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REPORT TO THE CONGRESS

Isolating High-Level Radioactive Waste From The Environment: Achievements, Problems, And Uncertainties

Atomic Energy Commission

BY THE COMPTROLLER GENERAL
OF THE UNITED STATES

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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D C 20548

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To the Speaker of the House of Representatives
and the President pro tempore of the Senate

This is our report on achievements, problems, and uncertainties in isolating high-level radioactive waste from the environment by the Atomic Energy Commission 743

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U S.C 53), and the Accounting and Auditing Act of 1950 (31 U.S C 67)

We are sending copies of this report to the Director, Office of Management and Budget, and to the Chairman, Atomic Energy Commission.

Comptroller General
of the United States

Contents

ABBREVIATIONS

AEC	Atomic Energy Commission
ARHCO	Atlantic Richfield Hanford Company
DPMM	Division of Production and Materials Management
DWMT	Division of Waste Management and Transportation
GAO	General Accounting Office
RSSF	Retrievable surface storage facility

THE COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

ISOLATING HIGH-LEVEL RADIOACTIVE WASTE FROM THE ENVIRONMENT ACHIEVEMENTS, PROBLEMS, AND UNCERTAINTIES
Atomic Energy Commission

DIGEST

WHY THE REVIEW WAS MADE

GAO made this review to evaluate the Atomic Energy Commission's (AEC's) progress in insuring safe storage of high-level radioactive waste generated by AEC and by industry

The accumulating, storing, and disposing of high-level radioactive waste has been of concern to the public, the Congress, and AEC for some time. This concern has recently received increased public attention because of

--leaks from underground tanks of AEC-stored high-level waste in 1973 and

--the large volume of high-level waste to be created by the nuclear power industry over the next 20 to 30 years

FINDINGS AND CONCLUSIONS

From the start of the nuclear weapons program during World War II to June 30, 1974, AEC had generated about 205 million gallons of high-level radioactive liquid waste and is presently generating this waste at the rate of about 7 5 million gallons annually. (See p 3.)

The commercial nuclear power industry has generated less than 600,000 gallons thus far, but it is estimated that the industry will create 60 million gallons by the turn of the century and 238 million gallons by the year 2020 (See p. 3)

The chemical reprocessing of fuel used in nuclear reactors is the largest source of radioactive waste.

This process generates radioactive waste in three forms gaseous, solid, and liquid. Liquid waste is classified as low and high levels, which basically reflects its content of radioactivity

Of all forms of waste, high-level liquid waste poses the most complex technical problems in management and the potentially most severe hazards, if released.

Strontium-90, cesium-137, and plutonium-239 contained in high-level waste are of greatest concern. Each is hazardous in terms of its potential effects on the human body, the pathways by which it may reach the body, and the length of time it remains dangerous. (See pp. 5 to 7.)

AEC-generated waste

By solidification, AEC had reduced its inventory of high-level waste to about 81 million gallons in liquid and solidified form at

June 30, 1974 This waste is stored at the following three locations.

--3 percent at the Idaho National Engineering Laboratory near Idaho Falls, Idaho,

--25 percent at the Savannah River plant near Aiken, South Carolina, and

--72 percent at the Hanford Reservation near Richland, Washington

Waste management activities at these sites are carried out by AEC contractors. (See pp. 8, 15 21, and 23)

AEC's program for managing its high-level waste consists of

--containing the liquid in underground tanks pending solidification,

--solidifying the liquid to prevent leaks and reduce volumes, and

--developing methods of further immobilizing the solidified waste.

Overall, AEC has made considerable progress in insuring safe storage of its high-level waste. However, problems have been encountered with containing liquid waste in underground tanks and with slippages in the solidification schedule at Richland AEC has taken actions to resolve these problems. (See p. 8.)

Containment of liquid waste

Since the early 1940s, AEC has experienced a total of 26 leaks in underground tanks Eighteen of these occurred at Richland, releasing about 430,000 gallons of high-level waste to surrounding soil. AEC has reported that none of this material migrated far enough from the point of the leaks to be of any danger, nor is it considered likely to in the future (See p. 9.)

Because of the increasing age of the tanks at Richland, leaks have been occurring with increasing frequency. Early detection is important so that waste can be transferred to nonleaking tanks

Both Idaho Falls and Savannah River have fairly sophisticated waste management systems. Richland's system is generally older than that of the other two sites and less sophisticated

A leak of 115,000 gallons of high-level waste at Richland in 1973 went undetected for 48 days, resulting in its release to the surrounding soil AEC attributed this delay in detection largely to human error (See pp. 9 to 18)

Since that time, AEC has taken steps to improve its leak detection capability at Richland--the surveillance work force was increased and monitoring procedures were strengthened

Near the conclusion of GAO's fieldwork, AEC identified and placed under routine surveillance 30 small special service tanks containing an undetermined amount of radioactive waste These tanks had not been monitored in at least 2 or 3 years--three of them not since 1949 (See p. 19.)

Solidification of liquid waste

GAO previously issued two reports on high-level waste management, one in 1968 and one in 1971 (See p 2)

At the time of the 1968 report, AEC hoped to solidify all liquid waste except that which was in process at Richland by 1974 Now AEC estimates that all waste cannot be solidified until the early 1980's because of a redetermination that more liquid waste can be solidified than was originally expected and continued reactor operations (See p. 19)

After the 1973 leak, a $30 million supplemental appropriation was provided to improve waste storage and accelerate the solidification program at Richland. (See p 20)

Immobilization of solid waste

AEC's solidification program consists of converting high-level liquid waste to salt cake at Richland and Savannah River and to calcine (a dry granular form) at Idaho Falls AEC does not consider either calcine or salt cake to be the most acceptable form for long-term storage primarily because they both are water dispersible A more acceptable form of storage has not yet been demonstrated on a production basis (See p. 20.)

Calcine may offer major advantages over salt cake for long-term waste management purposes because of the volume reduction involved in the process, the relative ease of handling, and existing technology for further immobilization to a glass form However, it appears that conversion from salt caking to a calcining process at either Richland or Savannah River is impractical at this time (See p 24)

Commercially generated waste

Large quantities of high-level waste will be generated by commercial fuel reprocessors over the next several years. AEC has progressed in three important aspects of managing this waste

- --Defining the respective responsibilities of commercial reprocessors and of AEC for waste storage
- --Developing the capability to solidify liquid waste to an acceptable form for long-term storage
- --Planning for Federal facilities to store solidified high-level waste

If this progress continues, AEC and industry should be in a better position to deal with commercially generated waste in the future than AEC has been to deal with its own waste in the past. (See p 25.)

A major pending decision involves selecting a site at which AEC will temporarily store this waste--perhaps as long as 100 years--until a solution is arrived at for permanent storage or disposal. (See p 25.)

In its site selection process, AEC evaluated 16 potential sites. Using a number of criteria, AEC narrowed the number of potential sites to three--the Hanford Reservation, Richland, Washington, the Idaho National Engineering Laboratory, Idaho, and the Nevada Test Site (See pp 28 to 39)

Selecting any of the sites presently under consideration will involve transporting large quantities of waste over considerable distances by train. On the basis of current

AEC projections, it is expected that over a 30-year period

--About 500,000 cubic feet of high-level waste will be transported. (See p 37)

--About 6,400 separate shipments will be made (See p 37)

--Waste will be transported as much as 14 7 million miles and be in transit 59,000 days (See p 39)

By the year 2010, as many as 15 train cars carrying high-level waste could be in transit at any one time (See p 39)

AEC studied the question as to whether transportation safety should be one of the site selection criteria considering (1) the large quantities of waste to be transported over various types of terrain and through various population centers, (2) the potential consequences in the event of an accidental release of this waste, and (3) the variances in distances between sites (See p 41)

AEC determined that the variances in transportation safety aspects relating to the sites under consideration, were small enough not to be considered in evaluating the relative merits of these sites

The probability of an accidental release of radioactive waste during transport was considered remote enough to represent an acceptable risk This was determined on the basis of an AEC study of the probability of transportation accidents and the design characteristics of the shipping cask (See p 39)

The Department of Transportation and the Environmental Protection Agency had previously supported AEC's position on transportation safety regarding shipments of radioactive materials to and from reactors Environmental Protection Agency stated that it will also evaluate the applicability of AEC's conclusions to the selection of a high-level waste storage site (See p 40)

RECOMMENDATIONS AND SUGGESTIONS

This report contains no recommendations or suggestions

AGENCY ACTIONS

AEC generally agreed with the information presented in the report

MATTERS FOR CONSIDERATION BY THE CONGRESS

This report should be helpful to the Congress in its oversight of nuclear programs and in furtherance of its interest in safeguarding the public from hazards that may arise from the storage, handling, and transportation of nuclear material and in resolving the ultimate disposal question concerning high-level radioactive waste

CHAPTER 1

INTRODUCTION

Under the Atomic Energy Act of 1954 (42 U.S C. 2011-2282), as amended, the Atomic Energy Commission (AEC) is responsible for insuring that the public and the general environment are protected from the hazards of radioactive waste Responsibilities differ for the waste created by reprocessing fuel elements used in AEC's reactors and fuel elements used in commercial power reactors It has permanent custody for its own wastes from the time they are created For industry waste, AEC has regulatory responsibility while the waste is in the possession of the commercial fuel reprocessors--from 5 to 10 years--after which it takes permanent custody

Within AEC, two organizational units are primarily responsible for management of high-level radioactive waste. The Division of Waste Management and Transportation (DWMT) is responsible for policy and planning, research and development, and long-term storage or disposal of both AEC and commercially generated waste. The Division of Production and Materials Management (DPMM) is responsible for processing irradiated fuel elements which produce high-level liquid waste 1/ in AEC operations, storing this waste as a liquid, and converting the liquid to a form suitable for transfer to DWMT

These responsibilities involve managing AEC waste stored at three sites the Idaho National Engineering Laboratory near Idaho Falls, Idaho, the Savannah River plant near Aiken, South Carolina, and the Hanford Reservation near Richland, Washington Actual waste management is carried out by contractors under the administration of local AEC operations offices

Actual and estimated operating costs for AEC waste management for fiscal years 1971 through 1974 were

	Actual			Estimated
	FY 1971	FY 1972	FY 1973	FY 1974
	(millions)			
DWMT	$ -	$ 6 2	$ 9 4	$16 7
DPMM	20 5	23 7	25 9	32 1
Total	$20 5	$29 9	$35 3	$48 8

About 80 to 90 percent of the costs were applicable to management of high-level waste In addition, during this same period, $76 4 million were appropriated for construction projects related to waste management, of which $72 5 million were for high-level waste

1/For a description of liquid high-level radioactive waste, see p 6

We have discussed this report with AEC representatives and have considered AEC's comments in finalizing the report

The Energy Reorganization Act of 1974 (42 U S C 5801), effective February 8, 1975, or such earlier date as the President may prescribe, abolishes AEC and establishes the Energy Research and Development Administration and the Nuclear Regulatory Commission The Energy Research and Development Administration will have responsibility for permanent custody of radioactive waste created by reprocessing fuel elements used in its own reactors The Nuclear Regulatory Commission will have regulatory responsibility while radioactive waste is in the possession of commercial fuel reprocessors, after which the Energy Research and Development Administration takes permanent custody

Under section 202 of the act, the Nuclear Regulatory Commission will have regulatory responsibility for Energy Research and Development Administration (1) facilities used primarily for the receipt and storage of high-level radioactive waste resulting from activities licensed under the act and (2) retrievable surface storage facilities and other facilities authorized for the express purpose of subsequent long-term storage of high-level radioactive waste generated by the Energy Research and Development Administration, which are not used for, or are part of, research and development activities

PRIOR REPORTS

We have previously issued two reports to the Joint Committee on Atomic Energy concerning AEC's high-level radioactive waste management program--one in 1968 and one in 1971 The first was entitled "Observations Concerning the Management of High-Level Radioactive Waste Material" (B-164052, May 29, 1968) The second was entitled "Progress and Problems in Programs for Managing High-Level Radioactive Wastes" (B-164052, Jan 29, 1971) Both reports dealt primarily with AEC-generated waste

Our 1968 report concluded that, considering the large volumes of liquid waste and the condition of the storage tanks, there was an urgent need to get this material into a suitable form for long-term storage as soon as possible We suggested that this might necessitate the commitment of substantial resources and a realinement of AEC's organizational structure AEC agreed and established a Division of Waste and Scrap Management in May 1970

Our 1971 report concluded that, although progress had been made, there were still problems associated with both interim and long-term storage of high-level waste to be resolved Fragmented responsibilities for waste management activities hindered progress We therefore recommended that AEC develop an overall plan which would provide sufficient information on relative costs and priorities to permit informed funding decisions and give the Division of Waste and Scrap Management responsibility for implementing the plan

This Division (later redesignated the Division of Waste Management and Transportation) developed an overall waste management plan and was given responsibility for implementing some of its major aspects--those dealing with policy and long-term storage.

RECENT EVENTS

From 1973 to 1974 the Richland site experienced five leaks of high-level liquid waste from underground storage tanks. In addition, at Savannah River two tanks of high-level liquid waste developed hairline fractures, but no waste escaped to the soil During the preceding 16 years, there were 19 confirmed leaks totaling about 309,000 gallons of high-level radioactive waste at Richland and Savannah River The largest of Richland's leaks, involving 115,000 gallons of waste during the spring of 1973, attracted national attention and heightened concern within AEC. On the basis of a detailed technical study, AEC concluded that none of this waste migrated far enough from the point of the leak to be of any danger, nor is it considered likely to in the future

The recent energy crisis has given impetus to development of the nuclear power industry as a means of relieving the Nation's dependency on petroleum The President, in his energy message on November 7, 1973, proposed a speedup in licensing and constructing nuclear power plants. One major concern about nuclear power is the handling of high-level radioactive waste generated from the reprocessing of irradiated fuel elements Less than 600,000 gallons of such waste have been generated thus far without any leaks occurring.

AEC estimated that 60 million gallons of commercial high-level liquid waste will be generated (but not accumulated) by the year 2000 and 238 million gallons by the year 2020. This will be in addition to the approximately 205 million gallons generated by AEC over the past 30 years and the 7.5 million gallons AEC presently generates each year Because of the uncertainty of nuclear weapons requirements, AEC is unable to predict, with any certainty, how long it will generate waste at this rate

Because of two concerns--the increasing frequency with which AEC waste was leaking and the projected future quantities of commercial waste--GAO undertook this review of the waste management program

SCOPE OF REVIEW

For this report, we reviewed current literature on the sources, quantities, and hazards of and methods of handling various types of radioactive waste We examined into policies and practices at the headquarters and field levels of AEC regarding storing and solidifying radioactive liquid waste We did our fieldwork primarily at the Richland Operation Office and made limited reviews at the Idaho Falls and the Savannah River Operations Offices We discussed management of radioactive waste at storage sites with officials of the three AEC contractors

We also examined into AEC policies and practices for regulating waste management of commercial fuel reprocessors and AEC's plans for ultimately taking custody of commercially produced wastes. Our review included discussions with officials of the three commercial fuel reprocessors

CHAPTER 2

RADIOACTIVE WASTE--DIMENSIONS OF THE PROBLEM

Radioactive wastes are generated in three forms--solids, gases, and liquids Each is handled differently to protect the environment from its potentially harmful effects. Of all forms of waste, high-level radioactive liquid waste poses the most complex technical problems in management and the potentially most severe hazards if released

SOLID WASTE

Most operations producing or using nuclear materials generate solid waste, such as rags, paper, clothing, laboratory supplies, tools, and processing equipment. The basic method of disposing of solid waste is land burial

From 2 million to 3 million cubic feet of contaminated solids are buried annually on State and Federal lands. About 75 percent of this volume is from AEC activities and 25 percent is from commercial sources.

GASEOUS WASTE

Gaseous waste is generated mostly by nuclear reactors and by reprocessing nuclear fuel. Although these gases contain large amounts of radioactivity, most radionuclides decay rapidly to nondangerous levels The vapors are condensed, the condensate is held long enough to permit decay of radionuclides, and the condensate is released to the atmosphere through high-efficiency filters The filters containing radioactive materials are then disposed of as solid waste.

The quantities of radionuclides which may be released to the environment are closely regulated by AEC in accordance with a table of concentration guides. This table specifies the amount of radioactive material that the National Council on Radiation Protection and Measurement and the International Commission on Radiological Protection have determined acceptable for an individual to be subjected to over specified periods

LIQUID WASTE

Liquid waste is classified into low-and high-levels, depending on the radioactive concentrations

Low-level waste is created in essentially all nuclear industrial activities, but most quantities are produced by reactors and fuel reprocessors It is usually produced in large volumes. For instance, the total generation by a single fuel-reprocessing plant may average several hundred thousand gallons a day Because of the low concentrations of radionuclides, these wastes are considered suitable for release to the environment after relatively simple processing or dilution which reduces the radionuclide concentrations to "as low as practicable" level Release to the environment usually takes the form of discharge to open ponds and percolation through the soil to the water table. This allows natural filtration and sufficient time for decay of radionuclides to nondangerous levels before the remaining material reaches plant, animal, or human life

High-level waste is created by chemically reprocessing irradiated reactor fuel As a reactor is operated, fission takes place in the fuel elements and the irradiated fuel must be replaced periodically. The replaced fuel still contains enough valuable uranium and plutonium to make recovery economical. Recovery is accomplished by reprocessing the fuel elements--dissolving the solid fuel and extracting the valuable isotopes High-level wastes are produced in the first extraction step This waste contains many radionuclides After several years, the most prominent of these are the long-lived fission products, strontium, cesium, and some quantities of plutonium that cannot be economically separated.

AEC has approximately 81 million gallons of high-level waste in storage and presently generates such waste at the rate of 7 5 million gallons annually. The basic method for handling this waste is to store it in large underground tanks in liquid form and convert it to either a granular solid--calcine--or a salt cake substance. Such storage, whether in liquid, calcine, or salt cake form, is considered temporary because the material is subject to dispersion under certain conditions Developmental work is being done on changing the calcine to a less leachable silicate glass form and salt cake to a silicate glass, concrete, or other mineralized form in order to minimize dispersion problems while the waste is being transported or stored. Chapter 3 contains further details on the solidification and storage of AEC generated high-level waste.

Only minor quantities of high-level waste have been created by commercial fuel reprocessors thus far. The growth of the nuclear power industry, however, is expected to result in the generation (but not accumulation) of about 60 million gallons of high-level waste by the year 2000 and 238 million gallons by the year 2020. Future wastes will come from power reactor fuels of high nuclear burnup which will contain much larger quantities of fissionable products per unit of volume than do current AEC wastes Storing these wastes will be even more difficult than storing current AEC wastes because they will generate higher temperatures and may be more corrosive

AEC requires that commercial fuel reprocessors solidify high-level liquid waste into an acceptable form not more than 5 years after it is generated and deliver the solid to AEC custody not more than 10 years after it is generated Currently calcine is considered to be an acceptable form, but AEC is developing methods of converting calcine to glass. Chapter 4 contains further details on the solidifying and storing commercially generated high-level waste.

Of all forms of waste, high-level liquid waste poses the most complex technical problems in management and the potentially most severe hazards if released.

HAZARDS OF HIGH-LEVEL WASTE

Strontium-90, cesium-137, and plutonium-239 in high-level waste are of greatest concern Each is hazardous in terms of its potential effect on the human body, the pathways by which it may reach the body, and the length of time it remains dangerous

Strontium and cesium emit penetrating radiation requiring shielding, whereas plutonium radiation is incapable of penetrating even paper It is generally recognized that the radioactivity produced by these materials can damage or destroy living cells, causing cancer or death, depending on the quantity and length of time involved. If ingested, most of the cesium will be excreted within a few weeks, however, strontium deposits itself in bone cells where it will continue to emit radiation to surrounding tissue for a number of years Plutonium, although relatively easy to shield against, is extremely dangerous in small quantities if absorbed into the body

These radionuclides cannot be neutralized Each must be allowed to decay at its own specific rate Strontium-90 and cesium-137 require about 600 years to decay to 1/1,000,000 of their original level of radioactivity For plutonium-239, it takes about 500,000 years

These radionuclides can reach man by several means if released to the environment Water supplies can be contaminated by accidental leaks of high-level waste and percolating through the soil to the water table. Vegetation may be contaminated directly by contaminated irrigation water or indirectly through contaminated soil. Man can be contaminated by eating the plants, eating animals that have eaten the plants, or using products (milk, cheese, etc) from such animals. Radioactive materials can also be inhaled or absorbed into the body through open wounds or sores

Because of these hazards, it is important that high-level waste be managed in such a way as to isolate it from the general environment.

CHAPTER 3

AEC-GENERATED WASTE

In addition to determining an ultimate storage method, AEC's program for managing its high-level radioactive waste consists of (1) containing the liquid in underground tanks pending solidification, (2) solidifying the liquid to a calcine (dry granular substance) or salt cake to prevent leaks and reduce volumes, and (3) developing methods of immobilizing the calcine and salt cake to a less soluble solid form. Overall, AEC has made considerable progress in insuring safe storage of its high-level waste Some problems have been encountered at Richland, with containing the liquid in underground tanks and with slippages in the solidification schedule AEC has taken actions to resolve these problems

Over the past 30 years, AEC has generated about 205 million gallons of high-level radioactive liquid waste Most of this waste has been generated and stored at--the Hanford Reservation and the Savannah River plant. Both of these installations were constructed and operated to produce nuclear materials for the Nation's nuclear weapons program. Additional high-level wastes have been generated and stored at the Idaho National Engineering Laboratory--AEC's principal experimental reactor site

During the early years of AEC little emphasis was placed on developing technology for alternative methods of managing high-level waste at Richland because of the priority of producing materials for nuclear weapons. Instead, the most expedient course of action was adopted--confining the liquid waste in underground storage tanks. At Idaho Falls, however, an alternative method was developed and placed online in 1963 which greatly reduced the quantity of waste and resulted in converting the waste to a more manageable dry form.

AEC is currently processing the stored high-level liquid waste at all three locations reducing the volume and placing it in safer forms At Richland and Savannah River, the liquids are being evaporated, leaving a damp salt cake in the tanks At Idaho Falls, the relatively smaller volumes of acidic wastes are routinely converted from liquid to a dry granular solid through a calcining process and stored in underground bins. At June 30, 1974, AEC's inventory of high-level radioactive waste in both liquid and solid form was

Location	Quantity in gallons		
	Solids	Liquids	Total
	---------(000 omitted)--------		
Richland	26,498	31,823	58,321
Savannah River	8,504	11,833	20,337
Idaho Falls	329	1,907	2,236
Total	35,331	45,563	80,894

The table below and the charts on pages 10 through 12, furnished by AEC, show the progress over the past several years in reducing the volume of high-level waste inventory.

Volume of High-Level Radioactive Wastes At AEC Production Sites

Date	Idaho	Richland	Savannah River	Total
		(millions of gallons)		
12-31-67	1.5	74.0	16.8	92.3
12-31-68	1.5	71.4	16.6	89.5
12-31-69	1.6	68.1	18.2	87.9
12-31-70	1.8	65.8	17.9	85.5
12-31-71	2.2	65.3	17.9	85.4
12-31-72	2.3	64.0	19.0	85.3
12-31-73	2.2	65.0	20.0	87.2
6-30-74	2.2	58.3	20.3	80.8

Management practices at the three sites vary because of factors such as geology, weather, and form of waste. However, unless specifically exempted, the waste management practices of each site should be compatible with AEC's fundamental objective of handling wastes at all times so that wastes (1) will not endanger the health and safety of AEC or contractor employees or the public, (2) will not have an adverse effect on man's environment or on the ecology, and (3) will be accepted by the public.

CONTAINMENT OF LIQUID WASTE

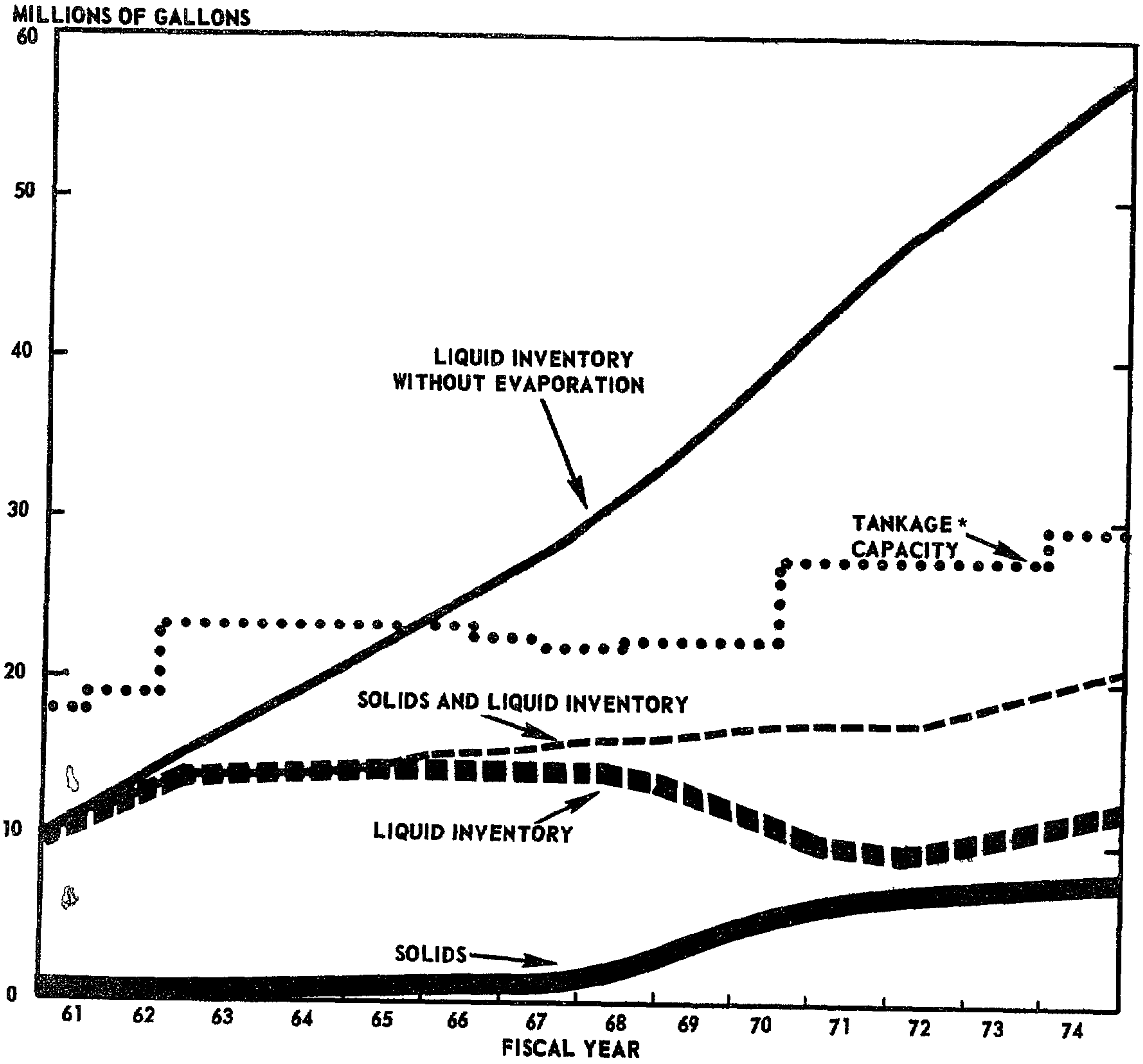
From inception of the nuclear weapons program in the early 1940s until June 30, 1974, AEC had experienced 26 leaks in underground storage tanks containing high-level radioactive liquid waste. Eighteen of these leaks occurred at Richland, releasing about 430,000 gallons of waste into the surrounding soil. The remaining eight leaks have occurred at Savannah River, only one of which resulted in the release of waste into the surrounding soil. AEC has reported that none of this material migrated far enough from the point of the leaks to be of any danger, nor is it considered likely to in the future. None of the tanks at Idaho Falls has leaked.

Details follow on waste containment practices at each of the three sites.

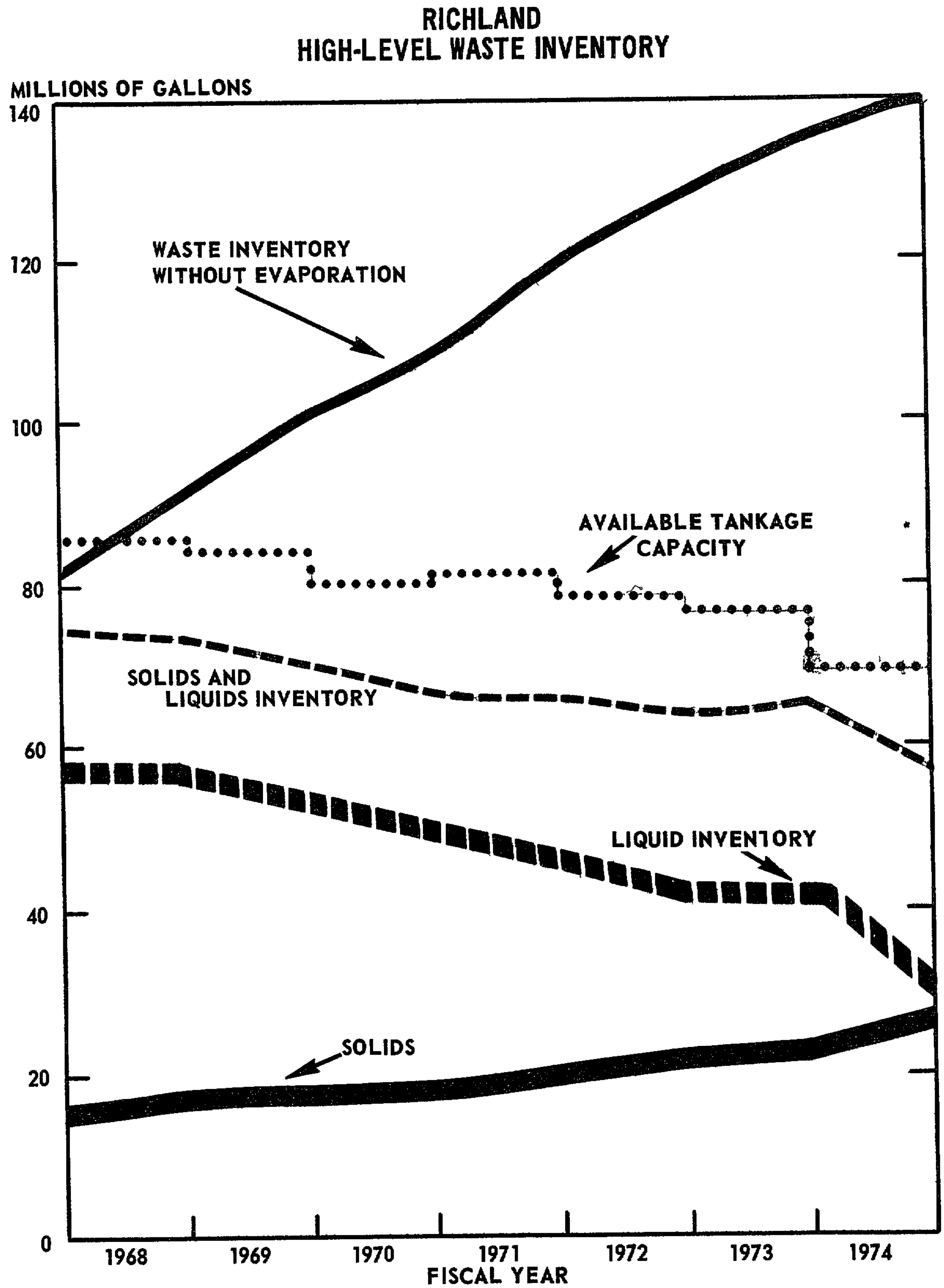
Idaho Falls

There are 15 stainless steel underground tanks at Idaho Falls--11 with a capacity of 300,000 gallons each and 4 with a capacity of 30,000 gallons each. The large tanks are completely enveloped in individual concrete vaults, which serve as secondary containment barriers if a leak occurs. The small tanks are not set in concrete vaults but rest on curbed

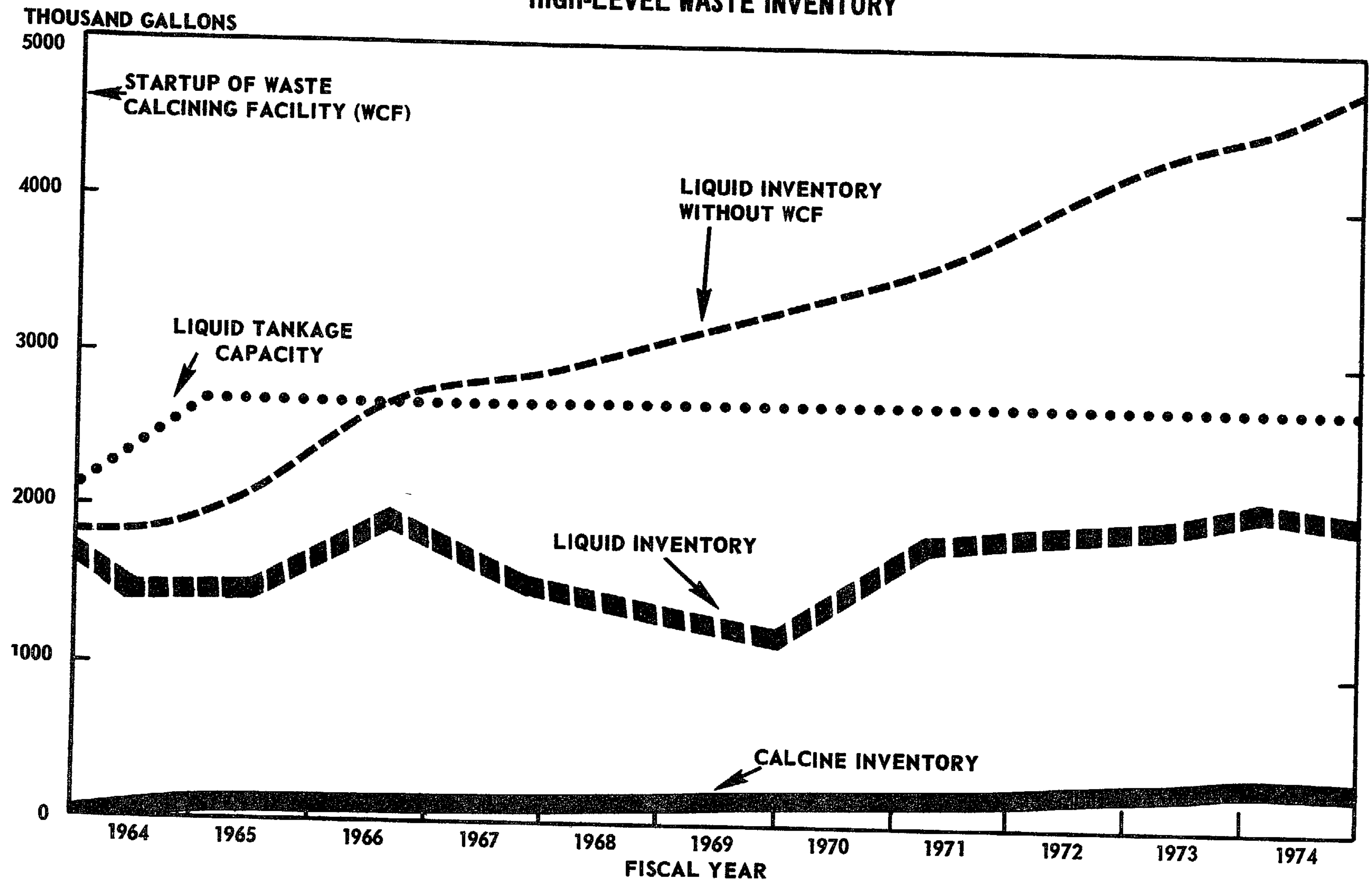
SAVANNAH RIVER
HIGH-LEVEL WASTE INVENTORY



* INCLUDES EMERGENCY SPARE TANKS


RICHLAND
HIGH-LEVEL WASTE INVENTORY
MILLIONS OF GALLONS
140
120
100
80
60
40
20
0
WASTE INVENTORY
WITHOUT EVAPORATION
AVAILABLE TANKAGE
CAPACITY
SOLIDS AND
LIQUIDS INVENTORY
LIQUID INVENTORY
SOLIDS
1968
1969
1970
1971
1972
1973
1974
FISCAL YEAR

IDAHO
HIGH-LEVEL WASTE INVENTORY



concrete pads designed to catch any leaked liquids. Leakage from these tanks can be drained into collection sumps. This material and the contents of the leaking tank can be transferred to a spare tank

The large tanks have automatic devices which monitor the liquid levels in the tanks, internal tank pressures, specific gravity, and temperatures Deviations from preset limits activate alarms at two control points The collection sumps are monitored continuously also, and if the liquid level exceeds a preset limit, alarms are activated at two control points

As of June 30, 1974, there had been no leaks to the surrounding soil at Idaho Falls.

Savannah River

There are 30 carbon steel underground tanks at Savannah River--14 with a capacity of 1.3 million gallons each, 4 with a capacity of 1 03 million gallons each, and 12 with a capacity of 750,000 gallons each. Eight of the 1.3 million-gallon tanks are of single-walled construction and the other six are double walled, enclosed in concrete vaults The remaining 16 tanks are single walled but are enclosed in concrete vaults and sitting in pans with 5-foot-high sides. Thus, 22 of the tanks provide secondary containment.

All of the Savannah River tanks are equipped with devices designed to activate alarms in continuously occupied areas if liquid leakage appears outside the primary container The liquid level devices that require manual operation are being replaced by automatic level-seeking devices that include activation of alarms if the level increases or decreases extensively Savannah River officials stated that these devices would be fully operational during calendar year 1974 The temperatures are read and recorded automatically at a control point, and the recorders are equipped with high and low temperature alarms

The single-walled tanks are steel-lined concrete tanks with collection channels in their concrete foundations These channels drain to a sump outside the tank walls, which can be pumped of collected liquids The annular space between the walls in the double-walled tanks can be pumped of collected liquids or the liquids can be air-dried in place

Eight of the 16 single-walled tanks enclosed in concrete vaults with secondary 5-foot-high steel pans have leaked AEC reported that liquid escaped secondary containment in only one case, and then less than 100 gallons was involved

Richland

According to AEC's official inventory records, Richland has 152 underground carbon steel tanks, with capacities as follows

Number of tanks	Gallons per tank
16	54,000
60	530,000
48	758,000
28	1,000,000
a/152	

a/Does not include four 1,000,000-gallon tanks under construction at June 30, 1974.

These 152 tanks are interconnected by extensive piping forming a system with the capability to transfer waste from any tank to any other tank.

The waste tank system at Richland lacks many of the more advanced concepts and sophisticated automatic equipment in evidence at Idaho Falls and Savannah River for two reasons First, most of Richland's system was built during the period 1943 through 1955, before the systems at the other two locations This was at a time when priorities were more related to production of nuclear material than waste management Second, the topographic and climatic conditions at Richland offer what AEC considered safe natural containment in the soil in the event of leaks It was considered safe enough, that during 1956-58 about 31 million gallons of radioactive waste were intentionally discharged to the ground after most of the strontium and cesium had been removed This waste contained about 1 3 million curies of radioactive material, which has since decayed to about 20,000 curies. Under present criteria, this waste would be contained in underground tanks, but, at that time, AEC considered discharge to the ground appropriate.

All tanks except the three built since 1968 are of single-walled construction--steel-lined concrete--without the annular space or pans used at the other two installations. Thus, the capability does not exist to capture leaked waste and return it to the system for these 149 tanks The three tanks built since 1968 and the four tanks under construction are of double-walled construction and have this capability

Beginning about February 1973, Richland began installing automatic tank-monitoring devices. This system was completed in October 1974. Monitoring has been, and still is to a large degree, dependent on manual reading of liquid levels at each tank and comparison to previous readings to determine if the levels have dropped.

As of June 30, 1974, Richland had detected 18 leaks, as follows

Date	Estimated gallons leaked
1958	55,000
1958	15,000
1959	20,000
1959	30,000
1960	35,000
1962	3,400
1963	(small)
1964	(small)
1965	(small)
1965	50,000
1969	30,000
1971	70,000
1972	(small)
1973	(small)
1973	115,000
1973	1,500
1974	2,500
1974	2,000
Total	429,400

The 115,000-gallon leak in 1973 focused national attention on AEC's waste management program, particularly at Richland. AEC extensively investigated the circumstances surrounding this leak, the results of which were published in AEC's Report on Investigation of the 106-T Tank Leak at the Hanford Reservation dated July 1973. As nearly as AEC could determine, this leak lasted 48 days, from April 20 to June 8. During this time, 115,000 gallons of liquid radioactive waste leaked, containing 40,000 curies of cesium-137, 14,000 curies of strontium-90, and 4 curies of plutonium--those radionuclides considered to be most hazardous AEC reported that none of this material migrated far enough from the point of the leak to be of any danger, nor is it considered likely to in the future Nevertheless, AEC expressed concern over the length of time that elapsed before the leak was detected AEC's later evaluation disclosed that, had the leak been recognized at the earliest possible date, the leak would have been limited to between 26,700 and 37,600 gallons of waste.

The Atlantic Richfield Hanford Company (ARHCO) is the operating contractor for AEC waste management activities at Richland. On the basis of its investigation of the incident, AEC attributed the delay in detecting the leak to (1) an oversight on the part of ARHCO tank surveillance personnel, (2) inadequate or unclear ARHCO operating instructions and (3) the absence of a detailed quality assurance program for waste management activities by ARHCO Weekly readings were being made of liquid levels in the tanks However, the area supervisor was not reviewing the readings because, according to him, he and many of his personnel had been assigned additional duties.

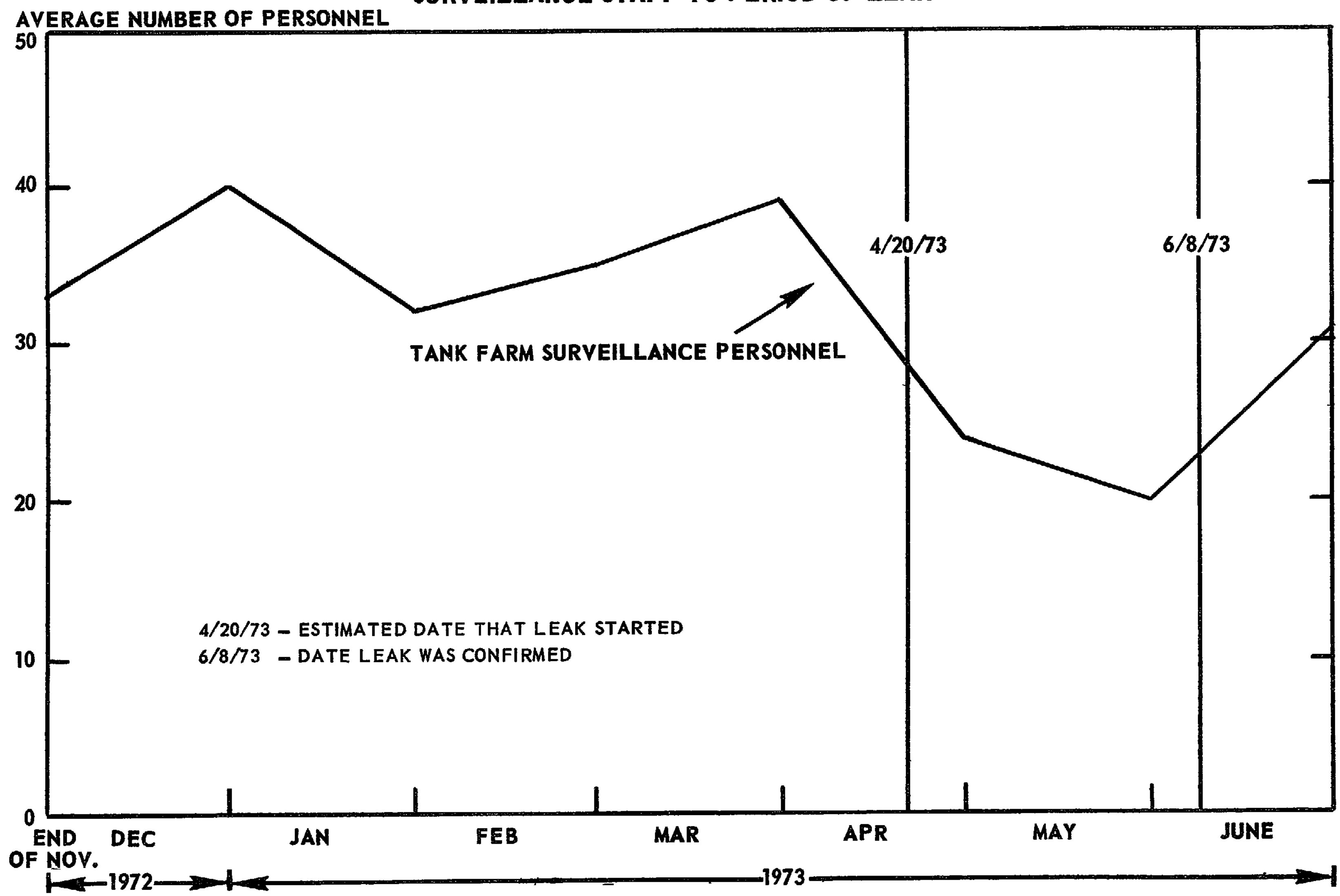
We noted some funding limitations on the waste management program at Richland during the fiscal year in which the leak occurred Because these limitations affected various aspects of the program and AEC records did not show their specific impact on tank surveillance activities, we could not determine whether the limitations contributed to the delay in detecting the leak We noted, however, a large reduction in the manpower level devoted to the tank surveillance activities immediately before the leak. The graph on page 17 depicts the manpower level before and during the leak

The following schedule, based on AEC records, summarizes pertinent events in the funding of ARHCO's operations for fiscal year 1973.

Date	Event	Waste management	Total operations
		(millions)	
Jan. 1972	Amount included in the President's budget to the Congress and subsequently appropriated	$20.1	$32 8
Apr 1972	ARHCO's revised estimate of fund requirements asked AEC for	20.7	37.9
May 1972	DPMM directed AEC Richland to require ARHCO to continue to plan operations at congressional funding level of	20.1	32 8
Oct 1972	AEC Richland advised DPMM that ARHCO had adjusted its waste management funding level to	19.1	32 8
Apr 1973	AEC Richland advised DPMM that funding for ARHCO was reduced in Feburary 1973 to	18 3	32 0
June 1973	ARHCO operating costs for fiscal year 1973 were	18 4	32 0

Regarding ARHCO's April 1972 revised estimate of $37.9 million and AEC's May 1972 decision to limit ARHCO's total operating funds to the congressionally approved $32 8 million, AEC said that providing funds above the congressional approval level is usually not possible because of priorities of other competing programs Since additional funds

RELATIONSHIP OF LEVEL OF TANK FARM SURVEILLANCE STAFF TO PERIOD OF LEAK



were not available, ARHCO notified AEC that certain waste management activities (see p 20), including implementation of a planned quality assurance program (estimated at less than $100,000), would be postponed and that immediate steps would be taken to reduce its workforce AEC approved these actions According to the AEC investigative report on the tank leak, the absence of a quality assurance program contributed to the delay in detecting the leak.

Funding of ARHCO's production and materials management program at Richland for fiscal year 1974 was increased by AEC ARHCO was advised that solidifing waste and controlling and reducing radioactive effluent discharges to the environment were to be assigned top priority ARHCO's program was provided $37 2 million, including $23 5 million for waste management operations, plus an additional $30 million supplemental appropriation specifically designated for construction of a waste evaporator-crystallizer, additional waste tanks, and other waste management facilities

For fiscal year 1975, ARHCO has been authorized $42 7 million in operating funds for the production and materials management program, including $31 million for waste management operations ARHCO reevaluated its funding needs in May 1974 to reflect the impact of inflation and increases in program effort and concluded that it needed $50 5 million ARHCO officials said that they may have to forego hiring new people in 1975 and postpone some waste management activities to stay within the authorized cost ceiling They stated that there was little doubt that the overall effect would be a delay in completing planned improvements to Richland's waste management program

AEC Richland officials stated that ARHCO's request for $50 5 million contained many wishfully desired items and that, with the acknowledged tight budget situation, it would be impossible to accomplish many of the items ARHCO desired AEC Richland officials stated, however, that the priority waste management activities would be accomplished within the authorized operating budget

Richland has made progress in upgrading its waste tank surveillance activities During fiscal year 1974, ARHCO's workforce in tank farm surveillance had increased to as many as 52 persons (although the average was somewhat less) and tank-monitoring procedures had been strengthened For example, tank level readings were increased from once a week to three times a day. In addition, 75 remote automatic liquid level gauges have been installed in tanks, although the system is not yet fully operational Additional tanks were being studied for possible application of these gauges

Also, near the conclusion of our fieldwork, we learned that 30 additional tanks with a total capacity of more than 300,000 gallons had been recently identified and placed under routine surveillance by AEC at Richland At that time the total quantity and level of radioactive waste in these tanks had not been determined These tanks are all smaller than the 152--ranging in size from a few hundred gallons to about 40,000 gallons--and are not tied in with the waste tank system. None of these tanks had been monitored in at least the last 2 or 3 years--three of them not since 1949

The tanks are special service tanks used in early processes or research and development activities at Richland After the first few tanks were identified, AEC requested that ARHCO make a comprehensive survey to identify all waste tanks not under routine surveillance As the tanks were identified, ARHCO included them in surveillance schedules and began studying the contents to determine the quantities and level of - waste and what should be done with it AEC Richland officials had no explanation as to why these tanks were not previously identified

- - - -

In summary, containment of high-level liquid waste has been quite successful at Idaho Falls and Savannah River, but not at Richland Additional leaks are likely to occur at Richland because of the age and type of tanks, which are largely a product of the technology and priorities existent at the time they were built Judging from the large quantities of liquid waste leaks occurring before 1973, Richland was not very effective in detecting leaks The massive leak in the spring of 1973 focused attention on this area to such a degree that noticeable improvements were made in Richland's leak detection capability Although it is not possible to predict the success of future leak detection with any certainty, the detection record for the three leaks since that time (see p.15) looks much better All were limited to relatively minor quantities.

SOLIDIFING LIQUID TO CALCINE AND SALT CAKE

The principal deterrent to leaks from underground storage tanks is AEC's program of solidifying the liquid to a less mobile calcine or salt cake form AEC has made considerable progress in this area during the past 6 years, as shown by the following schedule

	Gallons of high-level liquid waste	
	At Dec 31, 1967	At June 30, 1974
	-----------(000 omitted)------------	
Total generated	127,000	205,000
Quantity in inventory	93,000	45,563
Volume solidified	34,000	159,437
Percent of total	27	78

For the most part progress has been in accordance with plans at both Idaho Falls and Savannah River, but delays have been experienced at Richland, where 75 percent of the waste is located. At the time of our 1968 report, Richland's target for solidifying all except in-process liquids was 1974 At the time of our 1971 report, this target had been extended to December 31, 1975 AEC has said that the target date for solidification is now December 31, 1976

All waste will not be solidified until 1982, AEC officials said, because of continued reactor operation and a redetermination that liquids within the salt cake, which make up as much as 30 percent of the solid volume, would be evaporated The inventory of these liquids and the residual liquids in the evaporator system in fiscal year 1976 are estimated at 19 million gallons The 1982 completion date includes evaporating and reducing this material as well as the liquid wastes in the tanks to a minimum working inventory of about 9 million gallons.

Although the decision to further evaporate the liquids within the salt cake has undoubtedly contributed to the extension of the schedule, funding limitations (as described on p. 16) may have also had an impact. For example, after being directed to conform to a congressionally approved funding level of $32 8 million in May 1972, ARHCO advised AEC of certain waste management operations which could be curtailed or postponed to reduce costs. Included in these were (1) deferral of a project to stabilize and isolate waste tanks, (2) shutdown of an old waste evaporator, and (3) reduction of process technology work by another Richland contractor AEC approved all of these actions ARHCO officials said that it was not possible to pinpoint any specific delays, but these actions probably did have a delaying effect on the waste management program.

It is uncertain whether Richland can now meet its scheduled date of 1982. However, the following steps have been taken to increase solidification capability

--Richland put an evaporator-crystallizer in service on November 1, 1973, to reduce stored liquid wastes to salt cake This device is converting wastes at nearly twice the rate expected

--AEC received a $30 million supplemental appropriation, after the 115,000 gallons leak, to build additional waste concentration and storage facilities, including another evaporator-crystallizer and storage tanks at Richland. These facilities are estimated to accelerate solidification by at least a year

INCREASED IMMOBILIZATION OF SOLIDIFIED WASTE

AEC does not consider either calcine or salt cake to be the most acceptable form for long-term storage, primarily because of the mobility of these forms, that is, they are water soluble and can be dispersed in the air A more acceptable form of storage has not yet been demonstrated on a production basis Details on immobilization practices at each site follow

Idaho Falls

Idaho Falls is the only AEC site which calcines its high-level liquid wastes. In this process, which is known as fluidized bed calcination, liquid acid waste is sprayed into a bed of calcine, which is agitated (fluidized) by a flow of heated air, and heated to the calcining temperature by injecting kerosene and oxygen. The mixture is converted to granular solids which are pneumatically transported to storage facilities.

Acid wastes with widely varying chemical compositions have been calcined at Idaho Falls with good results. Acidic aluminum, ammonium nitrate, zirconium fluoride, and stainless steel sulphate wastes have all been calcined. By January 1974, nearly 2.6 million gallons of aluminum and zirconium wastes have been calcined, producing 42,500 cubic feet (equivalent to about 320,000 gallons) of solids--a volume reduction by more than 8:1. Idaho Falls has reduced the volumes of some other acid wastes by 30:1 on a pilot-plant basis.

AEC and contractor (Allied Chemical Corporation) officials at Idaho Falls are enthusiastic about their waste calcining facility. They stated that the calcine is less mobile than a liquid, the volume of waste is significantly reduced, and the cost of solidification and storage is less than the cost of building more tanks for liquid wastes. In addition, the calcine is expected to be retrievable and can be converted to less soluble forms, such as glass.

Richland

While Richland has the greatest quantity of stored waste, it will not generate much more in the future since there is only one reactor in operation. Richland's waste management activities are now aimed at evaporating the liquid waste stored in tanks to a salt cake form. AEC officials said that the Richland waste cannot be calcined effectively because it was too alkaline. Further, they said that it would not be cost effective to build a calcining facility and to change other facilities to process any future wastes because the quantity to be generated in the future is expected to be very small.

Richland is studying various schemes for further immobilizing its salt cake. Two basic approaches to these studies are, (1) removing the material from the tanks for disposal or storage elsewhere on site or off site and (2) treating the salt cake and leaving it in the tanks for the foreseeable future.

This first approach calls for removing the waste, which may amount to several hundred thousand tons. Studies show that it will have to be mined from the tanks either hydraulically or mechanically. After reviewing these studies, we find both methods risky with respect to releasing contamination and costly. AEC officials said that introducing water into the tanks would dissolve previously self-sealed leaks and that much waste would leak from the tanks. Mechanical mining could release contamination to the atmosphere unless some sort of containment is devised Either method could be very costly--according to AEC Richland officials, billions of dollars--and there is still the question of what to do with the waste once it is removed from the tanks

AEC is also studying methods of adding material to the salt cake and possibly covering the tanks with concrete or asphalt to prevent water, animals, or humans from getting into the tanks and dispersing the wastes Considering safety, economics, and the fact that 5 to 10 square miles of the Richland site--containing waste tanks, reactors, burial grounds, etc --is so grossly contaminated from past operations that it probably never can be cleaned up, leaving the waste in place, after immobilization, might be a reasonable alternative to cleaning up the site

Richland has a major unresolved problem as to salt cake's ultimate disposition After the waste is converted to salt cake, however, AEC will have time to work on a long-range or permanent solution The site's arid climate and favorable hydrologic characteristics--a great distance to ground water--will permit AEC to further study the problem and to develop technology for handling the salt cake

<u>Savannah River</u>

High-level liquid waste at Savannah River is also evaporated to salt cake However, the situation there is considerably different from that at Richland in that Savannah River is an active production plant, therefore, substantial future quantities of wastes may be generated. This raises the question of whether it is more appropriate to continue salt caking all of this material or to switch part or all of the operation to calcining, similar to Idaho Falls The answer to this question involves considering (1) the relative advantages of the two materials, (2) the ability to calcine the liquid generated, and (3) the relative costs of each operation.

There are three principal advantages to calcine (1) expected retrievability from storage bins, (2) convertibility to a more insoluble form under present technology, and (3) reduction of the volume involved Salt cake, on the other hand, requires a lower temperature of preparation and is less susceptible to becoming airborne

Not all liquid waste, however, can be calcined successfully Liquid waste is generated as an acid or as an alkaline solution Acid waste can be calcined, but under present technology, alkaline waste cannot. Alkaline waste is converted to salt cake by evaporation

Savannah River's liquid waste is made up of several waste streams from two fuel reprocessing plants. Most of the waste is originally generated as an acid but made alkaline by adding a sodium compound equal to more than 60 percent of the original volume--a great penalty in terms of eventual volume reduction. The remainder of Savannah River's liquid waste is generated in a natural alkaline state. AEC stated that under current operating conditions, Savannah River would generate 1.9 million gallons of liquid waste in a natural acidic and alkaline form during a year

After neutralization of the acidic wastes, the total volume would be about 3 million gallons

Costs, as well as benefits, however, are certainly factors to consider in determining which operation to choose Since some of the liquid waste is generated in a natural alkaline form, the salt caking operation would undoubtedly have to be continued Additional costs, then, would be incurred for a parallel calcining operation Also, the acid waste necessary for calcining requires stainless steel storage tanks rather than the less costly carbon steel tanks used for alkaline waste However, fewer tanks may be needed because of the lesser quantities involved where the acid would not have to be converted to an alkaline. To determine the relative costs would require an in-depth analysis, which we did not make during our review, essentially because AEC's operating contractor at Savannah River (E. I. du Pont de Nemours & Company), was studying the relative advantages of calcining versus continuation of the salt caking program.

After our fieldwork was completed, du Pont completed this study which indicated that Savannah River's current alkaline-salt cake waste management system, with some improvements, was preferable to an acid-calcining system This conclusion was based principally on economics, considering plant operations through the year 2000 The cost of a modified alkaline system was estimated at about \$1 5 billion, whereas the most competitive acid system was estimated to cost about \$1 8 billion. A combination acid and alkaline system was estimated to cost about \$2. 1 billion.

AEC said that there were two main reasons acid-calcine waste management would be more costly than alkaline-salt cake waste management. First, the possibility exists for developing a method for separating the alkaline waste inventory into two levels (high and low) which would greatly reduce the amount of high-level waste to be stored. Second, the change to acid would require separate systems for old and new waste, whereas continuing to produce alkaline waste allows the same system to be used for both

CONCLUSIONS

Overall, AEC has made considerable progress in insuring safe storage of high-level waste Containment of high-level liquid waste has been quite successful at Idaho Falls and Savannah River but not at Richland. At Richland, AEC has encountered some problems with detecting leaks in underground tanks but has taken action to resolve these problems.

AEC has made significant progress in solidifying its liquid wastes in the past few years and appears to be giving this program even more emphasis for the future Although Richland's program has been delayed because of technical problems and funding, the program was being accelerated at the time of our fieldwork

Calcine, as produced at Idaho Falls, may offer major advantages over salt cake for long-term waste management purposes because of the volume reduction, relative ease of handling, and existing technology for further immobilization to a glass form However, it appears that conversion from the present salt caking process to a calcining process at either Richland or Savannah River is impractical at this time

CHAPTER 4

COMMERCIALLY GENERATED WASTE

Substantial quantities of commercial waste will be generated over the next several years by reprocessing irradiated reactor fuel AEC has made considerable progress in handling this waste If this progress continues, AEC and industry should be in a better position to deal with commercially generated waste in the future than AEC has been to deal with its own waste in the past A major decision pending during our review involved the selection of a site at which AEC will temporarily store this waste--perhaps for as much as 100 years--until a solution is arrived at for permanent storage or disposal Selecting any of the sites presently under consideration would involve transporting great quantities of waste over long distances AEC considers the probability of an accidental release of radioactive waste during transport to be so remote that it is an acceptable risk.

Nuclear Fuel Services was the first commercial fuel reprocessor in the United States Nuclear Fuel Services operated from 1966 until 1972, when it closed for modification and expansion of its facilities. Since 1972 no commercial fuel reprocessor has operated in the United States Three reprocessors are scheduled to begin operations as follows.

Fuel reprocessor	Planned operational date
General Electric's Midwest Fuel Recovery Plant at Morris, Illinois	(a)
Allied-General Nuclear Services' Barnwell Nuclear Fuel Plant at Barnwell, South Carolina	1976
Nuclear Fuel Services' Plant at West Valley, New York	1979

a/General Electric's Midwest Fuel Recovery Plant at Morris, Illinois, was scheduled to begin operations in 1974, but General Electric recently announced an indefinite postponement of operations because of technical difficulties.

There have been only about 600,000 gallons of high-level liquid waste generated from commercial fuel reprocessing This waste is stored in underground tanks located on State-owned land at West Valley, New York. Because commercial reprocessing has been at a standstill since 1972, additional liquid waste is not presently being generated According to AEC projections as of July 1970, the reprocessing of fuel elements is expected to produce the following quantities of high-level waste.

Calendar year	Estimated volume of generated high-level waste	
	Annually	Total
	(millions of gallons)	
1980	0 97	4.4
1990	2 69	23.8
2000	4 60	60 1
2020	13 70	238.0

Under existing regulations, the total amount will not be accumulated in liquid form for this long length of time but will be solidified periodically However, as is apparent from these statistics, it is important that AEC be prepared to properly manage this waste as it accumulates

RESPONSIBILITIES FOR WASTE STORAGE

In late 1970 AEC issued Code of Federal Regulations (10 CFR 50, app F) for the siting of commercial fuel reprocessing plants and related waste management facilities Among other things, the regulations require that high-level liquid waste be stored by the reprocessors for not more than 5 years before conversion to a solid form and that physical custody of the waste be transferred to AEC not more than 10 years after it is generated. From that point on, AEC is to provide permanent storage or disposal, with the cost to be borne by the reprocessors

The reprocessors are responsible for short-term storage and solidification of the waste, and AEC is responsible for long-term storage and disposal Technology involved with short-term storage has been well developed and demonstrated over the past 30 years Technology for ultimate disposal is still in the research stage and offers no viable answers at the present time Of most immediate concern is the development of methods of solidification and AEC storage facilities

SOLIDIFICATION OF LIQUID WASTE

According to the 1970 regulations commercial reprocessors must convert liquid waste to an acceptable solid form not more than 5 years after it is generated 1/ The regulations did not, however, specify the solid form that would be acceptable AEC has accepted the use of calcine, although it does not consider calcine the most acceptable form for long-term storage because of its leachability and dispersability

1/The 600,000 gallons of liquid waste in the possession of Nuclear Fuel Services were exempted from this requirement A separate determination is to be made on the disposition of this waste.

AEC has been conducting research for several years into the conversion of waste to other, more solid forms This research has successfully demonstrated the technology of converting calcine to a solid glass form Glass is considered very desirable for long-term storage because of its low leachability AEC does not consider it appropriate to require reprocessors to glassify waste, until the feasibility of this process has been demonstrated on a production basis AEC is planning a demonstration plant for this purpose

AEC said that, if it decided to proceed with the demonstration plant, funds would be requested to start construction in fiscal year 1977 Although the plant is to be used for demonstration, AEC's conceptual design is for a facility large enough to glassify all of the Nation's waste through the year 1990. The demonstration plant is to be an integral part of AEC's planned facility for temporarily storing commercial waste.

FEDERAL STORAGE FACILITIES

Since the early 1960s, AEC has been studying the feasibility of an underground repository in bedded salt for permanent storage of solidified high-level waste. Bedded salt offers several advantages, the principal one being its stability

Investigations by AEC showed that salt cake caverns near Lyons, Kansas, held considerable promise, and in 1970 AEC announced plans to locate a demonstration repository there. Because of adverse public reactions and uncertainties concerning integrity of the overlying formations which protect the salts from water, this project was canceled in 1972, and a decision was made to proceed with an aboveground retrievable surface storage facility (RSSF) large enough to store all commercial high-level waste generated through the year 2000 and capable of storing this waste for a minimum of 100 years According to AEC, this will permit a more orderly exploration of permanent storage and disposal in bedded salt or other geological formations.

Although AEC has decided to proceed with the RSSF concept, it has continued a geologic disposal research program to find a permanent storage site for high-level radioactive waste. The objectives of this program are to (1) develop information necessary to identify suitable geologic formations, (2) identify potential locations for geologic disposal facilities, (3) conduct related analytical and experimental evaluations of formations, and (4) prepare concepts for the related facilities. From fiscal years 1972 through 1974, AEC spent about $4 6 million on such work and has budgeted $2 1 million for fiscal year 1975.

Also, to complement the geological disposal program, AEC is making studies of advanced methods for management and disposal of high-level waste such as transmutation--the changing of a material from one form to another This concept would minimize the radioactive levels of waste From fiscal years 1972 through 1974, AEC spent about $1 2 million on such studies and has budgeted $1 3 for fiscal year 1975

Type of retrievable surface storage facility

Between 1972 and 1974, AEC had studies made on three basic concepts for an RSSF. At the time of our review, AEC was still considering all three concepts

--The water-cooled basin concept consists of suspending canisters of solid waste in steel-lined concrete basins filled with circulating water. (See drawings obtained from AEC on pp. 29 and 30) This method has been used for several years in the United States to store irradiated fuel elements from both commercial and AEC reactors. AEC considers this to be a thoroughly proven technique which offers expansion capability simply by adding additional basins It also provides ready visibility for monitoring purposes On the other hand, it depends on mechanical means for pumping of the water and close control of water quality to minimize corrosion.

--The air-cooled vault concept consists of canisters of waste in underground vaults with cooling provided by ambient air. (See drawing obtained from AEC on p 31.) It offers the advantage of simplicity but does not provide ready access for surveillance

--A more recent development is the sealed storage cask concept This consists of waste canisters enclosed inside heavy-walled steel shields and placed inside concrete shields on concrete pads in opened areas Cooling is provided by natural flowing ambient air. (See drawing obtained from AEC on p. 32) The casks are then placed on concrete pads in open areas This concept has the advantages of simplicity, easy access, and no dependence on mechanical systems It does, however, require more land area than the other two concepts

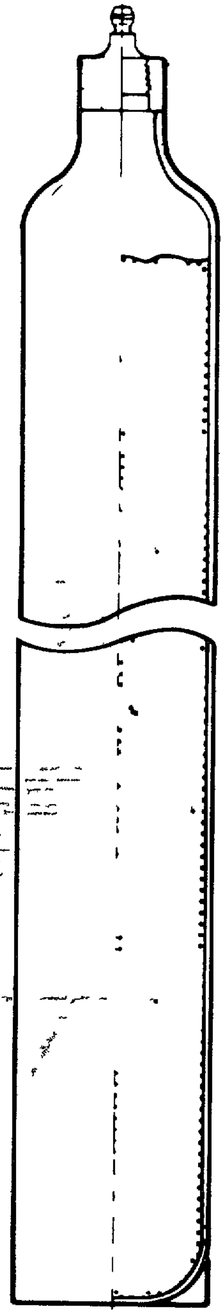
Evaluation of alternative sites
for retrievable surface storage facility

Under contract with AEC, ARHCO evaluated locations suitable for an RSSF ARHCO is also responsible for AEC's waste management activities at Richland. Siting criteria used in the evaluation were developed by ARHCO with AEC guidance and consultations These criteria were as follows

--Isolation The required degree of isolation was defined as 3 miles or more from a population center of over 25,000.

--Economics. Consideration should be given to transportation, capital, and operating costs over the intended life of the RSSF

"TYPICAL" CANISTER



	DIAMETER	LENGTH
TYPICAL	12"	10'

Contents of Typical Canister

Volume 6.3 cu ft.

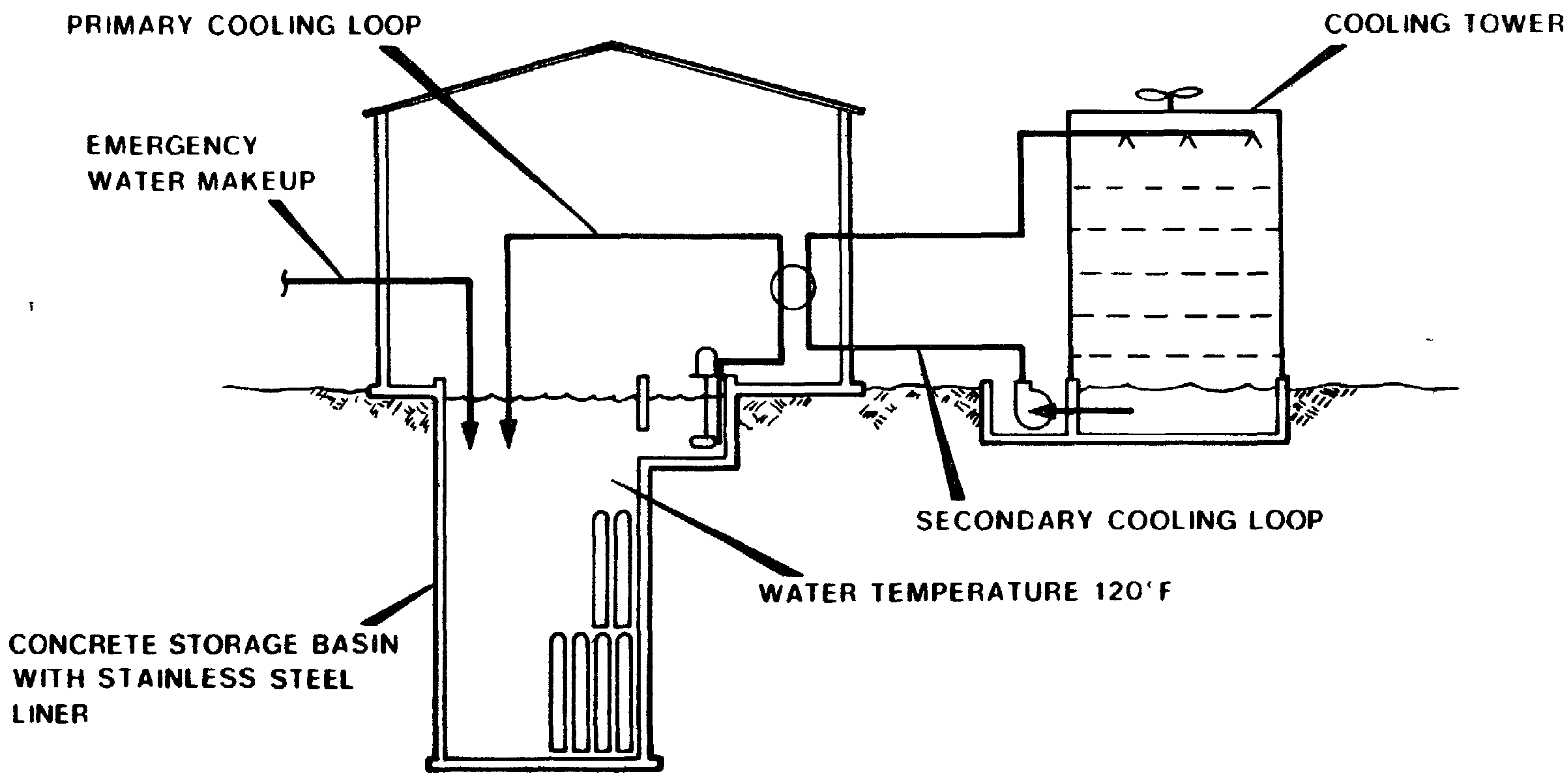
Weight 2000 - 4000 lbs

Heat Output 5 kilowatts

Curies: 20,000,000

RETRIEVABLE SURFACE STORAGE FACILITY

WATER BASIN CONCEPT



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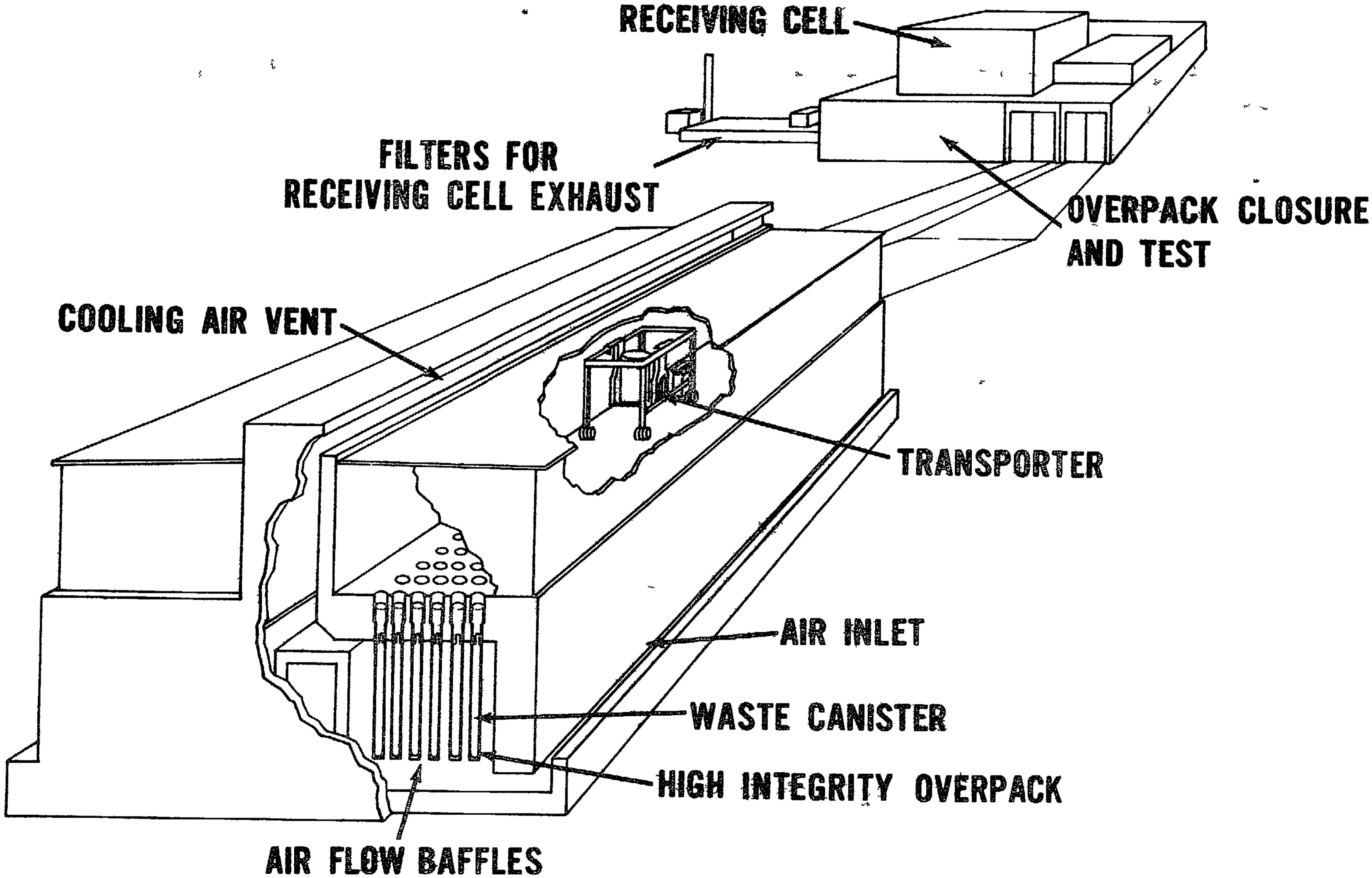
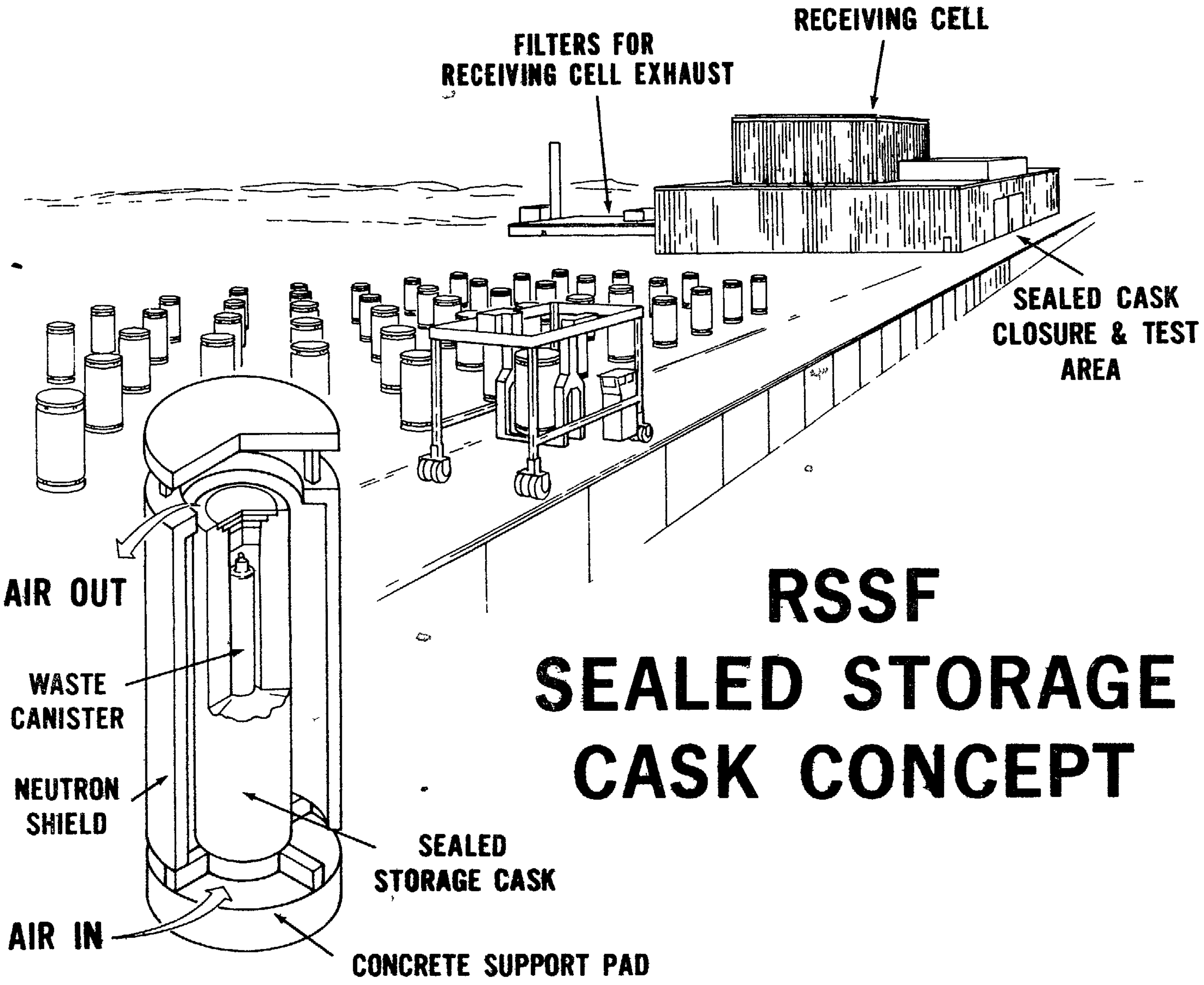
RSSF AIR COOLED VAULT CONCEPT




FILTERS FOR
RECEIVING CELL EXHAUST
RECEIVING CELL
SEALED CASK
CLOSURE & TEST
AREA
AIR OUT
WASTE
CANISTER
NEUTRON
SHIELD
SEALED
STORAGE CASK
AIR IN
CONCRETE SUPPORT PAD
RSSF
SEALED STORAGE
CASK CONCEPT

--Seismicity Sites in low seismic risk zones were preferred over sites in acceptable, higher seismic risk zones

--Access highways and railroads Proximity to first-class highways and railroads is required because high-level waste will be transported in heavy shielded casks estimated to weigh about 35 tons for truck transport and 100 tons for rail transport

--Water supply. Under the water basin concept, water is used to cool the high-level waste canisters, therefore, an assured supply of water must be available at all times The air vault and sealed storage cask concepts need a lesser amount of water

--Power The water basin concept requires electrical power primarily for the operation of cooling water pumps The air vault and sealed cask storage concepts depend on natural air draft for cooling

--Land ownership On the basis of cost, compatibility to other use and public acceptance, federally-owned, AEC controlled land is considered the most desirable alternative. The least desirable is the use of privately owned land.

--Site compatibility Sites already having long-term surveillance commitments for high-level waste have an advantage over other sites because long-term surveillance is also required for RSSF

--Public acceptance Public acceptance is assumed to be best near sites where AEC is one of the major employers.

In its initial site evaluation work, ARHCO reported that many locations in the United States might be acceptable because the siting requirements are not unique and, in many respects, are similar to those of other nuclear facilities such as power plants and fuel reprocessing plants Using this criteria plus work already done for other nuclear facilities and general knowledge, a list of the following 16 sites was made These sites were all considered acceptable for water basin storage However, because of the need for more land area for air cooled vault and sealed storage cask, only 11 were considered acceptable for these methods

Located at or near	Site considered for		
	Water basin storage	Air-cooled vault and sealed cask storage	Land ownership
Dugway Proving Ground, Utah	X	X	Federal
Fernald, Ohio	X		Federal--AEC
Richland, Washington	X	X	"
Los Alamos, New Mexico	X		"
Loving, New Mexico	X	X	Federal
Lyons, Kansas	X	X	Private
Morris, Illinois	X	X	"
Idaho Falls, Idaho	X	X	Federal--AEC
Nevada Test Site, Nevada	X	X	"
Oak Ridge, Tennessee	X	X	"
Paducah, Kentucky	X		"
Portsmouth, Ohio	X		"
Savannah River, South Carolina	X	X	"
Tatum Salt Dome, Mississippi	X	X	Private
Weldon Springs, Missouri	X		Federal
West Valley, New York	X	X	State

ARCHO applied the site selection criteria to these sites and, as a result, 12 were eliminated for water basin storage.

--Four because of a lack of a proven water supply
Dugway Proving Ground, Utah
Loving, New Mexico
Lyons, Kansas
West Valley, New York

--Four because of a lack of site compatibility·
Fernald, Ohio
Paducah, Kentucky
Portsmouth, Ohio
Weldon Springs, Missouri

--Two because of private ownership
Morris, Illinois
Tatum Salt Dome, Mississippi

--One because of a questionable water supply and the long distance to the railhead

Nevada Test Site, Nevada

--One because of the high cost of building a railroad to service the RSSF
Los Alamos, New Mexico

Six were eliminated for air-cooled vault and sealed cask storage

--Four because of non-Federal ownership
Lyons, Kansas
Morris, Illinois
Tatum Salt Dome, Mississippi
West Valley, New York

--Two because of a lack of site compatibility
Dugway Proving Ground, Utah
Loving, New Mexico

As a result, ARHCO recommended four sites if the water basin method is used and five if either the air-cooled vault or sealed cask method is used These sites were selected primarily on the basis of land ownership, site compatibility, and commitment for long-term surveillance The recommended sites follow

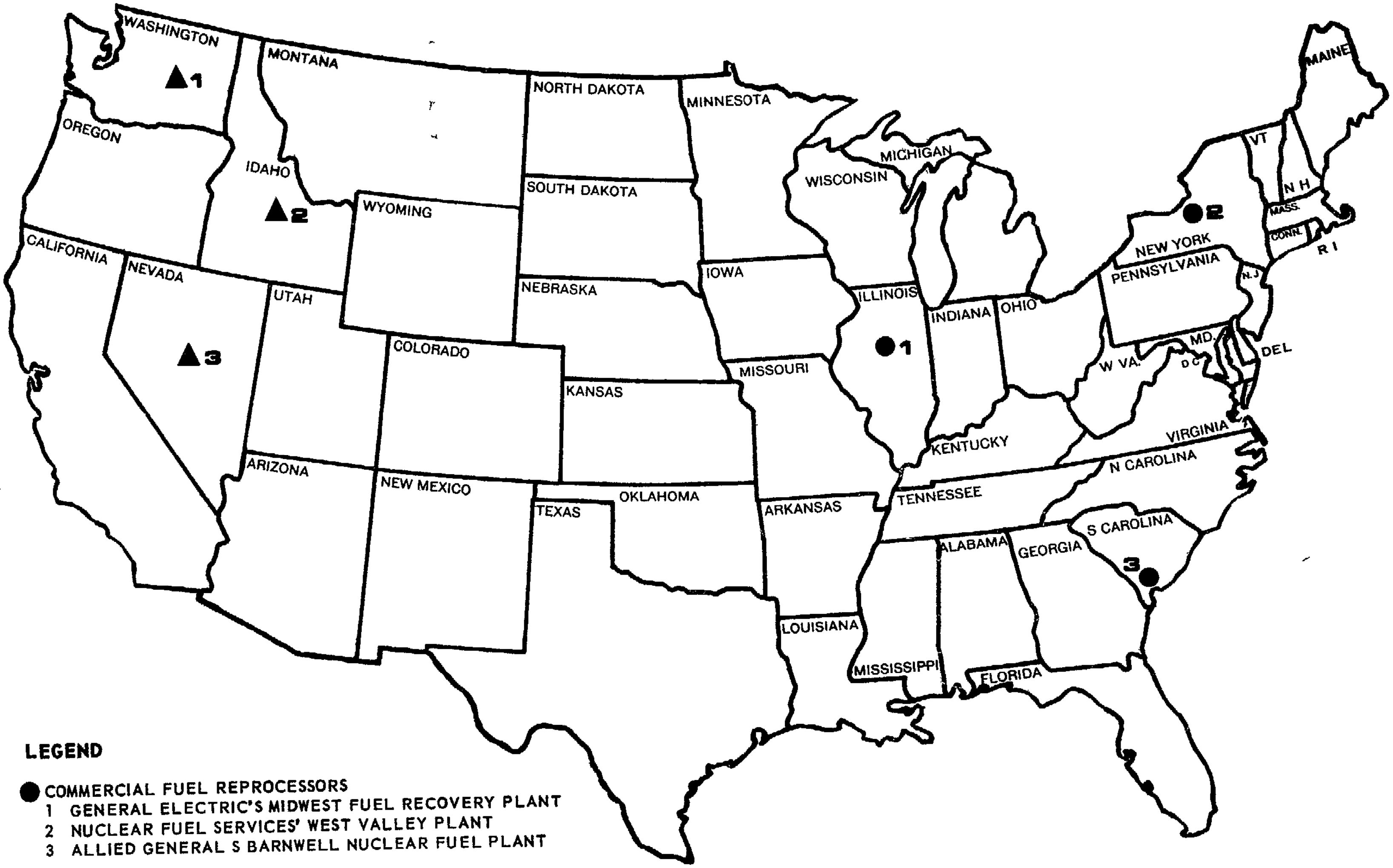
	Water basin	Air-cooled vault and sealed cask
Richland	X	X
Idaho Falls	X	X
Nevada Test Site	(a)	X
Oak Ridge	X	X
Savannah River	X	X

a/AEC is still considering the Nevada Test Site for water basin storage, recognizing the problems associated with water supply and the railhead (See p 34.)

After further evaluation, AEC removed Oak Ridge and Savannah River sites from further consideration AEC officials said that Oak Ridge was eliminated because public acceptance was lacking and because the use of available flat land most suitable for RSSF construction may conflict with on-going or future research activities Savannah River, according to AEC officials, was eliminated because acceptance by public officials was lacking This leaves three sites in the western part of the United States under consideration--Richland, Idaho Falls, and the Nevada Test Site

Selecting any of the three sites presently under consideration would involve transporting high-level waste over long distances because the reprocessing plants are located in the Midwest and the East (See map on p 36)

LOCATIONS OF COMMERCIAL FUEL REPROCESSORS AND POTENTIAL AEC STORAGE SITES



LEGEND

● COMMERCIAL FUEL REPROCESSORS
1 GENERAL ELECTRIC'S MIDWEST FUEL RECOVERY PLANT
2 NUCLEAR FUEL SERVICES' WEST VALLEY PLANT
3 ALLIED GENERAL S BARNWELL NUCLEAR FUEL PLANT

▲ POTENTIAL AEC STORAGE SITES
1 RICHLAND WASHINGTON
2 IDAHO FALLS IDAHO
3 NEVADA TEST SITE, NEVADA

If a separate RSSF were located at each commercial fuel reprocessor's plant, transportation would be postponed until the permanent storage or disposal question is resolved and the interim step of transportation from the reprocessor's plants to the temporary storage site would be eliminated

Operation of an RSSF would be consistent with the reprocessors' primary functions considering

--the relative simplicity of each of the three storage concepts under consideration,

--the relatively small amount of land required,

--the expressed objective of providing interim storage for a finite period of time, and

--the financial liability of the reprocessor to provide this storage

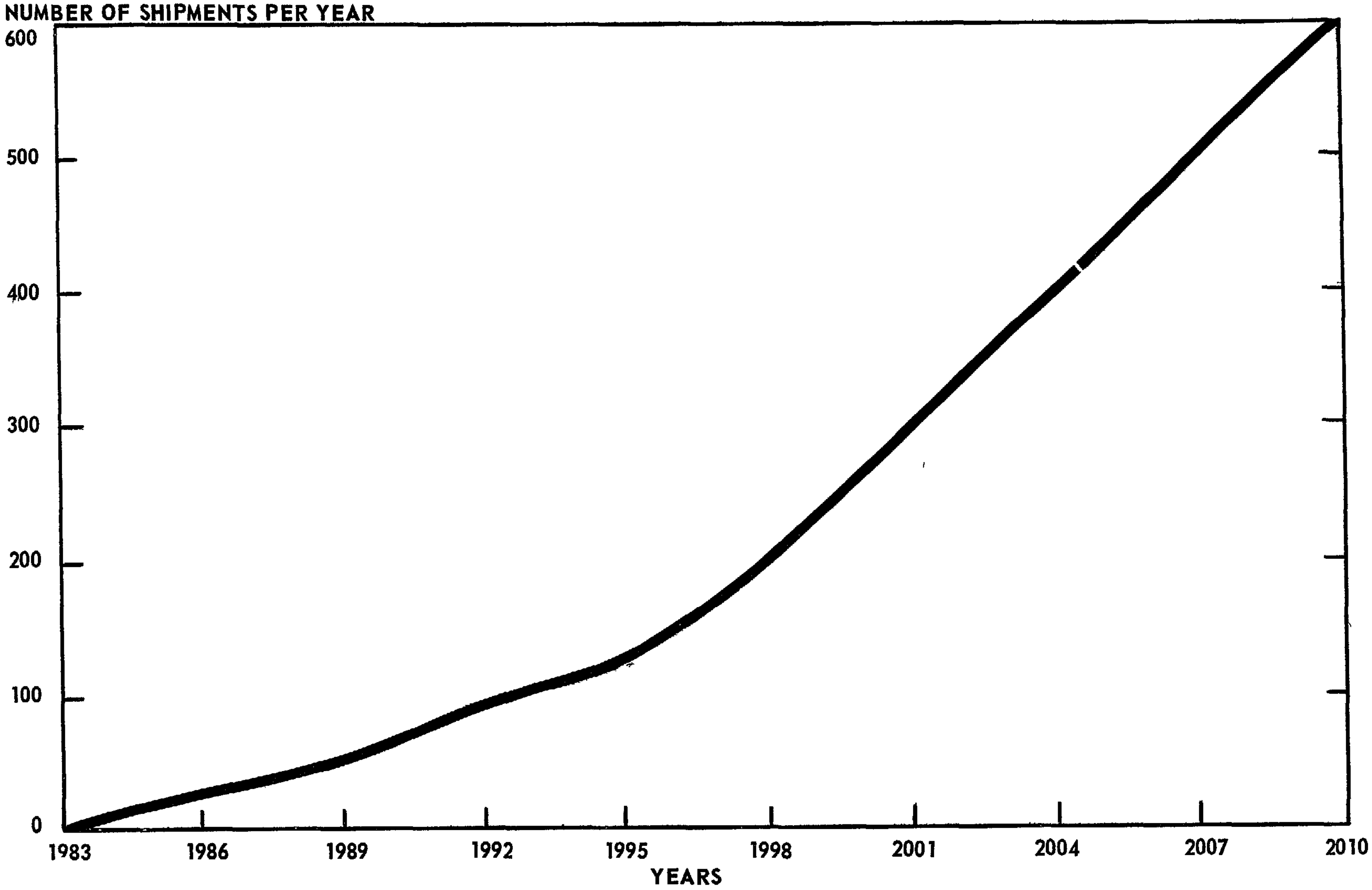
In discussions with the three reprocessors which intended to or are scheduled to begin operations in this decade, they stated that they were technically able to operate RSSFs One reprocessor stated, however, that there would be public opposition to its operation of a RSSF and that it did not recommend such a course of action AEC said that it had not evaluated the reprocessors' ability to operate RSSFs

For the present AEC has proposed to have only one central RSSF, on Government-owned and preferably AEC land, to minimize any environmental impact and to provide closer AEC control The waste must be transported if a site other than at the reprocessors' plants is selected According to ARHCO's study, this will necessitate transporting about 500,000 cubic feet of waste in about 6,400 shipments during the 28-year period from 1982, when the first shipments are expected, until the year 2010 AEC expects that shipments will grow in number as time passes, as shown by the graph on the following page

According to AEC, transportation will probably be by rail because of the weight involved in shielding this material and the economics of making a large enough shipment to be profitable.

The number of miles involved and the time in transit vary by location The following table shows the estimated miles and in-transit time involved for the sites still being considered, assuming rail transportation during the period 1982-2010

SHIPMENTS OF SOLIDIFIED HIGH-LEVEL WASTE
FROM COMMERCIAL FUEL PROCESSORS



Comparison of rail transportation factors for various site locations

RSSF location	Loaded cask miles (note a)	In-transit time (Loaded cask days)
Idaho National Engineering Laboratory	11,200,000	50,000
Nevada Test Site	12,500,000	51,000
Richland	14,700,000	59,000

a/Factored in the mileage figures are estimated shipping distances for future processing plants.

The in-transit time and miles traveled increases as time passes Whereas relatively few shipments are expected to be made in the early years, an ARHCO official estimated that by the year 2010 approximately 15 train cars carrying high-level nuclear waste could be in transit at any one time, assuming a western storage location

AEC determined that the variances in transportation safety aspects relating to the sites under consideration were small enough that they need not be considered in evaluating the relative merits of those sites The probability of an accidental release of radioactivity during transport to any of the sites was considered by AEC to represent an acceptable risk The determination was based primarily on an AEC study of the probability of transportation accidents involving the uncontrolled release of radioactivity. This study, the results of which were published in AEC document WASH-1238, concerned the transportation of irradiated fuel from reactors to fuel reprocessors--a situation very similar to transportation of waste. Another study, AEC document WASH-1248, presents a generic treatment of the transportation of high-level waste

Using historical data primarily from the Department of Transportation, AEC analyzed accidents on the basis of (1) vehicle speed at impact and (2) incident and duration of fire, and categorizes the accidents by severity ranging from minor to extreme Probability factors were then computed for each category of accident severity, as follows

Severity of an accident	Probability of an accident
Minor	Once each 1 million miles
Moderate	3 times each 10 million miles
Severe	8 times each 1 billion miles
Extra severe	Once each 100 billion miles
Extreme	Once each 10 trillion miles

Although present plans call for high-level waste to be shipped by rail without special or extraordinary handling, according to AEC, the waste will be shipped in specially built casks Specific casks for high-level waste have not been designed yet, but AEC anticipates them to be similar to those presently used for shipping irradiated fuel elements Considering the integrity offered by the anticipated design characteristics for the shipping cask and the accident severity data, AEC computed the probability per vehicle mile of an accident with a small breach, a medium breach, and a large breach as follows

Cask breach	Probability
Small	5 times in 10 billion miles
Medium	8 times in 1 trillion miles
Large	1 time in 100 trillion miles

As a result of these calculations, AEC concluded that the likelihood of an accidental release of radioactivity during transport is so remote that it was an acceptable risk for all sites and that although the safety factor could vary between sites, it would not vary enough to be a determining factor in the selection of the site

The Department of Transportation in written comments evaluating AEC document WASH-1238 and in subsequent discussions with us supported AEC's conclusion and methodology of using national transportation accident data in arriving at its conclusion

The Environmental Protection Agency similarly supported AEC's conclusions and methodology, although with some reluctance on the amount of quantitative data provided by AEC Environmental Protection Agency officials also stated that their acceptance of AEC's conclusion was regarding transportation to and from reactors They stated that they are presently evaluating AEC's similar conclusion on transportation between fuel reprocessors and the RSSF site They further stated that using national data rather than site related data will be specifically considered in their evaluation

CONCLUSIONS

During the past 4 years AEC has made progress in defining waste storage responsibilities, developing technology to solidify liquid waste, and planning for Federal storage facilities If progress continues, AEC should be in a better position to deal with the large quantities of commercial waste that will be generated in the future than AEC has been to deal with its own waste in the past

AEC approached its selection of an RSSF site logically and systematically by drawing up a list of feasible sites and then evaluating those sites on the basis of a set of criteria Considering the large quantities of waste to be transported over various types of terrain and through various population centers, the potential consequences if this waste was accidentally released and the variances in distances between sites, AEC studied the question as to whether transportation safety should be included among the site selection criteria

On the basis of national transportation accident data and the integrity of the shipping casks, AEC has determined that the variances in risk among the sites to be sufficiently negligible as not to represent a determining factor in site selection Therefore, AEC did not include transportation safety among its site selection criteria

Although we are making no recommendation concerning AEC's site evaluation work, we believe the pertinent facts as set forth in this report will be helpful to the Congress in its oversight of nuclear programs and in furtherance of its interest in safeguarding the public from hazards that may arise from the storage, handling, and transportation of nuclear material and in resolving the ultimate disposal question concerning high-level radioactive waste

PRINCIPAL AEC MANAGEMENT OFFICIALS
RESPONSIBLE FOR ADMINISTERING THE ACTIVITIES
DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
Chairman		
Dixy Lee Ray	Feb 1973	Present
James R Schlesinger	Aug 1971	Feb. 1973
Glenn T Seaborg	Mar. 1961	Aug. 1971
General Manager		
John A Erlewine	Jan 1974	Present
Robert E Hollingsworth	Aug 1964	Jan 1974
Director of Regulation		
L Manning Muntzing	Oct. 1971	Present
Harold L Price	Sept 1961	Oct 1971

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