanford's tank waste

[5]Nuclear Waste: Pretreatment Modifications at DOE Hanford's B Plant Should Be Stopped (GAO/RCED-91-165, June 12, 1991).

[6]The TWRS program does not include disposal of residual wastes left in the tanks, tank farm structures, or contaminated soil around the tanks.

remediation program, especially as they affect the program's cost and schedule. He also asked us to assess the effectiveness of DOE's management of the program. Because the Hanford vitrification program was undergoing a major reevaluation while we were performing our review, our assessment is based on DOE's current official planned approach for dealing with Hanford's waste. To ensure that our work reflects any potential changes that might result from the ongoing evaluation, we have included preliminary or draft information available as of February 1993, where appropriate.

To assess technical uncertainties in the TWRS program, we reviewed technical reports, engineering reviews, internal reviews, issue papers, and analyses prepared by DOE, Westinghouse, and other contractors. We interviewed Westinghouse engineers responsible for developing tank waste disposal technology and officials responsible for conducting DOE's 15-month assessment of the TWRS program. We also interviewed DOE's Assistant Manager for Tank Waste Disposal and other DOE officials at the DOE Richland Field Office. At DOE headquarters in Washington, D.C., we interviewed the Assistant Secretary for Environmental Restoration and Waste Management and his assistants. We also interviewed DOE officials in Germantown, Maryland. We obtained the views of EPA's Region X staff, which includes Washington State, and officials in the Washington State Department of Ecology.

To determine the effect of these uncertainties on the program's cost and schedule, we reviewed project plans, DOE budget documents, contractor and consultant studies, project funding summaries, and other related documents. We interviewed DOE, Westinghouse, EPA, Department of Ecology, and other officials to obtain documentation and their views on these matters.

To help assess the effectiveness of DOE's management of the program, we obtained the views of Department of Ecology and EPA officials as to their judgments about DOE's performance. We reviewed applicable organizational documentation and discussed management issues with DOE headquarters and DOE Richland Field Office officials.

We also reviewed pertinent laws, federal and state regulations, DOE orders and directives, and internal DOE and Westinghouse memorandums. We conducted our review primarily at the DOE Richland Field Office and at DOE headquarters in Washington, D.C., and in Germantown, Maryland. Technical assistance in performing this review was provided by Dr.

George W. Hinman, D.Sc. Dr. Hinman, currently Director, Office of Applied Energy Studies at Washington State University, has worked 40 years in the nuclear energy field in industry, government, and academia.

We discussed the facts presented in this report with the Director, Hanford Program Office at DOE headquarters and with DOE Richland Field Office and Westinghouse officials responsible for managing the TWRS program. While they agreed that there are many uncertainties associated with the program's technology, cost, and schedule, they stated that these are being considered during the 15-month evaluation, which is scheduled to end March 31, 1993. As agreed with your office, we did not obtain written agency comments on this report. We performed our review between July 1991 and February 1993 in accordance with generally accepted government auditing standards.

Characterization, Retrieval, and Pretreatment Technical Uncertainties Could Produce Delays

The first three steps of the waste treatment process—characterization, retrieval, and pretreatment—all contain problems and uncertainties that could (1) delay the scheduled startup of vitrification plant operations in December 1999 and (2) disrupt continued vitrification operations once the plant becomes operational. Specifically, DOE is behind schedule in characterizing the contents of the tanks, and even when this work is completed, DOE may not have taken enough samples of the tanks' contents to make decisions about handling the waste. Whether DOE will have workable methods in place for retrieving and pretreating the various types of tank wastes is also unclear. For example, the schedule for testing retrieval and pretreatment methods for the first type of waste to be treated calls for completion of this process by March 1997. However, if testing problems are encountered, there may not be a sufficient stream of waste when the vitrification plant is scheduled to begin operations in December 1999. In addition, it is not clear that the needed tank space for the retrieval and pretreatment operations will be available.

Characterization Efforts Are Behind Schedule and May Prove Insufficient

DOE is unlikely to meet existing schedules for determining the physical, chemical, and radiological constituents of the wastes in each tank. It also has no assurance that it will have sufficient information for making waste treatment decisions once it completes this work.

Schedules for Waste Characterization Are Not Being Met

The following schedules have been established for sampling the tanks:

- The Tri-Party Agreement calls for DOE to draw 309 samples from the 149 single-shell tanks—essentially 2 samples per tank—by 1998. The Tri-Party Agreement sets out year-by-year expectations for the number of samples to be drawn.
- A separate DOE schedule outlines requirements for sampling 11 of the 28 double-shell tanks, which will have their wastes pretreated and vitrified. For these 11 tanks the schedule calls for drawing a total of 59 samples by the end of fiscal year 1996 and sets year-by-year expectations for doing so.

Because of problems it has experienced with safely drawing samples, DOE was about 2 years behind its original schedule for drawing samples from single-shell tanks as of the end of fiscal year 1992—the latest date for which data could be compared. DOE is about 2 years behind its schedule for double-shell tanks, even though it has planned since 1987 to retrieve and pretreat double-shell tank wastes first. According to its original

characterization schedule, DOE was to have drawn 67 samples from a total of 28 single-shell tanks by the end of fiscal year 1992. It had actually drawn 39 samples from a total of 12 tanks. Also, DOE was to have drawn 27 samples from double-shell tanks; it had actually drawn 18.

After obtaining tank samples, DOE must analyze them, because various other milestones in the Tri-Party Agreement are contingent on the decisions that will stem from the analysis. However, DOE currently does not have adequate laboratory capacity to analyze the required samples. As a result, by December 1992 DOE had analyzed only 17 of the 40 core samples taken from single-shell tanks and only 10 of the 18 core samples obtained from the double-shell tanks. According to a March 1992 Westinghouse study, DOE faces the likelihood that Hanford's laboratory capacity will continue to be insufficient to analyze core samples in time to comply with Tri-Party Agreement milestones and to meet other analysis requirements at the site. On the basis of the study's characterization schedule, we found that, even with increased laboratory capacity anticipated in 1994, Hanford may need until July 2001 to finish analyzing samples needed no later than September 1998 to meet Tri-Party Agreement milestones.

The study outlined additional steps that, if taken before 1995, would allow DOE to finish the sample analyses in time to meet Tri-Party Agreement milestones. These steps included having greater use of laboratory space for tank waste characterization, increasing laboratory staff, and shipping many core samples and subsamples off-site to other DOE laboratories for analysis. However, because of the relatively low priority assigned to characterization, funding needed to support these steps, according to DOE Richland's tank characterization manager, has not been made available. This official further told us that DOE's schedule also does not allow for potential unscheduled sampling and analysis that may be needed to resolve tank safety problems.

Characterization Schedules, Even If Met, May Provide Insufficient Results

Even if DOE were on schedule in sampling the tanks and analyzing the samples, it is not clear that these characterization efforts would give DOE sufficient information about the contents of the tanks. As of December 1992 DOE still had not determined whether two samples are adequate to obtain a representative sample of waste in Hanford's single-shell tanks. Many tanks contain a mixture of wastes from a variety of processes. The uncertainty surrounding the large tanks' contents leaves

DOE with little assurance that a sample taken in one part of the tank will necessarily be representative of wastes elsewhere in the tank.

DOE has been addressing the adequacy of the two-sample approach since May 1989 but has yet to resolve it. Westinghouse studies on this issue, scheduled for completion by March 1991, remained unfinished as of December 1992, when we were completing our field work. To provide some indication of what the studies were finding, we asked DOE and Westinghouse officials for their best estimate of how many core samples would be needed to determine with reasonable certainty the amount of certain major constituents in the two tanks already analyzed. They said that between 2 and 14 samples may be needed to adequately characterize each tank.

DOE's tank waste characterization schedules were based on the need to determine if some single-shell tank wastes could be left in the tanks for final disposal. According to DOE and Westinghouse officials, before the waste could be left in the tanks, it would have to be completely characterized to ensure that it could be effectively immobilized to meet federal long-term storage requirements. However, if the waste is removed from the tanks, as currently assumed under the TWRS program, they said that complete characterization may not be needed. The Washington Department of Ecology's program manager of nuclear and mixed waste management told us that until DOE makes a final decision to retrieve all tank wastes, the state expects DOE to fully characterize the wastes as scheduled.

Uncertainties About Retrieval Methods May Affect Availability of Waste for Treatment Operations

Tank waste exists in a variety of forms, such as liquid, sludge, slurry, and solid waste. Removing such diverse waste for treatment requires such steps as dislodging, pulverizing, cutting, and pumping. To deal with this diversity, DOE will need to develop several different retrieval methods. DOE has used various waste retrieval techniques over the years, such as dislodging the sludge with high-volume sprayers and pumping it out of the tanks, but other techniques for retrieving the large volumes in Hanford's tanks are still largely in the conceptual stage of development.

DOE's ability to meet waste processing milestones depends in part on the availability of a steady supply of waste from the tanks. DOE faces potential problems both in readying its retrieval methods for the first wastes to be removed and in developing retrieval methods for the remaining wastes to ensure this steady supply. DOE acknowledged that it faces numerous

technical challenges, including acceptable retrieval techniques that balance available technologies, retrieval rates, and potential leaks to the soil during retrieval.

Methods for Removing the Initial Waste Not Fully Tested

The first type of waste DOE intends to remove is called "neutralized current acid waste" (NCAW). According to DOE officials, this waste was placed in two double-shell tanks and is relatively well defined. It constitutes about 6 percent of the waste in double-shell tanks. The second type of waste DOE plans to retrieve is from one of its single-shell tanks; this waste is believed to be similar to NCAW.

In retrieving the NCAW waste from the double-shell tanks, DOE plans to first mix the sludge using mixer pumps installed in the tanks. The pumps, which are to be placed under the surface of the tank liquid, will direct a jet stream of liquids already in the tanks onto the surface of the waste to dislodge or dissolve it. The dislodged or dissolved waste is then pumped out in the resulting liquid to a double-shell tank for subsequent pretreatment.

The effectiveness of sludge mixing—at least in the manner DOE will have to use it—has not been fully demonstrated. DOE has tested sludge mixing at Savannah River and in model studies at Hanford, but only with an approach that uses two mixing pumps. According to the Westinghouse retrieval manager, two pumps may be sufficient only for the limited number of tanks that contain wastes in liquid and near-liquid form. For thicker wastes, DOE plans to use four pumps. The Westinghouse manager stated that DOE has not yet specified the number of pumps that individual tanks will require. DOE has expressed concern that using four pumps to mix tank wastes may result in unacceptable stress on tank walls that may permanently damage the tanks and result in radioactive waste leaking into the environment. DOE told us it has planned a series of laboratory and scale tests to resolve these uncertainties, and it plans to conduct tank retrieval operations within allowable stress limits so that the tanks will not be damaged.

The time between full-scale testing of DOE's retrieval approach and the scheduled start-up of treatment operations is too short to allow for major changes in the retrieval method. DOE plans to conduct a full-scale test of these retrieval methods in 1997. A 1991 DOE engineering review has concluded that this demonstration will be too late to incorporate any major changes if operation of the vitrification plant is to start in

December 1999 as scheduled. Consequently, delays in conducting this test or major problems disclosed by the test could delay vitrification plant operations.

Retrieval Methods for Subsequent Wastes Not Yet Developed

The first type of waste—NCAW—DOE intends to retrieve from two double-shell tanks is projected to take about 2 years to vitrify, assuming that retrieval and pretreatment operations are successful. In selecting the next waste to be retrieved, DOE will attempt to provide a continuous supply of waste to the vitrification plant so that vitrification operations will not be disrupted. Although DOE has identified potential subsequent wastes to be retrieved from some of the tanks with the most serious safety problems, it has not made a final decision, in part because of uncertainties about how these wastes should be retrieved.

One waste that DOE considers a potential next choice is contained in one of Hanford's single-shell tanks known as tank 106-C. On the basis of limited characterization and available records, DOE believes the high-heat waste in this tank is similar to the NCAW waste that will be retrieved, and it has stated in formal briefings to DOE headquarters that retrieval of this waste and NCAW could provide up to 8 years' supply for the vitrification plant. However, the sludge mixing method to be used to retrieve the NCAW waste may not be suitable for retrieving tank 106-C waste, because the high-pressure pumps could permanently damage the fragile walls of this single-shell tank, allowing waste to leak out. Consequently, DOE may use a retrieval method called "sluicing" to retrieve wastes from tank 106-C. This method consists of directing a stream of water from an external source onto the surface of the waste. The dislodged or dissolved waste is then pumped out in the resulting liquid. However, this method may be unacceptable because it increases the volume of waste. In addition, DOE and Washington State are trying to determine whether this tank is leaking. In the meantime, DOE is continuing to develop and test the sluicing method with the goal of minimizing the amount of water to be used.

DOE is also examining other wastes in double-shell and single-shell tanks as potential next choices.[1] These wastes may require different retrieval approaches. DOE's 1991 engineering review addressing the matter stated:

> The extent of technology and engineering development required for these wastes is unknown, but programs similar to those being carried out for NCAW wastes will be required.

[1]These include waste in tank 101-SY, plutonium finishing-plant waste, complexant concentrate waste, neutralized cladding removal waste in double-shell tanks, and waste in tank 105-C, a single-shell tank.

Post-NCAW wastes are poorly characterized. Sample data may come too late to factor into current design and development programs. Sample data could hold surprises about physical characteristics or chemical composition that would require changes in retrieval . . . technology.

Uncertainties about retrieval methods for these wastes could interrupt the waste flow to the vitrification plant. DOE's 1991 engineering review concluded that vitrification plant operations could be interrupted for at least 2 years while retrieval methods are developed and tested for the second supply of wastes.

Ability to Pretreat Waste on Schedule Is Also Doubtful

Because DOE believed for many years that B Plant could be used as a pretreatment facility, it did not develop alternative plans. DOE's current plans for pretreatment involve processes that have not been fully tested or are in early development. DOE's schedule for vitrifying the waste leaves little room for testing pretreatment methods and making any necessary changes if a supply of waste is to be available by December 1999. Even if DOE successfully tests these methods, the delays it has already announced in pretreating part of the initial waste make it unlikely that an uninterrupted stream of waste will be available. Plans for pretreating subsequent waste are based on methods that are still in early developmental stages, leaving additional opportunity for subsequent schedule slippages.

Pretreatment Methods for the First Waste Face Tight Deadlines

Under DOE's plans, neutralized current acid waste, the first waste to be vitrified from the double-shell tanks, requires two pretreatment processes—in-tank sludge washing and ion exchange. DOE faces potential difficulties with both processes.

In-Tank Sludge Washing

In-tank sludge washing consists of washing tank wastes with water using large pumps inserted into the top of the tanks. Sludge washing is not the same as sludge mixing, the retrieval method discussed earlier in this chapter. Unlike sludge mixing, it introduces large volumes of additional outside water into the tanks. This approach will allow solid, high-level waste to settle to the bottom of the tank, while lower-level waste will remain near the top where it will be pumped to holding tanks for further pretreatment. DOE will wash the waste in this manner at least twice to separate the high-level waste solids from lower-level waste.

DOE has used in-tank sludge washing at other sites, but not in the environment in which it will be used at Hanford for pretreating high-level waste. Consequently, some uncertainty exists as to whether the method will work successfully. DOE's schedule allows for 3 months of testing, not enough, according to a 1991 DOE engineering review, to make any major changes and still supply the pretreated neutralized current acid waste when the vitrification plant is scheduled to begin operations.

If testing is successful, other related aspects of the schedule remain very tight. Before the pretreated high-level waste can be transferred to the vitrification plant, it will have to be sampled and analyzed, according to Westinghouse's pretreatment manager. DOE needs the information to select the correct quantity and chemical composition of glass material that will adequately immobilize the waste and meet waste disposal and performance criteria. DOE will then order the glass material from a manufacturer. Under DOE's schedule, accomplishing these steps means that once the waste is pretreated, DOE will have only a 1-month margin for error to get the glass material on site before vitrification is scheduled to begin (see table 2.1).

Table 2.1: Pretreatment Schedule for Neutralized Current Acid Waste to Be Treated at the Vitrification Plant

Function	Scheduled completion
Mixing pump test completed	March 1997
Pretreatment operations begin	April 1997
Pretreatment of initial waste completed	September 1997
Waste sample obtained	October 1997
Analysis of sample completed	April 1998
Glass material ordered	May 1998
Glass material received	October 1999
Waste available for vitrification	November 1999
Vitrification plant to begin operations	December 1999

DOE and Westinghouse officials acknowledged that this schedule is "very aggressive" and contains no room for problems or delays. However, they emphasized that they intend to meet the schedule.

Ion Exchange

Ion exchange is the second step in pretreating NCAW. The supernate, or liquid waste that remains near the top of the tank during sludge washing, will contain cesium 137, a highly radioactive material that must be separated through further pretreatment. To separate the cesium 137, DOE plans to use an ion exchange process in which the supernate liquid

containing cesium passes through tubes containing resin, a material that adsorbs it. As currently planned, the separated cesium will be sent to the vitrification plant for treatment as high-level waste. DOE has used this process before at Hanford to extract cesium from radioactive waste.

Delays in completing facilities for the ion exchange process will likely disrupt a steady supply of the pretreated neutralized current acid waste to the vitrification plant. DOE expects that vitrification of this waste, including the portion that will receive the ion exchange process, will take about 2 years. However, DOE's schedule for completing the facility that will house the ion exchange process has slipped 2 years and may be delayed longer.[2] The facility is now scheduled to come on line in December 1999—the same month the vitrification plant is scheduled to begin operations. The manager of Hanford's pretreatment operations said this revised date was still unrealistic given construction funding levels. The delay means that the vitrification plant may have less than an initial 2-years' supply of pretreated neutralized current acid waste until high-level waste from ion exchange becomes available.

Pretreatment of Remaining Wastes Rests on Untested Methods

DOE has determined that it will need other pretreatment approaches for remaining types of waste. Other methods will be needed for such problems as dealing with potentially explosive tank wastes and with wastes that have vastly different chemical characteristics from the first type of waste to be treated. The methods under consideration for treating the remaining types of waste are still in the conceptual stage or have already encountered delays in development, making it quite possible that a continuous supply of waste to the vitrification plant could be further disrupted. The same 1991 DOE engineering review that projected potential delays from uncertainties about retrieval methods concluded that such interruptions will likely occur. The director of the Hanford program office at DOE headquarters estimated that the plant could potentially be shut down for up to 3 years if other pretreatment processes are not operational as planned. A 3-year shutdown could result in an expenditure of about $345 million, an amount based on an estimated cost of $115 million annually (in 1993 dollars) to maintain the facility in standby status.

Methods for Resolving Explosion Problems

In December 1991 the Secretary of Energy stated that DOE's top priority was to resolve tank safety issues. Cited as the most critical problems were 54 tanks containing potentially explosive mixtures of ferrocyanide,

[2]This facility, called the initial pretreatment module, will also pretreat potentially explosive wastes. These wastes are discussed later in this chapter.

organic-nitrate material, and flammable hydrogen gas. While DOE is taking steps to mitigate these safety problems, the first of these tanks may not be pretreated until after 2000 because DOE must first characterize the wastes and then construct the facilities and technologies to process them. In the interim, DOE's plans call for processing waste that is easier to process to ensure that waste will be available for treatment in the vitrification plant in December 1999, according to DOE's director of the Hanford program office.

DOE has stated that it plans to perform a process called oxidation to destroy potentially explosive ferrocyanides, organic salts, and hydrogen-forming constituents after they are retrieved from the tanks. When these components are eliminated, the potential for an explosive reaction will be eliminated. DOE planned to have a facility operational by December 1997 that would be capable of resolving these problems. Westinghouse developed preliminary plans to build the facility but has not yet developed a conceptual design for it. Completion has already been delayed to at least December 1999 because of significant technical uncertainties and funding limitations, and DOE and Westinghouse officials indicate that the delay could be longer.

High-Level Waste Separation

To reduce the volume of remaining waste that will have to be vitrified, DOE plans to develop new methods of high-level waste separation. DOE is considering the construction of another pretreatment facility in which the high-level waste extraction process will be installed. According to draft planning documents, DOE has estimated that this new facility may cost between about $2 billion and $3 billion. However, DOE will not be able to design this facility until it has selected, developed, and tested a viable high-level waste extraction technology. As a result, design and construction of this facility has been revised by 2 years. According to DOE's May 1992 schedule, facility design will begin in 2000, and construction is tentatively forecast to be completed between 2010 and 2016, 2 years later than previously planned.

During its 15-month evaluation of the TWRS program, DOE is evaluating several high-level waste extraction technologies aimed at reducing the volume of high-level waste to be vitrified. These technologies include dissolution and solvent extraction, use of solid sorbents or precipitation, selected leaching, and calcination and dissolution. These processes are experimental and have not been tested at Hanford. The calcination process has been used at DOE's Idaho National Engineering Laboratory, but it has not been tested using Hanford tank wastes. DOE expects studies of these technologies to continue well beyond the end of the 15-month

evaluation period in March 1993. A final decision on a high-level waste separation technology may not be made for up to 5 years. After a decision is made, DOE plans to conduct a pilot project, which may last about 3 years, to test the selected process. After the technology is successfully tested, the required hardware will be installed in the new pretreatment facility.

According to DOE documents, transuranic extraction (TRUEX), a solvent extraction process for reducing the volume of waste to be vitrified, may be a promising technology. However, laboratory tests using gram-sized waste samples have not been fully successful, and extensive, long-term laboratory and pilot-plant testing is necessary to fully demonstrate the technology for the many different waste types that will be processed. A 1991 DOE headquarters engineering review concluded that DOE should not assume the TRUEX process will be successful, labeling it "a high-risk concept with considerable potential for failure." This study also noted that other extraction processes had not been evaluated and that DOE did not have a backup if TRUEX technology failed.

Lack of Tank Space May Also Delay Retrieval and Pretreatment Operations

Retrieval and pretreatment operations will require a substantial amount of double-shell tank space that currently does not exist. DOE's plans are based on the assumption that up to 18 double-shell tanks will be available during retrieval and pretreatment operations for storage and in-tank processing. DOE has no assurance, however, that any of these tanks will be available. The tanks currently contain waste that DOE plans to treat as low-level waste in ways described in chapter 3. Objections from Washington State about DOE's plans for treating this waste have already delayed DOE's schedule by 3 years and could prevent these tanks from being available when they are needed.

DOE has initiated a project to construct four new double-shell tanks primarily for resolving tank safety issues that will also be used for retrieval operations. These tanks, scheduled to be completed in 1999, will not provide sufficient space for planned retrieval operations. DOE told us that the number of new tanks needed depends on the methods DOE will use to retrieve and pretreat the waste. DOE stated that as many as 70 new double-shell tanks may be needed, but it believes there is sufficient time to construct new tanks to support the treatment of Hanford wastes.

Conclusions

Given the large number of technical uncertainties that DOE faces in just the first three steps of its tank waste disposal program, it appears doubtful

that DOE will be prepared to supply wastes for treatment operations by the December 1999 vitrification plant start-up date. Specifically, not only is DOE behind schedule in obtaining core samples from the tanks for characterization purposes, but it does not have sufficient facilities to analyze the samples after they are obtained. Even if it could analyze the samples to meet its characterization schedule, as many as 14 samples from each of the 149 single-shell tanks rather than 2 samples—the minimum number now required—may be needed to know enough about how the wastes should be processed. As a result, it is not clear that DOE will have enough tanks characterized to provide a continuous supply of waste for retrieval and pretreatment.

It is also unclear whether waste retrieval and pretreatment methods will be ready in time to process NCAW—the first type of waste scheduled to be vitrified. DOE's proposed schedule for executing these steps allows only 3 months to resolve any problems and still supply pretreated waste to the vitrification plant by its scheduled December 1999 operational start date. In addition, DOE's shortage of tank space, as well as uncertainties about retrieval and pretreatment methods for processing subsequent tank wastes, raises serious doubts about whether DOE can provide a continuous supply of waste to the vitrification plant. Consequently, if the vitrification plant is ready to begin operations as scheduled, it is quite possible that it could sit idle for years at a cost of $115 million annually while DOE develops methods for retrieving and pretreating tank wastes.

Waste Treatment Approaches Are Not Fully Defined

DOE's vitrification plant capacity, as currently designed, is based on DOE's initial plans to vitrify only double-shell tank wastes and on the success of an untested pretreatment method. If this method is not successful, the number of canisters needed would increase significantly, and at the plant's current design capacity, well over 100 years would be needed to vitrify all the waste from the tanks. Moreover, DOE is moving ahead with design and site work for the vitrification plant before uncertainties, such as the size of the plant, are resolved and even as it examines other waste treatment approaches that would require no vitrification plant at all.

Uncertainty also surrounds DOE's plans to dispose of the low-level portion of the waste in grout vaults. Washington State's Department of Ecology argues that the waste contains high-level materials that will eventually leak into the environment before they cease being radioactive. The Nuclear Regulatory Commission is reviewing this issue but has not rendered a decision. In the meantime, the schedule to dispose of this waste has slipped about 3 years.

Vitrification Plant Design Assumes Successful Development of Untested Pretreatment Technology

The vitrification plant is now scheduled to deal with a volume of waste much larger than originally expected. When DOE initiated the vitrification plant project in 1987, it planned to use the facility to treat only the waste from the double-shell tanks. DOE planned to defer its decision on how to dispose of single-shell tanks wastes until it completed a separate environmental impact statement in 2003. Our review of DOE documents indicates that DOE considered the possibility that a substantial amount of single-shell tank wastes would be disposed of permanently in the tanks rather than be retrieved and vitrified.

Announcement of the TWRS program in December 1991 meant that the vitrification facility, as currently designed, would be used to treat single-shell as well as double-shell tank wastes. This change significantly increases the amount of waste to be vitrified. Assuming that the TRUEX pretreatment process or a similar process (discussed in ch. 2) would reduce the volume of high-level waste, vitrification of wastes from both types of tanks would require about 12,000 canisters as compared to 1,530 for double-shell tank waste only. At the current design capacity of 320 canisters per year, vitrification would be completed about 38 years after the plant began operation, in contrast to an estimated 5 to 7 years under DOE's previous double-shell tank waste disposal program.

As discussed in chapter 2, the success of the TRUEX process remains unproven. If TRUEX or a similar process does not work, a minimum of 38,000 canisters would be needed.[1] At the plant's currently designed capacity of 320 canisters per year, well over 100 years would be needed to vitrify all the waste from the tanks.

DOE's "Fast Track" Construction Schedule Increases Possibility of Problems

As part of the current 15-month evaluation of the TWRS program, DOE is evaluating whether to build the vitrification plant as designed—or whether to build it at all. The evaluation includes an analysis of 22 options, including the existing approach. About half of the alternatives include the vitrification plant as currently designed. However, five alternatives call for a larger capacity vitrification facility; two of the options that do not require vitrification include converting the waste into another form, such as a dry granular solid, through the use of a calcine process, or ceramic pellets, for final disposal in thick metal containers.

The evaluation has raised serious questions about whether the plant, as currently designed, should be built. Westinghouse, the DOE contractor analyzing alternatives to the TWRS program, issued a draft analysis in October 1992 indicating that the current design is not the best treatment option. Analyzing the options on the basis of long-term environmental impact and performance of the waste products, cost-effectiveness, and safety, the draft analysis implies that the vitrification plant as currently designed is too small to treat all tank wastes and still meet program milestones. Westinghouse officials said that remediating tank wastes with the plant as currently designed would cost nearly $50 billion, take 3 or 4 decades, and be dependent on unproven pretreatment technologies.

Westinghouse's draft analysis suggests that an alternative involving a larger vitrification plant and a somewhat different vitrification process may be needed. Under this alternative waste would undergo limited pretreatment—the sludge washing process discussed in chapter 2—and all tank wastes would be vitrified. According to a Westinghouse systems engineer, vitrified high-level waste would be placed in about 3,150 large, self-shielded casks about 7 feet in diameter and 19 feet long that would eventually be deposited in the proposed repository at Yucca Mountain,

[1]DOE officials said that this is the minimum number of canisters that has been projected. Depending on the assumptions used, they said that well over 60,000 canisters has also been projected.

Nevada.[2] Disposal of high-level wastes in casks of this size is consistent with DOE's analyses of acceptable disposal methods of such waste in the repository, according to the Westinghouse engineer involved in analyzing program alternatives. Under this alternative vitrified low-level waste would be mixed with a sulfur polymer and deposited in an estimated 43 large, underground vaults, in contrast to the estimated 240 grout vaults in DOE's current approach. Westinghouse estimated that under this approach all tank waste could be treated within 10 to 20 years at a total cost of about $16 billion-$20 billion.

In the midst of this reevaluation, DOE is moving ahead with plans to start actual construction of the vitrification facility, as currently designed, in March 1993—the same month that Westinghouse's analysis is scheduled to be completed. DOE officials indicate that construction needs to begin at that time if the facility is to be ready for operation by December 1999, the date called for in the Tri-Party Agreement. Westinghouse officials told us that a redesigned facility capable of vitrifying all potential waste volumes in about two decades would cost about $2.3 billion, compared to the estimated $1.8 billion for the proposed facility that may take more than 4 decades to vitrify Hanford's tank wastes.

Even if DOE's reevaluation results in a decision that the current design is the best approach, DOE's construction schedule raises concerns. DOE is managing the plant's construction on a "fast track" schedule, which involves starting construction before the facility's design is substantially finished. Site preparation began in April 1992, and actual construction of the building is to start in March 1993, when the detailed design will be only about 60 percent complete. For a commercial nuclear reactor, nuclear industry guidelines recommend that construction not begin until the detailed design is 90 percent complete. DOE believes this approach is needed, however, if it is to meet Tri-Party Agreement milestones.

DOE believes the effort is aided by the fact that the design is partially adapted from another DOE facility—the Defense Waste Processing Facility,[3] which will vitrify waste at DOE's Savannah River site. Construction of this facility is completed, but it is not yet operational because of extensive retrofitting needed to make it operational. This facility has experienced major start-up problems, cost increases of nearly $1 billion, and schedule

[2]The radionuclide content of high-level wastes in the large casks would be equivalent to the radionuclides contained in the smaller canisters DOE has proposed, according to a Westinghouse systems engineer.

[3]See Nuclear Waste: Defense Waste Processing Facility—Cost, Schedule, and Technical Issues (GAO/RCED-92-183, June 17, 1992).

delays of about 5 years. The Manager of DOE's Savannah River Site acknowledged in a November 1986 letter to DOE headquarters that the Savannah River facility's problems resulted in part from the "fast track" approach used in constructing it before the facility design was complete and before major technical uncertainties were resolved.

Moreover, questions also have been raised about the facility's design. Given that Hanford's high-level wastes have been extensively mixed and comingled over the years in ways that have never been studied before, the vitrification plant will be a one-of-a-kind facility. An October 1991 DOE headquarters engineering review concluded, "Continuation with the present design is likely to result in a facility that is inefficient, difficult to start-up, operate, and/or maintain." The review referred to 53 unresolved design issues that had "considerable impact on the site plan, building floor plans, plant operations and maintenance."

As of December 1992, 22 of these issues remained unresolved. Westinghouse's manager of the Hanford vitrification project reported to us that 31 of these concerns had been resolved. Many of the remaining 22 issues will still be unresolved when construction of the plant begins, according to this vitrification project official. He emphasized, however, that all of the design issues will be resolved by December 1994, when the detailed design of the vitrification plant is scheduled to be completed.

Grout Vaults May Be Unacceptable for Disposal of Low-Level Wastes

DOE is facing technical uncertainties with the grout process. When radioactive materials are grouted, heat is produced, and generally speaking, the amount of heat rises with the level of radioactivity. If the temperature rises above 90 degrees centigrade, the grout may not effectively immobilize liquid wastes, according to the manager of the Hanford grout facility. In laboratory demonstration projects conducted in the 1990s, DOE used gram-sized samples of low-level waste simulants to determine the estimated temperature of waste that would be grouted. Test results revealed that the estimated temperature of the grout would likely exceed 90 degrees centigrade due to the heat generated from the solidification of grout and the decay of radioactive waste components in the grout. As a result, DOE may have to change the grouting process or process the low-level waste in another pretreatment sequence to remove more radionuclides. A DOE internal document, dated December 1992, stated that the feasibility of the grouting process has yet to be demonstrated.

Even if the process works from a technical standpoint, the contents of the low-level waste have raised questions about the appropriateness of using grout vaults as a disposal method. The low-level waste designated for disposal in grout vaults will contain materials that have a high level of radioactivity. These materials include cesium 137, strontium 90, technetium 99, iodine 129, and transuranic waste. On the basis of an October 1990 Westinghouse analysis of the radionuclide content of double-shell tank waste, the grout in each vault could contain about as much radioactivity as would be contained in eight canisters produced by the high-level waste vitrification plant.[4] Under the current program about 240 grout vaults will be needed. Compared to the total amount of grout in a vault, however, DOE Richland anticipates that the amount of high-activity materials will be small enough that the grout will meet the Nuclear Regulatory Commission's criteria for shallow-ground disposal.[5] In contrast, the director of the Hanford program office at DOE headquarters told us that Hanford's low-level waste may not meet the Nuclear Regulatory Commission's criteria for shallow-ground disposal.

Washington, Oregon, and the Yakima Indian Nation have challenged the adequacy of DOE's disposal plans for this waste. Among their concerns is that the waste DOE considers low-level waste may be high-level waste. Some of the highly mobile radioactive material in this waste will retain its radioactivity past a grout vault's ability to keep the material in place. Technetium 99 and iodine 129 require 230,000 years and 16 million years, respectively, before half of their radioactivity has decayed. These materials are also highly mobile if they enter the ground. The manager of Hanford's grout facility acknowledged that these radioactive materials will eventually leak into the ground, but he stated that they represent a small fraction of the total radioactive content of the grout vaults. DOE claims the grout vaults will retain the waste for up to 10,000 years but acknowledges that this is an assumption not based on empirical evidence.[6] The challengers petitioned the Nuclear Regulatory Commission in 1990 for clarification of whether DOE could proceed with shallow-ground disposal of this waste. The Nuclear Regulatory Commission has not yet indicated whether it intends to render a decision.

[4]These estimates are based on analysis of waste in the double-shell tanks only. DOE has yet to determine how much radioactivity from the single-shell tanks will be deposited in the grout.

[5]Regulations promulgated by the Nuclear Regulatory Commission (10 CFR Part 61) specify the concentration limits for disposing of radioactive waste components in the ground. DOE anticipates that the low-level waste will meet the class C radionuclide concentration limit, the highest radioactive content allowable for shallow-ground disposal.

[6]To meet Nuclear Regulatory Commission requirements, the vaults should have the capability of isolating the waste in place for at least 500 years.

Westinghouse's ongoing evaluation of alternative waste disposal methods also raises questions about DOE's approach. The Westinghouse study includes an evaluation of seven other methods for disposing of the low-level waste.[7] Westinghouse's draft study implies that DOE's current approach is not the best, in part because the grout facility was not designed to handle wastes from both the single-shell and double-shell tanks. The draft study states that an improved approach would be to vitrify low-level waste, mix the vitrified product with sulfur polymer cement, and pump the mixture into large near-surface vaults like the five DOE has already constructed. According to the study's team leader, the vitrified waste would be more effectively immobilized for an indefinite period of time and would be retrievable for processing sometime in the future if a better technology were developed.

The plan to dispose of low-level waste in grout vaults is about 3 years behind schedule. Because DOE has not resolved technical uncertainties or completed ongoing assessments and because the Nuclear Regulatory Commission has not made a final decision, DOE has delayed further grouting of low-level waste until late 1993. DOE's position, as with the vitrification plant, is that any additional delays to the current schedule would delay other steps in the treatment process and jeopardize the Department's ability to meet the milestones of the Tri-Party Agreement.

Conclusions

Even if DOE can overcome the technical problems discussed in chapter 2 and successfully prepare tank waste for final treatment, it faces formidable obstacles in actually treating the waste. DOE's current plans are to construct a vitrification plant that was intended to treat only double-shell tank waste on a "fast-track" schedule before its design is complete. If DOE stays with this approach, it is likely to end up with a plant that is far too small, may require extensive modifications before it can operate, and may require well over 100 years to vitrify waste from both single-shell and double-shell tanks. The desire to hold to deadlines needs to be balanced against the very real possibility that billions of dollars could be spent on a vitrification plant that simply cannot do the job. Moreover, DOE is now considering other waste treatment options, including the possibility of not vitrifying tank waste at all, at the same time it is proceeding with the design of the vitrification plant.

[7]The various options include such things as in-situ vitrification, vitrification and disposal in containers, conversion to grout, and mixing with other materials prior to disposal.

Technical and regulatory uncertainties in grouting Hanford's waste are also not resolved. Because the waste DOE intends to grout contains long-lived, high-level radioactive waste components that will eventually leak into the environment, grout vaults may not be an acceptable approach for final disposal of the waste. The Nuclear Regulatory Commission is studying these issues to determine whether DOE should proceed with the underground disposal of this waste, but it has yet to make any decisions. These concerns have already put DOE's grout program about 3 years behind schedule, and DOE has delayed further grouting of low-level waste.

Recommendations

To ensure that DOE designs and constructs the most cost-effective treatment facilities, we recommend that the Secretary of Energy direct the Manager of the DOE Richland Field Office to

- seek the concurrence of EPA and the Department of Ecology to postpone construction of the Hanford vitrification plant until a final decision is made on how high-level waste will be immobilized and
- begin construction of the plant only after the design is sufficiently complete that DOE can demonstrate that the plant can be started and operated efficiently.

Cost, Schedule, and Management Problems Need Attention

The technical uncertainties discussed in the previous two chapters raise several concerns about the waste disposal program's cost, schedule, and management. Although DOE has yet to develop a reliable cost estimate, the limited information available indicates that costs may substantially exceed earlier estimates. A 1991 estimate placed the cost at $25 billion to $45 billion, compared with a 1988 estimate of $4 billion to $14 billion. However, an ongoing Westinghouse engineering study indicates that the 1991 estimate may be too low, and that the cost may ultimately amount to nearly $50 billion.

DOE's program schedule, which is based on Tri-Party Agreement milestones, is no longer realistic, because the agreement has not been revised to reflect recent program changes and technical problems. For example, DOE has decided not to use the existing B Plant for pretreatment purposes but instead to plan, design, and build totally new pretreatment facilities. Uncertainties surrounding pretreatment processes mean that the new pretreatment facility may not be operational until 2016, or 2 years before the single-shell tanks are to be closed under the Tri-Party Agreement. Despite the program's numerous conceptual changes and technical uncertainties, the Tri-Party Agreement schedule continues to drive DOE's cleanup program.

DOE's fragmented management approach has contributed to program problems. DOE has managed the program elements as separate projects with different funding priorities. Consequently, program elements that affect other elements, such as waste characterization, have received less funding, resulting in delays. DOE has recognized these problems and is considering a plan to integrate its management of the program during its current TWRS evaluation. However, this plan does not address potential funding inconsistencies for the various program elements—inconsistencies that could lead to delays.

Lack of Reliable Cost Estimates Reflects DOE's Lack of Emphasis on Life-Cycle Costs

Projecting a program's full cost means developing estimates of its "life-cycle" costs. Life-cycle costs comprise not only the cost of planning and building facilities but also the cost of executing the program, including operating all facilities over the program's full lifetime. To date DOE has provided only very broad estimates of the life-cycle cost of the tank waste disposal program. These estimates have also risen considerably in the last 4 years. For example:

- In 1988, under the pre-TWRS program, DOE estimated the disposal cost of double-shell and single-shell tank wastes at between $4 billion and $14 billion. This estimate included about $2.8 billion for immobilizing double-shell tank waste[1] and between $1 billion and $11 billion for disposing of single-shell tank wastes. In part, the wide range of the estimate for single-shell tanks reflected DOE's uncertainty at the time as to how much of the waste it would remove from the single-shell tanks. DOE officials were unable to provide details on the elements used to develop the single-shell tank portion of the estimate.
- In December 1991 DOE announced that it was switching to the TWRS program, which significantly increases the volume of waste to be treated and vitrified. At that time an internal DOE briefing placed the estimated life-cycle cost of the TWRS program at between $25 billion and $45 billion. DOE officials cautioned that this estimate is still highly uncertain. The $20 billion range included in the estimate, they said, reflects this uncertainty.
- Ongoing studies suggest that the 1991 estimate may be understated. Westinghouse's draft study, being prepared as part of DOE's ongoing 15-month study of the TWRS program, stated that under DOE's current plan to dispose of all tank waste, the cost just to retrieve waste from double-shell and single-shell tanks could exceed $15 billion. The draft study stated that total life-cycle costs of DOE's tank waste remediation program could amount to nearly $50 billion. DOE Richland's assistant manager for tank waste disposal agreed that the program could cost as much as $50 billion, but he emphasized that DOE still does not have a reliable estimate of total program costs.

The assistant manager for tank waste disposal at DOE Richland acknowledged that, because of uncertainty about how it would execute the program, DOE has not developed a good cost estimate of the remediation program. Westinghouse is developing life-cycle cost estimates as part of DOE's evaluation of the TWRS program. The estimates will compare 22 waste cleanup program alternatives, including DOE's established program strategy. Some of these options could cost less than DOE's current program.

While the absence of a reliable life-cycle cost estimate for the TWRS program reflects uncertainty about how it will proceed, it also reflects DOE's overall approach to life-cycle costs. DOE orders and regulations

[1]This cost estimate included research and development, waste characterization (retrieval was not mentioned), waste pretreatment processes and facilities, immobilization facility design and construction, on-site canister storage facilities, and operational and other capital costs necessary to prepare and store the high-level waste pending shipment to the geologic repository.

primarily address the management of projects, and it is not clear whether they require a life-cycle cost estimate for a program like TWRS.

In late October 1992 Westinghouse provided us with its draft Systems Engineering Management Plan, which stated that "TWRS life cycle costs shall be developed and maintained in accordance with DOE-RL 5700.3." However, this DOE order does not provide specific guidance on developing life-cycle cost estimates. The contractor official who prepared the plan told us that, while DOE does not have specific requirements for developing life-cycle costs, the general guidance provided in DOE-RL 5700.3 on project cost estimating can be applied to developing life-cycle costs.

In a recent report examining cost, schedule, and technical issues for the high-level waste cleanup program at DOE's Savannah River Site, we concluded that DOE had not provided complete and accurate information to the Congress on the total cost of the program.[2] This information cannot be determined from current annual budget requests. DOE acknowledged that it needed to provide more complete information to the Congress on the Savannah River vitrification program.

Similarly, the director of the Hanford program office at DOE headquarters told us that DOE has never briefed the Congress on the estimated cost of Hanford's tank waste remediation program. This information has not been reported to the Congress, because DOE has not developed a reliable life-cycle cost estimate of the whole program. He stated that until DOE fully evaluates its tank remediation program, it would not be able to develop a reliable cost estimate. He also said that he is trying to improve the program so that he can eventually develop reliable life-cycle costs and report them to the Congress.

DOE Does Not Have a Realistic Program Schedule

DOE does not have a realistic overall schedule for its waste disposal program. In the absence of an alternative, DOE has continued to use Tri-Party Agreement milestones as the basis for executing its program. While the Tri-Party Agreement represents the judgments, expectations, and assumptions of agency representatives who negotiated it in 1989, our review of documentation of the agreement indicates that, at the time, the milestones were considered the best estimates, rather than accurate predictions, of when and how the waste cleanup program would be conducted.

[2]Nuclear Waste: Defense Waste Processing Facility—Cost, Schedule, and Technical Issues (GAO/RCED-92-183, June 17, 1992).

Since 1989 significant changes have occurred in the overall approach to the cleanup program. For example, DOE

- decided not to use the existing B Plant for pretreatment purposes but to plan, design, and build totally new pretreatment facilities instead;
- decided to include single-shell tank waste in the pretreatment process and to give particular priority to resolving issues related to potentially explosive tank wastes; and
- decided to use the vitrification plant for single-shell and double-shell tank waste rather than for double-shell tank waste alone, increasing significantly the amount of waste to be vitrified.

In addition, in chapters 2 and 3 we pointed out that technical uncertainties at nearly every step of the waste treatment process make this schedule unrealistic. The Tri-Party Agreement states that its milestones support a schedule to complete all cleanup actions in accordance with a 30-year (1989-2018) site cleanup schedule. However, completion of all phases of the tank waste remediation program may take significantly longer than 30 years. For example:

- Uncertainties surrounding pretreatment processes mean that the new pretreatment facility, which, according to a Westinghouse pretreatment engineer, is to pretreat most of the high-level radioactive tank wastes, may not be operational until 2016, or only 2 years before the Tri-Party Agreement's scheduled closure of the 149 single-shell tanks in 2018. Waste that cannot be pretreated in this facility and vitrified within 2 years will have to be stored in new tanks until it can be immobilized sometime after 2018.
- As currently designed, the vitrification plant's production capacity is such that at least 38 years will be needed to vitrify all tank wastes. Thus, even if the vitrification plant begins operations in December 1999, as scheduled, and even if the supply of waste to the plant is not interrupted by any of the technical problems associated with retrieving and pretreating the wastes, vitrification will continue until about 2038—20 years beyond scheduled closure of the single-shell tanks. If advanced pretreatment processes such as TRUEX fail, well over 100 years would be needed to vitrify all the waste at the plant's current capacity.

While Tri-Party Agreement milestones cover a 30-year period, the agreement shows a potentially open-ended period for processing tank waste that could extend well beyond this date. DOE told us that waste treatment is expected to extend "quite some time" after the waste is

removed from the tanks, but its schedule does not show how long it will take to process all tank wastes or when it will close the additional tanks that will be constructed to contain the waste that will be processed after 2018.

Despite the program's numerous conceptual changes and technical uncertainties, the Tri-Party Agreement schedule continues to drive DOE's cleanup program. DOE Richland justifies virtually all of its funding for the tank waste cleanup program as being necessary to meet Tri-Party Agreement requirements. DOE has stated that it is committed to Tri-Party Agreement milestones and that it is legally bound to meet them. In contrast, an October 1991 DOE engineering review cautioned that

> . . . if schedule becomes the dominant driving force at the expense of having time available to resolve technical/operational issues, then the federal government can expect significant additional expense in correcting problems generated by providing systems or initiating operations before technical issues have been adequately resolved.

Although the Tri-Party Agreement contains a provision for revising the schedule as needed, the process of changing the agreement is lengthy and tedious. To change a milestone, EPA and the Department of Ecology require that DOE submit a technical justification. This process can result in DOE's technical support being rejected and resubmitted several times before agreement is reached. Also, the Department of Ecology's Assistant Director of the Office of Waste Management told us that except in rare circumstances, the two agencies to date have not approved or even accepted requests for change unless DOE proposes a new milestone date that is acceptable. This part of the process, like the technical justification, is subject to an exchange of numerous proposals.

While DOE and the Department of Ecology officials have met frequently (about every 2 months) during the evaluation of the TWRS program to discuss DOE's progress in meeting the milestones, there is no assurance that frequent contact will streamline milestone change processes. The Department of Ecology's program manager of nuclear and mixed waste management told us the state will consider proposed changes to the Tri-Party Agreement if DOE's technical justifications are sound, but the state will also ". . . ensure the TPA is an effective driver of Hanford cleanup." In an October 1992 letter to DOE, the program manager stated that "USDOE's assumption that TPA milestones are continually negotiable damages the integrity of the TPA. . . ." Washington State Department of

Ecology officials told us they will stand firm against any unwarranted changes to the agreement that would result in delays to its schedule.

DOE has taken only limited steps to develop an alternative overall program schedule. DOE officials told us that after the evaluation of the TWRS program is completed in March 1993, DOE will submit proposals to the Department of Ecology and EPA for amending certain milestones. In the interim, DOE is preparing issue papers that may lead to revisions of some Tri-Party Agreement milestones. According to DOE Richland's assistant manager for tank waste disposal, DOE is preparing issue papers to discuss problems, including those associated with the vitrification of high-level waste and the grouting of low-level waste. DOE sent issue papers to the state and EPA on grout issues in June 1992 and on vitrification issues in late November 1992.

While these issue papers deal with certain aspects of the program's technical uncertainties and may lead to proposed revisions of certain dates, DOE has not developed a revised overall schedule. DOE Richland's assistant manager for tank waste disposal told us that there are no plans to develop a comprehensive schedule during the current evaluation of the TWRS program. The director of the Hanford program office at DOE headquarters told us that an integrated program schedule will not be finalized until well after the TWRS program evaluation is completed in March 1993 because many technical uncertainties affecting the schedule will not be fully resolved.

Fragmented Management Approach Has Contributed to Program Problems

DOE's overall approach to Hanford's tank waste disposal program has been to manage it as a series of separate projects—such as retrieval, pretreatment, and vitrification—without developing a plan that integrates these projects. A 1991 DOE engineering review stated that this approach left DOE without a decision-making process for resolving technical problems, estimating costs, and establishing a realistic program schedule. The review said,

> A formal, management controlled, well understood and executed, technical assessment and decision process is not evident. As a result, it is not evident that management is bringing technical uncertainties and development efforts to closure.

DOE's fragmented management approach has led to inconsistency in program funding. For example, the vitrification plant receives routine annual funding because it qualifies as a major systems acquisition under DOE's project management requirements. In contrast, tank waste

characterization and other activities have been assigned a lower priority and received relatively less funding. However, the vitrification plant cannot operate unless the earlier steps, such as characterization, have been put successfully in place.

When the TWRS program was established in December 1991, the Secretary of Energy directed DOE's Richland Field Office to develop a plan to manage its tank waste disposal program in an integrated manner. At the time, DOE's Assistant Secretary for Environmental Restoration and Waste Management, citing DOE's 1991 engineering review, stated that such a plan was needed because

> tank safety and operations, waste characterization, retrieval, and pretreatment technology were . . . not in place to support the [vitrification plant]. In other words, Hanford lacks an integrated systems approach.

Subsequently, DOE proposed some organizational changes to integrate its program. In October 1992 DOE's Richland Field Office proposed to DOE headquarters a single organizational structure reflecting the integration of all project and program functions associated with the TWRS program. The proposal includes three line organizations for managing tank waste storage, remediation, and disposal.

The director of the Hanford program office at DOE headquarters told us DOE Richland's proposed organization changes are being reviewed, but as of December 1992 they had not been approved. He stated that DOE has not yet determined how it will integrate Hanford's tank safety program, which has been managed separately from the disposal program.[3]

DOE Richland is also currently drafting a plan for TWRS in response to the Secretary of Energy's directive to improve the integration and management of Hanford's tank waste remediation program. The plan is scheduled to be completed in March 1993. However, the plan does not address the funding inconsistencies of program elements, such as characterization, that could result in delays and jeopardize the schedule for subsequent waste treatment operations.

Conclusions

After several years of planning, DOE still does not know how much its tank waste remediation program will cost. While DOE has recognized the need

[3]During the processing of this report, the director of the Hanford program office in DOE headquarters told us that DOE Richland's proposed organizational changes were approved in February 1993. We were unable to assess the impact of these changes.

for developing life-cycle cost estimates, its management procedures and orders still do not clearly require it to develop such estimates for a program like the TWRS. Recent contractor estimates show that potential costs for this program could amount to nearly $50 billion. Moreover, while DOE's estimates of potential program costs have risen substantially, it has never reported the potential costs of this program to the Congress.

Given the magnitude of program changes and technical problems that have arisen since the agreement was signed, DOE's current program schedule as outlined in the Tri-Party Agreement is not realistic. While the desire to ensure speedy progress in cleaning up the Hanford Site is understandable, the magnitude of changes since the Tri-Party Agreement was signed is such that the entire schedule requires reexamination. Strict adherence to the milestones could result in money being spent on the wrong facilities just for the sake of meeting deadlines. Consequently, there is a need for a new, comprehensive schedule that would incorporate all program changes.

DOE's fragmented management approach has contributed to significant program problems. DOE has managed tank disposal program elements as separate projects with differing funding priorities. Program elements that affect other elements, such as waste characterization, have received less funding, resulting in potential program delays. DOE's Richland Field Office has proposed organizational changes that may lead to a more integrated program, but DOE headquarters has not approved the changes. However, these changes, if made, will not ensure that funding is adequately prioritized and that inadequate funding for one program element does not delay the development or deployment of another element.

Recommendations

To strengthen DOE's ability to make sound program decisions and to ensure that the Congress is informed about the potential costs of the TWRS program, we recommend that the Secretary of Energy

- amend DOE's project management orders to require that major programs, like TWRS, develop life-cycle cost estimates;
- direct the Manager of the DOE Richland Field Office to develop a reliable life-cycle cost estimate for the TWRS; and
- include the estimated life-cycle costs of TWRS in annual TWRS appropriation requests.

To ensure that DOE has a realistic program schedule and adequately funds each program element, we recommend that the Secretary of Energy direct the Manager of the DOE Richland Field Office to

- renegotiate the Tri-Party Agreement with the Department of Ecology and EPA to establish a comprehensive program schedule that includes all elements of Hanford's tank waste disposal program, including changes proposed in the TWRS program, and
- implement an integrated program management approach that includes establishing funding priorities that ensure that all elements receive adequate funding to support the development of needed technologies and processes.

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Related GAO Products

Nuclear Waste: Defense Waste Processing Facility—Cost, Schedule, and Technical Issues (GAO/RCED-92-183, June 17, 1992).

Nuclear Waste: Hanford Single-Shell Tank Leaks Greater Than Estimated (GAO/RCED-91-177, Aug. 5, 1991).

Nuclear Waste: Pretreatment Modifications at DOE Hanford's B Plant Should Be Stopped (GAO/RCED-91-165, June 12, 1991).

Nuclear Waste: Problems and Delays With Characterizing Hanford's Single-Shell Tank Waste (GAO/RCED-91-118, Apr. 23, 1991).

Nuclear Energy: Consequences of Explosion of Hanford's Single-Shell Tanks Are Understated (GAO/RCED-91-34, Oct. 10, 1990).

Nuclear Waste: DOE's Program to Prepare High-Level Radioactive Waste for Final Disposal (GAO/RCED-90-46FS, Nov. 9, 1989).

Nuclear Waste: DOE's Management of Single-Shell Tanks At Hanford Washington (GAO/RCED-89-157, July 18, 1989).

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