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United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

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June 12, 1989

The Honorable James D. Watkins
The Secretary of Energy

Dear Mr. Secretary:

Enclosed for your review and comment are two copies of our draft report entitled Nuclear Waste: DOE's Management of Single-Shell Tanks at Hanford, Washington (GAO/RCED-89-157).

To meet the needs of the congressional requesters, we are asking that your written comments be provided to us within 15 days from the date of this letter. If you have any questions, please call Mr. Carl Bannerman on 353-3711.

Twenty copies of this draft report are also being sent to the Office of the Controller, DOE.

As the report cover states, the report's use is restricted, and it should be safeguarded to prevent publication or other improper disclosure. The draft and all copies thereof remain the property of, and must be returned on demand to, the General Accounting Office.

Sincerely yours,

Keith O. Fultz

Keith O. Fultz
Director, Energy Issues

Enclosures-2

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United States General Accounting Office

# Draft Report

NUCLEAR WASTE: DOE's Management of Single-Shell Tanks at Hanford, Washington

This draft report is being provided to obtain advance review and comment from those with responsibility for the subjects it discusses. It has not been fully reviewed within GAO and is, therefore, subject to revision.

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in the tank farm areas to reduce the volume of precipitation that drains through the soil and carries the contaminants toward groundwater. The environmental risk of future leaks could be reduced by accelerating the program to pump liquid from the single-shell tanks.

For more than 13 years, DOE's stated strategy for limiting the dangers associated with leaks from single-shell tanks has been to remove the liquid waste as soon as practicable. However, schedules to pump the liquid from the tanks have been repeatedly delayed. In May 1989, DOE signed a tri-party agreement with the Environmental Protection Agency (EPA) and Washington State that establishes a schedule to remove all feasibly pumpable liquid waste from single-shell tanks by 1995. The establishment, within a formal agreement, of a definitive date to complete the tank pumping program may help ensure successful program completion. However, we believe that the agreement's 1995 date should not be used as a guideline to delay removal of liquid that could be pumped before 1995.

## BACKGROUND

Hanford's 149 single-shell tanks have capacities that range from about 55,000 to about 1 million gallons. They are covered with about 6 to 9 feet of soil topped with gravel and are clustered in 12 groups called tank farms. (See fig. I.1.) From 1959 through 1988, DOE officials identified definite or possible leaks in 66 of Hanford's 149 single-shell tanks--5 of the 66 tanks were identified in 1988. DOE contractor staff currently estimate that about 750,000 gallons have leaked--recent estimates had ranged from about 670,000 to about 900,000 gallons. (See table I.1.)

DOE estimates that the single-shell tanks contained about 77 million gallons of liquid and solid waste in 1966 but this volume was reduced to about 37 million gallons by October 1988. (See fig. II.1.) All tanks built at Hanford since 1968 have been double-shell tanks (concrete encased tanks that have two steel shells), and DOE estimates that most of the liquid waste in single-shell tanks was reduced by pumping it into double-shell tanks or by evaporating the liquid and leaving the solid residue in the single-shell tanks.[1] Recent production activity at Hanford has resulted in about 8 to 12 million gallons of waste being added to double-shell tanks annually. Evaporation processes reduce this amount to about 2 to 4 million gallons.

Some radioactive and nonradioactive contaminants that leak from the tanks tend not to migrate through the soil very much because they attach to soil particles and essentially remain in place. However, other contaminants are more mobile and migrate more quickly because they are soluble and do not adhere to soil particles. One DOE contractor study estimated the time required for contaminants to reach the groundwater ranges from several decades to several thousand years, depending on such things as the volume of the leak, the extent to which the soil retards movement of the contaminants, the distance from the tank to the groundwater, and the amount of water draining through the soil where leaks have occurred.[2] (See table I.2.)

[1]For the remainder of this report the word "tank" and the term "single-shell tank" will be used interchangeably.

[2]Precipitation at Hanford averages a little more than 6 inches a year.

DOE completed an environmental impact statement in 1987 for disposal of most defense wastes at Hanford, but it deferred decisions on disposal of the remaining single-shell tank waste until the issuance of a supplemental environmental statement for this waste in about the year 2000. A May 1989 tri-party agreement signed by DOE, the Environmental Protection Agency (EPA), and Washington State, calls for removal of feasibly pumpable liquid waste from single-shell tanks by 1995 and final disposal or removal of the remaining single-shell tank waste by 2018. Appendix III contains a chronology of major events in the tanks' history.

## BETTER DATA NEEDED TO ASSESS EFFECTS OF SINGLE-SHELL TANK LEAKS

As discussed below, there are serious limitations in DOE's efforts to assess the leaked wastes' movement through the soil and to assess the environmental impact of past leaks. First, DOE has not collected adequate data upon which informed management decisions can be made, or program priorities established concerning single-shell tank hazards or remedial actions required. And second, although DOE has maintained that the environmental impact of leaks will be extremely low or nonexistent, the studies we reviewed do not provide convincing evidence that this is the case.

this is a value judgment

judgment

### Current Data-Gathering Techniques Inadequate

DOE has gathered extensive data about tank leaks, but its current monitoring efforts do not provide sufficient data to adequately trace the migration of the leaks or to fully assess their effects. DOE contractor scientists say that better waste migration data can be obtained through expanded

use of current monitoring methods and through adoption of new methods.

According to DOE contractors, DOE traces the migration of tank leaks through the soil by monitoring the movement of ruthenium-106. However, DOE contractor scientists say that ruthenium-106 is not an adequate tracer, in part, since it has a relatively short half-life[3] (approximately 1 year) and is no longer measurable in many locations. They also say that DOE could use additional methods to trace the movement of leaked long-lived mobile contaminants--radioactive contaminants such as technetium-99 (half-life about 230,000 years) and iodine-129 (half-life about 16 million years) and [illegible] mercury. These contaminants should be monitored since they are more likely to reach groundwater in measurable concentrations than ruthenium-106. DOE officials said that it is much more expensive to trace some of these contaminants than it is to trace ruthenium-106.

DOE could collect more complete data and better trace the mobile contaminants, according to contractor scientists, by (1) analyzing soil samples from beneath the tank farms for mobile contaminants that have not been monitored directly, (2) deepening dry wells in the tank farm areas that have had contamination at or near the bottom to determine how much farther contaminants may have penetrated toward the groundwater, and (3) increasing the number of groundwater

[3]A half-life is the time required for a substance's radioactivity to decrease to half of its earlier level through radioactive decay.

monitoring wells to detect contamination due to tank leaks. DOE officials agree that more could be done and DOE is developing a plan to study soil samples beneath the tank farms. However, there is no consensus on the merits of increased dry-well or groundwater monitoring.

DOE-contractor scientists have also noted that DOE needs to better determine the characteristics of the waste stored in and leaked from the tanks if it is to assess fully the impact of the tank leaks. For example, some waste products may accelerate contaminant migration through the soil, but DOE does not know to what extent these products are still present in the tanks--since some may have been destroyed by radiation or heat, according to scientists. Also, DOE needs more information about the soil between the tanks and the groundwater. One sediment layer below some tank farms, for example, could--depending on the type of waste--accelerate the migration of highly concentrated contaminants or could slow and disperse the contaminants. However, the sediment layer's location has not been adequately mapped and its effects on waste migration have not been fully assessed.

## Studies Are Inconclusive About Environmental Impact

DOE officials have stated that the environmental impact of the single-shell tank leaks will be low or nonexistent and have cited several studies as a basis for their assessment. DOE contractor studies report that a small amount of leaked tank waste reached groundwater because of the drilling of a groundwater monitoring well in 1970. More recently, however, contractor scientists told us that there are insufficient data to confirm how the waste reached groundwater, and that there is some chance that the waste reached the water by normal migration through the soil.

However, we believe the studies do not provide conclusive evidence about the degree of environmental impact attributable to tank leaks. Some studies indicated there would be limited environmental impact but they did not analyze the impact of several mobile contaminants on Hanford's groundwater. One study predicted groundwater contamination would exceed safe drinking water standards but did not project the impact on the Columbia River. Four of the studies we reviewed are discussed below.

Three studies focused on the impact of radioactive substances leaking from the tanks. Two of them considered only substances that move so slowly through the soil that virtually all of them decay before they can reach groundwater. The third study addressed the potential radiological effects of leaks on the Columbia River and on surrounding populations but not on groundwater near the tanks. Only the third study included any discussion of the impact of nonradioactive substances.[5]

A fourth study that reviewed 20 radioactive and nonradioactive contaminants that leak from the tanks, predicted that many substances will reach Hanford's groundwater and that several will be in concentrations greatly above the safe drinking water standards established by EPA and Washington State. However, this study did not project the impact on the Columbia River. On the basis of varying assumptions, this study concluded that peak concentrations of one radioactive contaminant (iodine-129) could reach groundwater as soon as 170 years or as late as

[5]The third study indicated that in a worst-case scenario the concentration of leaked nitrates in the groundwater directly below a tank farm could be as high as about 67 times the drinking water standard.

5,500 years and at levels exceeding the safe drinking water standard by 4,800 and 31 times, respectively. According to the study, contaminant concentration levels and migration speeds are highly dependent on the volume of water that drains through the soil. (See table I.2.) This study's conclusions sharply contrast with some DOE statements that the impact will be extremely low or nonexistent. However, the study does not provide conclusive answers about the environmental effects of tank leaks because its conclusions are based, as are the other studies, on unproven assumptions about such things as the characteristics of the waste in the tanks and of the soil beneath them.

to what end?

## DOE CAN DO MORE TO MINIMIZE RISKS ASSOCIATED WITH TANK LEAKS

DOE has reduced the volume of liquid waste in the single-shell tanks by solidifying a large volume of the liquid, primarily through evaporation, and by pumping liquid from the tanks. However, DOE can help to reduce the risk of future single-shell tank leaks and can help to minimize the risks associated with past leaks by (1) accelerating its program to pump liquid from the tanks and (2) providing better ground covering in the tank farm areas to minimize the volume of precipitation that drains through the soil and carries the contaminants toward the groundwater.

subjective — no cost/benefit consideration

As early as 1973, DOE's stated strategy for limiting the danger from tank leaks was to remove the highly radioactive liquid waste as soon as technically and economically feasible and seal the tanks to prevent liquid, such as rainwater, from washing through them. According to DOE documents on waste volume projections (September 1986-88), about 2 million gallons of single-shell tank waste could be pumped annually. In the May 1989 tri-party agreement, DOE



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agreed that all feasibly pumpable liquid waste would be removed from the single-shell tanks by 1995. We believe that the risk of environmental damage from future leaks makes it imperative that DOE follow its stated strategy to remove the liquid as soon as it is practicable--the agreement's 1995 date should not be considered the optimum time to complete the pumping program; it should not be used to delay removal of any liquid that could be pumped before 1995.

## The Tank-Pumping Program Has Been Repeatedly Delayed

To reduce the single-shell tank liquid, DOE has sought to solidify the waste through evaporation, and to pump liquid waste into double-shell tanks. By 1981 DOE had removed nearly all of the liquid that rested above the solid waste in the bottom of the tanks. DOE had planned to remove all liquid that could feasibly be pumped by September 1985--about 8.5 million gallons that was mostly interspersed within the solid waste. DOE did not meet this deadline and repeatedly extended the completion date for the program. From September 1985 through October 1988, DOE, with one exception,[6] limited the pumping program to tanks suspected of leaking. As of October 1988, about 5.3 million gallons of pumpable liquid remained in the tanks. (See fig. II.3.)

Delays in DOE's pumping program occurred in part because DOE allocated most of its available double-shell tank space through fiscal year 1993 for waste from ongoing production of nuclear materials. Additionally, waste previously

[6] In 1986 DOE pumped 16,000 gallons from one tank that was not assumed to have leaked.

discharged to the soil is now stored in double-shell tanks and space previously allocated for single-shell tank waste was reallocated to receive other wastes. However, in September 1988, a DOE contractor task force identified several options that, collectively, could make available an additional 7 million gallons of double-shell tank space. These options include concentration of some double-shell tank waste, accelerating low level waste disposal and evaporation programs, and using alternative storage methods for some wastes. DOE officials said these options would require vigorous evaluation and they are being studied. DOE officials at Hanford said pumping program delays also occurred because some scientists had concluded that the effects of tank leaks would be insignificant, and because DOE placed greater priority on funding other programs.

By 1987 DOE had established a revised schedule to complete the pumping program by September 1996, but, according to program officials, funding has not been adequate to meet this schedule. During the last 5 years, as shown in table II.1, funding for programs to pump and seal the tanks has been, on average, about 5 percent of the amount requested by DOE officials at Hanford. In the May 1989 tri-party agreement, DOE agreed to seek the money necessary to pump the remaining 5.3 million gallons by September 1995. According to DOE officials, completion of pumping on this schedule is contingent on timely receipt of about $56.3 million through fiscal year 1995.

## New Ground Surface Material Could Slow Movement Of Leaks

The movement of leaked waste towards the groundwater is determined to a great extent by how much water drains

through the soil. A 1987 DOE contractor study noted that more water drained through the soil at a Hanford site where coarse material covered the ground surface than at those locations covered by vegetation or finely textured soil. Since coarse material (gravel) covers the ground surface at the tank farms, experiments are currently being conducted to determine if the same results occur within the tank farms.

If DOE's final disposal plan involves leaving any waste at the tank farms, regulations established under the Resource Conservation and Recovery Act (10 CFR 265.197, and 265.310; 42 U.S.C. 6901-6991) require that a permanent barrier (ground surface material) must be placed over the tank farms to minimize the amount of surface water that could drain through the soil. Because DOE does not plan to complete final disposal until at least 2018, some scientists have suggested the gravel over the tank farms be replaced with an interim surface material--such as finely-textured soil planted with grass--in the intervening period to reduce water draining through the soil.

DOE and its contractor officials gave two reasons for not placing a new ground surface material over the tank farms. First, they said that monitoring data have not indicated a problem with accelerated movement of wastes. As discussed above, however, we believe DOE's current data cannot adequately demonstrate that no problem exists. Second, they said that data are needed on the volume of water that moves through the soil at gravel-covered and unvegetated sites near the tanks. In this regard, they told us that results from ongoing experiments should provide such data beginning in about November 1989. They expect these experiments will confirm the results of the 1987 study and will show that gravel surfaces in the tank farm areas allow greater volumes

of water to drain through the soil than would surfaces covered by vegetation or finely textured soil.

## INSUFFICIENT DOE EMPHASIS ON ENVIRONMENTAL CONCERNS

Since 1981, GAO has reported or testified many times on the environmental, safety, and health aspects of DOE's nuclear weapons complex. (See p. 36 for a partial listing of related GAO products.) We have presented information that demonstrates, and DOE's studies concur, that DOE has emphasized the production of nuclear material to the detriment of environmental concerns. We did not evaluate DOE's production and environmental priorities for this report. However, some problems associated with the management of Hanford's single-shell tanks that we examined during this review are indicative of DOE's insufficient emphasis on environmental concerns:

-- Scientists suggested as early as 1980 that DOE test soil samples from beneath the tank farms to improve its monitoring of certain mobile contaminants that have leaked from the tanks However, as we discussed, DOE has not used readily available techniques to accomplish this.

priority issue

-- Single-shell tank leaks were first suspected in 1956 and confirmed in 1961, but wastes continued to be added to the tanks as late as November 1980. (See app. III.)

history

-- DOE's stated strategy for limiting the danger of future tank leaks is to pump the liquid into double-shell tanks whenever practicable. However, as we discussed, the pumping program has been repeatedly delayed, at least in part, because most of the available double-shell tank

space is allocated through fiscal year 1993 to ongoing production and waste-processing programs.

## CONCLUSIONS

DOE has not taken advantage of available techniques to track leaked contaminants or to predict their movement. Until DOE obtains better data, information about the impact of the tank leaks will continue to be inconclusive. DOE should, for example trace the movement of the contaminants--such as technetium-99, iodine-129, nitrates, chromium, and mercury--that are more likely to reach groundwater in measurable concentrations than ruthenium-106.

Available studies do not provide convincing support for DOE assertions that the environmental effects of tank leaks will be extremely low or nonexistent. To resolve uncertainty about the effects, DOE needs to obtain better data from the tank farms to support future study assumptions and validate study results.

The program to pump liquid from the single-shell tanks has often been delayed because insufficient space has been reserved in double-shell tanks for this purpose. Insufficient space allocation in the double-shell tanks has been the result, at least in part, of higher priorities being assigned to waste from ongoing production activities.

DOE may lessen the effects of tank leaks if it replaces the gravel surfaces above the tanks with a less permeable ground surface material to reduce the volume of water that drains through the soil. In view of the potential for long-term environmental damage from tank leaks, DOE should develop immediate, specific plans to place an interim ground surface

material over the tank farms. If, as expected, the current experiments indicate that the gravel surfaces at the tank farms significantly affect water drainage through the soil, DOE would then be able to expeditiously replace the gravel surfaces in the tank farm areas.

## RECOMMENDATIONS

To minimize the environmental effects of tank leaks on the surrounding soil and eventually on the groundwater, we recommend that the Secretary of Energy take the following action:

-- Conduct a data-gathering program sufficient to assess th risks and extent of groundwater contamination from tank leaks of mobile and long-lived radioactive substances.

-- Assign appropriate resources and priority to the single-shell tank pumping program to ensure that (1), as a minimum, all feasibly pumpable liquid is removed from th tanks by 1995, and (2) the 1995 goal is not used to dela removal of liquid that could be pumped before 1995.

-- Develop specific plans to replace the gravel surfaces at the tank farms with a less permeable material and promptly replace the gravel surfaces if ongoing studies indicate that these surfaces could promote the movement of waste toward the groundwater.

- - - - -

To obtain our information, we interviewed engineers, managers, and scientists at DOE headquarters and field offices, Pacific Northwest Laboratories, EPA, and

Washington State Department of Ecology. We also reviewed official files and various published and unpublished reports. (See app. IV.)

Our review was conducted between August 1988 and February 1989, in accordance with generally accepted government auditing standards. As agreed with your office, we obtained official agency comments on a draft of this report and, where appropriate, modified the report accordingly. As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution until 10 days from the date of this letter. At that time, we will provide copies to DOE and other interested parties upon request.

Major contributors to this report are listed in appendix V.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

CONTENTS

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ABBREVIATIONS

| | |
|---|---|
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| GAO | General Accounting Office |

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APPENDIX I

## BACKGROUND

This appendix provides background information about some of the features of a typical Hanford single-shell tank, the extent of leaks from the tanks, and one study's conclusions about the impact of those leaks on Hanford's groundwater. The Department of Energy (DOE)[1] assumes that 66 of the 149 single-shell tanks at Hanford have leaked, but data concerning the amount leaked from many tanks are inconclusive. According to the study, the time required for peak concentrations of leaked contaminants to reach groundwater and the levels of those concentrations are highly dependent upon the amount of water that drains through the soil each year (recharge rate).

## A TYPICAL SINGLE-SHELL TANK

Figure I.1 shows some of the features of a typical Hanford single-shell tank that can hold 1 million gallons. Special pump equipment extends into wells created in the mostly solid waste. To detect leaks, DOE monitors the liquid levels in the tanks and measures levels of radiation in the dry wells near the tanks.

There are 25 single-shell underground waste storage tanks at Hanford with 1-million-gallon capacities. As of October 31, 1988, each of these tanks contained, on average, 280,000 gallons of waste--about 7,000 gallons of liquids resting above the solids (such as sludge and crystalline salt deposits), and about 87,000 gallons of drainable liquids interspersed in the solids.

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[1]For convenience, we identify DOE throughout this discussion as the federal agency responsible for operations at Hanford. DOE was preceded in this responsibility by the Army Corps of Engineers (1943-46), the Atomic Energy Commission (1946-75), and the Energy Resources and Development Agency (1975-77).

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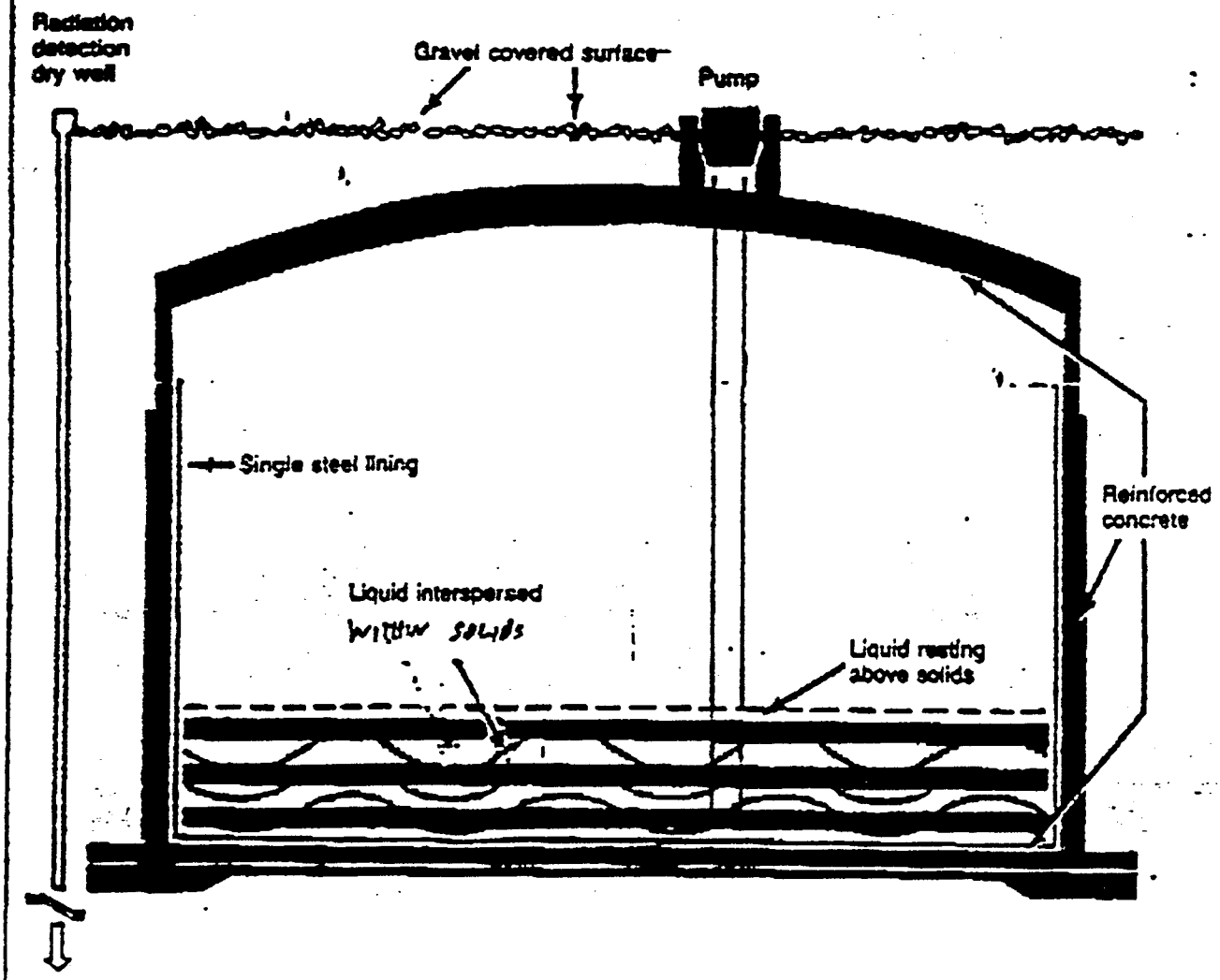
APPENDIX

Figure I.1) Cross-Section of a Typical Single-Shell Tank
(Capacity of 1 Million Gallons)

Figure 1.1: Cross-Section of a Typical Single-Shell Tank (Capacity of 1 Million Gallons)



APPENDIX I

## SINGLE-SHELL TANKS THAT DOE ASSUMES HAVE LEAKED

DOE cannot measure the liquid level in many tanks and depends or dry-well monitoring to detect tank leaks and estimate the amoun of leakage. According to DOE officials, the designation "assume leaker" does not indicate the tank is currently leaking, but rather that DOE assumes the tank has leaked at some time. The list of assumed leakers includes tanks in each of Hanford's 12 single-shell tank farms as well as 2 of the 4 most recently constructed single-shell tanks. DOE estimates that the 149 single-shell tanks contain about 6.9 million gallons of drainab waste and, as shown in table I.1, about 1.2 million gallons of this remains in the 66 tanks that DOE has identified as assumed leakers. The volumes for tank leaks shown in table I.1 are bas on estimates by DOE contractor staff. The other information in the table is based on DOE records.

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Table I.1: Single-Shell Tanks at Hanford that DOE Assumes Have Leaked (Gallons in Thousands)

| When identified as an assumed leaker | Number of tanks | Gallons of waste: Estimated leakage | Gallons of waste: Drainable liquid[a] remaining in tanks assumed to have leaked |
|---|---|---|---|
| 1959-63 | 7 | 162 | 16 |
| 1964-68 | 5 | 90 | 44 |
| 1969-73 | 13 | 284 | 101 |
| 1974-78 | 30 | 180 | 831 |
| 1979-83 | 3 | 10 | 14 |
| 1984-88 | 8 | 17 | 188 |
| Total | 66 | 743[b] | 1,194[c] |

[a]Drainable liquid includes all liquid waste (as of October 1988) that could drain from the tanks due to gravity if the tanks ruptured. It does not include a portion of liquid waste that would adhere to the solid waste within the tanks.

[b]DOE contractor staff rounded this figure to the nearest 50,000 gallons (750,000) and has no precise estimate of the amount of leakage from many individual tanks. Until recently, the staff had estimated the leakage could range from about 670,000 to 900,000 gallons.

[c]DOE estimates that about 600,000 gallons of this drainable waste could be pumped from six of these tanks. (See fig. II.4.)

## RECHARGE RATE CAN SIGNIFICANTLY AFFECT ENVIRONMENTAL IMPACT OF LEAKED WASTE

The length of time required for peak concentrations of leaked tank contaminants to reach the groundwater and the level of the peak concentrations vary greatly depending on the annual recharge rate. Higher recharge rates reduce the time required for contaminants to reach groundwater. In the study upon which table I.2 is based, the highest annual recharge rate examined was 5 centimeters. (Average annual recharge at one Hanford site has since been estimated at about 10 centimeters.) The study assumed

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that a ground covering installed over the tank farms would reduce the annual recharge rate to 0.1 centimeter.

The study results presented in table I.2, below, were based on the impact of assumed leaks of 250,000 gallons from 27 tanks in 2 of Hanford's single-shell tank farms. The table is based on a study by a DOE contractor. The recharge rate of .1 centimeter for an installed ground covering is an assumed figure and the actual figure could differ but the value of the study is that it demonstrates that relatively minor differences in the recharge rate can greatly affect the environmental impact of tank leaks.

Table I.2: The Effect of the Annual Recharge Rate on Peak Levels of Contaminants in the Hanford Groundwater--Time of Arrival and Concentration

| | Number of years after leak before peak concentration reaches groundwater* at an annual recharge rate of: | | | Peak concentration compared with drinking water standards (Predicted level of contamination is this many times the standard)** at an annual recharge rate of: | | |
|---|---|---|---|---|---|---|
| Contaminant | 0.1 cm | 0.5 cm | 5.0 cm | 0.1 cm | 0.5 cm | 5.0 cm |
| Iodine-129 | 5,500 | 1,300 | 170 | 31 | 640 | 4,800 |
| Technetium-99 | 5,500 | 1,300 | 160 | 22 | 478 | 4,111 |
| Plutonium-239 | 20,000 | 5,000 | 700 | 1.3 | 41 | 429 |
| Carbon-14 | 5,500 | 1,500 | 150 | .65 | 20 | 120 |
| Uranium-238 | 9,500 | 1,700 | 180 | .11 | 1.3 | 6 |
| Chromium | 4,900 | 1,230 | 155 | .74 | 15 | 136 |
| Nitrates | 4,900 | 1,230 | 155 | .06 | 1.3 | 12 |
| Mercury | 4,900 | 1,230 | 155 | .33 | 7 | 60 |

*This is the elapsed time between the occurrence of the tank leak and the arrival of peak concentrations in the groundwater 300 meters from the tank farms.

**This is the predicted peak concentration of contaminants in the groundwater 300 meters from the tank farms as a multiple of drinking water standards set by the Environmental Protection Agency and the state of Washington. Concentrations directly below the tank farm could be higher.

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## DOE'S STORAGE AND MANAGEMENT OF HANFORD SINGLE-SHELL TANK WASTE

This appendix describes past DOE management of the single-shell tank liquid waste and the current status of that waste including:

1. decrease in tank waste from 1966 to 1988,
2. annual data on amounts pumped and amounts remaining in the tanks that could be pumped (1981-88),
3. disposition of liquid waste in and around the tanks,
4. amount of liquid that could be pumped from each of 43 tanks, and
5. amounts of money spent to pump and seal the tanks (1964-88).

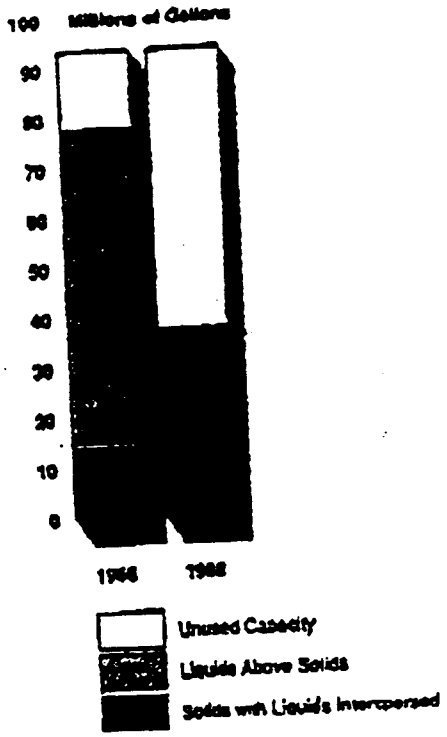
### CHANGES IN SINGLE-SHELL TANK WASTE CATEGORIES, 1966-88

Figure II.1 shows the decline in peak levels of both total waste and liquid waste stored in the tanks over the past 2 decades--from about 77 million gallons of mostly liquid waste to about 37 million gallons of mostly solid waste. The volume of solids increased (from 13.7 million gallons to about 36.2 million gallons) primarily because residue, such as salt deposits, left in the tanks from evaporation of liquid wastes has solidified. DOE continued to put waste into the tanks until 1980. Also, DOE placed solids into some tanks to help absorb the liquids. The amount of liquid resting above the solids declined from about 64 million gallons in 1966 to about 0.7 million gallons in 1988.

APPENDIX II

Figure II.1: Waste Stored in Hanford's Single-Shell Tanks (1966-1988)

Figure II.1: Waste Stored in Hanford's Single-Shell Tanks, 1966 - 1988




## TANK PUMPING PROGRESS SINCE 1981

As shown in figure II.2 the estimated amount of liquid in the tanks that could be feasibly pumped has declined since 1981, but the rate of decrease has been lower since 1985. Scheduled pumping ended in August 1985 and, with one exception, DOE has pumped liquids since August 1985 only from tanks with suspected leaks. (DOE pumped about 16,000 gallons from one tank in 1986 that was not suspected of leaking.)

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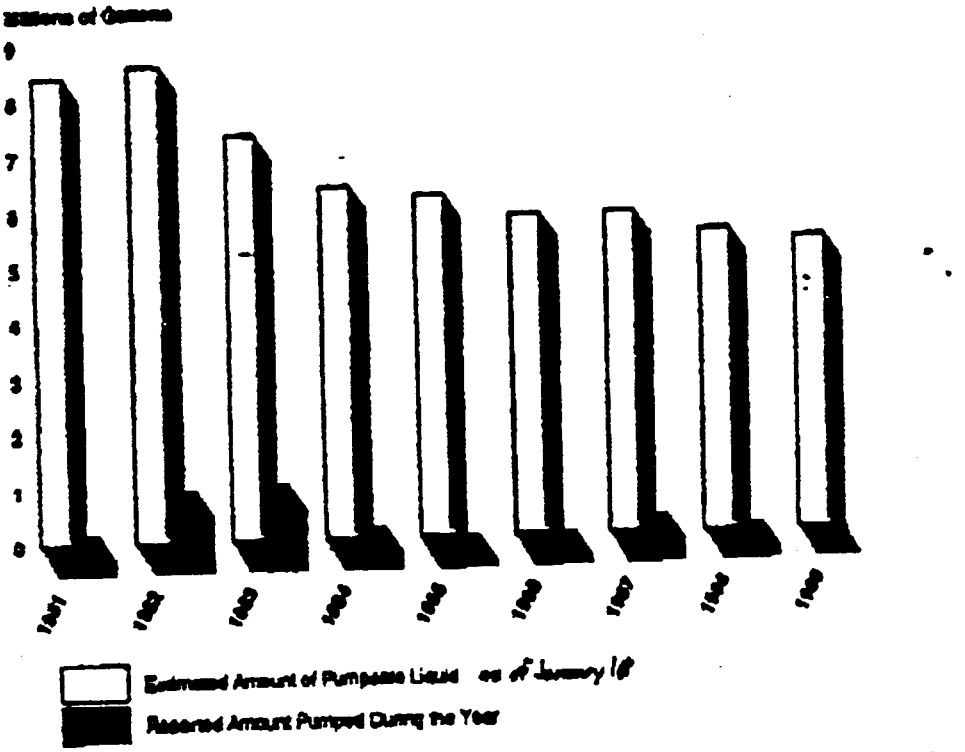
APPENDIX II

Figure II.2: Estimated Amount of Pumpable Liquid in Single-Shell Tanks and Reported Amount Pumped Each Year, 1981-1988




Most but not all of the decline in the estimated amount of pumpable liquid from 1981 through 1988 resulted from DOE's pumping. The reported amount pumped during this period was about 2.5 million gallons (about 80 percent of the decline).

Although DOE pumped liquid from five single-shell tanks in 1988, the amounts were not reported.

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APPENDIX II

Most of the change in the volume of pumpable liquid volume is attributable to DOE's pumping program (about 2.3 million gallons pumped since 1981). According to a DOE contractor, most of the other changes are due to changes in methods to estimate and report the amount of pumpable liquid in the tanks. According to this official, evaporation of the waste, leaks of liquid out of the tanks, and leaks of water (such as rainwater) into the tanks, have had a minimal effect.

## LIQUID WASTE STORED IN AND LEAKED FROM SINGLE-SHELL TANKS

As of October 1988, the tanks contained about 8.2 million gallons of liquid waste. About 6.9 million gallons of that waste could drain into the soil through tank ruptures. However, as shown in figure II.3, DOE estimates that only 5.3 million gallons of this could be feasibly pumped because either some of the liquid drains too slowly through the solid waste to be feasibly pumped. The remaining 1.3 million gallons of liquid waste will not drain (as a result of gravitational forces) because it adheres to the solids.

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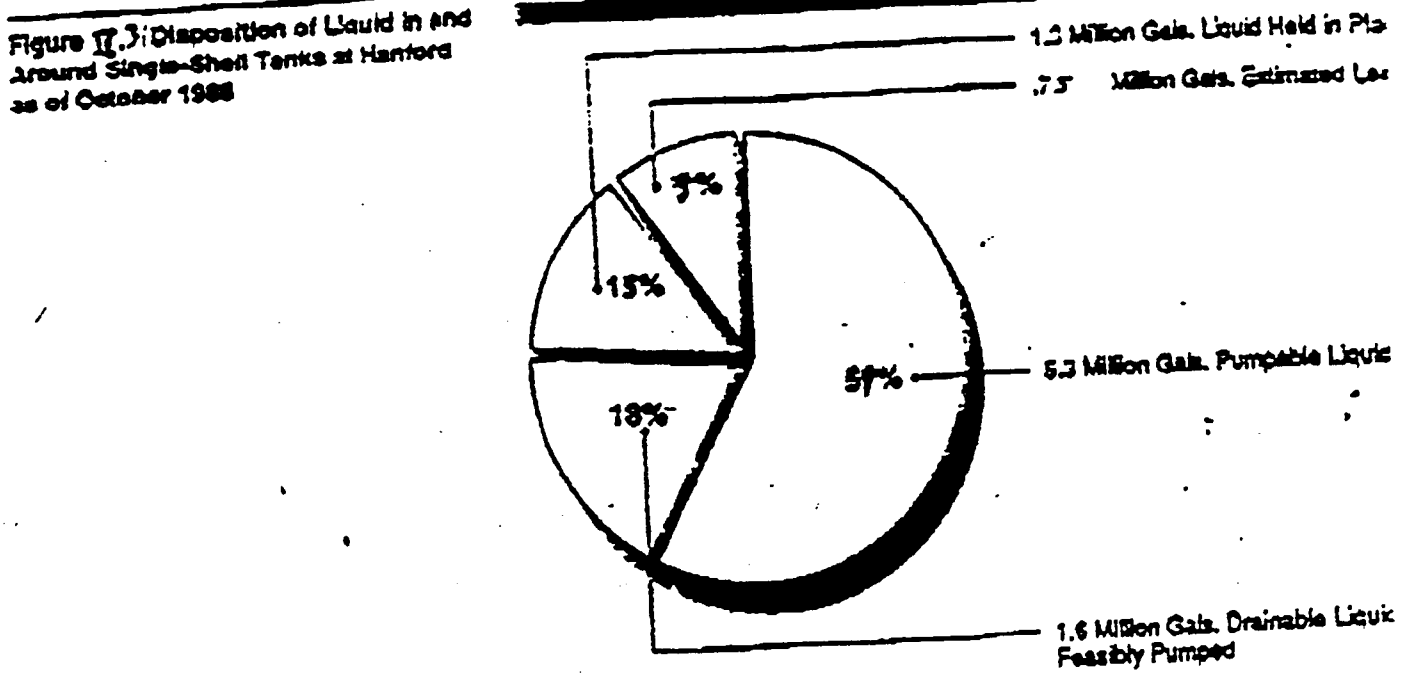
APPENDIX II

Figure II.3: Disposition of Liquid In and Around Single-Shell Tanks at Hanford as of October 1988 (millions of gallons)



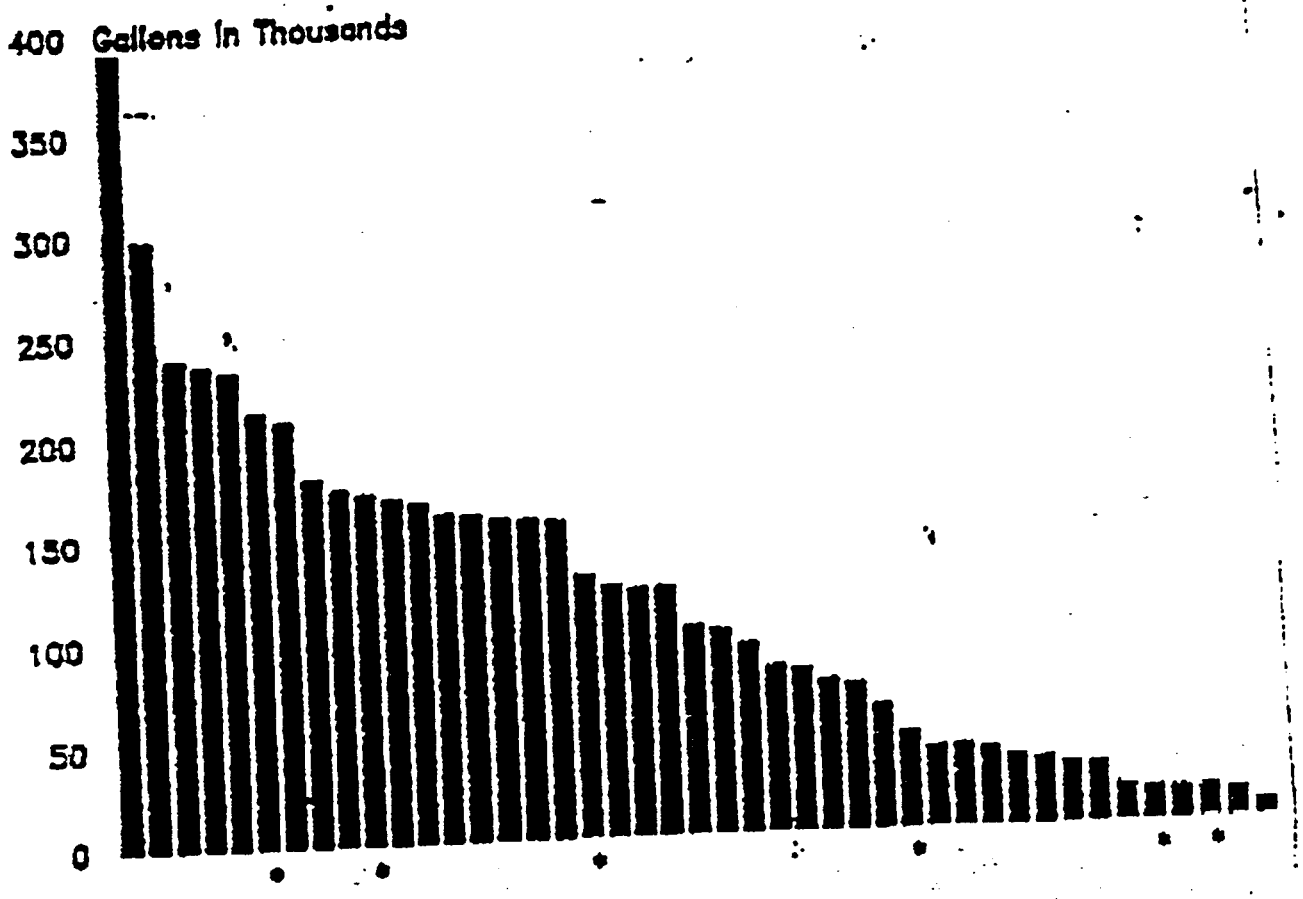

## SINGLE-SHELL TANKS WITH LIQUID THAT COULD BE PUMPED

DOE has two basic criteria to identify tanks that contain drainable liquid that could be feasibly pumped: (1) those that have 50,000 gallons or more of drainable liquid interspersed within solid waste and (2) those that have 5,000 gallons or more of liquid above solid waste. By applying these criteria GAO found that 43 of Hanford's 149 single-shell tanks contain liquid that could be feasibly pumped. (See figure II.4.) According to a DOE official, DOE may identify additional tanks with feasibly pumpable liquid when it performs engineering analyses and reviews its current pumping criteria.

APPENDIX II

Figure II.4: Amounts of Pumpable Liquid in Each of 43 Single-Shell Tanks As of October 31, 1988

# Figure II.4: Amount of Pumpable Liquid in Each of 43 Single-Shell Tanks as of October 31, 1988




* Tanks that DOE assumes have leaked

Note: Engineering analyses and a review of DOE's current pumping criteria may indicate that liquid can feasibly be pumped from additional tanks.

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Fig. II.4

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APPENDIX II

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Fig II.4

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APPENDIX II

## AMOUNTS SPENT TO PUMP AND SEAL SINGLE-SHELL TANKS

As shown in table II.1, DOE expended about $1.8 million during the 5-year period 1984-88 (fiscal years) to pump liquid from the tanks and seal them to prevent unwanted intrusions of liquid such as rainwater into the tanks. This amount is about 3 percent of the money requested by Hanford officials for those years and about 3 percent of the total $56.3 million officials now estimate (as of April 1989) it will cost to complete the pumping and sealing programs. Hanford officials requested about $5.6 million for these programs for fiscal year 1989.

Table II.1: Hanford Budget Requests and Expenditures To Pump and Seal Single-Shell Tanks (Dollars in thousands)

| Fiscal year | Hanford budget request | DOE expenditures | Expenditures as a percent of requests |
|---|---|---|---|
| 1984 | $11,120 | $ 100 | 1 |
| 1985 | 10,180 | 454 | 4 |
| 1986 | 3,710 | 219 | 6 |
| 1987 | 8,680 | 592 | 7 |
| 1988 | 1,271 | 394 | 31 |
| Total | $34,961 | $1,759 | 5 |

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APPENDIX III

## CHRONOLOGY OF MAJOR EVENTS IN THE HISTORY OF SINGLE-SHELL TANKS AT HANFORD, WASHINGTON

| | |
|---|---|
| 1944 | First single-shell tanks went into service. |
| 1956 | First indication of a potential leak. |
| 1959 | First single-shell tank identified as assumed to have leaked. |
| 1961 | First leak confirmed. |
| 1964 | Construction completed on the last group of single-shell tanks. |
| 1966 | The last of the 149 single-shell tanks went into service. |
| 1966 | The total volume of waste in the single-shell tanks reached about 77 million gallons. |
| 1968 | Construction of the first double-shell tanks began. |
| 1970 | Drilling of a groundwater monitoring well reportedly caused spread of leaked highly radioactive contaminants from single-shell tank to groundwater. |
| 1972 | Pumping program was begun to transfer liquid from single- to double-shell tanks. |
| 1973 | The largest single-shell tank leak occurred--an estimated 115,000 gallons. |

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APPENDIX III

1980 DOE stopped placing any waste into the single-shell tanks.

Liquid waste levels in single-shell tanks reduced to no more than 1 foot above the solid waste.

Plans adopted to transfer the remaining 8.5 million gallons of single-shell tank waste that could be feasibly pumped into the double-shell tanks by 1985.

1985 Planned pumping schedule not followed and scheduled pumping of the single-shell tanks ended. Since August 1985, DOE has pumped liquids only from tanks it assumed had leaked, with the exception of about 16,000 gallons pumped from one tank in 1986.

1988 Five tanks were added to the list of assumed leakers.

1989 DOE, EPA, and Washington State signed an agreement in which DOE agreed to pump the remaining 5.3 million gallons of feasibly pumpable liquid waste from the single-shell tanks by the end of fiscal year 1995.

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APPENDIX IV

## OBJECTIVES, SCOPE, AND METHODOLOGY

As a result of discussions with the offices of Senator Adams and Representative Unsoeld's predecessor, Representative Bonker, in August and November 1988, we reviewed DOE's management of underground single-shell waste storage tanks at its Hanford, Washington site. Specifically, we

- reviewed DOE's efforts to monitor the movement of leaked single-shell tank waste and assess the effects of leaks on groundwater, and
- examined some methods DOE could use to reduce the environmental impacts of past leaks and the risk of future leaks.

To meet these objectives we interviewed scientists, engineers, and managers working for DOE's operations office at Richland, Washington, and at the DOE headquarters Office of Environmental Audit, the Westinghouse Hanford Company, the Battelle Memorial Institute at the Pacific Northwest Laboratories, the Environmental Protection Agency's Region 10 office, and the Washington State Department of Ecology. We also reviewed official records of tank farm surveillance data, monthly waste inventory reports for both single- and double-shell tanks, reports on single-shell tank pumping, annual and quarterly projections of single- and double-shell tank space utilization, and various published and unpublished studies and reports concerning such things as single-shell tank-pumping plans, safety of single-shell tank operations, and the mobility of various contaminants in Hanford soils.

We provided a statement of facts concerning our audit findings to DOE officials in the office of Defense Programs and the office of

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## RELATED GAO PRODUCTS

Modernization and Cleanup Problems are Enormous in the Nuclear Weapons Complex (GAO/T-RCED-89-17, March 15, 1989)

Environmental Problems at the Department of Energy's Nuclear Weapons Complex (GAO/T-RCED-89-12, February 24, 1989)

Nuclear Health and Safety: Summary of Major Problems at DOE's Rocky Flats Plant (GAO/RCED-89-53BR, Oct. 27, 1988)

Ineffective Management and Oversight of DOE's P-reactor at Savannah River, S.C., Raises Safety Concern (GAO/T-RCED-88-68, Sept. 30, 1988).

Nuclear Health and Safety: DOE Needs to Take Further Actions to Ensure Safe Transportation of Radioactive Materials (GAO/RCED-88-195, Sept. 27, 1988).

Nuclear Science: Issues Associated With Completing WNP-1 as a Defense Materials Production Reactor (GAO/RCED-88-222, Sept. 21, 1988).

Status of the Department of Energy's Waste Isolation Pilot Plant (GAO/T-RCED-88-63, Sept. 13, 1988).

Nuclear Waste: Problems Associated With DOE's Inactive Waste Sites (GAO/RCED-88-169, Aug. 3, 1988).

Nuclear Health and Safety: Stronger Oversight of Asbestos Control Needed at Hanford Tank Farms (GAO/RCED-88-150, July 29, 1988).

Nuclear Health and Safety: Oversight at DOE's Nuclear Facilities Can Be Strengthened (GAO/RCED-88-137, July 8, 1988).

Nuclear Waste: DOE's Handling of Hanford Reservation Iodine Information (GAO/RCED-88-158, May 25, 1988).

Nuclear Health and Safety: Summary of Problem Areas Within the DOE Nuclear Complex (GAO/RCED-88-130, Mar. 28, 1988).

Nuclear Waste: Unresolved Issues Concerning Hanford's Waste Management Practices (GAO/RCED-87-30, Nov. 4, 1986).

Nuclear Energy: Comparison of DOE's Hanford N-Reactor With the Chernobyl Reactor (GAO/RCED-86-213BR, Aug. 5, 1986).

Decommissioning Retired Nuclear Reactors at Hanford Reservation (RCED-83-104, Apr. 15, 1983).

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