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Final Environmental Statemen

Waste Management Operations

Hanford Reservatior

Richland, Washingtor

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December 197

United States
Energy Research & Development
Administration

VOLUME 1

(1 of 2 Volumes)

I	Summary
II	Detailed Description of Hanford Site
III	Environmental Impact
IV	Unavoidable Adverse Effects
V	Alternatives
VI	Relationship Between Local Short-Term Uses of Man's Environment and the Maintenance of Enhancement of Long-Term Productivity
VII	Relationship of Proposed Action to Land Use Plans, Policies, and Controls
VIII	Irreversible and Irretrievable Commitments of Resources
IX	Comparison of Costs and Benefits
X	Comments

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Environment & Safet

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FOREWORD

GENERAL

Since 1944, when the first Hanford facilities were operated to produce plutonium for the Manhattan Project, radioactive waste has been generated at Hanford. Consequently, there has been a continuous and evolving program for waste management and environmental assessment for over 30 years. The Energy Research and Development Administration's (ERDA) actions and concern with respect to waste management and its environmental impact over the 30-year period are partially reflected in over 2,000 studies and documents which have been collected in "Radioactive Waste Management," a bibliography of available literature pertaining to the ERDA's Hanford, Washington, Production Site (TID-3340, August 1973.)*

SCOPE [RPB, X.24]**

This document is an environmental impact statement on the Waste Management Operations Program at Hanford. The draft statement was issued as WASH-1538. This final statement is issued by the recently established Energy Research and Development Administration as ERDA-1538. The purpose of this statement is to reassess the environmental impact associated with continuation of the Hanford Waste Management Operations Program to provide an informational record for use in future planning and decision making in order to assure that further waste management practices will be conducted so as to minimize adverse environmental consequences.[1] The statement will serve as a base for evaluating the environmental impact of future actions in relation to the existing environment at Hanford. In comments (dated January 23, 1975 and included in Section X) on the draft statement, the Environmental Protection Agency (EPA) agreed that this is the proper scope for the statement.

In order to project future impacts, a complete analysis is given of the environmental impact of existing waste management operations at Hanford. This analysis is primarily based upon extensive environmental monitoring which has been conducted and reported on for the past 30 years. This statement is the evaluation of a long-existing program; the results are presented as of a particular date. The cut-off date selected for the inclusion of fully evaluated data and experience was December 31, 1972, because preparation of the statement began in September 1973. Additional pertinent data have been included in this final statement; in particular Appendix III-G, Environmental Sample Collection Analysis and Evaluation for 1974.

Since the purpose of this statement is to reassess an existing program, the Foreword provides an introductory summary of: 1) the current policies, plans, and standards applicable to the Hanford Waste Management Operations Program,[2] 2) the current waste management program, and 3) the programs and activities at Hanford that are not covered in this environmental impact statement.

The quantities of radioactive and nonradioactive materials released to the environment from future Hanford operations is anticipated to decline as a result of: 1) modifications and construction of new facilities for effluent control and 2) curtailment of production activities. Since this is an ongoing program, the data base is not static. All of the critical areas, such as geology, seismology, hydrology, meteorology, and ecology, are the subject of continuing study and research, subsequent to the issuance of this statement. These studies will be published and made available to the public as they are issued.

The statement covers waste generated by production, research and development and other programs and activities at Hanford. This statement does not cover the alternatives and/or costs and benefits with respect to the production of special nuclear materials or the operation of research and development programs, since it is not a statement on the operation of those programs. The operation of N Reactor and the Purex Chemical Processing Plant to produce and recover plutonium and other materials for national defense and research and development activities is therefore beyond the scope of this statement. However, in order to compare and evaluate waste management

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* The Energy Research and Development Administration was established by the Energy Reorganization Act of 1974 (Public Law 93-438) and was made effective January 19, 1975, by Executive Order 11834 dated January 15, 1975 (40 Fed. Reg. 2971). The Atomic Energy Commission (AEC) was abolished and certain of the AEC's responsibilities, including production and basic research activities, were transferred to ERDA. The AEC was responsible for the operation at the Hanford site from 1947 to 1974. Since the draft environmental statement on the Hanford Waste Management Operations was issued by the AEC (WASH-1538) and the final statement by ERDA (ERDA-1538), both AEC and ERDA designations are used.

** See Section I.1 for explanation of the use of brackets after subsection headings.

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alternatives in terms of their environmental impact, the section on alternatives includes an analysis of impact if production or research and development activities and facilities ceased to operate. This should provide a clear basis for comparing the impact of managing the waste to be generated in the future with managing the waste that was generated over the last 30 years. An environmental assessment will be prepared covering all of the operational aspects of the Hanford site such as N Reactor operations, Purex, and Z Plant. That assessment will determine whether the continued operation of these facilities may require the issuance of a supplement to this statement.

Since the waste management program at Hanford is an ongoing program (as distinguished from a proposed action or a proposed program), many of the long-term, as well as the short-term, options for the control, handling and disposal of radioactive waste are in various stages of research and development. Although the status of these research and development efforts will be discussed in the statement, some of these research and development programs may require their own environmental statements at a later time. In accordance with ERDA's regulations,[3] these statements will be written late enough in the development process to contain meaningful information, but early enough that whatever information is contained may be factored into the decision-making processes. These statements will be prepared before the development process has reached a stage of investment or commitment to implementation likely to foreclose or restrict later alternatives.

A number of comments on the draft statement questioned the relationship of this statement to the research and development program currently being conducted on the ultimate disposal of Hanford generated high-level and transuranic wastes. In its comments dated January 23, 1975, the EPA suggested that at the conclusion of the ongoing effort to prepare impact statements for all major ERDA waste management operations (Hanford, Savannah River and Idaho), ERDA should prepare a generic environmental statement addressing the long range program for both interim storage and ultimate disposal of all ERDA generated high-level and transuranic wastes. This environmental statement describes the research and development programs on solid forms for Hanford radioactive waste which may be suitable for final storage. The acceptability of storing these solid waste forms in formations being considered for final storage of commercial radioactive waste will be addressed in ERDA's expanded environmental statement on commercial radioactive waste.

Policies, Criteria, and Standards for Management of Radioactive Waste

The current basic policies, criteria, and standards for management of ERDA-generated radioactive waste at Hanford and at other sites are contained in the ERDA Manual Chapter 0511 (hereafter referred to as ERDAM-0511) (September 19, 1973), which provides in part:

"(1) Field offices and their contractors shall conduct their operations and dispose of and store radioactive waste in such a manner as to assure that present and future radiation exposures to individuals and population groups will be at the lowest levels technically and economically practical not exceeding limits established in ERDAM-0524 Appendix Parts I and II.

(2) Continuing efforts shall be made to develop and use improved technology for reducing the radioactivity releases to the lowest technically and economically practical level.

(3) High-level liquid radioactive waste shall not be transported offsite.

(4) The extent and degree of radioactive contamination of land by ERDA waste management activities shall be minimized."

The basic standards for protection of the health and safety of the public are those contained in ERDA Manual Chapter 0524 (hereafter referred to as ERDAM-0524), which provide, in part:

"ERDA and ERDA Contractor operations shall be conducted in such a manner as to assure that radiation exposures to individuals and population groups are limited to the lowest levels technically and economically practical."

The policies in ERDAM-0524, including the specific protection standards for external and internal exposures, are based on the guides and recommendations of the International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements, and the Federal Radiation Council. In 1959, the Federal Radiation Council was formed to provide a policy for Federal agencies on human radiation exposure. A major function of the Federal Radiation Council was to "Advise the President with respect to radiation matters, directly or indirectly affecting health, including guidance for all Federal agencies in the formulation of radiation standards and in the establishment and execution of programs in cooperation with the States...". [Public Law 86-373 (1959)].

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In February of 1970, the Federal Radiation Council requested the National Academy of Sciences-National Research Council to review and re-evaluate the existing scientific knowledge concerning radiation exposure to human populations. On October 2, 1970, the Environmental Protection Agency was established by the President's Reorganization Plan No. 3 of 1970. On December 2, 1970, the activities and functions of the Federal Radiation Council were transferred to the Office of Radiation Programs of the EPA. In November of 1972, the National Academy of Sciences-National Research Council published a report which included their view on the existing scientific knowledge concerning radiation exposure to human populations. The publication of that report was preceded by the following statement;

> "This report was prepared under contract No. PH-43-64-44 between the Department of Health, Education, and Welfare (on behalf of the Federal Radiation Council) and the National Academy of Sciences. Publication is made jointly by the Department of Health, Education and Welfare and the Environmental Protection Agency, which succeeded to the authorities of the Federal Radiation Council under Reorganization Plan No. 3 of 1970. The report is solely the product of the contractor. The data and analysis contained in the report represent a major review of the effects of low levels of ionizing radiation and the role of such information in measures to protect the public. They will be reviewed extensively and with the utmost deliberation and care by the Department of Health, Education, and Welfare and the Environmental Protection Agency, with particular regard to their usefulness and applicability in the regulatory and other program activities of the Department and the Agency.
>
> Publication of the report does not constitute acceptance or approval of its contents; neither does it indicate their rejection or disagreement. Publication is made at this time so that the report will be available as a resource to the scientific community and the public generally."

The report of the National Academy of Sciences-National Research Council is currently undergoing review by the Department of Health, Education, and Welfare, EPA, ERDA and other interested organizations. The analysis in this environmental impact statement uses the existing standards and guides recommended by the Federal Radiation Council and others. These guides are contained in ERDAM-0524.

CURRENT PROGRAM

1) High-Level Waste

Approximately 47 million gallons of liquid waste and 25 million gallons of solidified waste (30 and 28 respectively as of March 1975) are stored in underground tanks at Hanford. This waste was generated during the period 1944 to 1974 as a result of processing fuel from up to nine production reactors. The processing of the fuel was required to extract plutonium, primarily for use in atomic weapons. This quantity of high-level waste represents about 90% of the total high-level waste expected to be generated through the operation period of the Hanford plutonium production facilities. At the present time, only one production reactor (N Reactor) is operating; the fuel processing required generates additional high-level waste. Based on current production plans, the operation of N Reactor* and the Purex processing plant results in the generation of approximately 1 million gallons of liquid high-level waste each year.

The thrust of the current waste management program for high-level waste has been to convert stored and currently generated high-level waste from a liquid to a salt cake form. The existing evaporators, along with one evaporator currently under construction, will solidify most of the stored and currently generated liquid waste to salt cake. Shown in Figure 1 is a graphical summary of the Hanford high-level waste solidification program progress. The large increase in the rate of reduction of liquid waste starting in late 1973 and continuing through 1976 is due to the high capacity of the larger new vacuum evaporator crystallizer installation. The residuum liquor from the older shutdown evaporators and the new vacuum evaporator crystallizers will remain and will be further evaporated to the extent possible. Finally, the residuum will be reduced in volume to a highly caustic liquid which will be solidified to an acceptable solid by chemical means or by evaporation techniques now under development. In the interim the current program provides for construction of double wall tanks of high integrity for storing the residum liquor removed from the salt cake. The spread in predicted waste volumes after 1978, shown in Figure 1, depends on whether the development work aimed at solidification of the residum is completed on schedule.

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* Pursuant to special statutory authority (Public Law 87-701, AEC Authorization Act for FY-1963) and special contract arrangements, the by-product steam from the N Reactor is used to generate approximately 860 megawatts of electrical power from the Washington Public Power Supply System generating facilities located on the Hanford site.

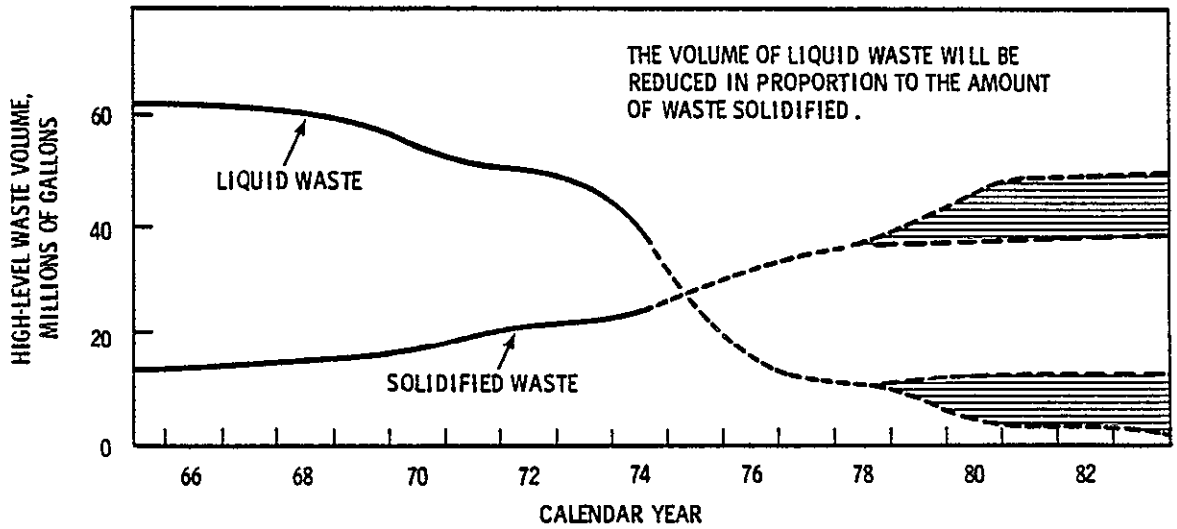

FIGURE 1 HIGH-LEVEL WASTE SOLIDIFICATION PROGRAM

The solidification of the liquid waste along with the use of high integrity tanks to contain the liquids in interim periods is considered the current program for the high-level waste. The objective of this program is to continue to maximize the isolation of the high-level waste from man's environment.

The current waste management program also includes research and development to determine the best ultimate long-term storage method for the salt cake by focusing on alternative solid forms and storage methods which would have minimum dispersability characteristics over very long periods of time. In addition, research and development efforts directed toward final disposal of high-level waste from the commercial power industry will be investigated for applicability to Hanford waste.

2) Other Radioactive Waste

- Liquid

  In addition to the high-level liquid waste from fuel processing plants, large volumes of water containing low concentrations of radioactive materials or no radioactivity are produced during operations and are released onsite (controlled areas). For some of this waste, it is practical to reduce the radioactivity to levels within established standards for release offsite (uncontrolled areas) by treatment methods, such as ion exchange, decontamination by evaporation, or retention to allow for the decay of radionuclides. Other waste, containing levels of radioactivity unacceptable for release to uncontrolled areas, may be safely released to controlled areas with suitable natural characteristics. Present practice uses soil columns, seepage basins, evaporative ponds, or retention ponds to retain or delay radionuclides. Wherever such practices are followed, a continuing program exists for extensive monitoring of the movement of these materials.

  The practice of using the favorable ion exchange properties of some soils to remove radioactivity from liquid waste and confine it in soil columns is a well established procedure. However, because of the long-term burden of control and surveillance inherent in the use of a technique that results in local accumulations of radioactivity in soil, the ERDA program at Hanford has been based on the goal of major reductions in the concentration of radionuclides in effluent streams. Alternate waste treatment techniques are being considered to decontaminate the bulk of the waste to levels within established standards for release to uncontrolled areas.

- Solid Waste

  Solid waste of widely diverse nature and contaminated to varying degrees with many different forms of radioactive materials is generated at Hanford. The sources of radioactivity in this waste are fission products, induced radionuclides, and transuranium elements, principally plutonium.

Solid waste containing ^{233}U or transuranic elements (plutonium, etc.) is being segregated, packaged and buried under soil in such a manner that retrieval in 20 years with the exterior surface of the container free of radioactive contamination could be accomplished. Other radioactively contaminated solids are packaged in boxes, drums, etc., and buried underground in trenches. Some large equipment from the chemical processing plant (Purex) is stored in adjacent railroad tunnels awaiting final disposition. Planning and development is proceeding to reduce the volume of solid waste by incineration of combustible solids and compaction of other solids.

- Gaseous Effluents

  Building ventilation systems are filtered with high efficiency filters to remove particulate matter. Process gas streams are treated by various means such as scrubbers, chemicals reactors, etc., and finally filtered before discharge. Radioactivity in the air at plant boundaries is well below ERDAM-0524, Table 2 concentrations. Plans are proceeding to provide further reductions which may be practical.

PREPARATION OF STATEMENT

The notification of the preparation of this statement, published in the Federal Register on August 14, 1973 (38 Fed Reg 156), invited suggestions from all interested persons. Comments were also requested on the draft outline of the statement from the EPA, the Washington State Department of Ecology, and the Natural Resources Defense Council. The AEC and the EPA held a public meeting in February 1974 in Richland, Washington, to discuss the environmental impact statement and the waste management activities at the Hanford Reservation (27 Fed Reg 4800, February 4, 1974).

The issuance of the draft statement was announced in the Federal Register on September 30, 1974 (39 Fed Reg 35199), and comments were requested by November 27, 1974. The comment period was subsequently extended to January 23, 1975, to provide additional time for public review of the DEIS and for appointment of a hearing panel. Public hearings were held on the DEIS in Richland, Washington, and Portland, Oregon, on January 21 and January 23, 1975, respectively.

The hearings were conducted by a presiding board consisting of Professor Robert W. Hamilton of the University of Texas School of Law, who acted as chairman of board; Professor Thomas F. Parkinson, Chairman of Nuclear Engineering at the University of Missouri; and Professor James A. Kittrick of the Department of Agronomy and Soils at the Washington State University. The record remained open following the public hearings to allow attendees further opportunity to submit supplemental comments. The Presiding Board transmitted its report on the hearings to the Administrator of ERDA on April 3, 1975 (40 Fed Reg 17317, April 18, 1975). The report of the Presiding Board and all the written comments received on the Draft Environmental Impact Statement are reproduced in Section X of this statement. The method of treatment of the issues identified by the Board and the written comments received is described in the introduction to Section X.

Copies of the final statement, the draft statement, the public hearing record, and all written suggestions and comments received, as well as the documents referenced by this statement are available for inspection at the ERDA public document rooms at the following locations:

20 Massachusetts Avenue, NW., Washington, D.C.

Richland Operations Office, Federal Building, Richland, Washington

Idaho Operations Office, 550 Second Street, Idaho Falls, Idaho

Savannah River Operations Office, Savannah River Plant,
Aiken, South Carolina

San Francisco Operations Office, 1333 Broadway, Oakland, California

Waste management operations at Hanford, as well as for all the ERDA sites, are continually reviewed, analyzed, and updated to reflect improved technology or administrative procedures for waste treatment and storage. As a result of this environmental statement, possible additional improvements may be identified.

REFERENCES

1. Guidelines, Council on Environmental Quality, 40 CFR, Part 1500.13, 38 Federal Register No. 147, August 1, 1973.

2. Plans of the Management of AEC-Generated Radioactive Waste, WASH 1202, July 1973.

3. 10 CFR 11.5(a) (4), 39 Federal Register No. 32, February 14, 1974.

4. The Effects on Populations of Exposure to Low Levels of Ionizing Radiation, National Academy of Sciences, National Research Council, Washington, DC 20006, November 1972.

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I SUMMARY

I.1 INTRODUCTION*

This environmental impact statement presents the impacts and alternatives available to the ongoing Hanford Waste Management Operations Program.

I.2 BACKGROUND

In early 1943, the United States Army Corps of Engineers selected the Hanford site as the location for reactor and chemical separation facilities for the production and purification of plutonium for possible use in nuclear weapons (Manhattan Project). A total of eight graphite-moderated reactors using the Columbia River water for once-through cooling, and a new type of dual purpose reactor (N Reactor) using a recirculating water coolant and producing both plutonium and steam for electricity, were eventually built along the Columbia River. Today, only the N Reactor remains in operation.

I.2.1 Description of Site

The semiarid Hanford site occupies about 570 square miles or 365,000 acres of the southeastern part of the State of Washington (Figure I.1). The reactor facilities are located along the Columbia River in what are known as the 100 Areas. The reactor fuel processing and waste management facilities are in the 200 Areas which are on a plateau about 7 miles from the river. The 300 Area, just north of Richland, contains the reactor fuel manufacturing facilities and the research and development laboratories.

Liquid waste containing high-level concentrations of radionuclides from the chemical processing plants is stored on an interim basis in large underground tanks in the 200 Areas. The waste storage complex includes:

- 149 single-wall tanks ranging in capacity from 50,000 to 1,000,000 gallons each which are constructed of reinforced concrete with a steel liner
- three new double-wall 1,000,000-gallon tanks
- four additional double-wall 1,000,000-gallon tanks now under construction
- four water evaporators (two now shut down-1975) to convert the radioactive waste from the storage tanks to a less mobile solid sludge; a fifth evaporator is under construction.

Some radioactive liquid effluents waste is released to ground via structures called cribs. Since most of the radionuclides discharged to cribs are absorbed on or filtered by the 150 to 300-ft soil column, most do not reach the water table. Continuing efforts are being made to develop and to use improved technology to reduce the amount of radionuclides discharged to cribs to the lowest technically and economically practical level. A total of 177 cribs are provided for disposal of intermediate-level liquid waste. Of these, 144 are now deactivated, 8 were not used, 10 are in standby, and 15 are in current use.

*Throughout the text, notations are used to identify the subject areas changed from the Draft Statement as the result of comments from 1) the Report of the Presiding Board [RPB] on the public hearings and 2) letters on the Draft Statement. For instance:

[RPB] - Text changes made as a result of an issue or comment made in the Report of the Presiding Board.

[X.1] [X.2] [X.3] etc., - Text changes made as the result of comments presented in Letter 1, 2, 3, etc. The comments that did not result in a text change are given in Section X followed by the ERDA responses.

New references were added to the end of the reference list of the appropriate sections of the draft statement.

New tables and figures were given the number of the preceding table/figure plus an alphabetical designation. For instance, tables inserted between Table III.1-15 and III.1-16 were numbered III.1-15a, -15b, etc.

New appendixes were added and given unused letters rather than relettering all the appendixes in order.

A glossary of terms and a list of abbreviations are given at the end of Volume I.

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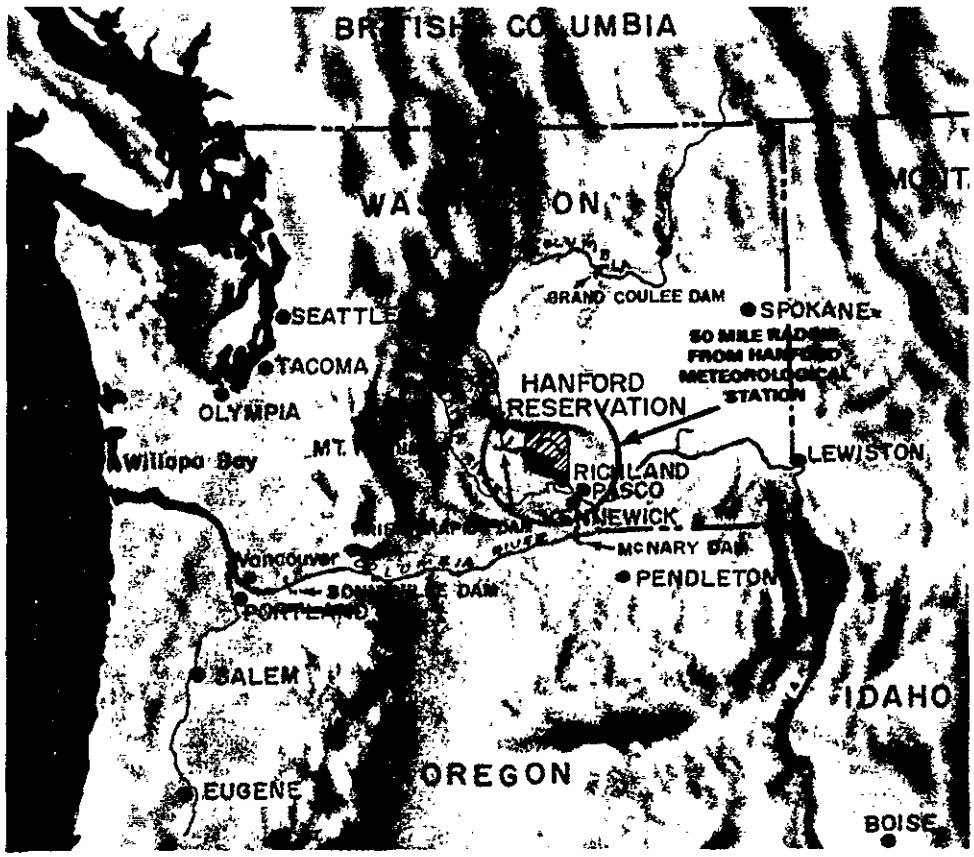

FIGURE I.1 LOCATION OF THE HANFORD SITE IN THE STATE OF WASHINGTON

Since the beginning of government activities at Hanford, about 130 billion gallons of cooling water have been discharged to 30 surface ponds or ditches. About 360 acres of land have been used for these disposal operations, with about 180 acres currently in use. Any radionuclides discharged to these facilities 1) result from accidental equipment failures, 2) are of low-activity level, and 3) are also absorbed on or filtered by the soil column which prevents significant quantities from reaching the water table. The depth to the water table and the good absorptive properties of the Hanford soils have made crib, trench, and pond disposal possible with a limited radionuclide inventory reaching the water table below the disposal sites.

More than 5 million cubic feet of contaminated dry solids are buried. Initially, transuranic waste received special packaging for containment, but was not buried for 20 year recovery. Since May 1970, transuranic waste is packaged in sealed metal containers, segregated from other waste, and placed in special burial trenches to permit recovery in the original packaged condition.

Sanitary waste is disposed to septic tanks draining to tile fields or leaching trenches via sanitary sewers. Most chemical waste is contained with the high-level liquid waste in tanks. Gaseous effluents are treated by multiple high-efficiency filtration and/or by chemical treatment where practical to assure that radioactive gaseous emissions are as low as practicable. Gaseous and liquid effluents are monitored to measure the quantities of radioactive materials that may be released.

Environmental measurements and comprehensive evaluation programs in radiation, ecology, hydrology and meteorology are maintained to measure the direct impact of the Hanford facilities on the environment and to help assure adequate process controls. Measurable environmental impacts that might occur in the future should be observed by these programs and corrective action promptly initiated.

I.2.2 Anticipated Benefits

The primary anticipated benefit of the Hanford Waste Management Operations Program is to continue isolation of significant quantities of radioactive and other waste materials from man's environment.

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Conduct of the Hanford Waste Management Operations Program makes possible 1) production of plutonium for the U.S. defense needs and byproduct steam for the generation of electricity and 2) research and development in most areas of nuclear energy. Many ecological and biological studies on the movement or behavior of radionuclides in the environment are performed as part of the overall waste management effort.

I.2.3 Characterization of the Existing Environment [X.11A]

The population living within a 50-mile radius of the Hanford site varies from about 250,000 for a radius center midway between the two chemical processing and waste storage areas to about 160,000 for a radius center at the 300 Area. Land uses in the surrounding area include urban, industrial, and irrigated and dry land farming. Of the irrigated crops, alfalfa hay uses 30% of the total area, wheat 15%, and sugar beets about 8%. Water removal rights, other than Hanford's, amount to about 200,000 acre ft/year within 50 miles of the N Reactor, from an annual average river flow of about 120,000 cfs or about 87,000,000 acre-feet.

The National Register of Historic Places does not list any sites on the Hanford Reservation; however, applications for three sites are currently being processed. Three listed sites are within 50 miles: 1) Marmes Rockshelter, 2) Olmstead Place State Park, and 3) Whitman Mission National Historic Site. The remains of many Indian campsites and fishing grounds are found along the Columbia River within the Hanford Reservation boundary.

Eastern Washington is dominated by the Columbia Basin geologic province encompassing about 50,000 square miles. It is underlain by the vast field of flood lavas of the Columbia River Basalt Group. Late in the Pleistocene epoch, large floods scoured and carved the Ringold formation surface beneath the Hanford Reservation. These floods, of about 18,000 to 12,000 years ago, deposited the sediments now found on the site.

The Hanford Reservation is in a region of low to moderate seismicity. On the basis of the damage that has been experienced since 1840, the U.S. Coast and Geodetic Survey designated the area a Zone 2 seismic probability, implying the potential for moderate damage from earthquakes. The underlying sands and gravels in the Hanford Reservation provide excellent protection against damage. Earthquake intensities greater than four on the Modified Mercalli Scale (MM-IV) have not occurred in the immediate Hanford area.

Over 1,500 wells were drilled at Hanford to provide data for evaluating the chemical and physical properties of the underlying materials and to study movement of radioactive materials in soils.

The climate has been recorded since 1912 and is characterized as mild and dry with occasional periods of high wind. The average maximum temperatures in July and January are 91.8°F and 36.7°F. The average annual precipitation is 6.25 inches. Tornadoes are rare in this region and tend to be small, with little damage when they do occur. In 29 years of observation, a single small tornado was observed on the Reservation and resulted in no damage.

The vegetation mosaic of the Hanford Reservation consists of eight major kinds of shrub-steppe communities.

The anadromous salmon and the steelhead trout are the fish of greatest economic importance in the Columbia River. About 9,500 fall Chinook salmon spawn in the Hanford reach of the river.

The mule deer is the only big game mammal, while the cottontail rabbit is the most abundant small game mammal on the Reservation. Small mammals are abundant, particularly the Great Basin pocket mouse. The chukar partridge is the most important gamebird. Hunting is not permitted on the south or west sides of the Columbia River, the major portion of the Reservation.

The Hanford Reservation provides refuge for several rare, threatened, or indeterminate species: 1) Prairie falcon, 2) American peregrine falcon, 3) ferruginous hawk, 4) American osprey, 5) Northern longbilled curlew, and 6) Western burrowing owl.

I.3 ENVIRONMENTAL IMPACT

I.3.1 Environmental Effects of Routine Operation of Plant Facilities [X.17]

The principal pathways of radiation exposure to the public involve only the releases of waste to the atmosphere and to the Columbia River. The maximum dose to an individual from effluents released at Hanford in 1972 was 0.6 mrem/yr, while the dose to the average individual was 0.01 mrem/yr. The total-body dose to the population within 50 miles of Hanford was 2.5 man-rem/yr for 1972 which is only 0.01% of the naturally-occurring radiation background of 27,400 man-rem/yr.

This is imperceptible when compared to the normal 10 to 15% fluctuations which occur annually in the natural background radiation levels. A conversion of the population dose to health effects using the data from the National Academy of Sciences BEIR Report indicates that the maximum potential number of cancer death ascribable to 1972 Hanford operations is 0.0007 for the population living within 50 miles of the site. Since the total number of health effects is far less than one, it may be concluded that there are no health effects due to Hanford operations for 1972. Well over 1000 years of operation at the 1972 population dose levels would not be expected to result in more than a single cancer death.

There are no specific genetic studies for terrestrial or aquatic ecosystems of a continuing nature being conducted on the Hanford Reservation. However, in the past, radiation effect studies have been conducted to determine whether or not waste management activities have adversely affected the stability of the Hanford ecosystem. To date, no adverse effects have been identified.

Water intake structures may lead to some loss of lower level trophic life in the Columbia River, but most intake structure velocities are not sufficient to entrap fish. No significant effects on the river ecosystems due to entrainment were noted even when all nine reactors were in operation and removing a substantially greater water volume. Studies show that the effluents from up to nine plutonium-production reactors have had no harmful effects on the migration or spawning of salmon or produced any biotic downgrading of the aquatic ecosystem in almost 30 years of plant operation and concurrent scientific observation. An annual survey in the Hanford reach of the river shows a fairly constant increase in Chinook salmon nesting from the late 1940's up through the fall of 1973.

Onsite, about 3% of the 365,000-acre Hanford Reservation is used for structures and waste disposal sites. The areas directly associated with the major waste disposal sites are currently committed to long-term control (thousands of years). Groundwater within the Hanford control perimeter contains small amounts of radioactivity and nitrate ion.

Chemical and waste heat releases to the atmosphere and to the Columbia River produce only limited, local disturbances, if any at all.

I.3.2 Postulated Waste Management Accidents

A range of accidents that might be expected to occur based on present facility design and operation were analyzed. The postulated accidents included tank leaks, tank gaseous releases, tank dome failures, transfer line failures, major facility filter failure, onsite shipment accidents of both solid and liquid waste, range fires, solid waste burial site fires, and accidents due to natural forces. In the selection of postulated accidents and in assumptions made for the analysis, a consistent attempt was made to be conservative in the analysis, that is--to analyze the worst conditions credible.

The analysis indicated that the maximum individual total-body dose (50-year dose commitment) of 0.4 rem resulted from the postulated solid-waste-carrying vehicle accident followed by fire occurring near the southern boundary of the site. The maximum population dose of 37 man-rem (50-year dose commitment) resulted from the postulated major waste transfer line break and resultant surface spill during the most severe weather conditions. The postulated accidents that provided a mechanism for atmospheric dispersion of radioactive materials produced the greatest offsite dose impact.

I.4 UNAVOIDABLE ADVERSE EFFECTS

Unavoidable adverse effects from the Hanford Waste Management Operations Program may arise from radioactive, chemical, or thermal components in waste effluents being released to the atmosphere, Columbia River, or the ground. The effects may be both onsite, such as limiting use of actual waste disposal areas for other purposes, and offsite, such as contributing less than 0.01% of the total population radiation dose.

The unavoidable radiation dose to the maximum individual for 1972 was 0.6 mrem. The population dose was 2.5 man-rem. For 1974 these are 0.03 and 1.1 respectively since improved effluent controls, a change in N Reactor product requirements, and the nonoperation in 1974 of Purex plant contributed to reduce effluent releases. The individual dose resulting from naturally-occurring radiation was about 100 mrem and the population dose was about 27,400 man-rem. The health effects were up to a maximum of 0.0007 cancer deaths of all types for the population living within 50 miles of the Hanford site. Since the total number of health effects is far less than one, it may be concluded that there are no health effects due to Hanford operations for 1972.

About 3% of the 365,000 acre Hanford Reservation is used for structures and for waste disposal sites that require long-term commitment to such use. Releases of heat and chemicals to the air and Columbia River produce no observable effects.

I.5 ALTERNATIVES

Reasonable alternatives to the current Waste Management Operations program are presented for treatment of high-level liquid radioactive waste, other radioactive liquid waste, radioactive gaseous waste, radioactive solid waste, nonradioactive waste, and other potential environmental pollutants. Waste management facilities and activities to reduce the quantities of radioactive materials released to the environment or to improve control of such materials in the event of abnormal operation conditions are included in the FY-1973 through FY-1975 budget in the amount of 42 million dollars.

Major alternatives to present programs for the treatment of high-level liquid waste, liquid effluents, and gaseous effluents are also presented. For the high-level liquid waste, the alternatives are:

- continue the present program with replacement of some or all of the single-wall tanks with new double-wall tanks
- shutdown of N Reactor
- shutdown of the Purex fuel processing plant
- discontinue the solidification to salt cake and
  - a) hold the waste as liquid in new double-wall tanks till a different form is found,
  - b) calcine the waste, or
  - c) prepare a special insoluble waste formation.

Liquid effluent cleanup alternatives to reduce discharges to the Columbia River and/or the ground involve the construction of new high capacity liquid evaporator and/or ion-exchange system and treatment of N Reactor effluents.

Adoption of these alternatives has essentially no effect on the overall population dose since the current dose from the facilities to be altered is near zero. The advantage is basically better containment of all radioactive materials.

I.6 RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Future plans for the Reservation call for the continuation of its present use as an area dedicated primarily to nuclear energy activities. Certain small areas will essentially require perpetual surveillance. Thus, the use of man's environment will be long-term. Therefore, the relationship to be considered is that of long-term use and the maintenance and enhancement of long-term productivity of the environment.

Current use of the land has probably barred major irrigation projects from the Reservation because of their potential impact on the water table levels. Also, an inventory of mostly tritium and ruthenium-rhodium-106 will remain in the groundwater under the Reservation for 10's of years. Fission products will remain in the soil columns under cribs, trenches, and ponds for many centuries. Plutonium can be recovered from the soil columns at a later date to avoid the need for multicentury control and surveillance of the site. The radionuclide concentrations in the groundwater are below the current drinking water standards except near a few disposal sites.

Large portions of the land on the Hanford site are being put to other productive uses:

- Arid Land Ecology Reserve
- Washington State Game Reserve
- Commercial Nuclear Power Plants
- Research and Development Facilities for Energy.

I.7 RELATIONSHIP OF PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS

The continued operation of the Hanford waste management facilities will not conflict with national, state, or local plans and programs. Implementation of the action proposed herein, i.e., a continuation of effluent and waste management practices at Hanford, calls for land use as described

in Sections II and III. All land is and will be managed consistent with federal regulations to assure the safety and well-being of the public.

Continued land use in addition to effluent and waste management on the Hanford Reservation includes 1) research and development associated with the Arid Land Ecology Program, and various laboratory facilities in the 100, 200, and 300 Areas, 2) N Reactor in the 100 Area and plutonium production facilities in the 200 Areas, and 3) the Fast Flux Test Facility in the 400 Area. Some of the land just north of the Columbia River will continue to be administered by the U.S. Bureau of Sport Fisheries and Wildlife and the Washington State Department of Game. The State of Washington leases land on the 200 Area plateau for radioactive waste burial. Private leases of land include the Washington Public Power Supply System (WPPSS) steam plant operating at 100-N Area and the WPPSS Power Reactor now under construction.

The potential environmental consequences and relationships of all specific proposed projects to the Hanford Effluent and Waste Management Operations program are studied and considered. Environmental impact statements for individual projects will be prepared, as appropriate. The impact and feasibility of each individual proposed program will be evaluated, including any potential impact on the Hanford Waste Management Operations.

I.8 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The resources that are considered to be committed in an irretrievable and irreversible manner by the Hanford Waste Management Operations are 1) land and materials containing or used for storing radionuclides with a half-life longer than 10 years, 2) labor expended by construction, operating and surveillance personnel, and 3) materials, such as fuel and chemicals, that are burned, diluted, or consumed during use. About half a million tons of fossil fuels and 50,000 tons of chemicals are expected to be irreversibly consumed by the Hanford Waste Management Operation. Some components of the concrete structures and equipment as well as about 6,000 acres of desert land are in essence irretrievable due to the practical aspects of reclamation and/or radioactive decontamination.

I.9 COST-BENEFIT ANALYSIS

The Waste Management Operations program objective is to maintain control over all waste materials in a manner resulting in the best balance of costs and benefit for the United States citizens. Currently planned waste management program improvements (FY-1973 through FY-1975) are budgeted at a cost of 42 million dollars. These programs will provide improved control over radionuclides during abnormal operations. In addition, about 77 million dollars are being budgeted for FY-1976 and FY-1977 for additional facilities, principally new double-wall tanks, for high-level waste.

There would be no detectable effects on aquatic or bird life and only minor habitat displacement for animal life by adopting any of the proposed alternatives. The dose to man would change only slightly with the adoption of any particular alternative. Chemical releases to the atmosphere and to the Columbia River would change only slightly. Some reduction in atmospheric releases would occur if alternatives requiring minimum consumption of fossil fuels were adopted, particularly termination of the operation of the steam heated evaporators.

The existence of the current inventory of radioactive waste requires that a waste management operations program be continued. The radiation dose to the population and consequently the health effects would be essentially independent of the alternative chosen. After weighing the cost and benefits of the alternatives to the high-level liquid waste program, it is concluded that the current program of solidification to salt cake should continue. This program will include the replacement of some or all of the single-wall tanks with improved double-wall tanks as required. However, research and development should continue on methods for solidification of residual liquors as well as alternative insoluble formations.

The liquid effluent alternatives would have no significant effect on the radiation dose to man or on land usage. The alternative to provide for Reinject Rupture Loop and Closed Loop Cooling for N Reactor is marginally justified on the basis of the cost per curie not discharged and the resultant reduction in the N Crib decay period. It is concluded that the multi-million dollar alternatives are not economically justified at this time.

II BACKGROUND

II.1 DETAILED DESCRIPTION OF HANFORD SITE

II.1.1 Plant and Waste Management Facilities

II.1.1.1 Plant Facilities

II.1.1.1.1 Introduction

The semiarid Hanford site occupies about 570 square miles of the southeastern part of the State of Washington just north of where the Yakima and Snake Rivers flow into the Columbia River. The first known occupants of this area were the Indians tens-of-thousands of years ago. Settlers, who in the latter 1800's and early 1900's began farming near the river, developed local irrigation districts to utilize the Columbia River as a source of irrigation water.

In early 1943, approximately a month after the successful Fermi experiment in Chicago showed that nuclear fission could be controlled in a small reactor, the United States Army Corps of Engineers selected Hanford as the location for a facility to build larger versions of the Fermi reactor to produce plutonium for possible use in military weapons. Actual construction started on three reactor facilities and three chemical processing facilities in March 1943. The first of the reactors went into operation about 18 months after the start of construction and the first plutonium was available some 4 months later. During the course of the construction effort, approximately 94,000 men and women were involved at various times in the project with a peak onsite population of 51,000.

Over the years following the war, a total of five reactors similar to those built during the war were constructed, making a total of eight graphite-moderated reactors using the Columbia River water for once-through cooling, i.e., water circulated through the reactor only once before being held for radioactivity monitoring and some heat dissipation prior to release back to the river.

In the early 1950's the construction of the research and development facilities known as the Hanford Laboratories began. This marked the first diversification of Hanford from a purely defense materials production facility to one heavily involved in the peacetime uses of the atom. In 1963, a new type of reactor, the N Reactor, was built. N Reactor is different in that it produces, in addition to plutonium, the byproduct steam which, since 1966, has been used by the Washington Public Power Supply System (WPPSS) to generate electricity. Thus, the N Reactor was the first--and so far, the only--dual purpose reactor constructed in the United States.

In early 1964, a Presidential decision to begin closing down the older Hanford reactors resulted in the shutting down of all eight of the older reactors by the end of 1971, leaving N as the only production reactor in operation. Another major change occurred in 1964 with the departure of General Electric who had, in 1946, succeeded DuPont as the prime operating contractor. In a unique "segmentation and diversification" program, 1) General Electric was replaced by a number of contractors, 2) the communities' economic base was diversified, and 3) Hanford became involved in many AEC programs relating to the peaceful use of nuclear materials and radiations.

The current principal operating contractors at Hanford are:

- Atlantic Richfield Hanford Company (ARHCO)--responsible for fuel processing, waste management, and all site general support services such as plant security, fire protection, central stores, electrical power distribution, etc.
- Battelle Memorial Institute (BMI)--responsible for the operation of the Pacific Northwest Laboratories (also referred to as Battelle-Northwest or BNW) which includes research in general areas of life sciences, environmental science, environmental surveillance, advanced methods of nuclear waste management and a wide variety of other physical and biological sciences.
- United Nuclear Industries (UNI)--responsible for operations of the one remaining production reactor, N Reactor, and the N Reactor fuel fabrication.
- Westinghouse Hanford Company (WHC)--responsible for the operation of the Hanford Engineering Development Laboratory (HEDL) which includes advanced reactor developments, principally the Liquid Metal Fast Breeder Program and the Fast Flux Test Reactor.

The Hanford site operating areas are identified by area numbers. Each area identified as a controlled or limited access area is totally enclosed in a high antipersonnel fence. The six

100 Areas, bordering directly on the Columbia River in the northernmost portion of the Hanford Reservation, are where the plutonium production reactors were built. At one time in the early 1960's, nine production reactors were operating. Currently, only the dual-purpose N Reactor is operating to provide plutonium for military purposes and ERDA research and development purposes and to provide the byproduct steam used for electrical power production in the WPPSS Plant.

In the middle of the site, on a plateau about 7 miles from the Columbia River, are the two 200 Areas where the fuel and waste processing and waste storage activities are located. The location of the 200 Areas was chosen because it provides the most isolation from the site boundaries and is the most removed from both surface and subsurface water. Under this area, the groundwater table is some 150 to 300 feet below the surface.

The 300 Area is nearest to Richland. The research and development laboratories and the fuel fabrication facility for the N Reactor are located in this area.

The 400 Area is about 7 miles north of the 300 Area and is the site of the Fast Flux Test Reactor now under construction.

The area of the Hanford Reservation not included as one of the 100, 200, 300, or 400 Areas is designated as the 600 Area. Figure II.1-1 is a map of the Hanford Reservation showing the locations of these various operational areas and other features (a detailed map is provided in Appendix II.1-A).

Currently, 86,000 acres of the site north of the Columbia River are being developed as a wildlife refuge and recreation area by the U.S. Bureau of Sport Fisheries and Wildlife and the Washington State Department of Game. In 1964, the AEC leased 1,000 acres of land near the 200 Areas to the State of Washington for commercial nuclear use. The Nuclear Engineering Company provides commercial solid waste burial service on 100 acres of this tract under a license from the State. A 120-square-mile ecology reserve, the Arid Lands Ecology (ALE) Reserve, is established between a public road, State Highway 240 which traverses the southwestern portion of the site, and the top of Rattlesnake Mountain.

A flowchart depicting waste management operations at Hanford is presented as Figure II.1-2.

II.1.1.1.2 100 Areas

Only one of the nine reactors constructed along the Columbia River is operational; the remainder have been retired or placed on standby. The size, construction schedule and current status of each reactor is shown in Table II.1-1.

II.1.1.1.2.1 B and C Reactor Area (100-B/C)

B/C Reactor Area is shown in its present condition in Figure II.1-3. The area of about 650 acres, which is the furthest upriver of the six 100 Areas, contains two reactors, 105-B and 105-C. Appendix II.1-B provides a map identifying major facilities and a table which lists the waste management facilities in the B/C Area. Very few personnel are currently assigned to the area. Essentially all facilities in the area are on standby with the exception of the B/C water system which provides all the water supply for the 200 Areas. Fire protection for all of the area and service utility water for some facilities are maintained. An electrical substation in the area taps power for the pumps providing the 200 Area water.

II.1.1.1.2.2 K Reactor Area (100-K)

The 100-K Area, about 135 acres, is almost 2.5 miles immediately downriver from the 100-B/C complex and contains two reactors, K East and K West. Although about 10 years newer than the original Hanford reactors, both were recently put on standby. The 100-K Reactor Area is shown in its present standby condition in the aerial photograph of Figure II.1-4. Appendix II.1-B provides an area map identifying major facilities and a table listing the waste management facilities in the 100-K Area.

Considerable use is made of the shutdown 100-K Area, and all services and utilities except the power house are in operation. The Reactor Plant Services Section of UNI operates from offices and laboratories in this area. United Nuclear Industries also operates a research and development laboratory in 1706-KE. This effort, which is in support of N Reactor activities, includes bench-scale studies of water quality, filtering and corrosion. Some small scale decontamination studies are also carried out under this program.

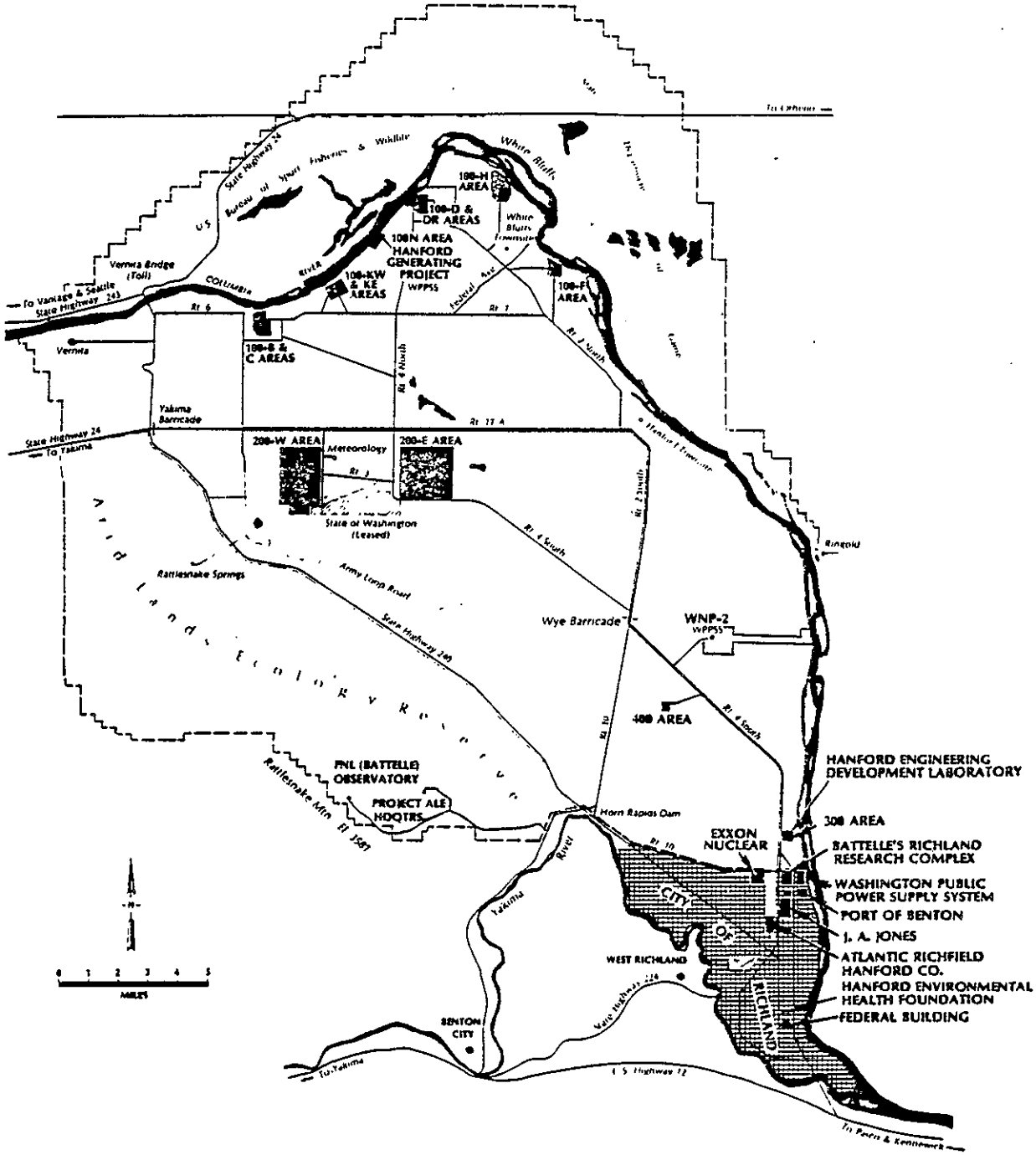

FIGURE II.1-1 MAP OF HANFORD RESERVATION

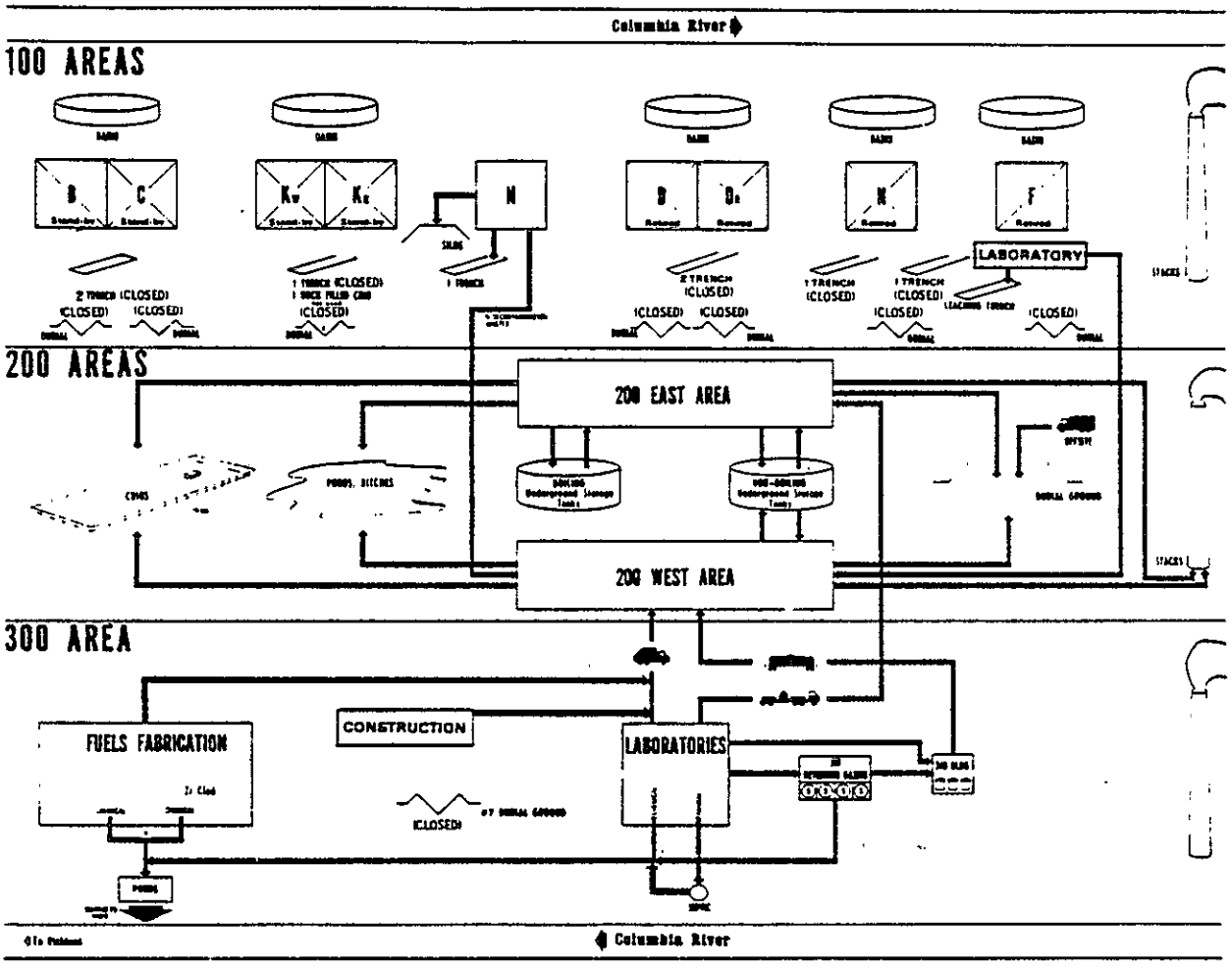

FIGURE II.1-2 RADIOACTIVE WASTE MANAGEMENT OPERATIONS AT HANFORD

TABLE II.1-1

SUMMARY - REACTOR STATUS

Area	Size-Acres	Reactors	Construction Start	Operation Start	Operation Shutdown
100-B/C	650	105-B	Aug-1943	Sept-1944	Feb-1968
		105-C	June-1951	Nov-1952	April-1969
100-K	135	105-KW	Nov-1952	Jan-1955	Feb-1970
		105-KE	Jan-1953	April-1955	Jan-1971
100-N	90	105-N	May-1959	Dec-1963	Operating
100-D/DR	960	105-D	Nov-1943	Dec-1944	June-1967
		105-DR	Dec-1947	Oct-1950	Dec-1964
100-H	320	105-H	Mar-1948	Oct-1949	April-1965
100-F	540	105-F	Dec-1943	Feb-1945	June-1965

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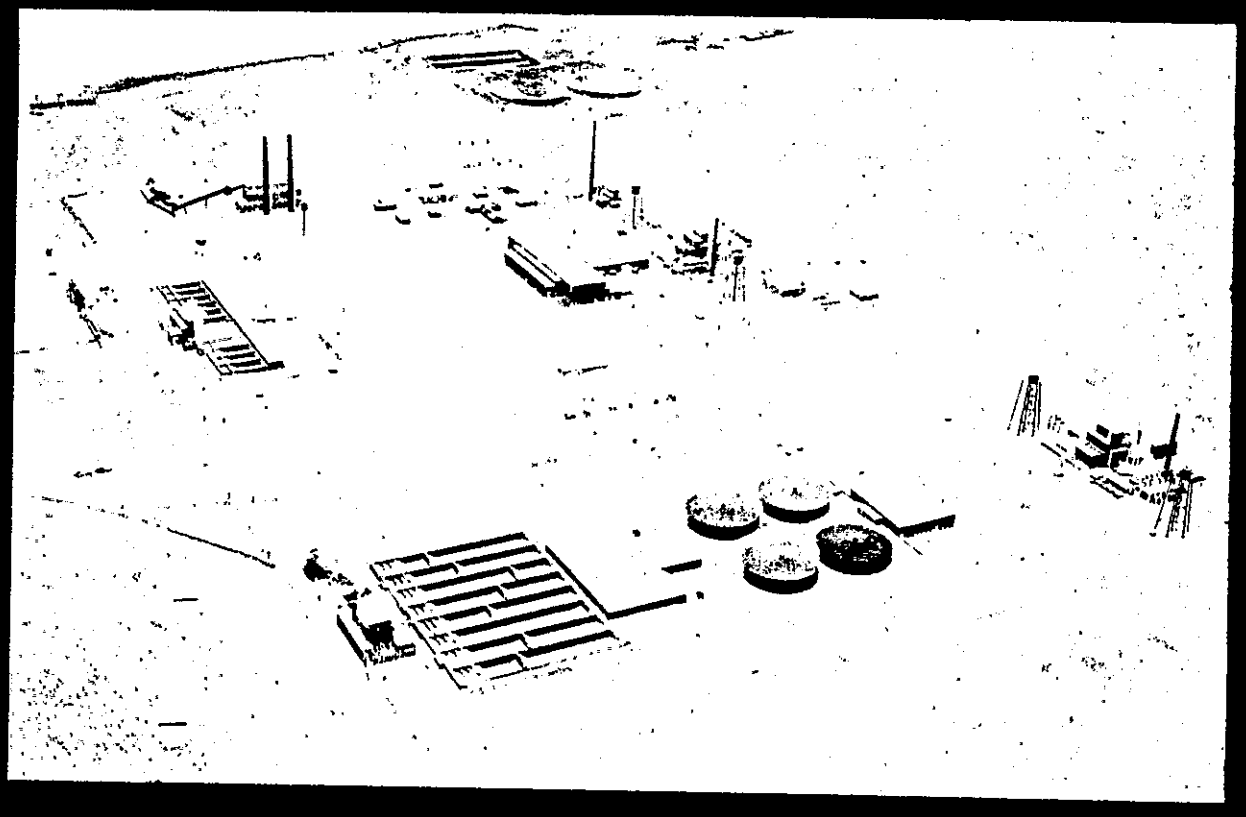

FIGURE II.1-3 100-B/C REACTOR AREA

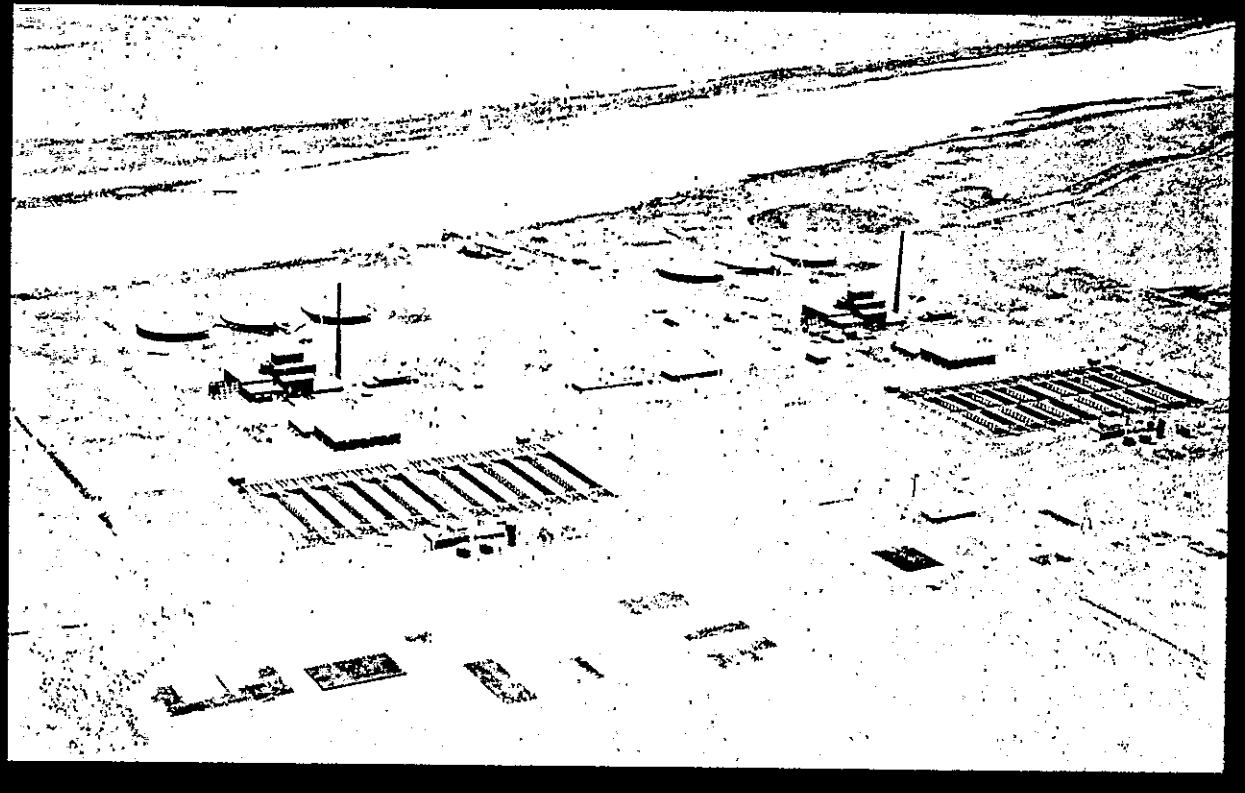

FIGURE II.1-4 100-K REACTOR AREA

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Battelle-Northwest is presently using the K East river pumps to analyze the accuracy of a venturi flowmeter for flows up to 450 cubic feet per second (cfs). The raw river water is pumped to the 100-K East sedimentation basins and then returned to the river.

II.1.1.1.2.3 N Reactor Area (100-N)

The 100-N Area, about 90 acres at river mile 380 and 2.3 miles immediately downriver of the 100-K Area, contains 43 buildings including the N Reactor and the WPPSS generating plant. About 330 people work in the area during the 5-day, 8 to 5 work week and about 53 during off shifts and weekends. N Reactor is the only Hanford reactor still in operation which was designed for the production of plutonium. The reactor is a dual-purpose unit and provides low pressure steam for the 860,000 kW WPPSS generating plant nearby.

The 100-N Area is shown in its present operating condition in the aerial photograph in Figure II.1-5. In Appendix II.1-B, each facility is identified in a map while a table lists the waste management facilities at 100-N Area.

II.1.1.1.2.4 D and DR Reactor Area (100-D/DR)

The 100-D/DR Area of about 960 acres is located 1.7 miles immediately downriver of 100-N Area. The area as it currently exists is shown in the aerial photograph of Figure II.1-6. In Appendix II.1-B, an area map identifies major facilities and a table lists the waste management facilities in 100-D Area.

Although both 100-D Area reactors are retired, this area is extensively used, and its utilities and services are in operation. The electrical substation serves as backup supply for 100-N Area. The water system in 100-D is a backup for systems from 100-B Area supplying the 200 Areas.

United Nuclear Industries operates an engineering laboratory (189-D) in support of N Reactor operations. This includes the NPR loop facility which was the original test facility for N Reactor.

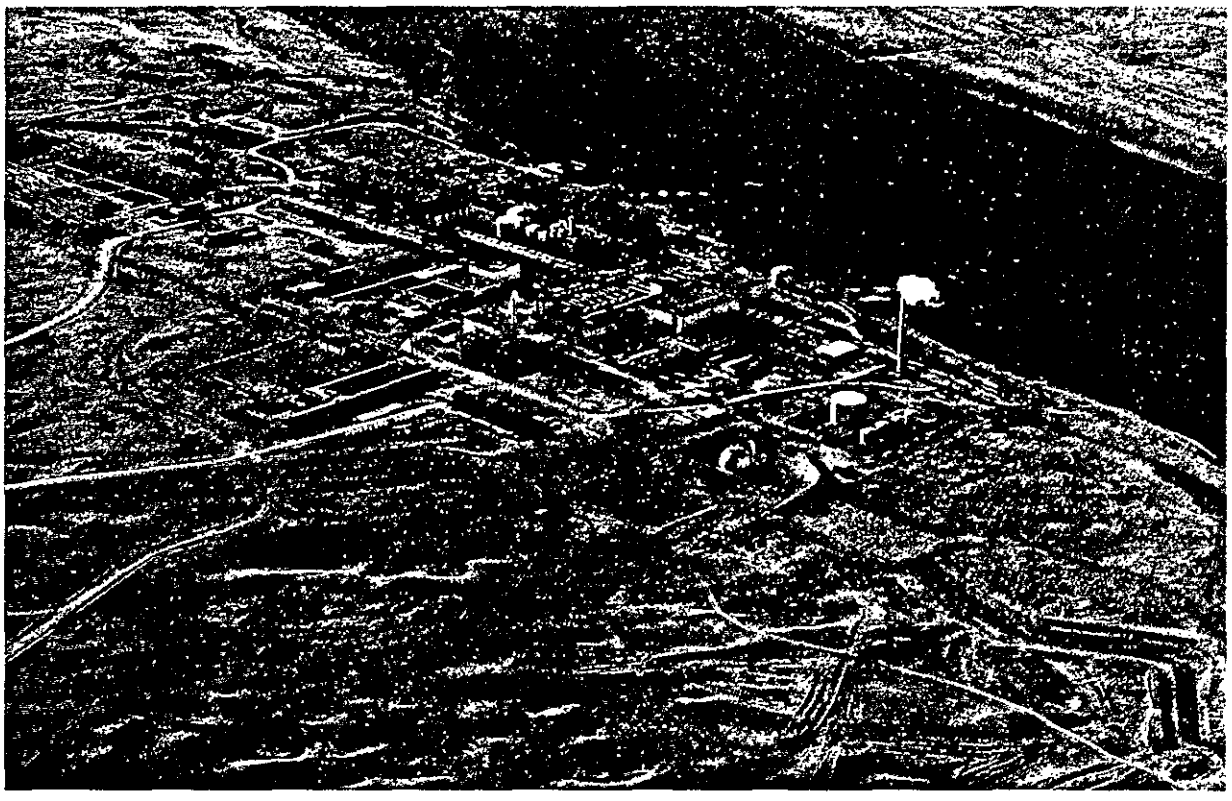

FIGURE II.1-5 100-N REACTOR AREA WITH WPPSS GENERATING PLANT TO LEFT

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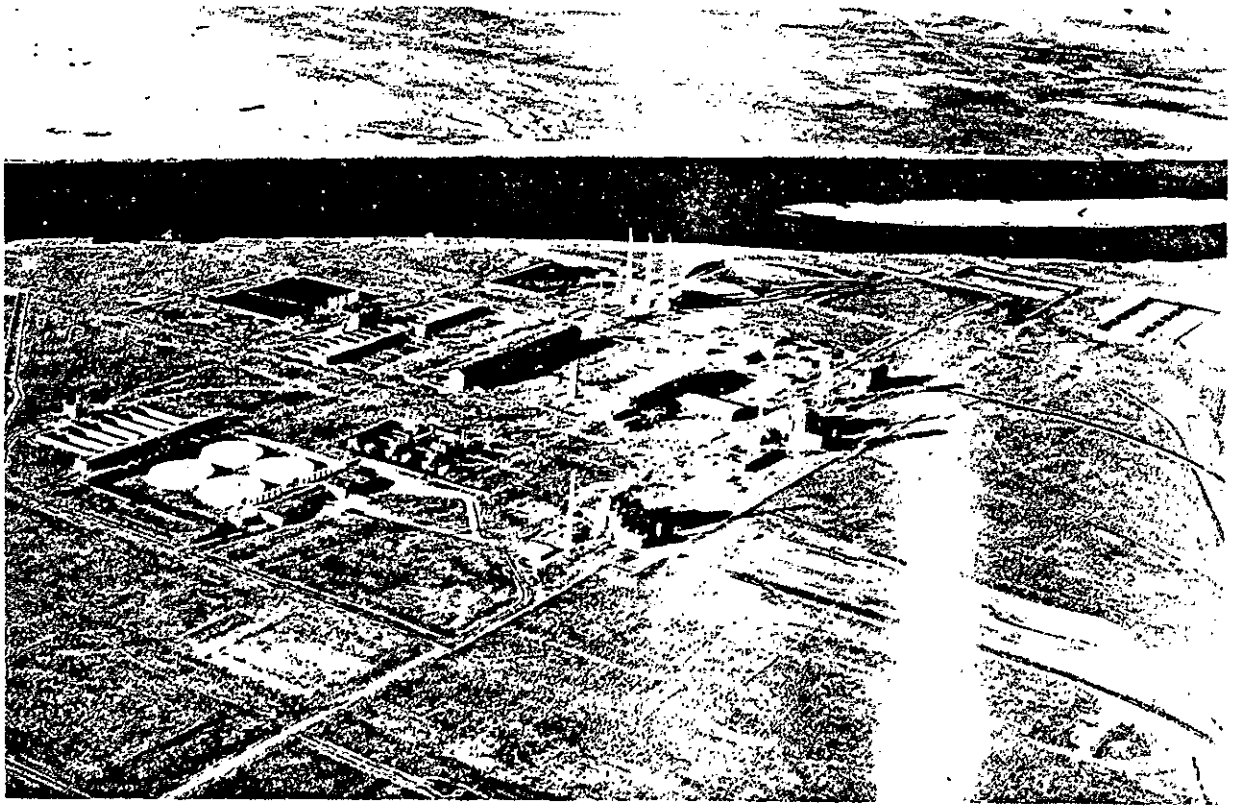

FIGURE II.1-6 100-D/DR REACTOR AREA

Various contractors use facilities such as the 183-D settling basin, 190-D and others for special studies; for example, thermal hydraulics, emergency core cooling, and treatment of oil spills. Hanford Engineering Development Laboratory is conducting experiments studying total control of high temperature sodium fires in the 105-DR fan room. Ventilation flows including gaseous oxides of sodium pass through a water scrubber and filter before exiting through the reactor stack.

II.1.1.1.2.5 H Reactor Area (100-H)

The 100-H Area is located about 3.2 miles downriver of 100-D/DR Area and contains about 320 acres. Very little activity continues in this area, which is shown in its present retired condition in the aerial photograph of Figure II.1-7. Several major buildings including the power house and stacks and some of the water treatment buildings have been removed. In Appendix II.1-B, an area map identifies major facilities while a table lists the waste management facilities in this area.

II.1.1.1.2.6 F Reactor Area (100-F)

The 100-F Area, shown in its present retired condition in Figure II.1-8, is located 3.2 miles downriver of 100-H and is the reactor area closest to Richland, Kennewick and Pasco. In Appendix II.1-B, an area map identifies major facilities and a table lists the waste management facilities remaining in the area of about 540 acres.

Although the reactor facilities in 100-F Area are shut down, BNW operates biology laboratory facilities located just outside the perimeter fence. Here, studies are conducted on animals of the effects of inhaled and ingested radioactive and toxic materials. Present plans call for these activities to be transferred to research laboratories in the 300 Area and south of the 300 Area starting October, 1974 and to be all transferred by October 1975.

II.1.1.1.3 200 Areas

The fuels processing and plutonium separation portion of operations at Hanford are located 18 miles northwest of Richland and near the center of the Hanford Reservation. The 200 East and West Areas are shown in the aerial photographs of Figures II.1-9 and II.1-10 and are located on the site map of Figure II.1-1. Additional area activities include plutonium fabrication and

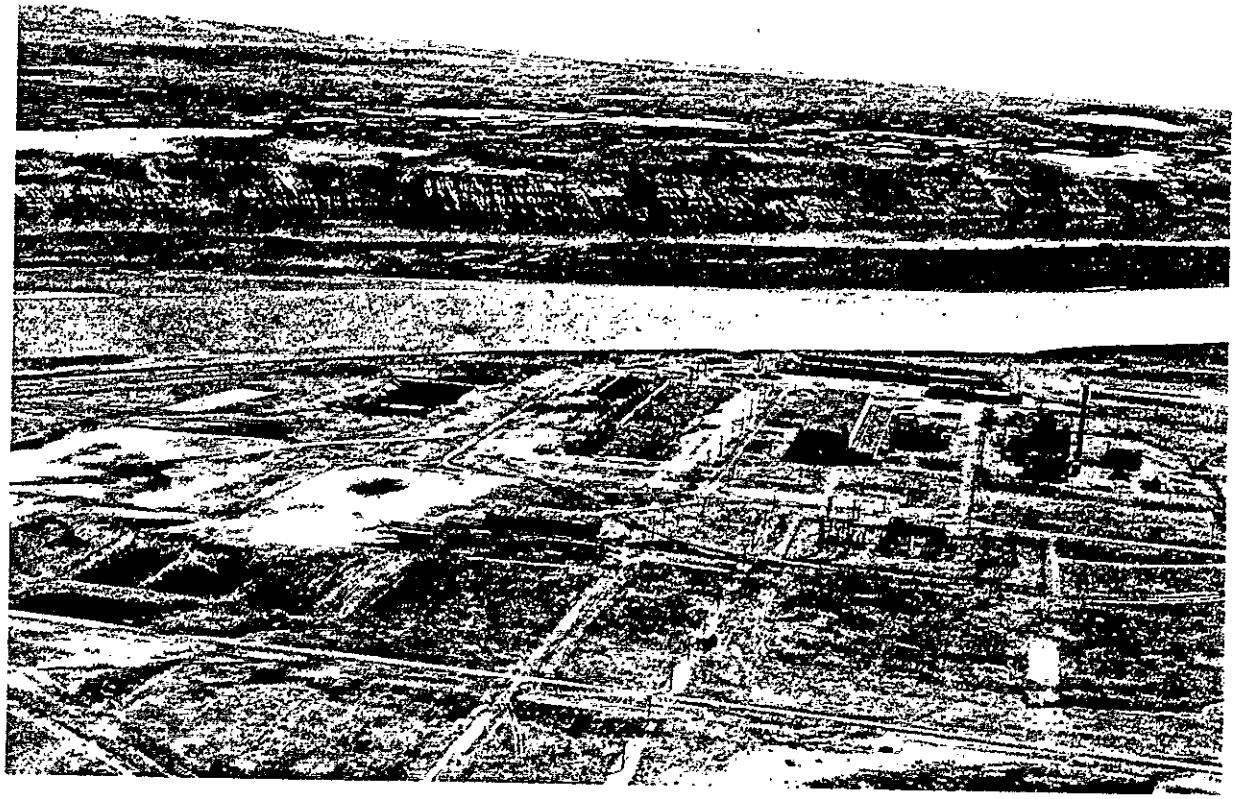

FIGURE II.1-7 100-H REACTOR AREA

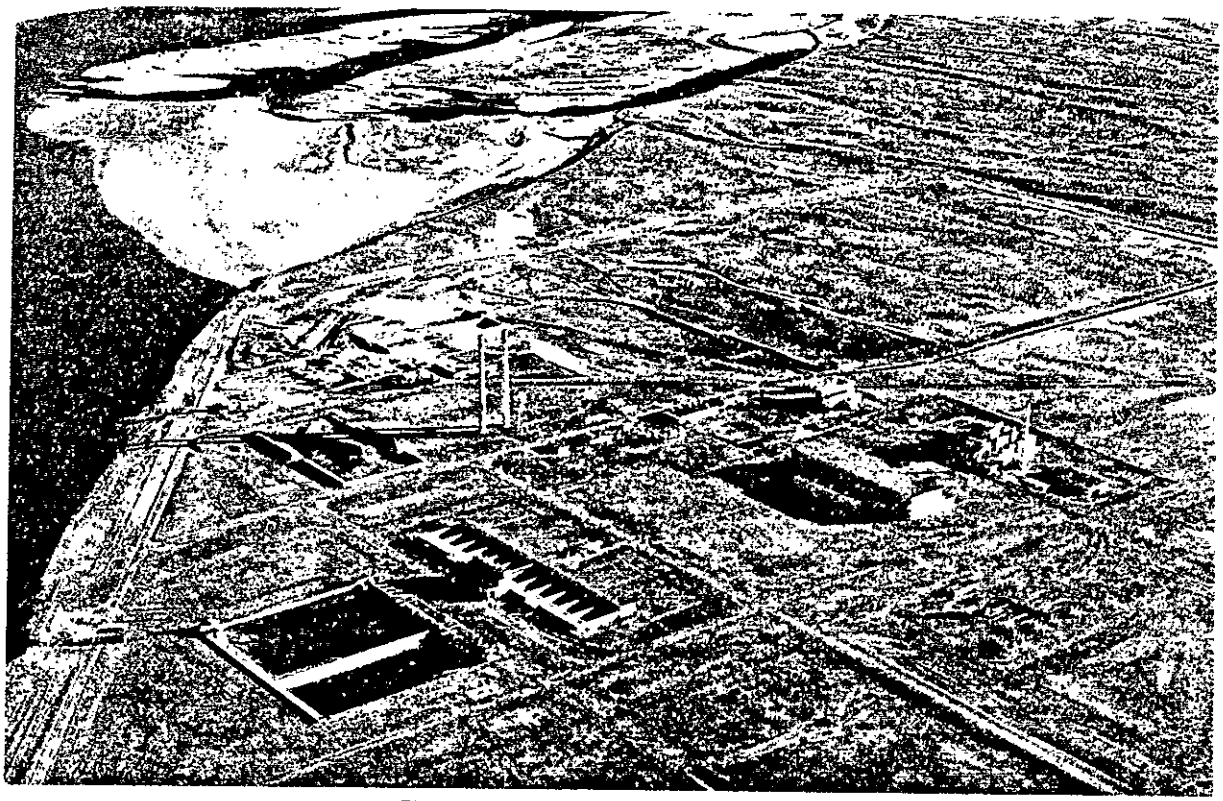

FIGURE II.1-8 100-F REACTOR AREA

9111391046 0

FIGURE II.1-9 200-E AREA (200-W Area and 100-B/C Reactor Area in Background)

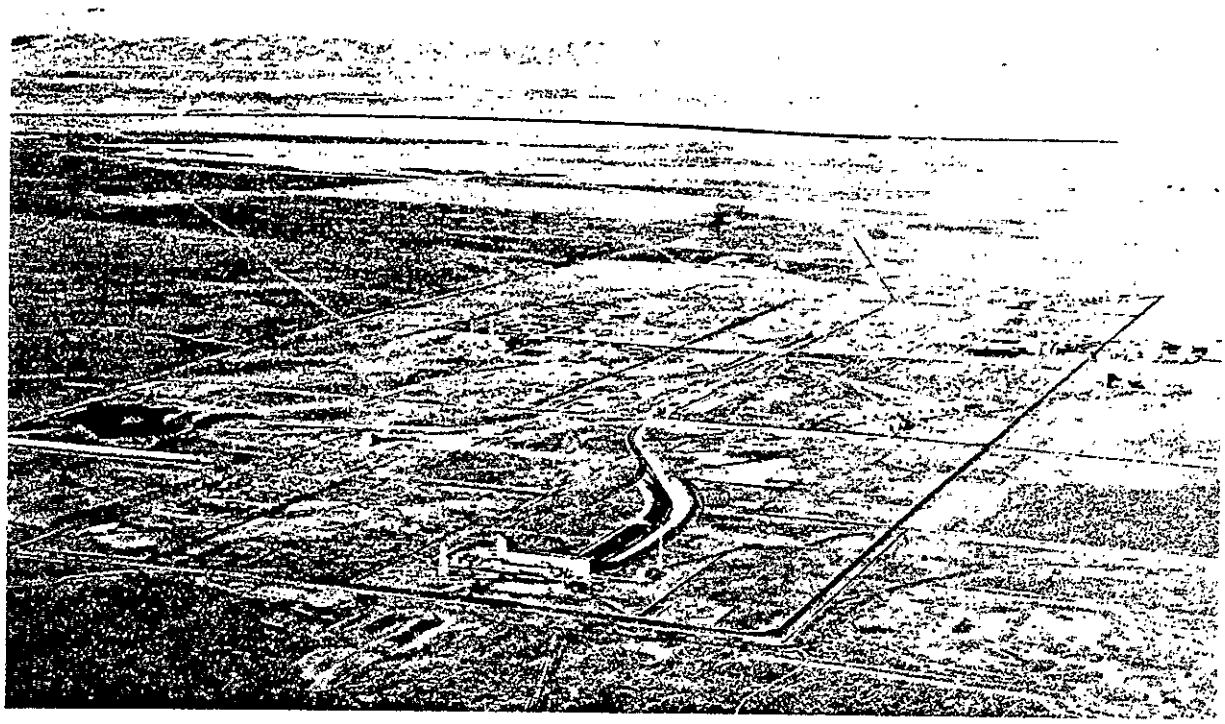

FIGURE II.1-10 200-W AREA (100-B/C Area in Background)

9 1 1 3 9 1 0 4 5 1

processing, waste fractionization, laboratory work and management of the high-level radioactive liquid waste resulting from the separations process. Radioactive waste from the 100 and 300 Areas also is sent to the 200 Areas for disposal. (Details of 200 Area waste management facilities and operations are presented in Appendix II.1-C.)

II.1.1.1.3.1 200 East Area Plants

Purex Plant

The Purex Plant is the most recently constructed of the irradiated fuel processing plants. Constructed between April 1953 and October 1955, Purex took over fuel processing operations from the Redox Plant. The Purex Plant, currently being maintained in standby condition, may be operated intermittently as required by N Reactor plutonium production.

Irradiated fuels processing is accomplished in the Purex Plant where plutonium (Pu), neptunium (Np), and uranium (U) are recovered from irradiated uranium fuels. The processing steps include metal dissolution, solvent extraction and ion exchange. Irradiated uranium fuel elements are charged to dissolvers, chemically declad, then dissolved with nitric acid. Chemical additions to the dissolver solution are made to produce suitable feed for the solvent extraction operation, where the major separation of the plutonium, neptunium and uranium from fission products is accomplished. The partition cycle separates plutonium from neptunium and uranium. The plutonium stream is routed through two additional solvent extraction cycles for further purification. After final concentration, the plutonium nitrate solution is loaded into containers for transfer to the plutonium finishing operations. The stream from the partition cycle, bearing the neptunium and uranium, is routed to the final uranium cycle where neptunium is separated and returned to the backcycle waste stream, and final purification and concentration of the uranium is accomplished. The product, uranyl nitrate hexahydrate solution (UNH), is stored in large tanks and ultimately transferred to the UO_3 Plant by truck-trailer for conversion to uranium trioxide (UO_3). A portion of the backcycle waste stream is routed to the neptunium recovery and purification process which consists of a solvent extraction cycle, a concentrator and an ion exchange column. The neptunium nitrate product solution is loaded into plastic containers for storage and shipment offsite. Supporting process systems include organic decontamination and recovery, nitric acid recovery, and waste concentration and treatment.

Figure II.1-11 is a flowchart of the Purex Process. The Purex Plant is shown in the aerial photograph of Figure II.1-12. Major facilities may be identified on the map in Appendix II.1-C, Part 1.

B Plant

B Plant, one of the original fuels separations facilities, was constructed between August 1943 and February 1945 and was operated, using the bismuth phosphate process, until 1952. This process produced a waste stream containing uranium from the irradiated fuel mixed with the bulk of the fission products. This very dilute waste required large storage volumes.

As a result of a program to develop methods for the solidification of high-level waste, B Plant was converted in 1968 to a waste fractionization plant. It now functions to remove ^{137}Cs and ^{90}Sr from Purex current acid waste and from high-level supernatant liquids, and sludges from self-boiling liquid waste. In addition, an encapsulation and storage facility was constructed on the west end of the B Plant building. Here the strontium and cesium are converted to solid strontium fluoride and cesium chloride, doubly encapsulated, and placed in retrievable water-cooled storage.

Semiworks and Critical Mass Laboratory

The Semiworks, built as a pilot plant for the Redox process in 1949, was later converted to pilot the Purex process. In 1960, the Semiworks was reactivated and equipped for the processing and loadout of fission products. Separating megacurie amounts of ^{90}Sr, ^{147}Pm and ^{144}Ce, it operated in the dual capacity of production and process demonstration to pilot the B Plant conversion to a waste partitioning facility. The Semiworks is presently shut down.

At the Critical Mass Laboratory (CML), research focuses on the criticality safety of plutonium in various forms and combinations with other elements. The resulting data are used to verify analytical methods used to predict criticality safety for plutonium in various fuel cycles.

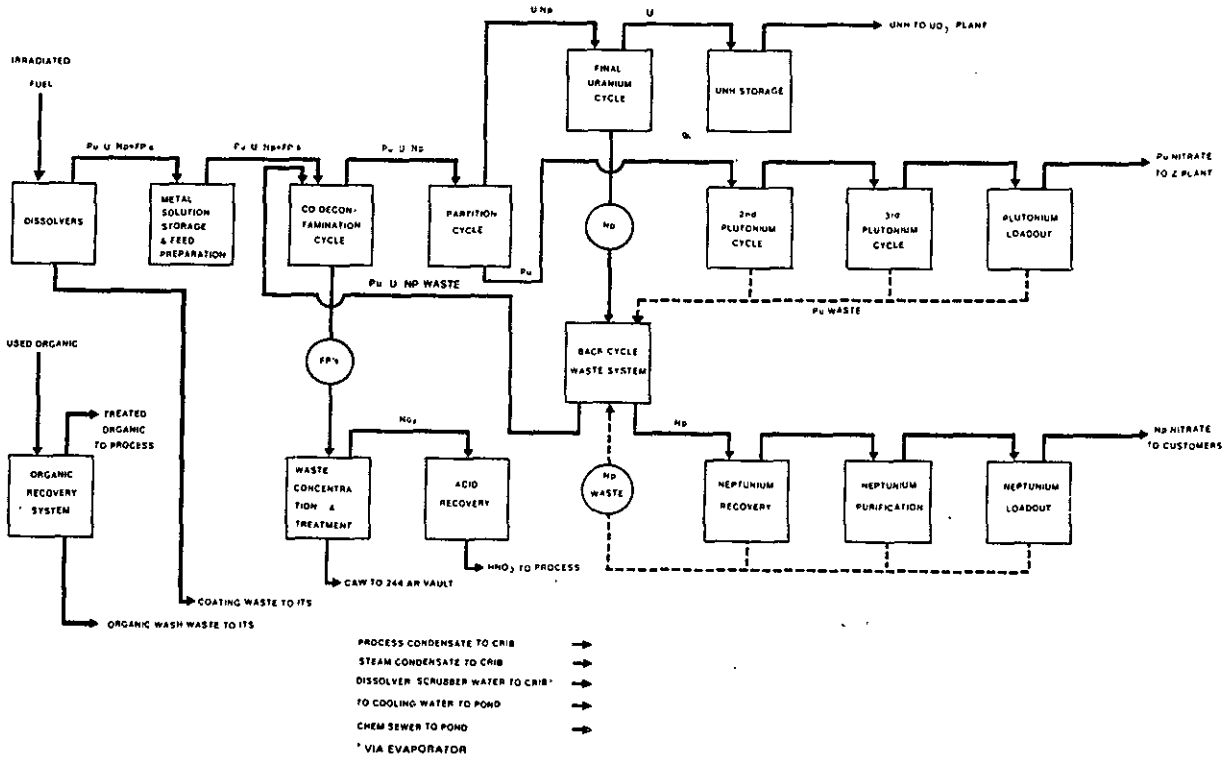

FIGURE II.1-11 PUREX PROCESS SCHEMATIC

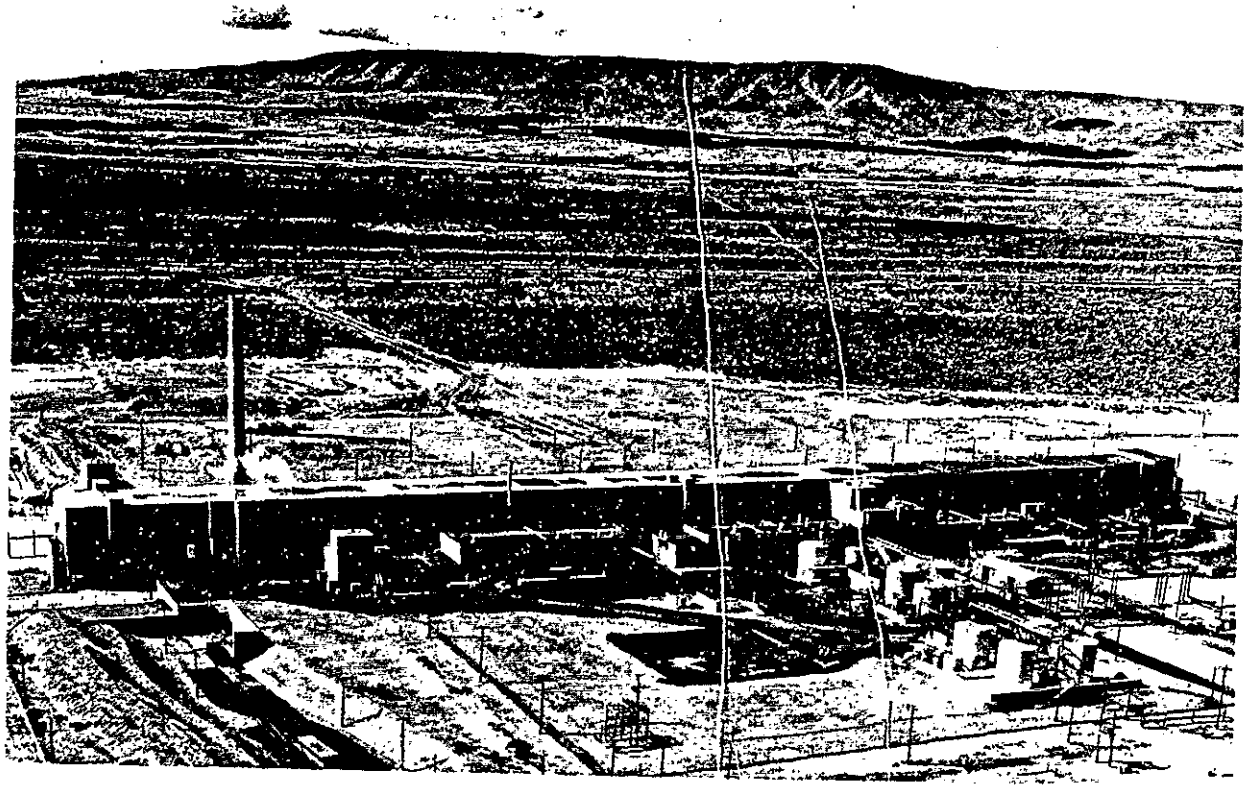

FIGURE II.1-12 200-E AREA PUREX PLANT

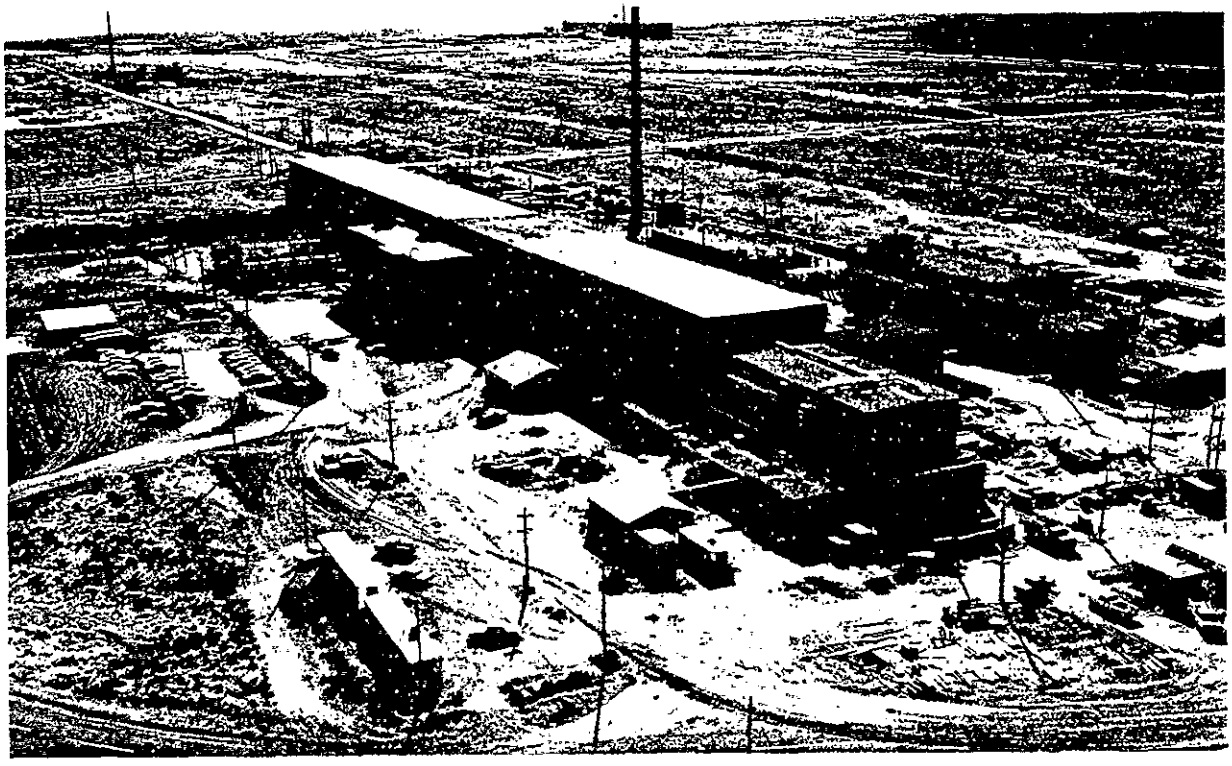

FIGURE II.1-13 200-E AREA B PLANT (Right Front Extension of Building is Encapsulation Facility)

The Semiworks and Critical Mass Laboratory are shown in the aerial photograph of Figure II.1-14.

Support Facilities

General area facilities not specifically related to the various plant processes are located near the main area gate. They may be identified on a map in Appendix II.1-C and are shown in the aerial photographs of Figures II.1-9, II.1-12 and II.1-13.

II.1.1.1.3.2 200 West Area Plants [X.11A]

U Plant

Although U Plant, shown in the aerial photograph of Figure II.1-15, was one of the three original fuels separations facilities (T Plant, B Plant, U Plant) designed to use the bismuth phosphate process, it was never used for that purpose.

Uranium was not recovered in the bismuth phosphate extraction of plutonium from irradiated fuel. However, the later Redox and Purex processes recovered the uranium which still retained economic value. Following startup of the Redox Plant, U Plant was converted to recover the uranium from stored radioactive waste. From 1952 to 1958, waste was mined from the storage tanks and U Plant was used for uranium recovery. Although this processing is now finished and the building is unused, the adjacent uranium oxide plant is still used to produce powdered UO_3 by calcining (UNH) solutions from Purex Plant. The UO_3 is sealed in steel drums for offsite shipment. A byproduct of the calcination process is nitric acid, which is returned to the Purex Plant for reuse. Figure II.1-16 depicts a simplified process schematic of the UO_3 Plant operation. The UO_3 Plant is currently being maintained in standby condition and will not operate until the Purex Plant resumes reactor fuels processing.

9 1 1 1 8 9 1 0 4 6 4

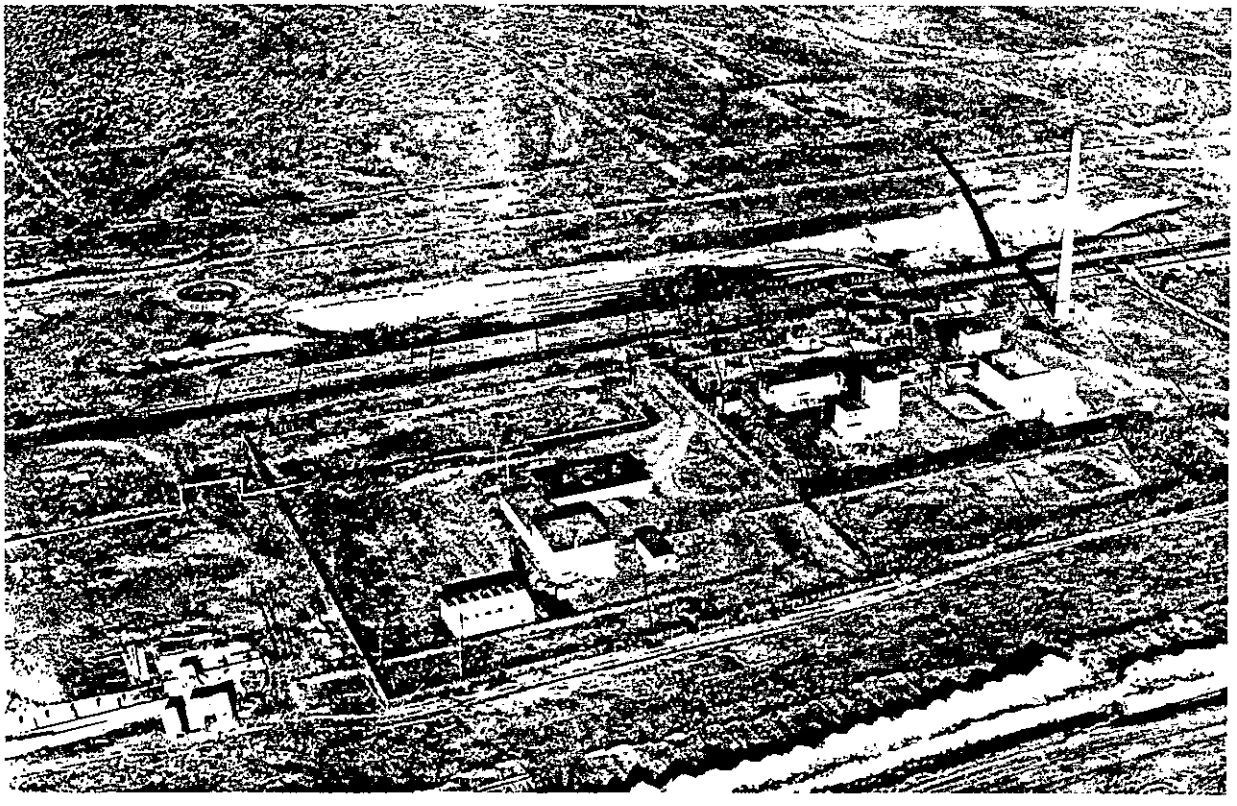

FIGURE II.1-14 200-E AREA CRITICAL MASS LABORATORY AND SEMIWORKS

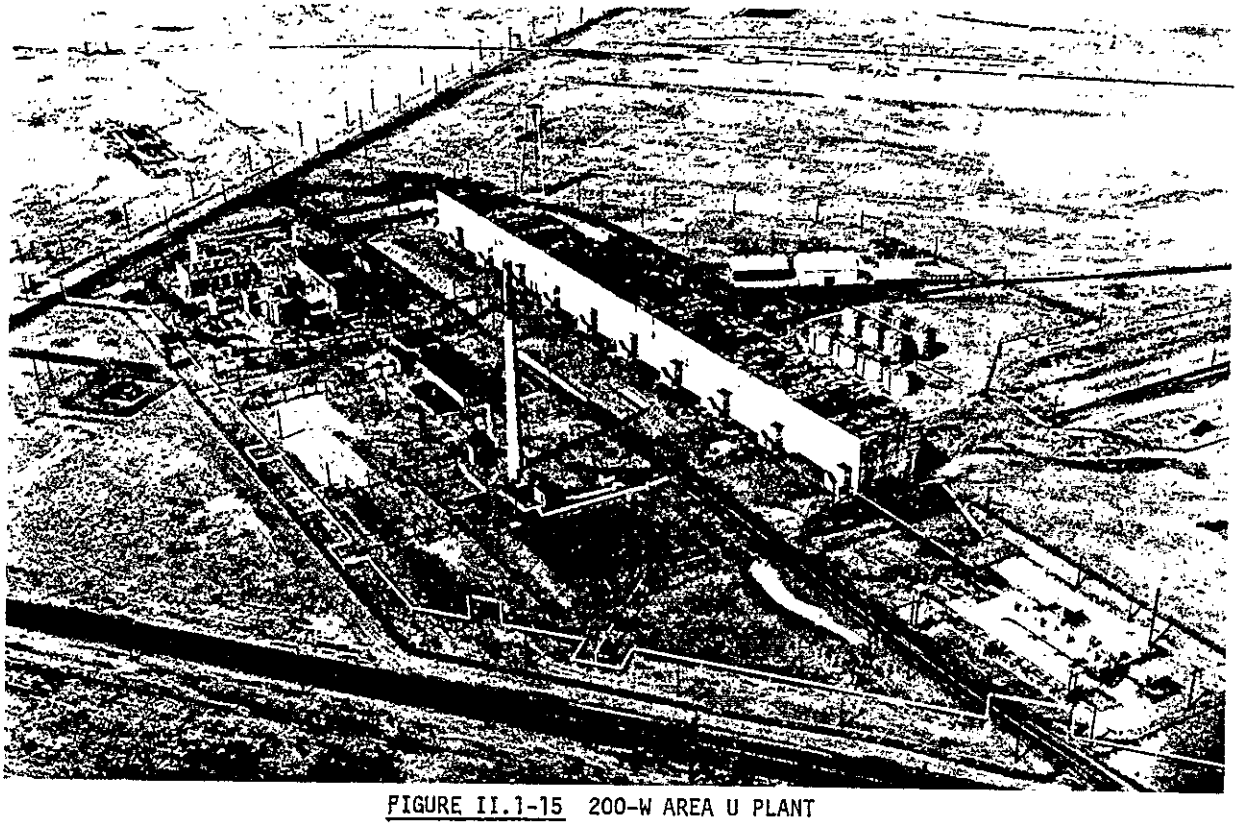

FIGURE II.1-15 200-W AREA U PLANT

9 1 1 6 9 1 0 4 6 5

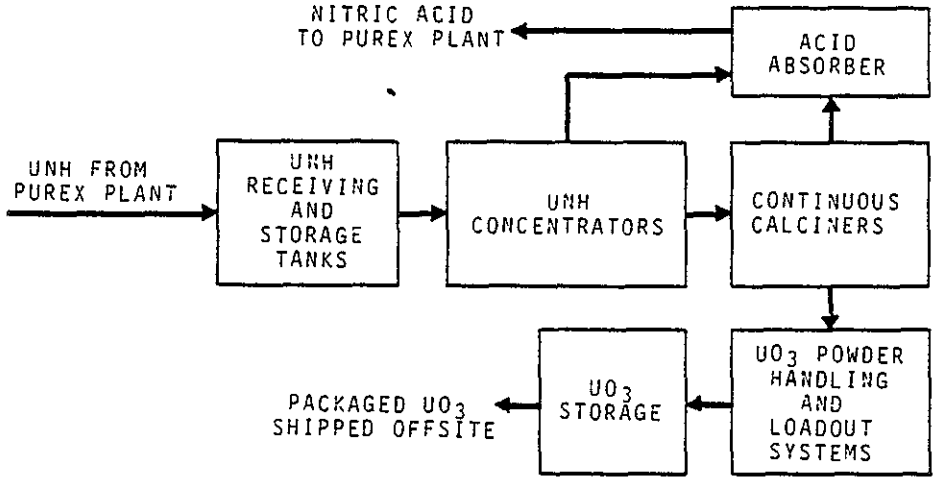

FIGURE II.1-16 UO_3 PLANT PROCESS SCHEMATIC

Redox Plant (200 West Area)

The reduction-oxidation process for fuel separation succeeded the bismuth phosphate process and preceded the Purex process. The Redox Plant is shown in the aerial photograph of Figure II.1-17. Redox Plant was constructed from May 1950 to August 1951. It operated until July 1967 when it was shut down. Although the building is shut down, the 222-S analytical laboratory is in operation. It supports the operation of B Plant, performs research, and helps develop waste management and environmental control processes.

T Plant

T Plant was one of the original fuel separation facilities and is shown on the aerial photograph of Figure II.1-18. T Plant was constructed from June 1943 to October 1944 and operated for the bismuth phosphate process. It was last used for this purpose in 1956. Floor space and facilities in T Plant are presently used on an irregular basis for decontamination projects and equipment repair. The 224-T building is used for plutonium storage.

Z Plant

Constructed in 1949, Z Plant, shown in the aerial photograph of Figure II.1-19, is the site of plutonium laboratory and finishing operations, including the processing of plutonium scrap materials and the preparation of plutonium products. The Plutonium Reclamation Facility processes plutonium scrap in a variety of forms and plutonium content to produce a pure plutonium nitrate solution. Americium is subsequently recovered from the solvent extraction high salt aqueous waste stream generated during the plutonium processing. Generally, the scrap is appropriately incinerated, then leached or dissolved with nitric acid in the feed preparation facilities. The solution generated is then adjusted chemically for feed to the extraction battery. Solvent extraction removes the impurities and produces a pure plutonium nitrate solution. The salt waste stream is further treated for trace plutonium and americium recovery. Contaminated waste streams consist of high and low salt aqueous solutions and degraded organic solutions. The high and low salt waste solutions are routed to underground storage tanks for conversion to salt cake. The degraded organic solutions are stored.

The Plutonium Processing Facility converts plutonium nitrate feed to either plutonium oxide or metal, depending upon customer requirements. The plutonium is precipitated with oxalic acid, filtered and calcined (for plutonium oxide product) and then fluorinated and reduced to metal (for the metal product). The facility is currently being operated as required to convert plutonium nitrate from the scrap process to metal. Waste streams consist of solids and the oxalate precipitation filtrate, which are recycled for plutonium recovery in the Reclamation Facility. Aspirator jet water, steam condensates and miscellaneous waste streams with very low concentrations of plutonium are routed to underground storage tanks for conversion to salt cake. Figure II.1-20 is a flowchart for this process.

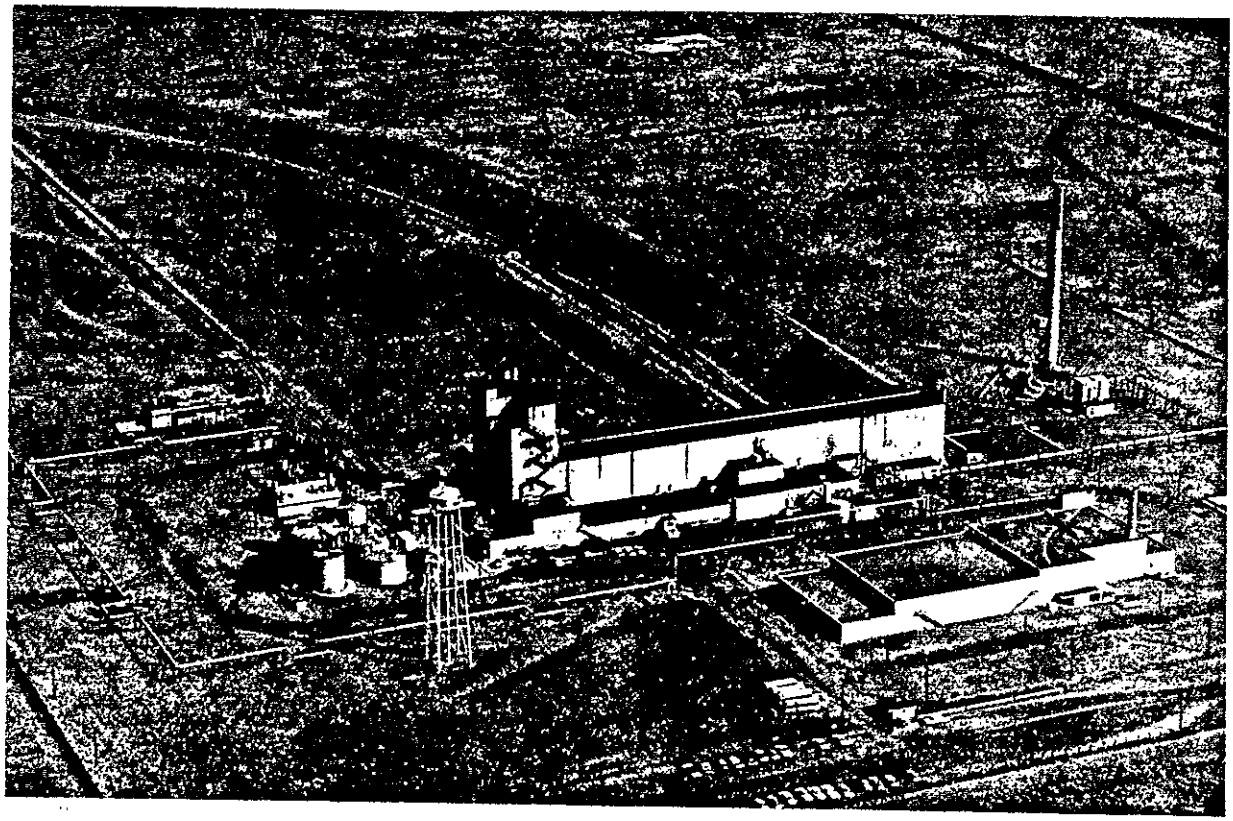

FIGURE II.1-17 200-W AREA REDOX (S) PLANT

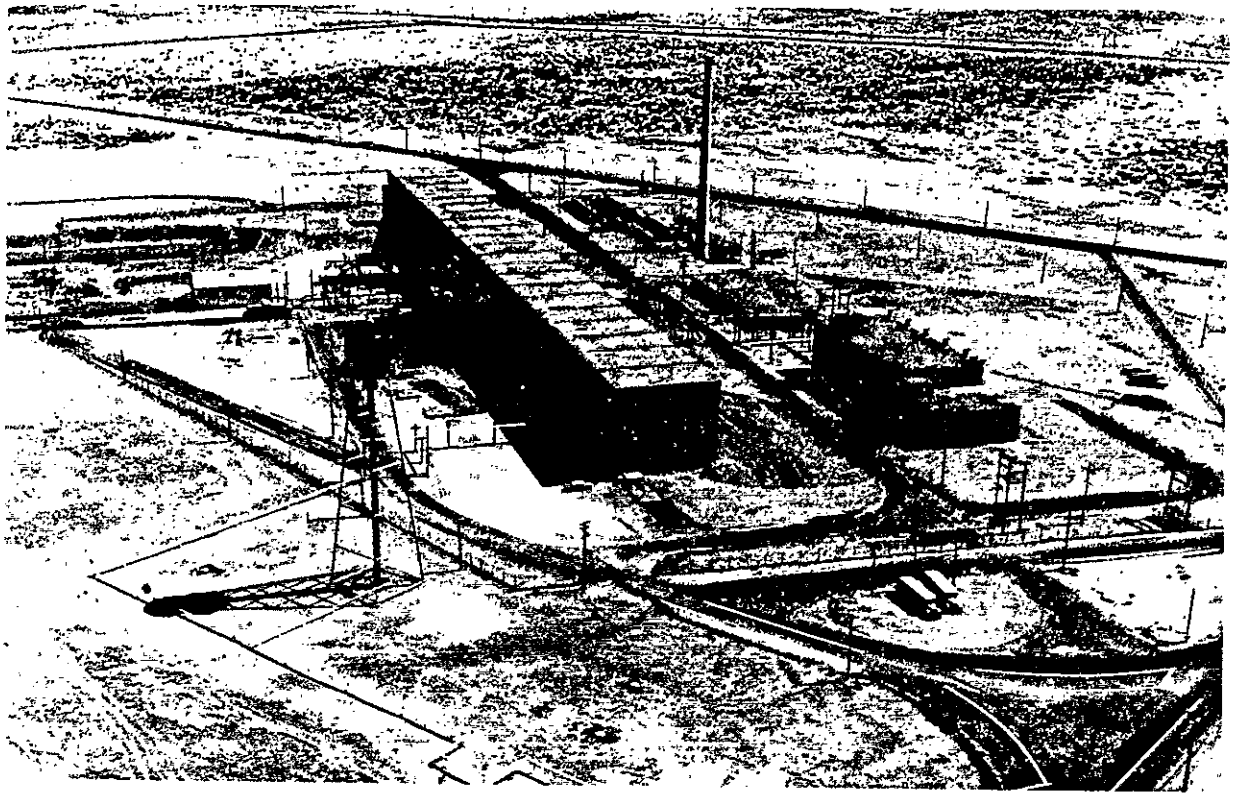

FIGURE II.1-18 200-W AREA T PLANT

9 1 1 1 3 9 1 0 4 3 7

FIGURE II.1-19 200-W AREA Z PLANT

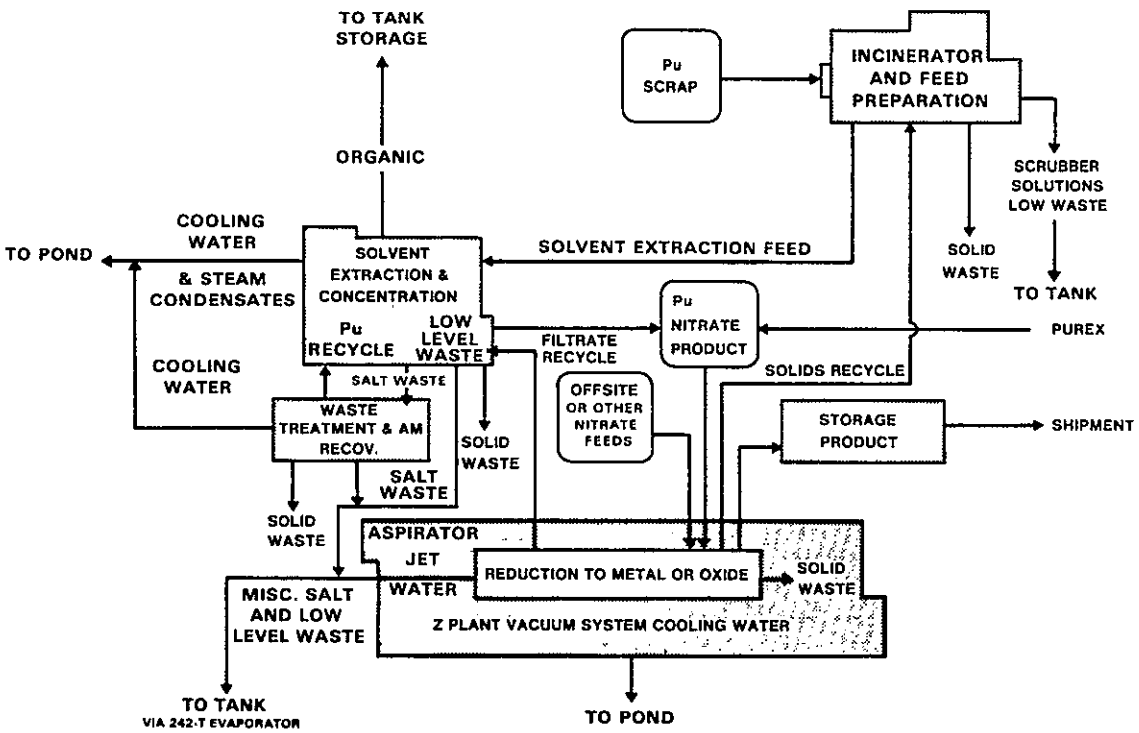

FIGURE II.1-20 PLUTONIUM RECOVERY AND FINISHING OPERATIONS

Support Facilities

General area facilities not specifically related to the various plant processes are located near the main area gate. They may be identified in Appendix II.1-C on a map and are shown in the aerial photographs of Figures II.1-10 and II.1-19.

II.1.1.1.3.3 Tank Farms and Solidification Facilities [X.11A]

Liquid waste containing high concentrations of radionuclides from the chemical processing plants has been stored on an interim basis in underground tanks at Hanford since startup. The complex of waste storage tanks, including 152 tanks with capacities ranging from 50,000 to 1,000,000 gallons, are constructed of reinforced concrete with a carbon steel liner on the bottom and side walls. The two new AY tanks, 1,000,000 gallons each, are of a tank-in-tank design with a primary containment steel liner and a surrounding liner to the fill line. In the new AZ tank farm, one additional tank was completed in October 1973 and another is complete except for piping interties into the system. Three additional tanks are under construction in a new SY tank farm.

Associated with the various tank farms are the evaporators used to convert nonboiling liquid waste to salt cake. Two units are presently in operation, and a third is under construction. Formerly, two units for in-tank solidification (ITS), designated ITS-1 and -2, were installed in specific tanks in BY Tank Farm in 200 East Area and operated by heating the waste in the tank. These units were shut down in mid-1974. The 242-S and 242-T evaporators in the 200 West Area, and the 242-A evaporator under construction in the 200 East Area, are separate facilities adjacent to the S and SX, and T, TX and TY, and the A, AX, AY and AZ tank farms respectively.

200 East Area

In Appendix II.1-C, Part 2, numbers and sizes of tanks and a listing of tank farm facilities are given for 200 East Area. These tank farms are shown in the aerial photographs of Figures II.1-21 and II.1-22 and in Figure II.1-23.

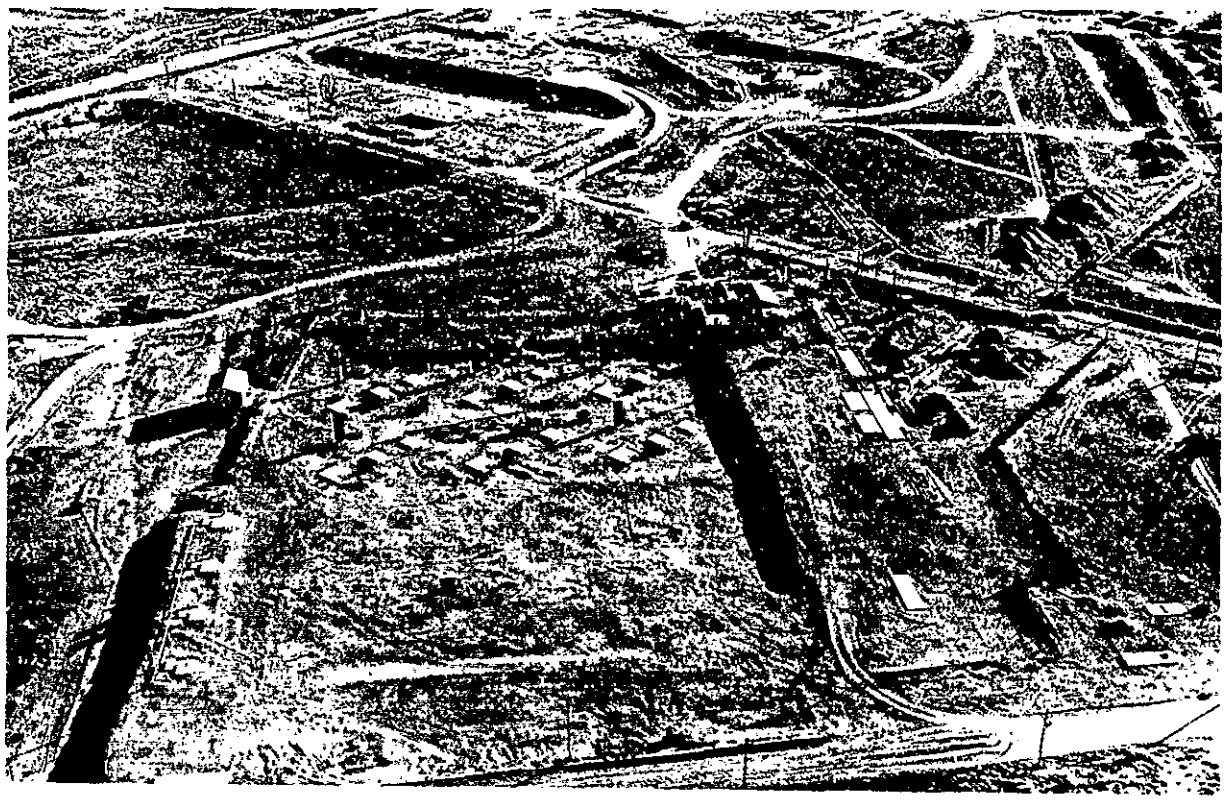

FIGURE II.1-21 200-E AREA TANK FARMS, AY, AX, A AND C

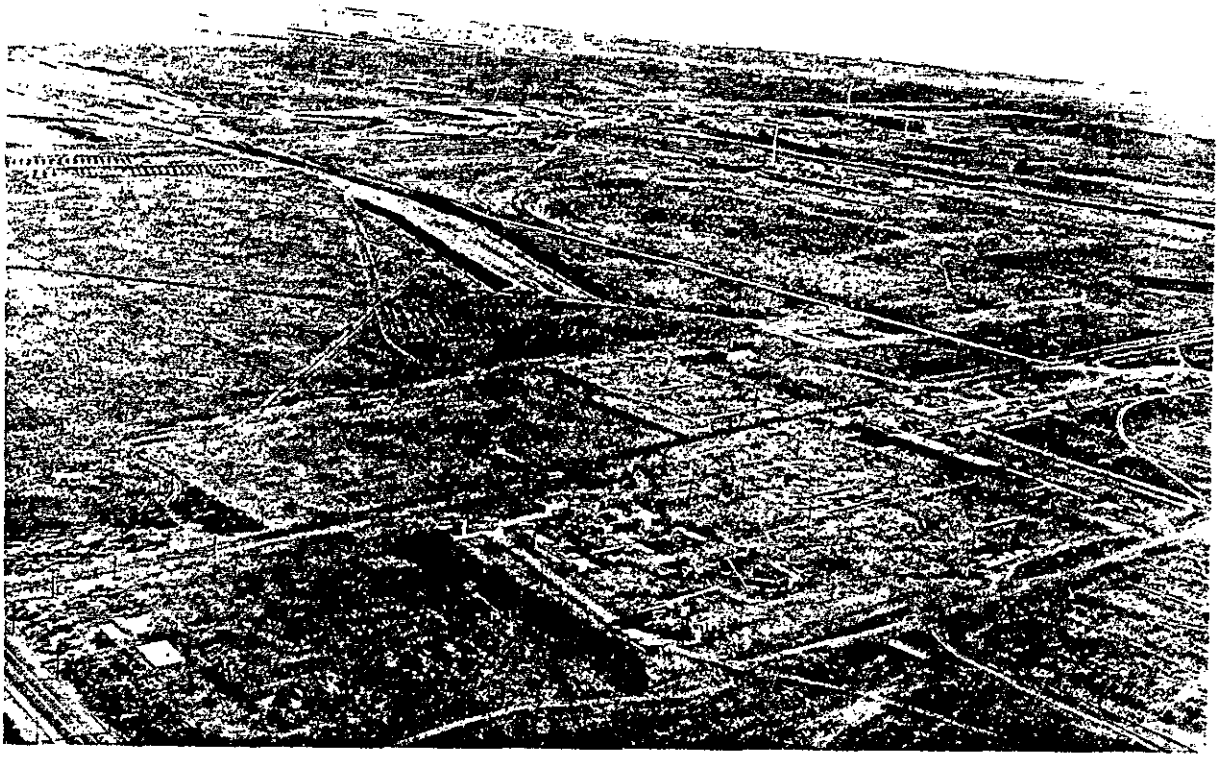

FIGURE II.1-22 200-E AREA TANK FARMS BY, BX AND B

200 West Area

Numbers and sizes of tanks and a listing of tank farm facilities in 200 West Area are given in Appendix II.1-C. These tank farms are shown in Figures II.1-24 and II.1-25.

II.1.1.1.3.4 Cribs, Ponds, and Ditches

Intermediate-level liquid waste is released to the ground via structures called cribs. Essentially all of the radionuclides discharged to these sites are retained in the soil column above the water table due to filtration and ion exchange sorption.

A total of 177 cribs have been provided for disposal of intermediate-level liquid waste since startup of the 200 Area facilities. Of these, 144 have been deactivated, 8 were not used, 10 are in standby, and 15 are currently being used.

The chemical processing operations use very large quantities of water, most of which never come in contact with radioactive materials. This aqueous waste, which is primarily cooling water with some steam condensates, is discharged to ponds for evaporation and/or percolation through the ground eventually to the groundwater.

Approximately 1.3×10^{11} gallons of cooling water and steam condensates have been discharged to 30 surface ponds and ditches in the 200 Areas since the start of chemical processing operations. Approximately 360 acres of land were used for these waste disposal operations, with about 180 acres of this total in current use. Radionuclides discharged to these sites, primarily from accidental releases due to equipment failures, are largely filtered or sorbed and held in the soil beneath the pond or ditch area.

200 East Area

In Appendix II.1-C, Part 2, cribs and ponds for 200-E may be located on area maps and are listed in a table along with size and use information. Aerial views of these cribs and ponds are found in the photographs of Figures II.1-12, II.1-14, II.1-21, II.1-22, II.1-26, II.1-27, II.1-28 and II.1-29.

9 1 1 1 3 9 1 0 4 7 0

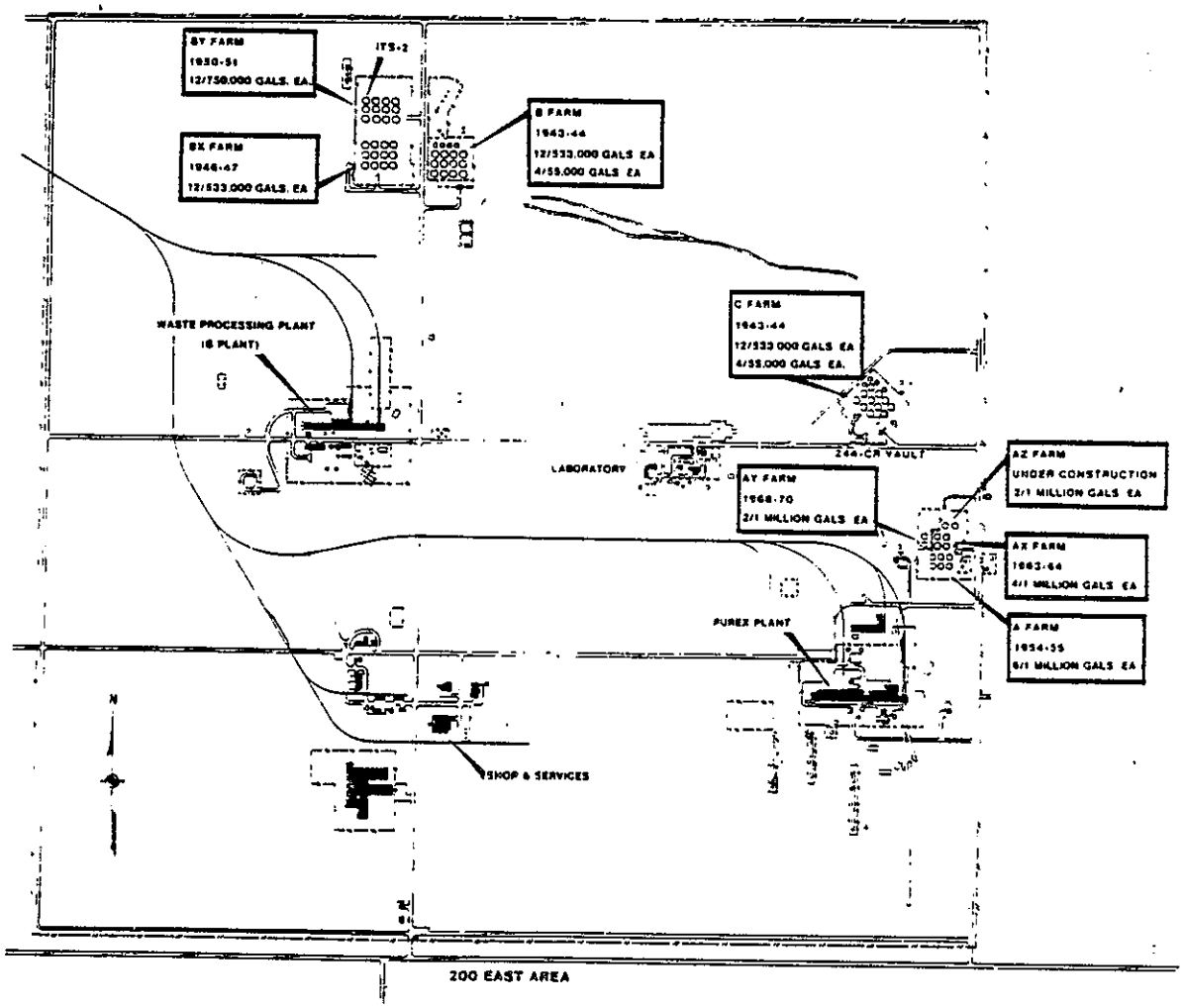

FIGURE II.1-23 200 EAST AREA TANK FARM FACILITIES

200 West Area

In Appendix II.1-C, Part 2, cribs and ponds for 200-W may be located on area maps and are listed in a table along with size and use information. Aerial views of these cribs are found in the photographs of Figures II.1-15, II.1-17, II.1-18, II.1-19, II.1-22, II.1-30 and II.1-31.

II.1.1.1.3.5 Solid Radioactive Waste Burial Grounds

More than 5 million ft^3 of contaminated solids have been buried on the 200 Area plateau since the start of chemical processing operations. These wastes consist of so-called "dry waste" (soiled clothing, laboratory supplies, tools, etc., packed in cardboard, wood or metal containers) and industrial waste (primarily items of failed process equipment packaged in heavy metal or concrete boxes). Transuranic bearing waste has been packaged in sealed metal containers and segregated in the burial trenches since May 1, 1970. Contaminated solid waste is buried in 19 sites on the 200 Area plateau using 155 acres.

Prior to 1968, essentially all of the waste buried was generated by the 200 Areas operating facilities. Since 1968, waste generated by 300 Area operations also has been buried in the 200 Areas sites. Beginning in December 1973, waste from reactor operations in the 100 Areas is being sent to the 200 Areas for burial. Small volumes of solid waste, generated by offsite ERDA operations, have been and will continue to be buried here. During 1973, approximately 2000 ft^3 containing less than 4 Ci of mixed radioactive materials were received from offsite.

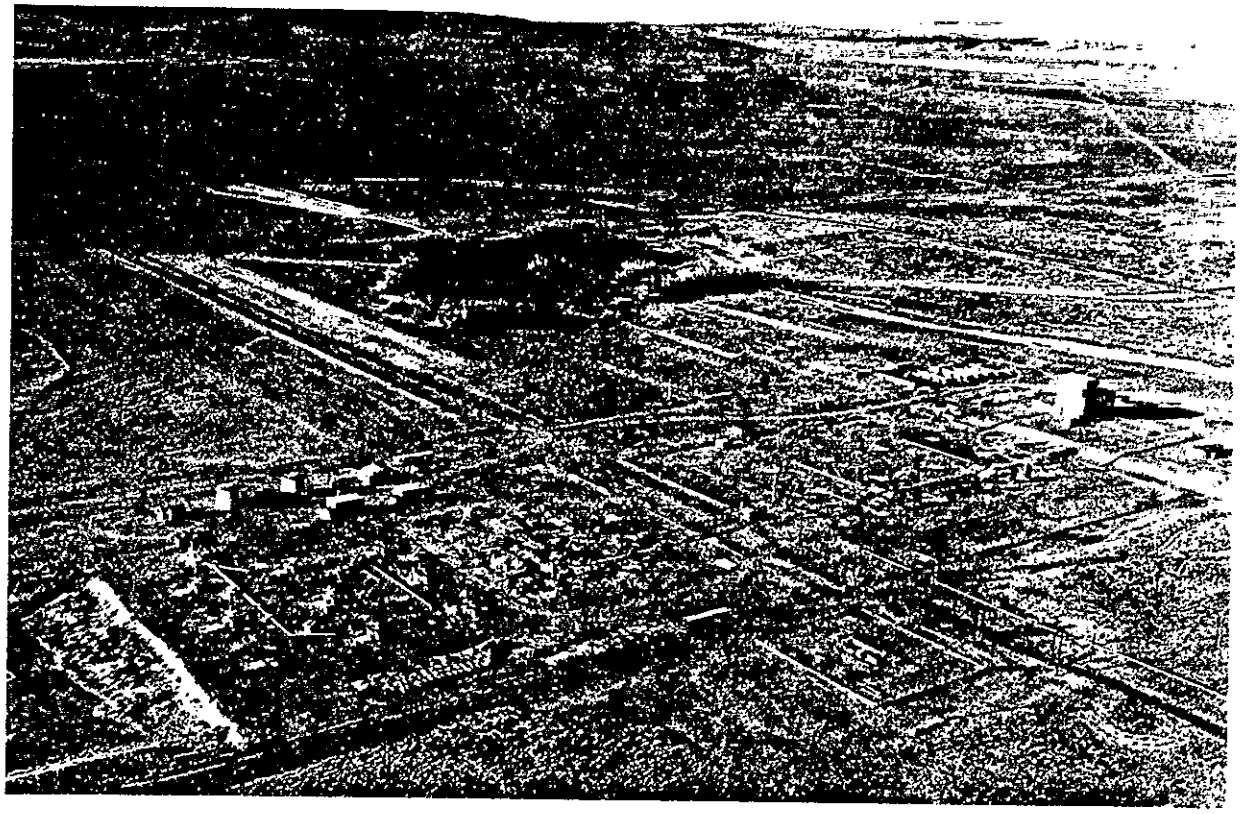

FIGURE II.1-24 200-W AREA TANK FARMS SX AND S

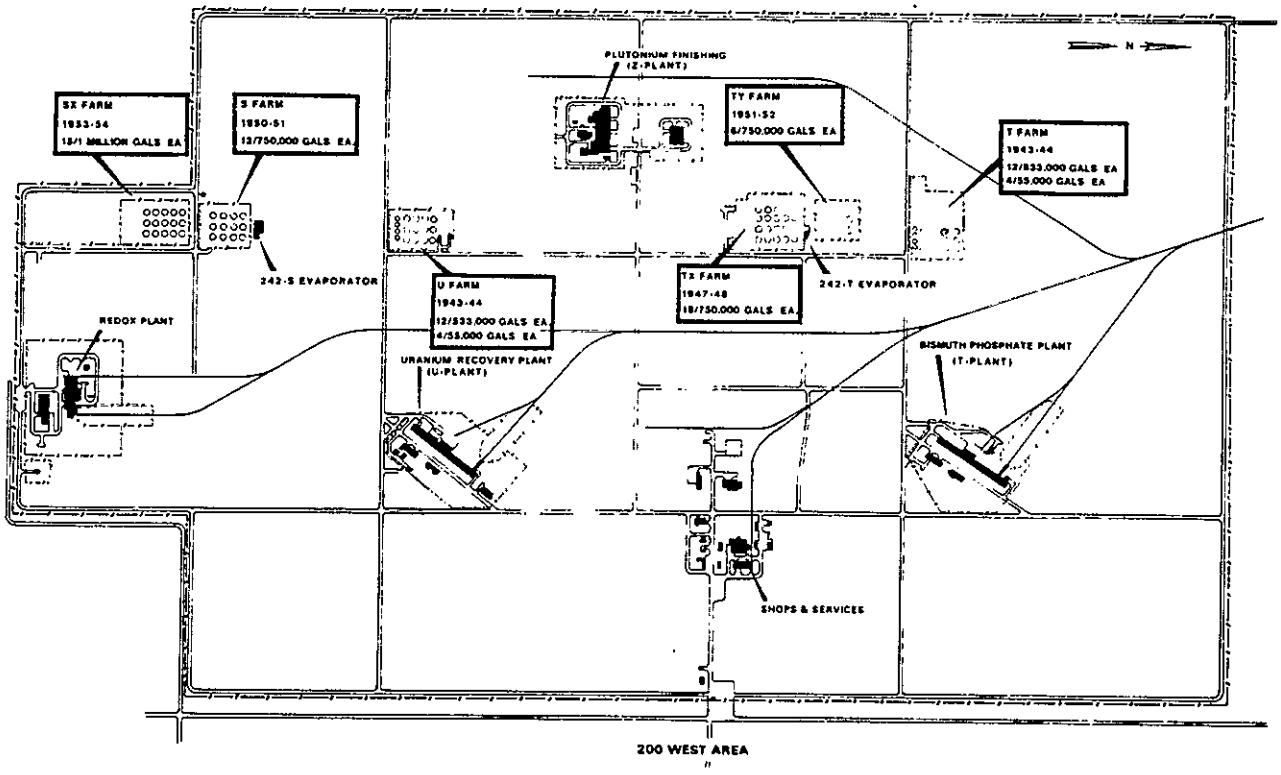

FIGURE II.1-25 200 WEST AREA TANK FARM FACILITIES

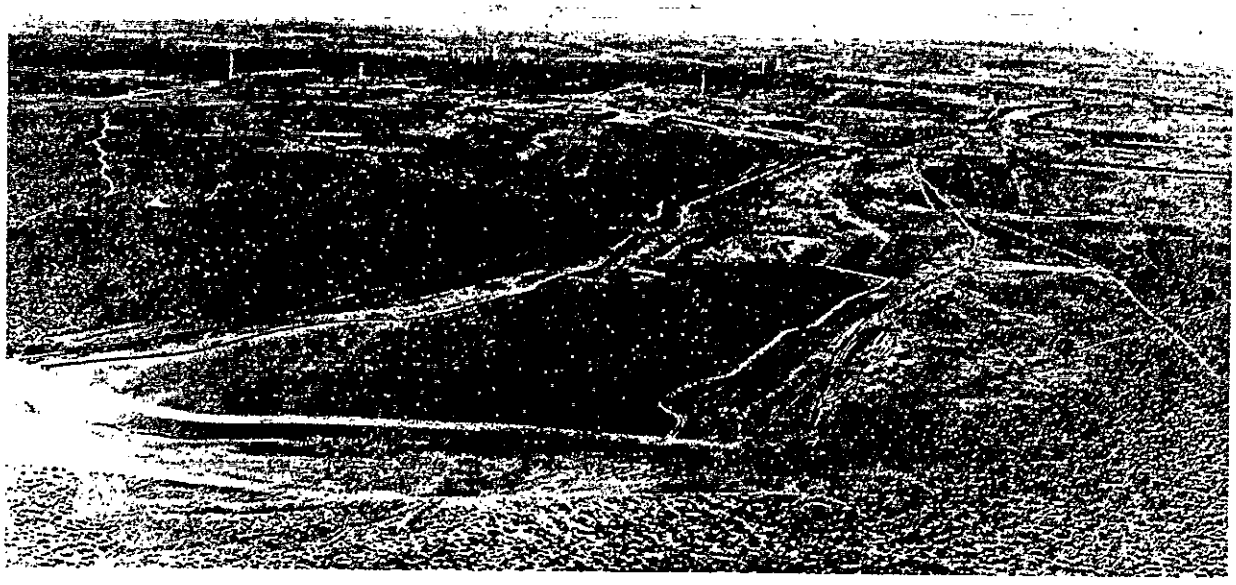

FIGURE II.1-26 216-B-3 POND

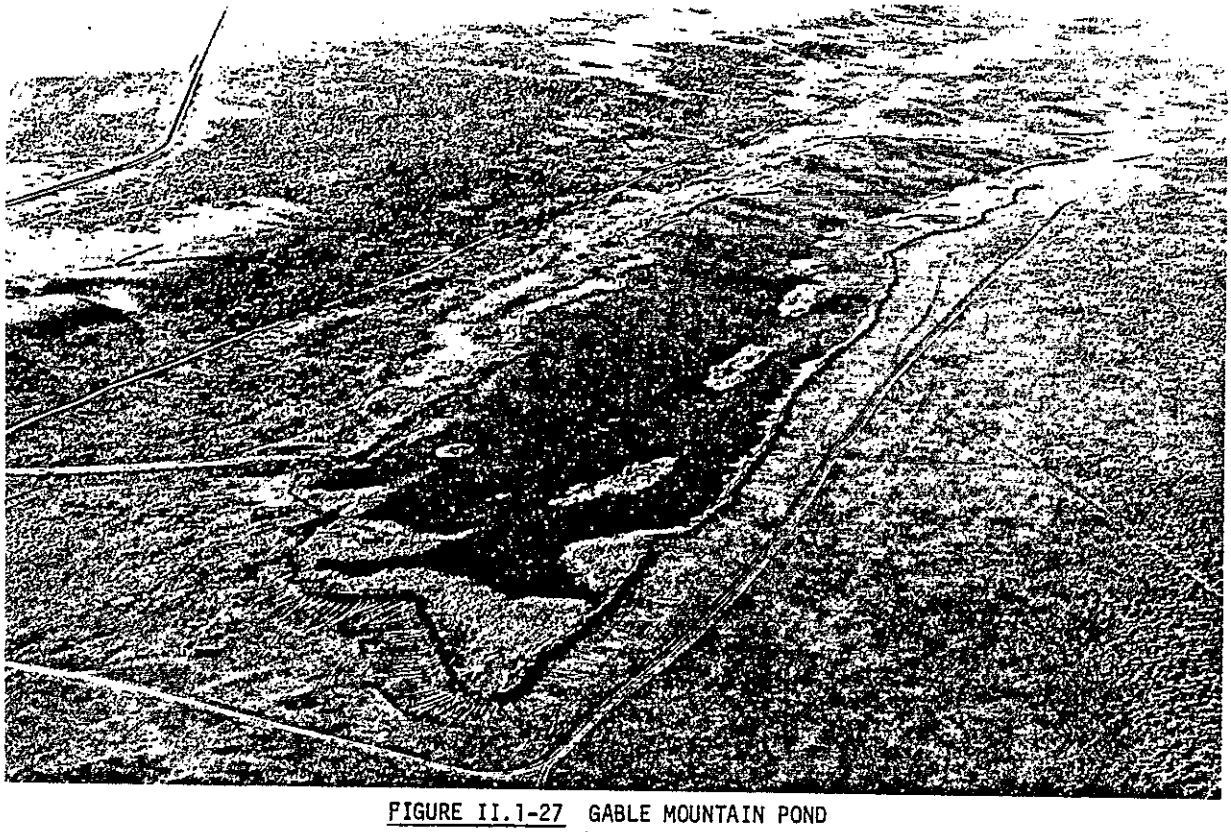

FIGURE II.1-27 GABLE MOUNTAIN POND

9111631 9 7 4 3

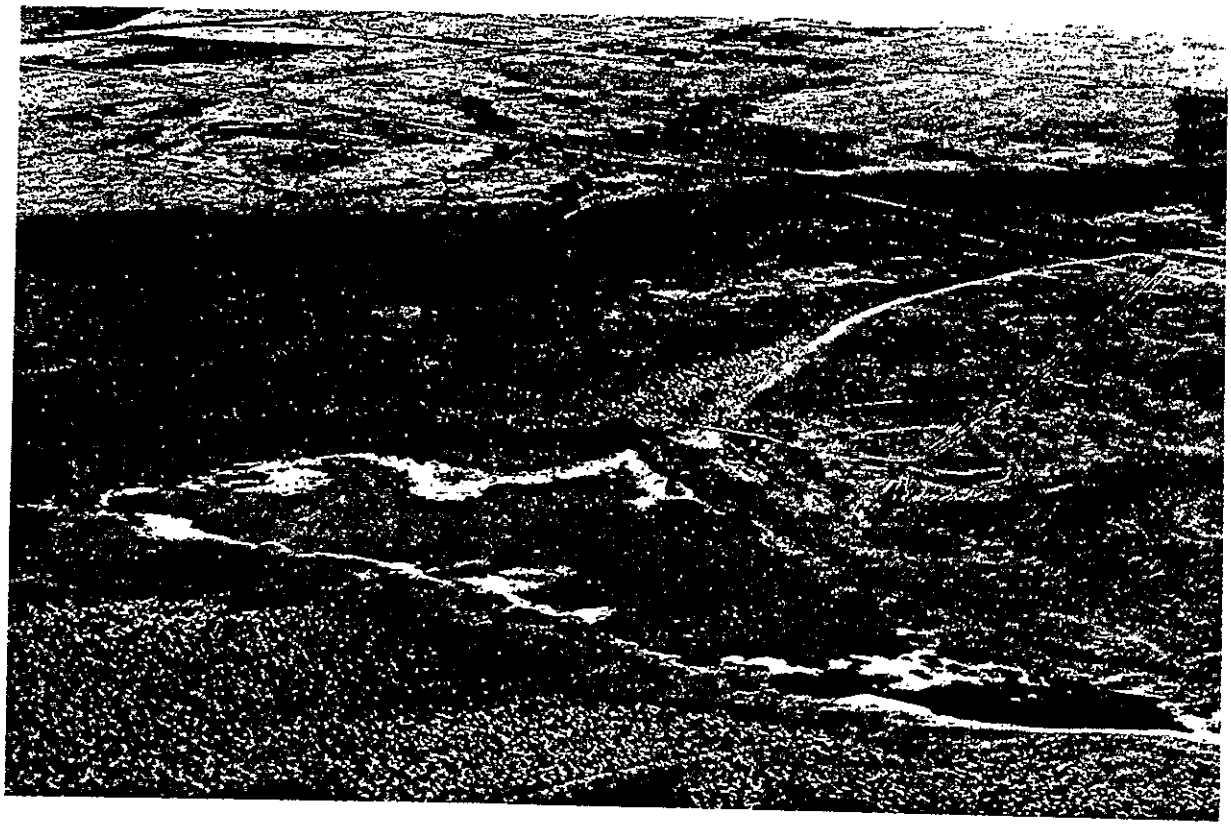

FIGURE II.1-28 WEST LAKE

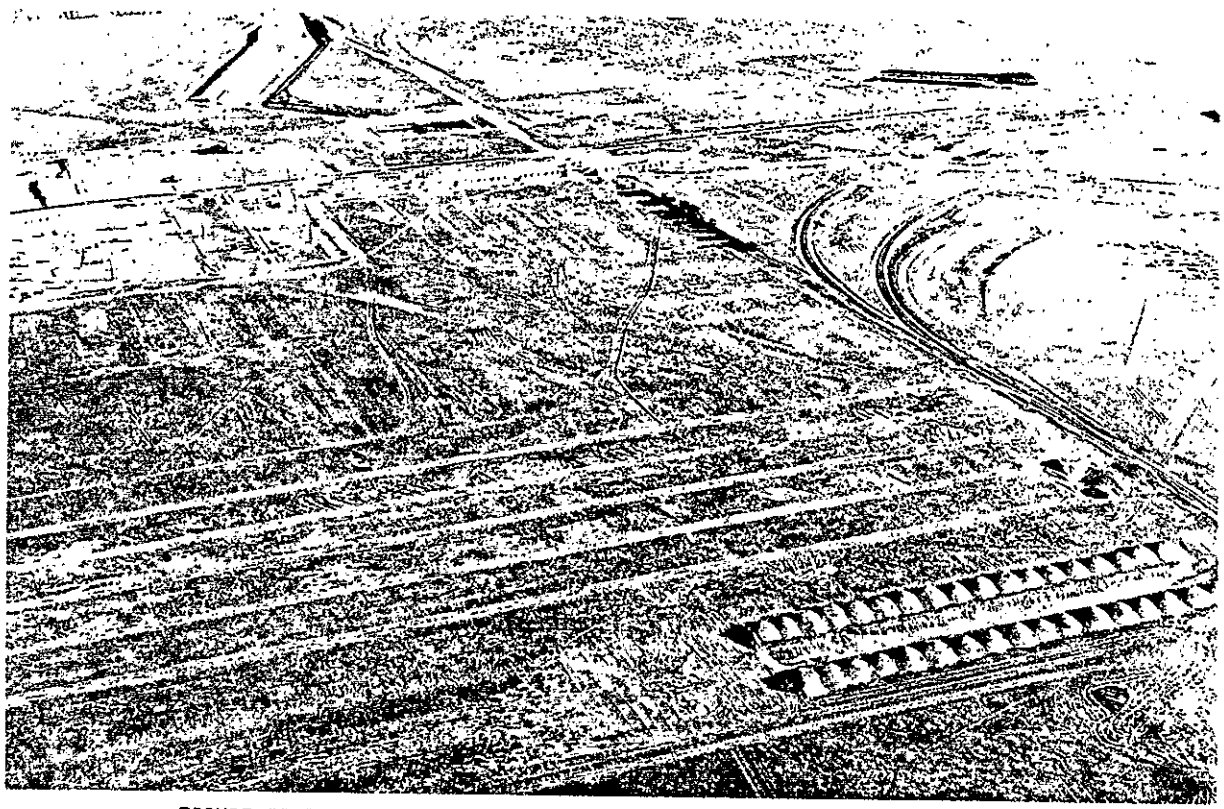

FIGURE II.1-29 200-E AREA BURIAL GROUNDS 218-E-10, 5A, 5, 2, 9 AND 4

9111139104 74

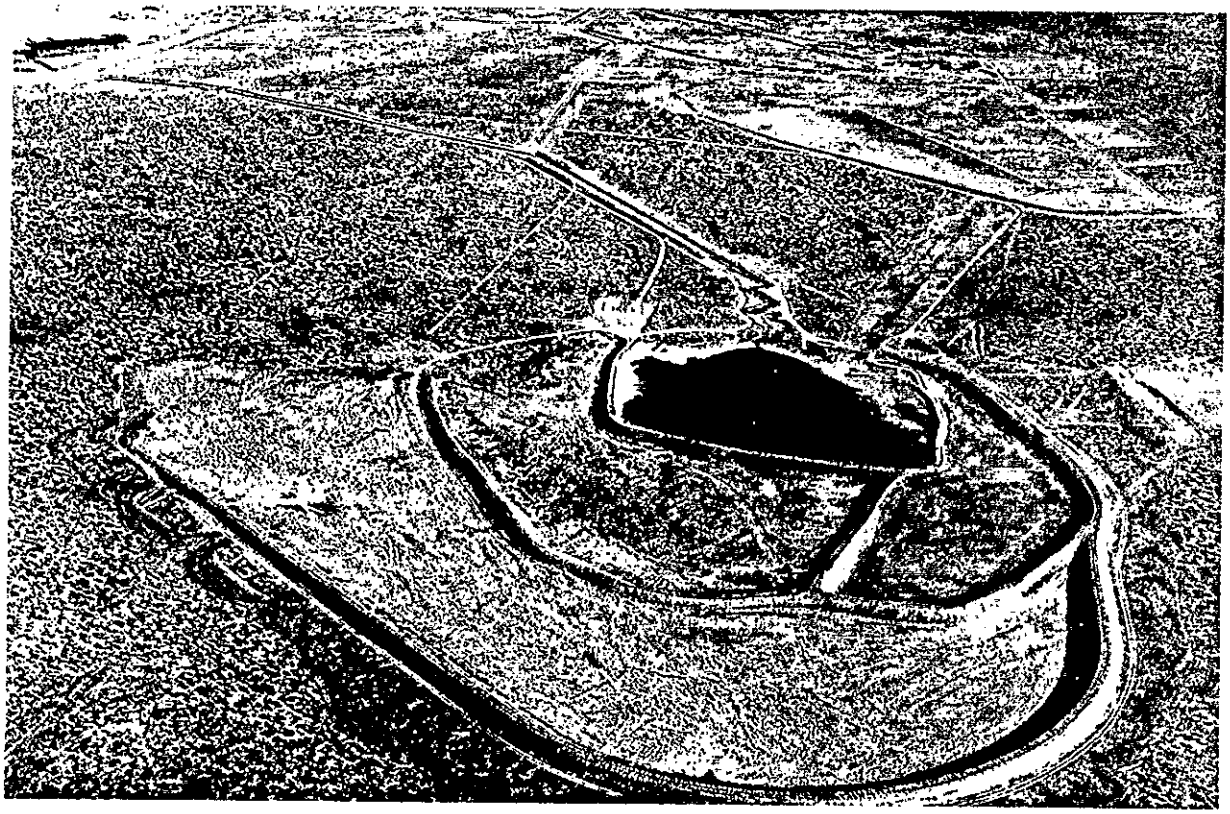

FIGURE II.1-30 216-S-16 POND

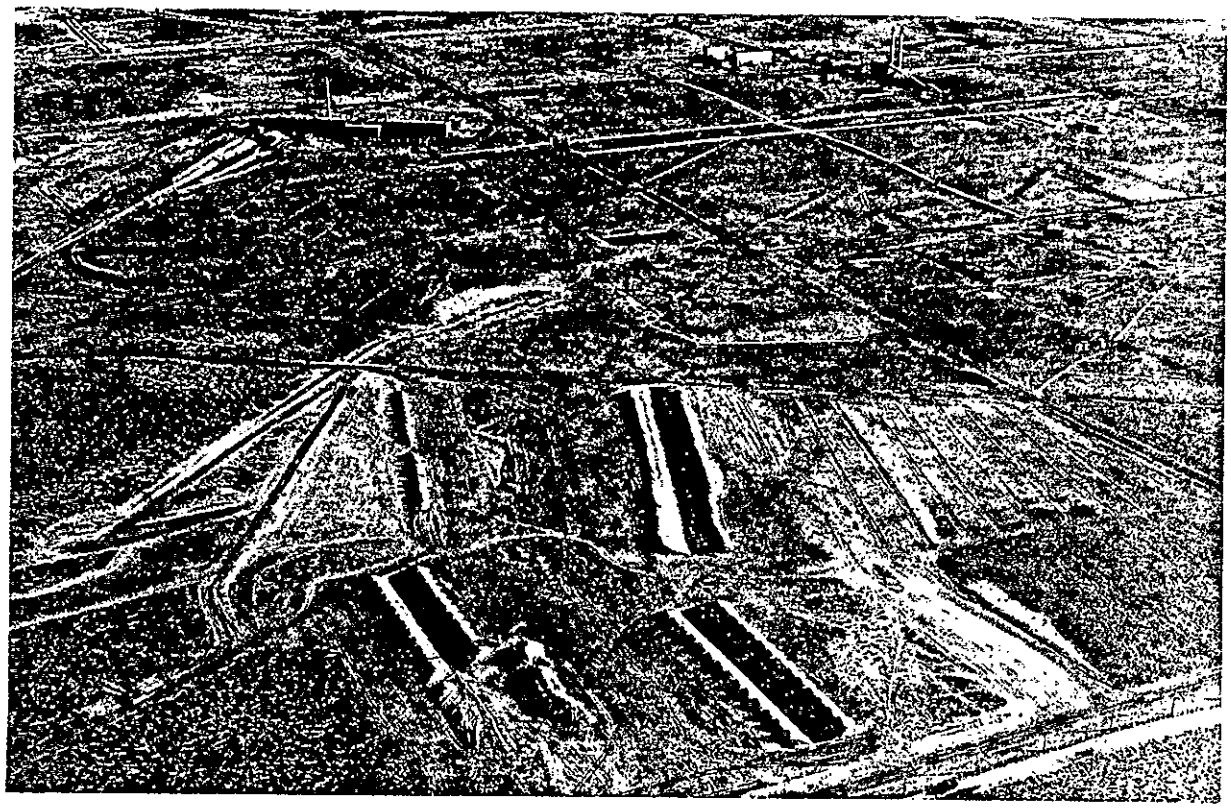

FIGURE II.1-31 200-W AREA BURIAL GROUNDS 218-W-2A, 3 AND 3A

9113096047

200 East Area

In Appendix II.1-C, Part 2, burial grounds are listed in a table and shown on a map. These burial grounds appear in the aerial photographs of Figures II.1-12, II.1-14, II.1-29 and II.1-32.

200 West Area

In Appendix II.1-C, burial grounds are listed in a table and shown on a map. They appear in the aerial photographs of Figures II.1-17, II.1-20, and II.1-31.

II.1.1.1.4 300 Area

The 300 Area is located about 1 mile north of the Richland city limits on the bank of the Columbia River. Roughly rectangular in shape, it includes about 375 acres and will soon expand northward for added waste management facilities. The aerial photo, Figure II.1-33, shows that the area is bounded by the Columbia River on the east and the highway on the west. The recently built Life Sciences Facility in the very lower left marks the southern boundary while the second process water discharge pond marks the southern boundary while the second process water discharge pond marks the northern boundary. This pond, separated by the V-shaped sanitary waste leach trench from a similar pond, is a distinctive landmark. Waste burial sites now covered are seen at the top (west) of this photo taken in 1973 and at the right side of the figure.

Most facilities in the 300 Area, completed in 1943 and the years immediately following, were related to the fabrication of reactor fuel. These included many technical and service support facilities as well as fuel manufacturing. As the Hanford production reactors were shut down, fuel manufacturing activities decreased. Thus, for over 15 years, research and development programs have constituted a major part of the activities in the 300 Area. The newer facilities house mostly laboratories and large test facilities in support of peaceful utilization of plutonium, reactor fuels development, liquid metal technology, fast flux test reactor support, gas cooled reactor programs and life sciences programs.

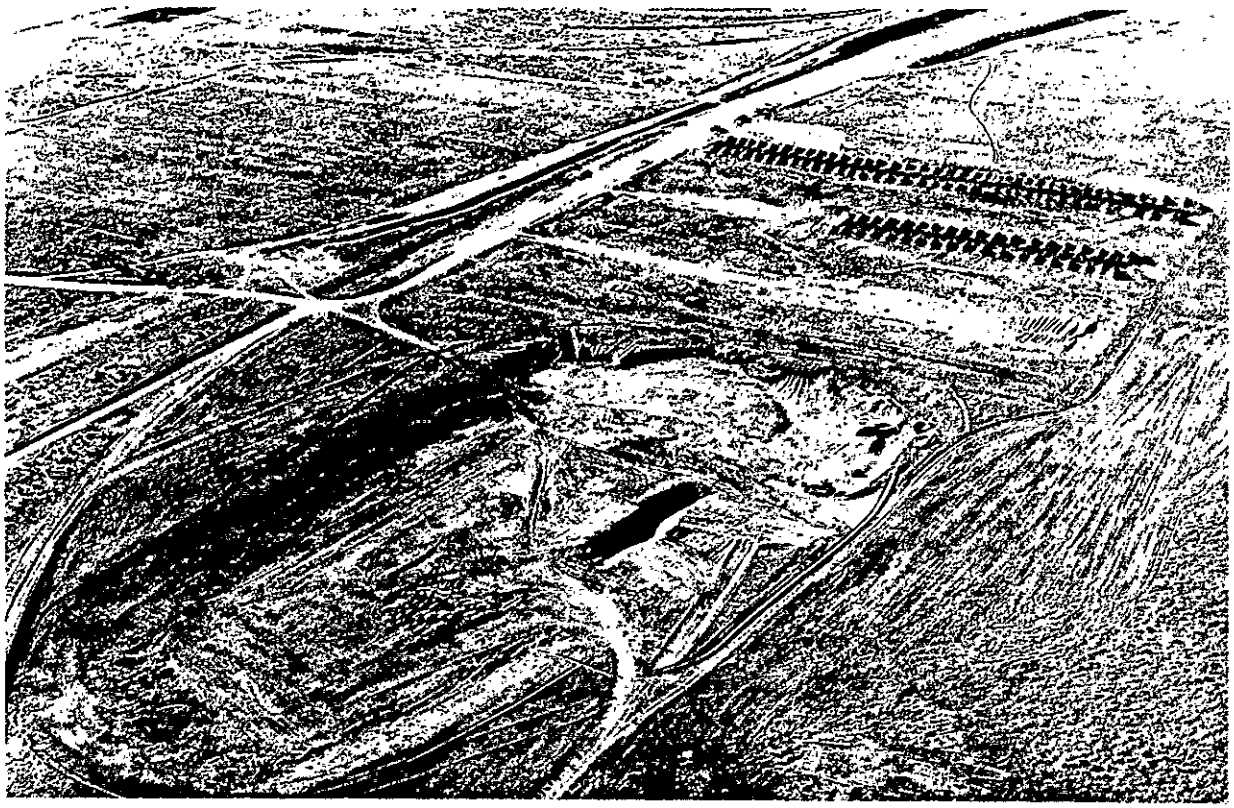

FIGURE II.1-32 218-E-12-B BURIAL GROUND

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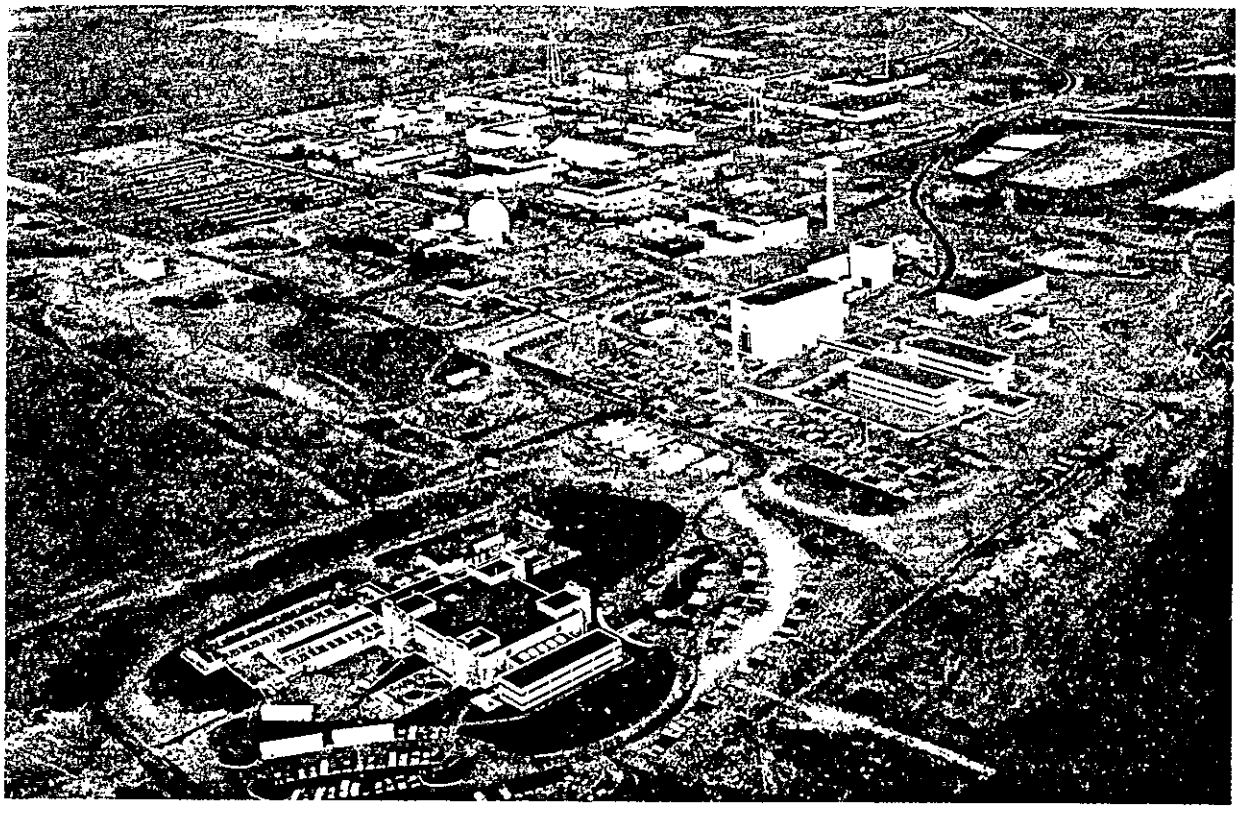


FIGURE II.1-33 300 AREA

II.1.1.1.5 400 Area

The 400 Area is the Fast Flux Test Facility (FFTF) Construction Area. An environmental impact statement has been prepared.[1]

II.1.1.1.6 600 Area

Included in the 600 Area (all of the Reservation which is not included as 100, 200, 300 or 400 Areas) are:

- the Arid Lands Ecology Reserve,* a 120-square-mile tract set aside exclusively for the study of ecology
- 1000 acres leased to the State of Washington
- 1,089 acres for WPPSS nuclear plant Hanford No. 2, of which 1,059 acres will remain in its natural state
- about 2,000 acres of the former Hanford Construction Camp which housed at one time over 40,000 workers
- 2 abandoned townsites, Hanford and White Bluffs
- many support facilities for the Controlled Access Areas
- 32,000 acres for U.S. Bureau of Sport Fisheries and Wildlife Refuge
- 54,000 acres for Washington State Department of Game

* Also referred to as the 1400 Area.

Table II.1-2 summarizes features of the 600 Area. None of the facilities in the 600 Area are generators of radioactive waste. However, parts of the 600 Area are or were involved in the Waste Management Operations Program.

TABLE II.1-2

PREVIOUSLY UTILIZED ACREAGE OF THE 600 AREA

Description	Size or Capacity	Existing Disturbed Acreage (Acres)
Hanford Camp (abandoned and razed)	1920 Acres	960
213 Storage	28 Acres	28
Old Central Shops	224 Acres	190
Army Anti-Aircraft (razed) Sites and/or World War II implacements	219 Acres	78
Graveled leveled areas not used in parking	354 Acres	338
Borrow Areas--1 acre or more in size	1448 Acres	1118
Fill Areas	266 Acres	200
Disturbed Surface--old railroad beds, fire breaks, or seismic test areas	212 Acres	212
Railroads with 35 ft wide roadbeds	178 Miles	755
Four-lane Blacktop Roadways with 80 ft widths	33 Miles	330
Two-lane Blacktop Roadways with 50 ft widths	155 Miles	939
Improved Gravel Roads	91 Miles	441
Telephone Lines[a]	144 Miles	436
Power Lines[a]	247 Miles	1497
Raw Water Lines	100 B/C and (and 100 D/DR) to 200 Areas	
Buildings	49 in use 6 abandoned	

(a) All lines have one dirt road plus fire break areas under the lines, 25 feet wide for phone lines and 50 feet wide for power lines.

II.1.1.2 Waste Management Facilities, Processes and Equipment

II.1.1.2.1 100 Areas [RPB]

The shutdown of eight production reactors and the recent (1973) elimination of solid waste burials in the 100 Areas significantly decreased waste management activity in the 100 Areas. Most of the 100 Areas now generate essentially no waste. Waste management facilities of the 100 Areas are arbitrarily divided into the active and inactive areas.

N Reactor differs significantly from all earlier Hanford reactors. At N Reactor, the primary coolant circulates through the reactor and absorbs heat from the fuel elements but is not returned directly to the river. Instead, heat is transferred through heat exchangers to a secondary coolant loop which ordinarily produces the steam to power the electrical generators of the WPPSS. By not releasing cooling water from the reactor core directly to the river, the amount of radioactivity released to the river is greatly reduced.

II.1.1.2.1.1 Radioactive Liquid Waste Facilities [X.12]

1301-N Crib and Trench

Figure II.1-34 outlines the 100-N liquid waste system. The major source of radioactive liquid waste released to the ground is the continuous bleed of primary coolant of the N Reactor. The cooling water is circulated through the reactor process tubes and over the fuel element surfaces repeatedly. Induced activity is minimized by purifying this water before injection into the primary coolant loop. However, the water accumulates radioactivity in the reactor coolant loop as follows:

- induced activity in dissolved piping corrosion materials (iron, chromium, manganese, zirconium and cobalt)
- fission product releases from fuel elements with failed cladding
- fission products from the fissioning of uranium residue resulting from fuel cladding failures.

Radioactivity in the coolant loop is reduced by continuous bleed-off of part of the coolant and replacement of it with treated river water. The average bleed rate of 1,000 gpm allows the entire primary coolant volume of 150,000 gallons to be replaced every 2.5 hours. Ammonium hydroxide is added to primary coolant water during operation to raise the pH to the alkaline side of neutral. The bleed-off coolant water is then released to the 1301-N crib which measures about 125 by 290 feet. Figure II.1-34 shows the sources of liquid discharges to the crib, trench, and Columbia River. The total flow to the crib during normal reactor operation is 2,500,000 gpd from:

- 36-in. contaminated drain with about 2,000,000 gpd during reactor operations
- 12-in. line of about 500,000 gpd during reactor operations
- 3-in. drain from waste disposal valve pit, 350 gpd
- 6-in. auxiliary decontamination line from 109-N, intermittent.

The overflow from the crib is directed to the adjacent 1,600-ft long by 50-ft wide trench. Some flow from the crib and trench forms a surface seepage at the river bank referred to as the N Area Riverbank Springs. About one-half of the discharged water reaches the river in 4 to 10 days. The remainder follows longer flow paths and requires weeks to months to reach the river.

Most radioactive species discharged to the crib are retained in the soil by chemical reactions, precipitation, and ion exchange. Since the pH is on the alkaline side, the hydroxides and basic salts of zirconium, cerium, and other rare earth and transition elements precipitate and are retained in the soil by filtration. Due largely to the type of clay minerals present in the region, ion exchange of the cations retains the long-lived radionuclides (^{60}Co, ^{90}Sr, ^{137}Cs) in the soil.

102-in. Discharge Line to the River

A 102-in. diameter discharge line terminates in the Columbia River about 500 feet out from water's edge during low volume river flows of ~50,000 cfs (Appendix II.1-D). The waste consists primarily of steam condenser cooling water discharged via the 102-in. line to the Columbia River channel. (Flow rates down the line with the reactor operating are about 225,000 gpm and with reactor shutdown are about 100,000 gpm.) The discharge points into the 102-in. line are detailed in Appendix II.1-D.

Decontamination Waste - 1310-N Facility

Approximately 600,000 gallons of liquid waste are shipped to 200 Areas each year. The bulk of the waste is generated once a year when the N Reactor primary coolant piping is internally decontaminated to remove radioactive corrosion products and deposited materials. Decontamination is a once-through process in which 250,000 gallons of 8 wt% phosphoric acid is flushed through the primary coolant loop and routed to the 1310-N tank.* The primary coolant system is then rinsed with water and NaOH is added to the 1310-N tank to neutralize the phosphoric

* Twenty thousand gallons of 70 wt% phosphoric acid is added to demineralized water, giving 250,000 gallons of 8 wt% H_3PO_4 which is then flushed through the primary loop.

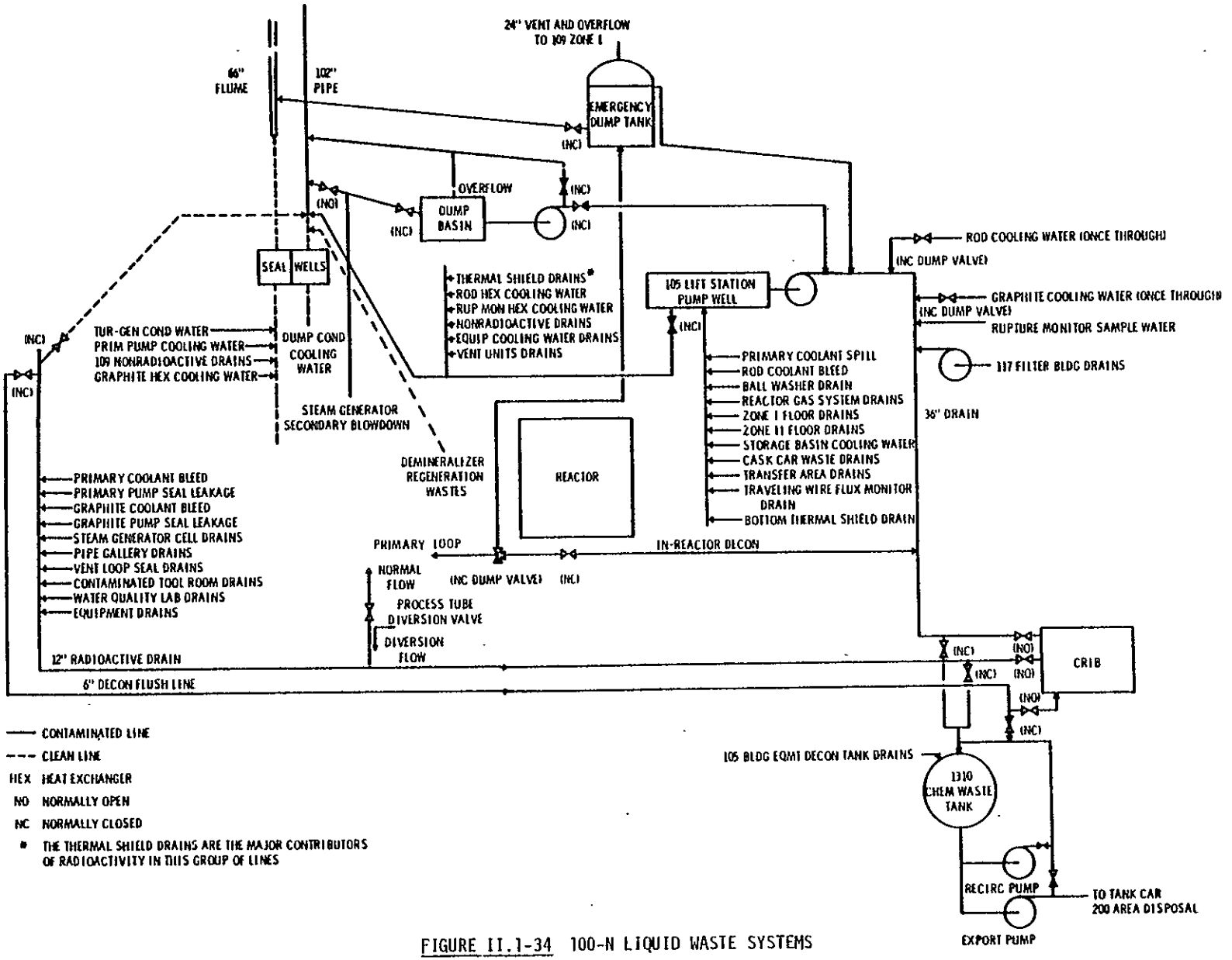


FIGURE II.1-34 100-N LIQUID WASTE SYSTEMS

acid, increasing the 1310-N tank's waste volume to approximately 600,000 gallons. The resulting intermediate-level liquid waste is shipped to the 200 West Area in 20,000-gallon railway tank cars for evaporation to a solid and for in-tank storage.

II.1.1.2.1.2 Radioactive Solid Waste Facilities

Solid waste from 100-N Area was buried in trenches in other 100 Areas in the past. The waste contained dried salts and oxides of the activation and fission products found in solution in the primary coolant water. A few metallic components, taken from the active reactor zone, containing zirconium, iron, and steel activated to ^{95}ZrNb, ^{60}Co, and ^{54}Mn were also buried in these facilities. Waste containing transuranium elements and/or high concentration (10 mCi/g) of long-lived radionuclides (>5-year half-life) was shipped to the 200 Areas for burial. Since December 31, 1973, all solid waste has been shipped to the 200 Areas for disposal with the following exceptions:

- Contaminated Equipment Storage. An area was set aside for temporarily storing contaminated equipment removed from radiation zones prior to reuse or disposal.

- Dummy Storage Silos. Silos are in active use for storage of irradiated process spacers, called dummies because they resemble fuel elements but contain no uranium and are used as spacers. No contamination exists on the ground surface. Radiation level at the top of pit 1 is 25 mR/hr and at pit 2 is 35 mR/hr. The dose rate at the Radiation Zone Boundary is <1 mR/hr. Dummies are periodically removed.

- 100-K Area Silos. Two silos in the 100-K Area (each 8 ft in diameter and 24 ft deep) are used for disposal of metallic scrap from N Reactor's fuel storage basin. This waste consists of irradiated fuel element support hardware, bent spacers and other metallic refuse found in the storage basin. Ruptured fuel element fragments are not included in this waste.

II.1.1.2.1.3 Radioactive Gaseous Waste Facilities

The tritium and radioiodines formed in the reactor primary water are bled out of the primary loop into the ventilation exhaust air. Air that leaks in and is purged out of the reactor core graphite gas atmosphere contains ^{40}Ar which is activated to ^{41}Ar. This outleakage is also carried away by the building ventilation exhaust air. The ventilation air and gases exhausted from the building pass through high efficiency particulate air filters (HEPA) and charcoal absorbers before being discharged to the atmosphere from the 200-ft high ventilation stack at 150,000 cfm. (Results for 1972 are presented in Appendix II.1-B, Part 4.)

Some of the 100 Area gaseous radioactive waste originate in the 105/109-N facility as activation salts that are dried on the outside of the reactor piping and surrounding surfaces. Some of the radioactive salts are entrained by the air currents and are removed by high efficiency filters prior to discharge through the ventilation stack.

II.1.1.2.1.4 Inactive Areas

Radioactive waste management facilities in the five 100 Areas in which the reactors (8) were retired are largely the terminated cribs, trenches, burial areas and the contaminated facilities such as the reactors, spent fuel basins and effluent holdup basins. The status of these facilities is constantly monitored and maintained in their terminated state pending permanent disposition. The 183-H basin is currently used for receiving the neutralized chemical waste from the 300 Area fuels fabrication facility for solar evaporation and eventual recovery of copper and uranium. Tables in Appendix II.1-B, Part 2, list all the cribs, burial plots, trenches and ponds. Very little work with radionuclides is currently in progress and the small quantity of low-level radioactive waste still being generated is also noted in this tabulation. Any radioactive solid waste generated is now transferred to the 200 Area for disposal.

No facilities or equipment for waste management of radioactive gases are needed or are now in service except at the 144-F animal farm facility performing plutonium inhalation studies. High efficiency particulate air filters are installed at 144-F at the experimental enclosures and on the stack, which has a normal flow of 6,500 cfm to the atmosphere. The stack exhaust is continuously sampled. (Results for 1972 are presented in Appendix II.1-B, Part 4.)

II.1.1.2.2 200 Areas[2]

Due to the high rates of heat generation in the high-level boiling Current Acid Waste (CAW), produced from the Purex Plant processing of irradiated reactor fuel, solidification is not

feasible without special processing because excessive temperatures would be encountered in the solids formed. With half-lives of about 30 years, ^{137}Cs and ^{90}Sr contribute much of the heat through their radioactive decay. Initially, decay of other fission products in the waste also generates sufficient heat to make the CAW boil even in the absence of ^{137}Cs and ^{90}Sr. However, due to the relatively short half-lives of the other radionuclides in the waste, the rate of heat generation drops to levels acceptable for solidification within about 5 years. Consequently, CAW is processed (in B Plant) to remove a majority of the cesium and strontium from the liquid waste; the cesium and strontium are encapsulated as a solid for long periods in water cooled storage. The remaining liquid waste is neutralized and stored in double-wall tanks until sufficient radioactive decay allows solidification to salt cake.

Dilute nonboiling liquid waste is stored in tanks and/or evaporated to solid cakes in an effort to minimize liquid waste storage inventories and convert the waste to immobile forms as soon as practicable.

The following subsections treat these processes in more detail, as well as the disposal of the less radioactive waste generated in the fuel and waste processing operations. Table II.1-3 indicates the sources and products of the waste output from the 200 Areas operations (shown schematically in Figure II.1-35). As indicated in the table, waste is also received from other areas. These transfers are indicated on the flowchart of Figure II.1-2.

TABLE II.1-3

RADIOACTIVE WASTE SOURCES

	Type of Waste					
	Liquid				Solid	Gaseous
	High-Level					
Source	Boiling	Non-Boiling	Intermediate Level	Low Level		
200 EAST AREA						
Purex Plant	X	X	X	X	X	X
B Plant	X	X	X	X	X	X
244-AR Vault	-	-	X	X	X	X
241-A, AX, AY Tank Farms	-	-	X	X	X	X
Critical Mass Laboratory	-	-	-	X	X	X
Semiworks	-	-	-	-	-	X
CR Vault	-	-	-	-	-	X
ITS-1 and 2 Concentrators	-	-	X	X	X	X
241-BX, BY and C Tank Farms	-	-	-	-	-	X
200 WEST AREA						
T Plant	-	X	X	X	X	X
242-T Concentrator	-	-	X	X	X	X
Laundry	-	-	-	X	X	X
231-Z	-	-	-	X	X	X
U Plant	-	-	-	X	-	X
Z Plant	-	X	X	X	X	X
UO_3 Plant	-	-	X	X	X	X
222-S Laboratory	-	X	X	X	X	X
241-SX Tank Farm	-	-	-	X	-	X
Redox Plant	-	-	-	-	-	X
241-TX Tank Farm	-	-	-	-	-	X
242S Evaporator	-	-	-	X	X	X
FROM OTHER CONTRACTORS						
Pacific Northwest Laboratory	-	X	X	X	X	X
United Nuclear Industries, Inc.	-	X	X	X	X	X
Westinghouse Hanford Company	-	-	X	X	X	X
J. A. Jones Construction Company	-	-	-	-	X	-

II.1.1.2.2.1 B Plant Waste Fractionization and Encapsulation [RPB, X.11A, X.25]

B Plant removes ^{90}Sr and ^{137}Cs from high-level radioactive waste resulting from the processing of Hanford reactor fuels. The isolated strontium and cesium fractions are further purified and are doubly encapsulated and stored in monitored water basins which provide both radiation shielding and cooling for the capsules.

Both currently-generated and stored self-boiling wastes are processed by B Plant. A flowchart for these operations is shown in Figure II.1-36. CAW from the Purex Plant is routed underground to B Plant via the 244-AR Vault. The solids are removed from the current acid waste and treated for removal of strontium, while the supernatant solution is processed for cesium removal by precipitation with phosphotungstic acid. The recovered cesium is further processed by ion exchange. Strontium is recovered by processing the acid waste through the solvent extraction system. Stored waste is processed similarly, with the exception that precipitation has already separated solutions into sludges and supernatant liquid in the storage tanks. After processing of the supernatant liquids for cesium removal, the alkaline sludges are sluiced from the tanks, acidified, and transferred by underground piping to B Plant for strontium removal. After clarification, the strontium is recovered by solvent extraction in four extraction columns. The overall strontium recovery rate to date is approximately 85%; the current recovery rate is over 90%. The overall recovery rate of cesium is about 88%; currently, cesium recovery rate averages about 93%.

Following recovery in B Plant, cesium and strontium solutions are purified and stored as liquids in stainless steel tanks equipped for cooling coils. The cesium and strontium are encapsulated in the Waste Encapsulation and Storage Facility (WESF). The cesium solution is transferred to WESF and converted to cesium chloride solution by the addition of concentrated hydrochloric acid. This solution is evaporated to yield solid cesium chloride which is melted. The molten material is vacuum transferred to 316 stainless steel or Hastelloy C-276 cylinders (capsules) where it solidifies as cesium chloride salt. After endcaps are welded on the capsules, they are leak checked with helium, decontaminated and enclosed in outer capsules. Endcaps are welded on the outer capsules and the welds tested ultrasonically. Completed capsules are transferred to the underwater storage basin.

The strontium solution is transferred to WESF where the strontium is precipitated as strontium fluoride by the addition of sodium fluoride. The strontium fluoride is separated by filtration, sintered and the dry powder packed into Hastelloy cylinders. Encapsulation proceeds as described for cesium. The filtrate from the precipitation step is returning to B Plant for rework or disposal. Figures II.1-37 and II.1-38 depict the respective flowsheets for cesium and strontium encapsulation.

Results of the compatibility of cesium chloride and strontium fluoride with their respective capsule materials have been studied.[34] A conservative extrapolation of corrosion test results shows that strontium and cesium inner capsules will maintain their integrity for at least 600 years when stored under water. In this period, radionuclide activity will have decayed to less than 200 millicuries per capsule. When an ultimate disposal method for Hanford radioactive waste is available, the strontium and cesium capsules can be sent to that facility or perhaps to a facility provided for commercial waste disposal. The lifetime of the capsule storage basins in the WESF is expected to substantially exceed the time required to develop an ultimate disposal method. There is no existing plan to convert the capsule storage basins to an "ultimate disposal site."

All liquid effluent streams will be continuously monitored and routinely sampled. Storage basin water will be circulated within a given storage cell. If radioactivity is detected, the water will be transferred to B Plant for rework or disposal and the source of the contaminations determined and appropriate repairs made. Cooling water streams will empty into the B Plant cooling water header. If radioactivity is detected, the cooling water will be diverted and transferred to B Plant for disposition. Gaseous effluents will be passed through HEPA filters to remove radioactive particulates, monitored, and exhausted to the atmosphere via a stack. Solid radioactive waste will be packed in barrels and buried.

II.1.1.2.2.2 Tank Farms Operations [X.11A, X.25, X.24, X.25]

High-level radioactive waste, produced in the chemical processing of irradiated Hanford reactor fuels, is stored in large underground tanks. Self-boiling waste produced by Purex Plant is stored in the 200 East boiling waste storage tank complex. Boiling waste produced at the Redox

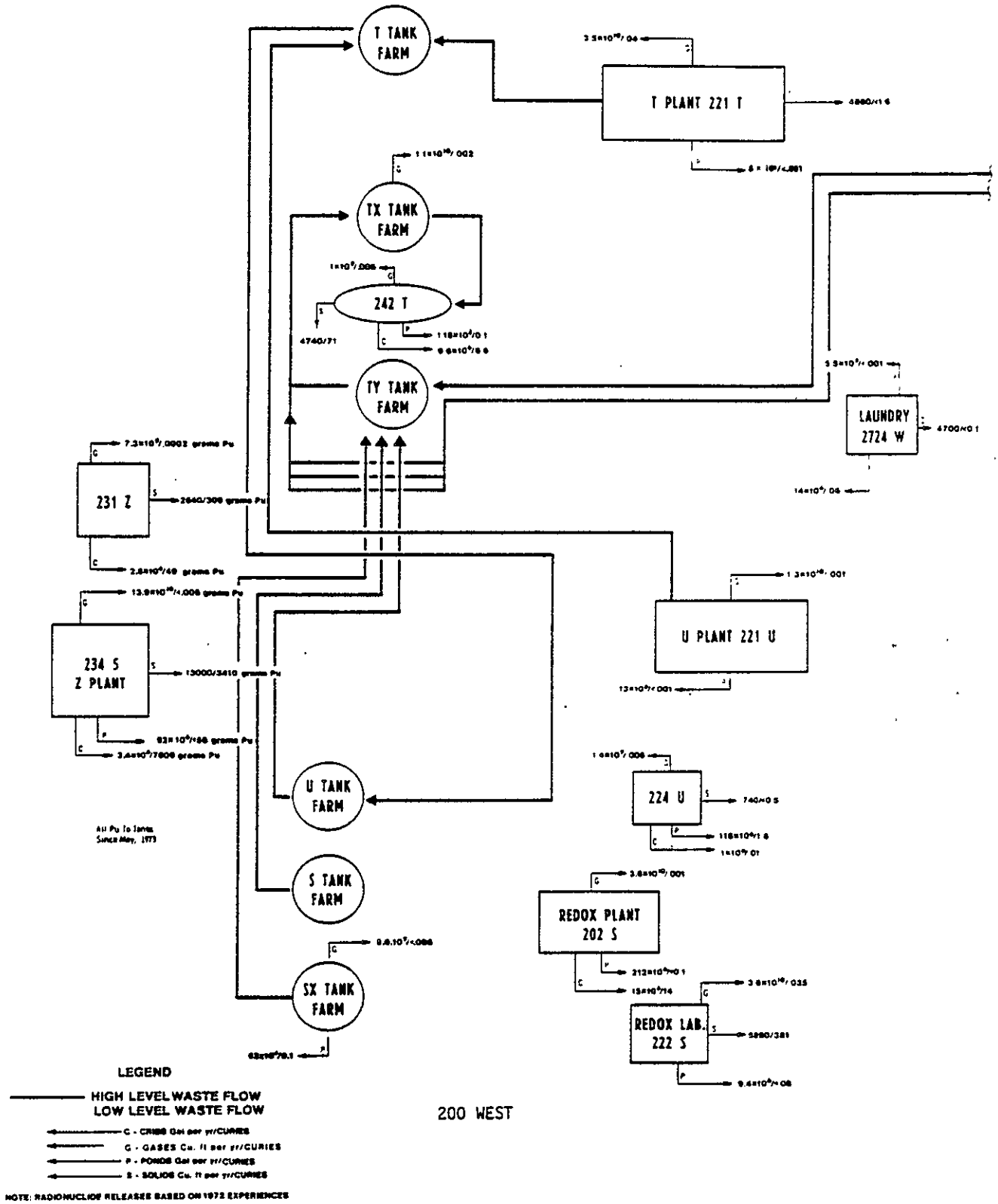


FIGURE II.1-35(a) 200 AREAS WASTE OUTPUT - 1972

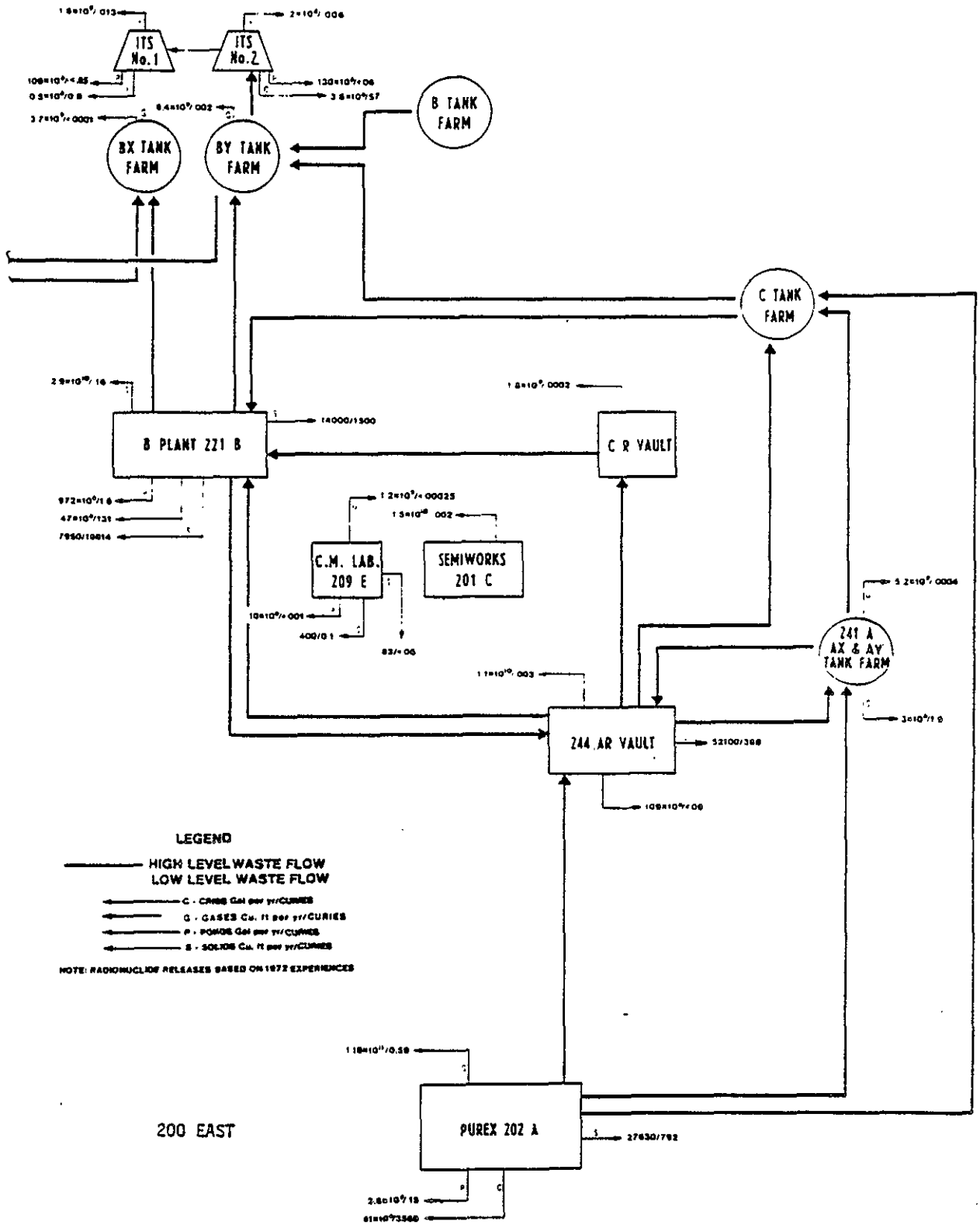


FIGURE II.1-35(b) 200 AREAS WASTE OUTPUT - 1972

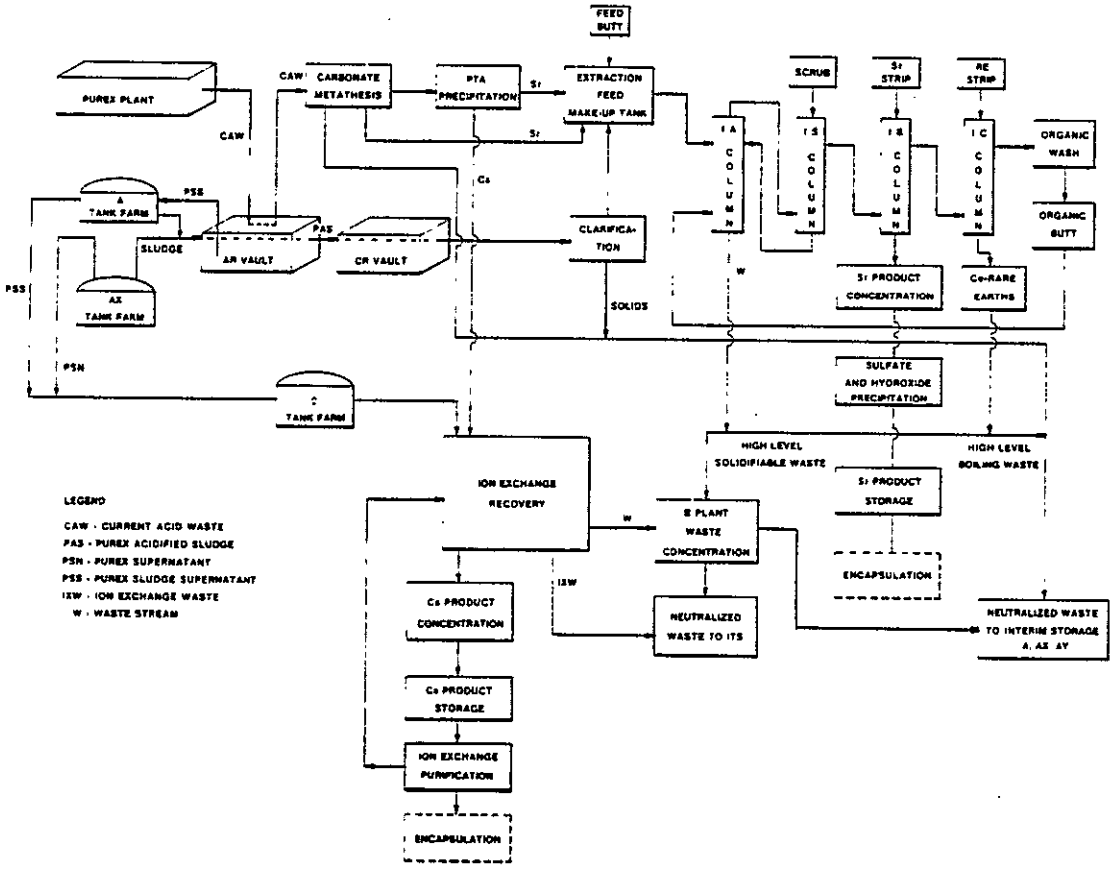


FIGURE II.1-36 WASTE FRACTIONIZATION FLOWSHEET

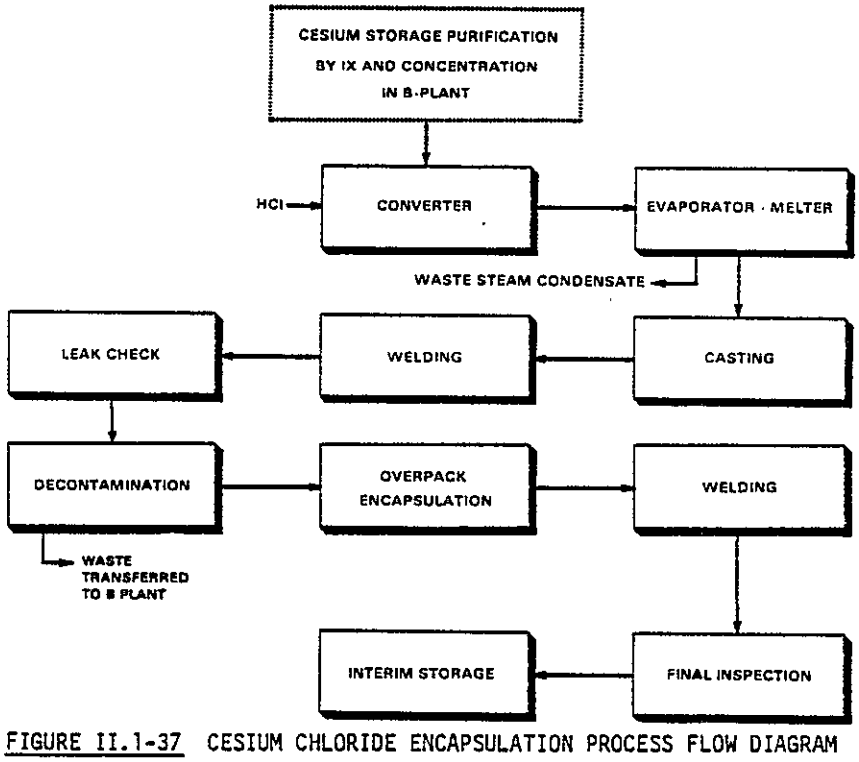


FIGURE II.1-37 CESIUM CHLORIDE ENCAPSULATION PROCESS FLOW DIAGRAM

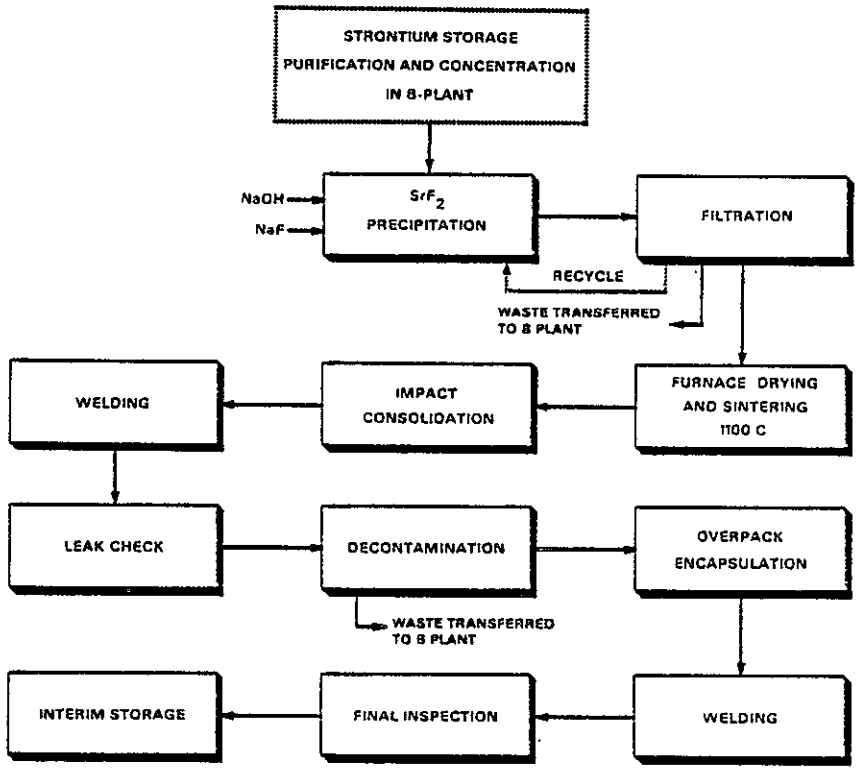


FIGURE II.1-38 STRONTIUM FLUORIDE ENCAPSULATION PROCESS FLOW DIAGRAM

Plant is stored in part of the SX tank farm. High-level waste is neutralized with sodium hydroxide or sodium carbonate, and then stored as an alkaline slurry. The neutralization precipitates a major portion of the fission products, resulting in a solids or sludge layer covered by supernatant liquid.

The accurate measurement of liquid level is difficult in tanks with active bottoms systems containing large amounts of liquid surface, build-up of salt cake at the vertical walls, and bottoms salt cake. From information obtained through operation of the three Hanford evaporative systems, a possible worst case type transfer between a "clean" tank and one with a large amount of salt cake is estimated to differ by a factor of 1.5 between the inches transferred and the inches received. Conversely, for a transfer between clean tanks without salt formation on the walls, one standard deviation uncertainty might be expected to be within 2,000 gallons. Therefore, the magnitude of a detectable loss is very dependent upon the current knowledge of salt and its disposition within the tanks. Other problems are related to surface crusts that present an irregular and often mobile profile of the tank waste-vapor space interface. For example, crustal movements have caused liquid level variations as great as six inches upon occasion. Also, a dry surface crust can render the conductivity probe inoperative. Under abnormal (unplanned) conditions, foaming can interfere with surface measurement until foaming subsides. Special facilities, such as well encased weight factor and conductivity probe measurement systems, are being studied as possible corrections for these latter problems.

High-level waste stored in the A and AX tank farms is presently being processed by B Plant to remove the long-lived fission products. This yields nonboiling waste which can be solidified for in-tank storage as solid salt cake. For B Plant processing, the supernatant liquid is pumped off a given tank, exposing the sludge. The sludge is then broken into a slurry by sluicing with water or supernate, using specially designed high pressure nozzles. The slurry is pumped to holding tanks in the 244-AR Vault where it is allowed to settle, and the supernate is routed to B Plant for cesium removal. The solids are then dissolved by acidification, and that solution is sent to B Plant for strontium removal.

Supernatant liquid from tanks in the SX tank farm has been processed by B Plant. Sludge temperatures in certain SX tanks are being controlled by air cooling, with offgases being partially condensed and returned to the tanks or filtered and discharged to the atmosphere. Sluicing of the sludges is not planned due to the age of the tanks and the possibility of liquid leakage.

No boiling waste is being generated at present since the Purex Plant is not in operation. The only planned new source of boiling waste will be Purex CAW resulting from future processing of irradiated N Reactor fuel. This waste will be routed directly to B Plant for removal of long-lived fission products. However, due to decay heat from the remaining short-lived fission products, the processed waste will self-boil. Storage as a liquid will be required until radioactive decay reduces the concentration of the shorter half-life radionuclides. Such processed waste will be suitable for solidification about 5 years after its generation.

Table II.1-4 presents a summary of tank farm data.[3] The first tanks were for nonboiling waste. Figure II.1-39 is a schematic drawing of a typical nonboiling tank design; Figure II.1-40 presents some tank construction data and the waste characteristics for which the tanks were designed.[3] These tanks are vented to the atmosphere through air-cooled reflux condensers. Instrumentation was provided to measure 1) the sludge and supernate temperature and 2) the liquid and sludge levels in the tanks. A grid of dry wells in each tank farm is used to monitor the soil for radioactive materials, thus serving as a secondary leak detection system. Well sites and well design were dictated by the specific site conditions and the suggested flow path of liquids both above the water table and within the groundwater.

TABLE II.1-4

WASTE STORAGE TANKS[a]

Tank Farm	Tanks In Farm	Capacity/Tank (gal)	Capacity/Farm (gal)	Year Constructed	Cost/Farm[b] ($)	Cost/gal ($)
T	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	3,087,000	0.469
U	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	2,969,000	0.45[illegible]
B	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	3,019,000	0.459
C	16	54,500 (4) 530,000 (12)	6,578,000	1943-44	2,938,000	0.447
BX	12	530,000	6,360,000	1947-48	2,208,000	0.347
TX	18	758,000	13,644,000	1947-48	5,859,000	0.429
BY	12	758,000	9,096,000	1950-51	2,651,000	0.291
S	12	758,000	9,096,000	1950-51	3,961,000	0.435
TY	6	758,000	4,548,000	1951-52	1,846,000	0.406
SX	15	1,000,000	15,000,000	1953-54	3,983,000	0.266
A	6	1,000,000	6,000,000	1954-55	5,865,000	0.978
AX	4	1,000,000	4,000,000	1963-64	2,577,000	0.644
AY[e]	2	1,000,000	2,000,000	1968-70	3,125,000	1.562
AZ[c,e]	2	1,000,000	2,000,000	1971-75	6,200,000	3.100
	153[d]		98,056,000		50,288,000	0.513 Avg

(a) In addition to the tanks listed, three new tanks (SY tank farm) are under construction.
(b) Includes original tank farm cost plus improvements, including instrumentation, agitation systems, and transfer lines from separations plants. Operating costs are not included. The A and AX farm costs include the actual cost of $761,000 for Project CAC-970, Essential Waste Routing System, and an estimated cost of $280,000 for Project IAP-609, Purex Tank Farm Vent System Expansion. The costs for these two projects are equally divided between A and AX farms.
(c) Both tank structures are complete. One has the piping interties and can be used; the other is not yet piped into the system.
(d) The 153 total includes one tank considered as under construction as noted in footnote (c).
(e) Double-wall tanks.

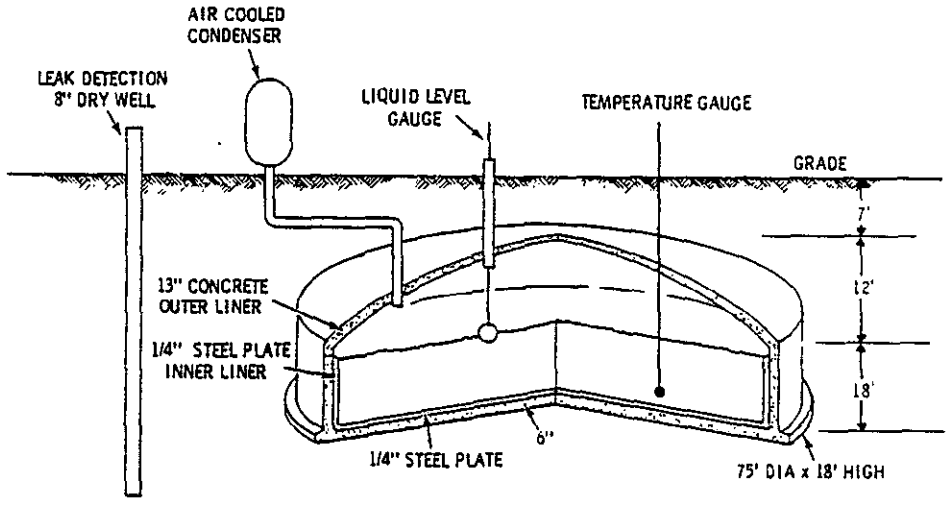


FIGURE II.1-39 TYPICAL STORAGE TANK FOR NONBOILING WASTE

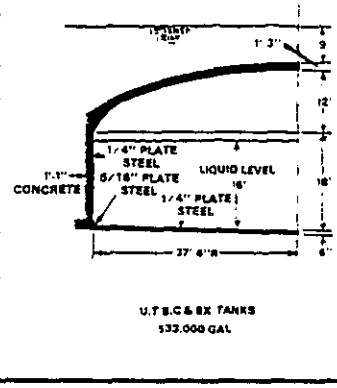
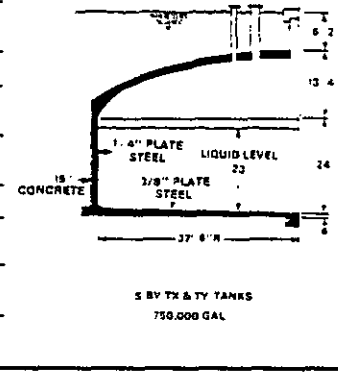
SPECIFIC GRAVITY	1.2		1.25	
MAXIMUM TEMPERATURE	220° F		220° F	
HEAT EVOLUTION (PER TANK)	NEGLIGIBLE		LESS THAN 10^5 BTU/HR (0.15 BTU/GAL/HR)	
BOILING PERIOD	NONE		NONE	
VAPOR PRESSURE	NONE		NONE	
STORAGE WASTE VOLUME	4 000 GAL/T		4 000 GAL/T	
pH	8 TO 10		8 TO 10	
CORROSION	CONCRETE DOME EXPOSED TO VAPORS		CONCRETE DOME EXPOSED TO VAPORS	
SLUDGE	NO CONTROL REG. OF SLUDGE TEMP		NO CONTROL REG OF SLUDGE TEMP	
CIRCULATION	NONE		NONE	

FIGURE II.1-40 WASTE CHARACTERISTICS USED FOR DESIGN OF NONBOILING LIQUID WASTE TANKS

Newer tanks were built to contain waste with greater heat generating characteristics, as shown in Figure II.1-41. These tanks are of the same general construction as those described for nonboiling waste. However, additional features are provided to permit self-concentration. The vapors are routed through headers to a de-entrainer and water-cooled condensers, which are vented to the atmosphere after passing through a wire mesh de-entrainer, high efficiency filters, and exhaust blowers. As shown in the schematic of Figure II.1-42, condensates can be sent to an underground disposal site or can be returned to the waste tank to avoid overconcentration. These tanks, shown in Figure II.1-43, are provided with airlift circulators for the agitation of the tank contents to prevent localized temperature buildup in the supernate and the resultant bumping caused by sudden steam release.

Each A and SX farm tank is closely encompassed by a complex of vertical dry wells. In addition, all A farm tanks and nine of those in the SX farm (Tanks 105, 107, 108, 109, 110, 111, 112, 114 and 115-SX) have systems of three underlying laterals 10 feet beneath the concrete bases of the tanks (Figure II.1-43). These facilitities provide for the early detection of leaking by monitoring the soil surrounding the tank. Each AX farm tank has a drainage grid beneath the tank liner which connects to an associated leak detection sump. Since 1968, all tanks constructed or planned are double-wall type and all are similar in design. Figures II.1-41 and II.1-44 show schematic drawings of the tanks. Tanks for boiling liquid waste storage (AY and AZ) have air-lift circulators with associated air handling system in order to agitate the waste; tanks for nonboiling liquid and salt cake storage service (SY tanks under construction and the six tanks planned for each of FY 1976 and 1977) do not have air-lift circulators. Each tank requires 360 tons of steel

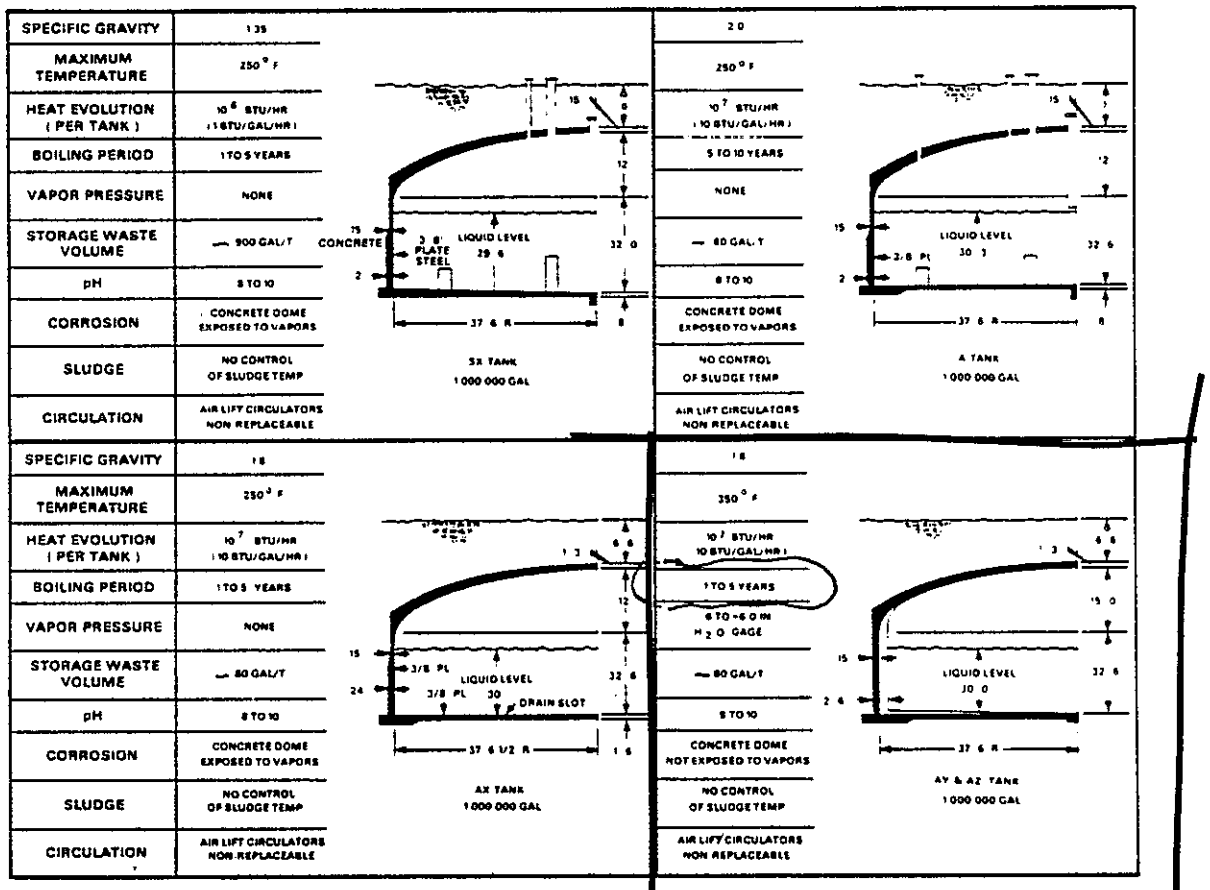


FIGURE II.1-41 WASTE CHARACTERISTICS USED FOR DESIGN OF BOILING WASTE TANKS

and 1000 cubic yards of reinforced concrete. The design life of these tanks for liquid waste or salt cake storage is at least 50 years. The steel utilized along with heat treatment exhibits the lowest corrosion rate of the many steels considered for this use. The primary tank is fabricated from ASTM-A515 Grade 60 steel, with wall thickness varying from 1/2 inch at the bottom to 7/8 inch at the knuckle to 3/8 inch at the top. This tank is heat treated prior to use. The secondary steel wall (same type steel) consists of 3/8-in. thick plate. An annulus is provided between the two tanks to collect leakage from the primary tank; capability is provided to detect and pump out liquids from the annular region. Appurtenances are provided to pump liquids and slurries, to permit sluicing of solidified waste if necessary, to monitor tank liquid level and temperature and to provide air agitation for boiling waste. Extensive piping interties are provided to move liquids and slurries between tanks, tank farms, evaporators and operating production plants. The major benefit of these double-wall tanks is to eliminate leakage of high-level liquid waste to the soil for the interim storage period until a terminal disposal method is developed.

A temperature element, liquid level instrumentation, and a radiation detector are located between tank and liner to monitor for any leakages from the primary tank. Any leakage which might be detected can be returned to the tank via an installed pump. Two additional tanks (AZ tank farm) similar to the AY farm tanks are being added in the 200 East area; one is complete and can be used and the other is complete except for piping connections into the system. Three additional tanks (SY tank farm) are under construction in the 200 West area. The design features of the double-wall tanks are shown in Figure II.1-44.

Extensive piping interties exist within and between tank farms so liquid can be transferred to or from any tank in the system. Within tank farms, certain tanks require pump-out jumpers or short lengths of overground piping to be installed before pumping can be initiated. These installations can be made in a short period of time (hours to days).

A total of 18 single-wall waste storage tanks have experienced confirmed leaks at the time this statement was prepared (Appendix II.1-C, Part 8). In each case, upon confirmation of the leak, the tank contents were pumped to another tank as rapidly as possible.

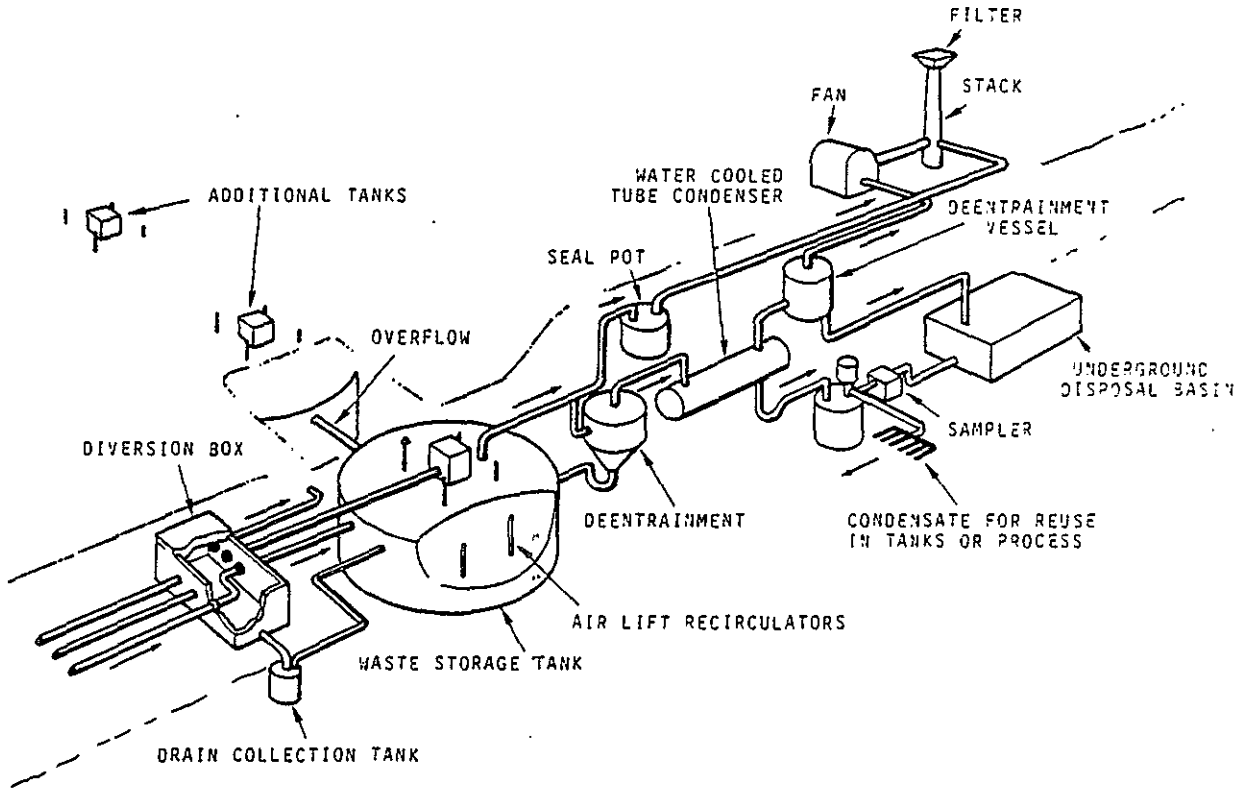


FIGURE II.1-42 TYPICAL HIGH-LEVEL BOILING WASTE STORAGE FACILITY

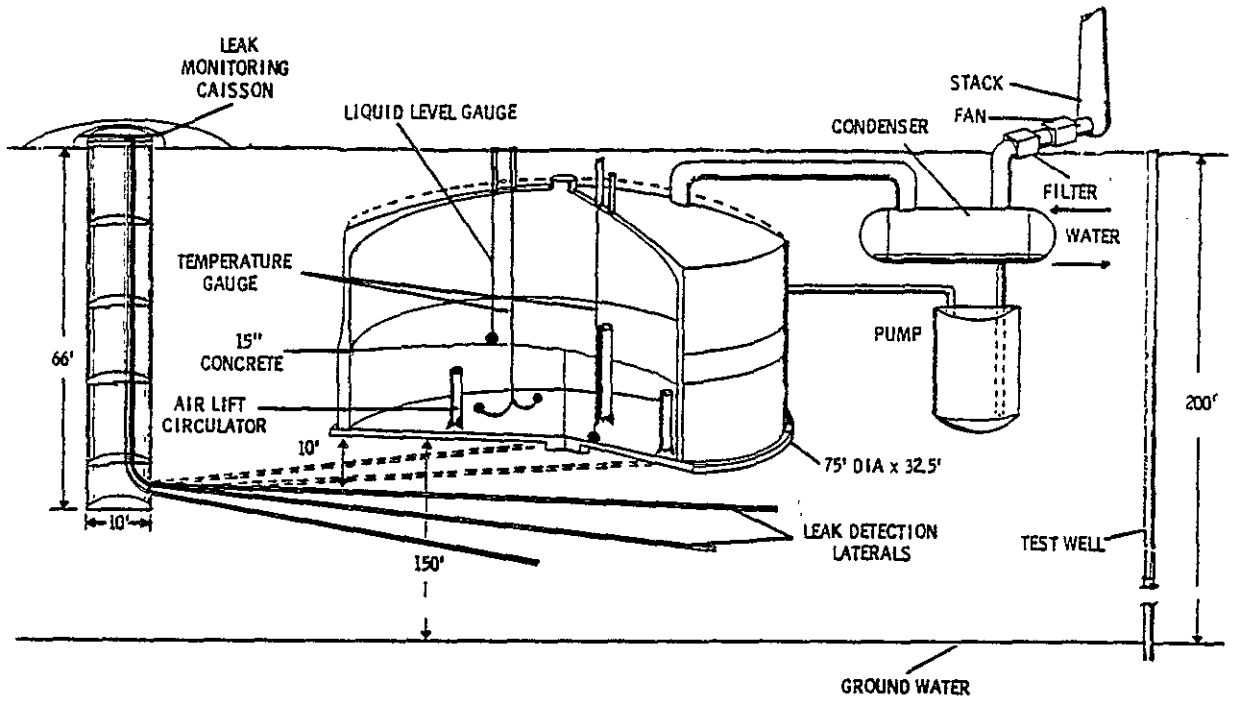


FIGURE II.1-43 TYPICAL CONTROL AND SAFETY FEATURES FOR HIGH-LEVEL BOILING RADIOACTIVE WASTE STORAGE

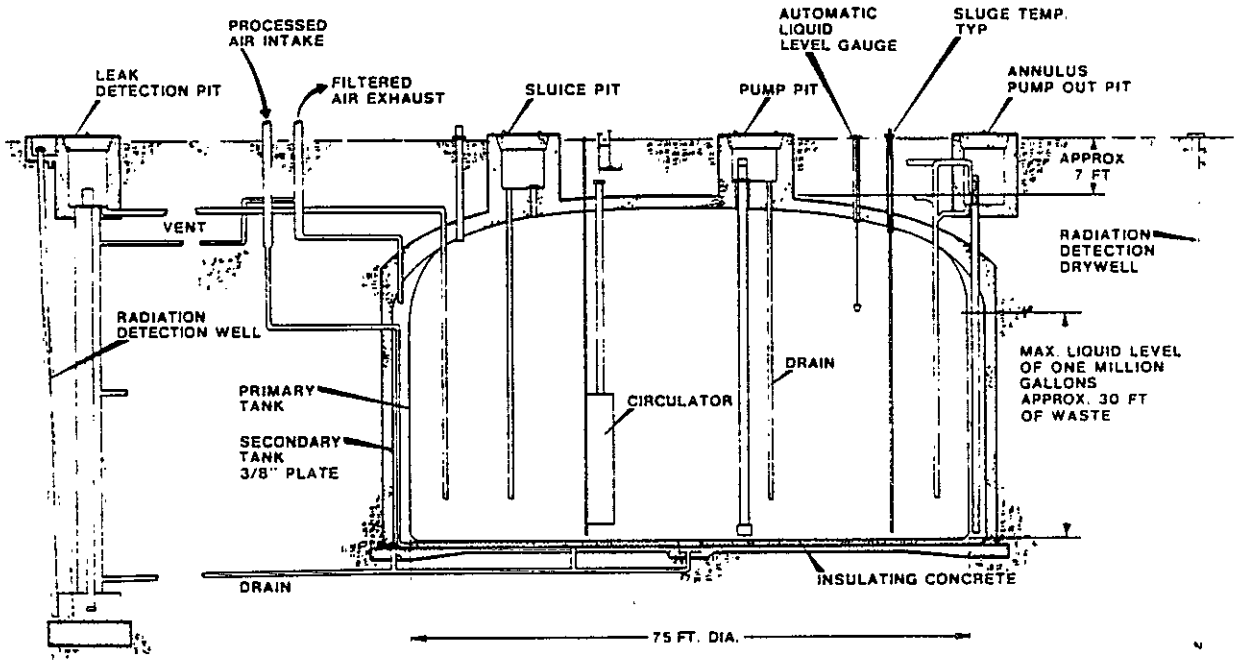


FIGURE II.1-44 DOUBLE-WALL BOILING WASTE TANK

In addition to these 18 confirmed leakers, another 14 tanks have been removed from service because of indications that the tank integrity was suspect. Reasons for questioning the operating quality of tanks have included: 1) excessive pitting or corrosion of the carbon steel tank liner as determined by photographic inspection techniques; 2) unexplained anomalies in leak detection measurements which might indicate leakage but which could not be confirmed as such; and 3) experience records with other tanks of the same age and service which would indicate that the effective useful life of such tanks had been reached.

Current operating policy at Hanford requires that tanks of questionable quality be pumped out and removed from further service as fast as spare tank space is made available by the current waste solidification program. Eleven tanks which have been filled with salt cake are no longer available for storage of liquid waste.

II.1.1.2.2.3 Waste Solidification and Stabilization [X.4, X.11A, X.18, X.24, X.25]

To ensure continued waste containment for long periods, nonboiling high-level liquid radioactive waste is being converted to salt cake. This is accomplished by evaporation and crystallization, and solids accumulation in existing storage tanks.

Currently, the four In-tank Solidification (ITS) systems in operation are ITS-1 and -2 (no longer in use in 1975) in the 200 East Area and the 242-T and 242-S evaporators in the 200 West Area. Figures II.1-45, II.1-46, II.1-47 and II.1-48 provide schematics on the operations of these evaporator systems. Organic liquid waste is also stored in tanks pending acquisition of equipment to process it. The waste is primarily degraded solvent which can no longer be used in solvent extraction processes.

The primary function of the ITS systems is to concentrate the nonboiling waste to produce a partially mobile salt cake. Ideally, the feed stream would be concentrated as far as possible so that the inventory of concentrated bottoms is minimized and the maximum amount of solids is formed and precipitated. Each of the ITS systems (Figure II.1-49 shows the 242-S bottoms tank system) include a heat exchanger for water evaporation and a series of bottoms tanks (bottoms loop). After concentration in the evaporator, the bottoms stream is routed through the bottoms loop. Heat losses to the ground and the tank ventilation systems progressively lower the bottoms temperature so that eventually the stream is saturated and solids are formed and deposited in the bottoms tanks. Some crystal growth occurs in tanks upon cooling but most occurs in the crystallizer. The saturated bottoms supernate stream is blended with fresh feed and recycled back to the evaporator.

When a tank is filled with salt cake, an estimated 50% of the salt cake volume is occupied by interstitial liquids. In addition supernatant liquid may be above the salt cake. The supernatant

9 1 1 1 8 9 0 4 6 3

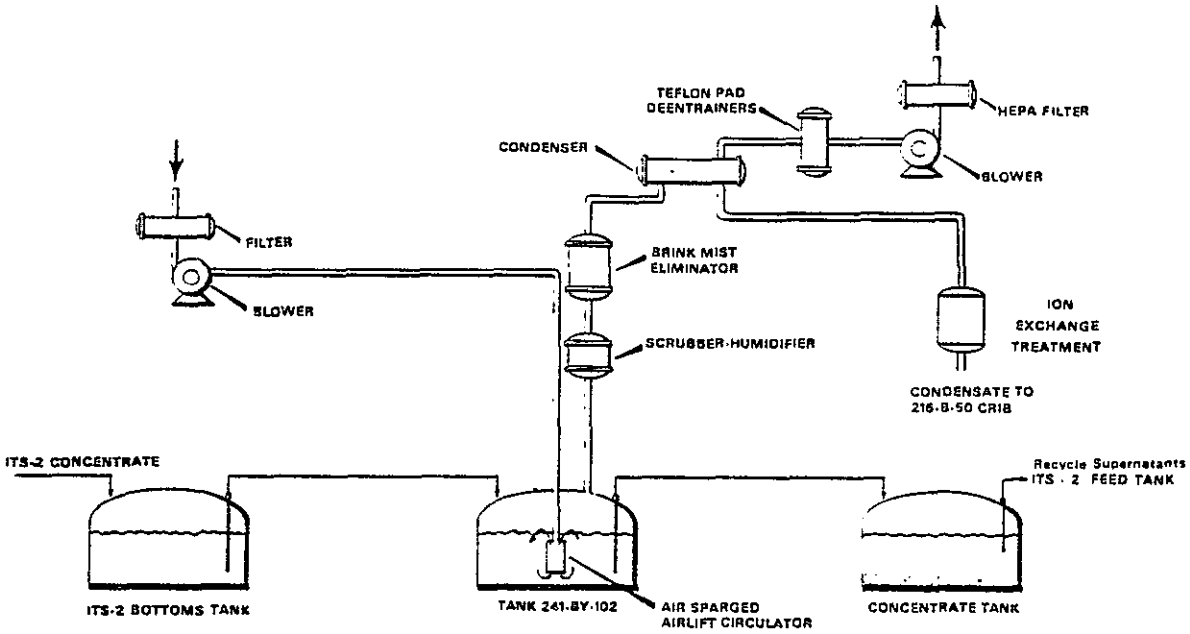


FIGURE II.1-45 IN-TANK SOLIDIFICATION-1 SCHEMATIC

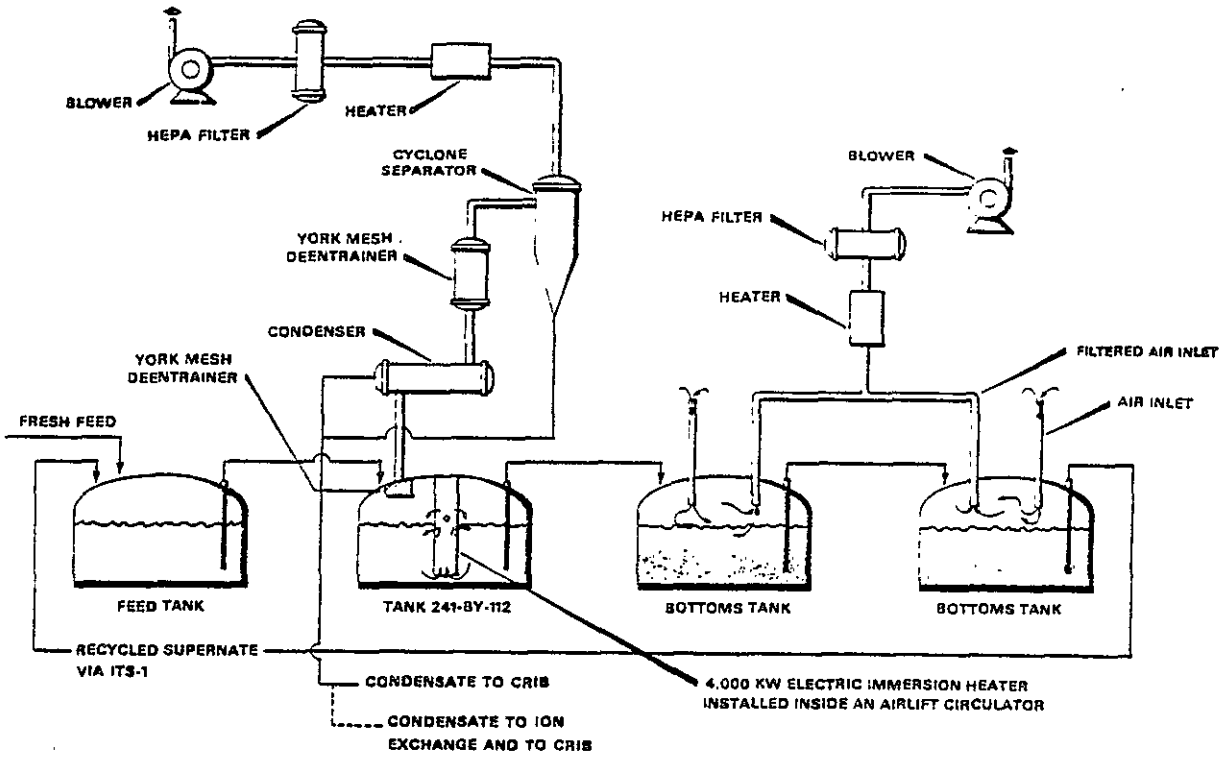


FIGURE II.1-46 IN-TANK SOLIDIFICATION-2 SCHEMATIC

liquid and as much of the interstitial liquid as possible will be pumped from the tanks via salt wells reaching to the bottom of the tanks. To remove all of the interstitial liquid may not be practical because of capillary holdup in the salt cake and limits to removing a residual heel from the bottom of the salt well. The interstitial liquid may remain associated with the

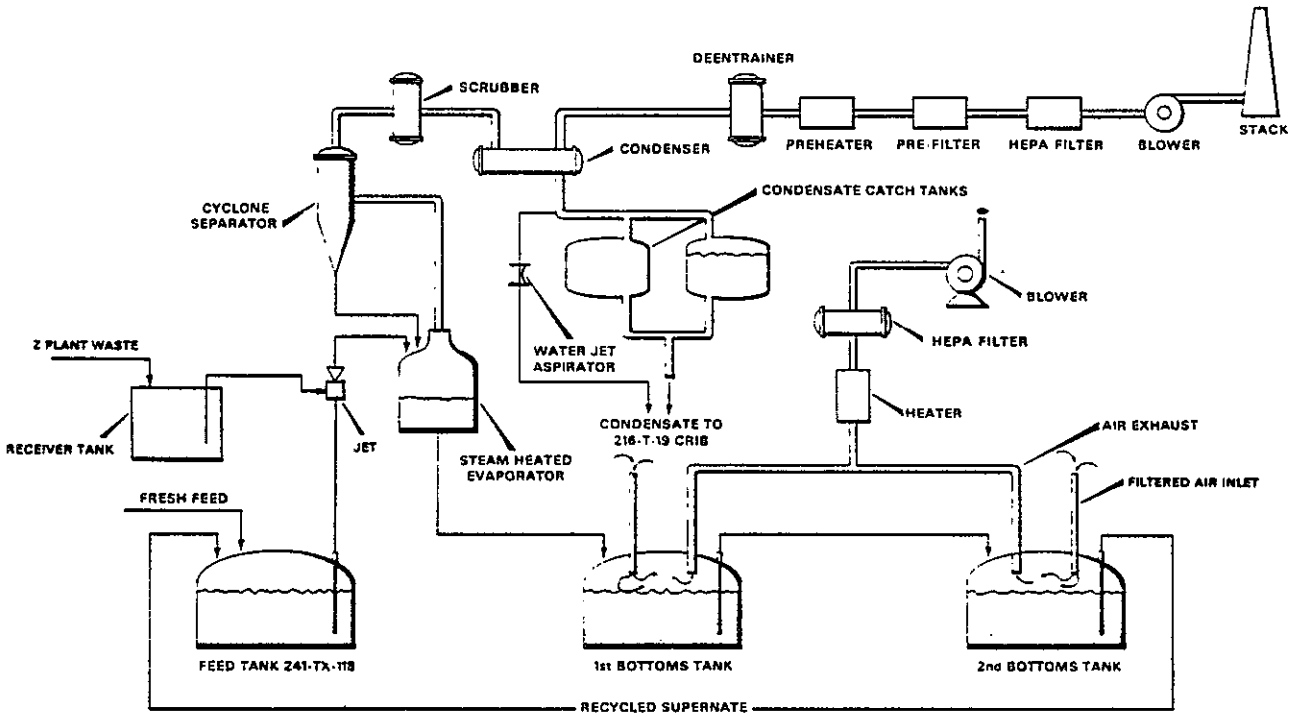


FIGURE II.1-47 242-T EVAPORATOR SCHEMATIC

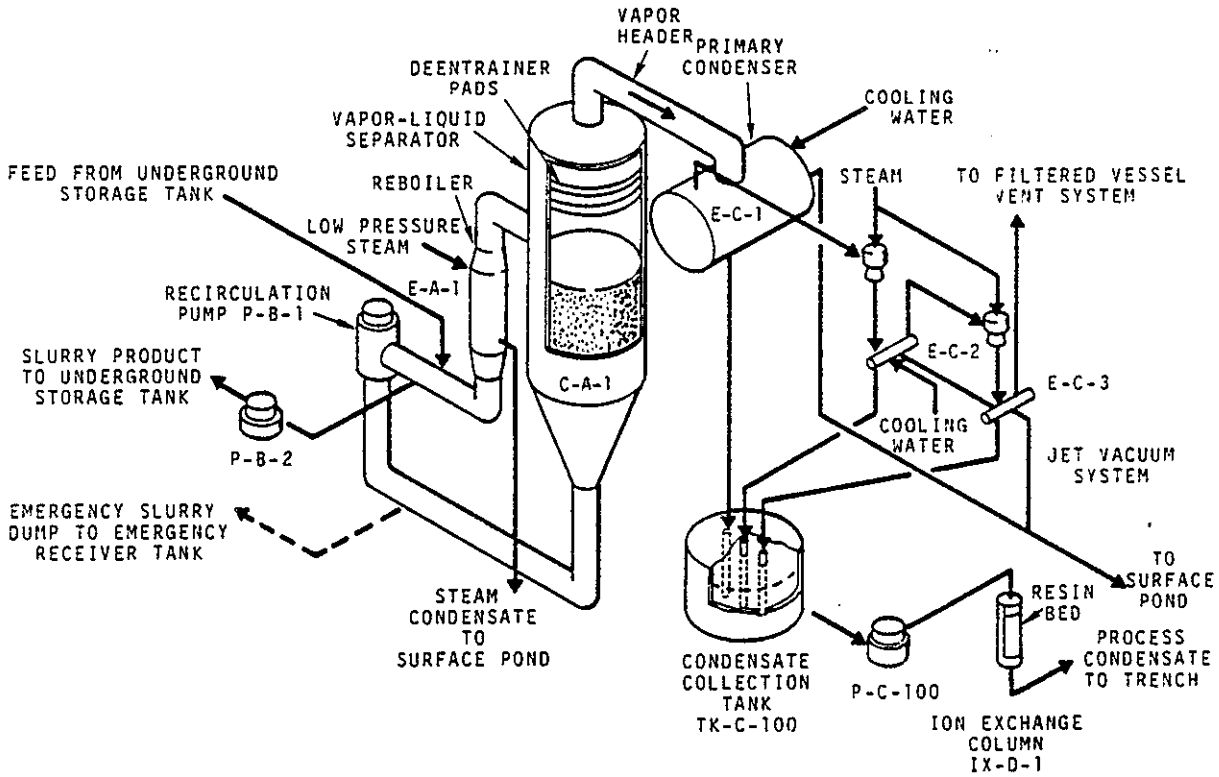


FIGURE II.1-48 242-S VACUUM EVAPORATOR-CRYSTALLIZER

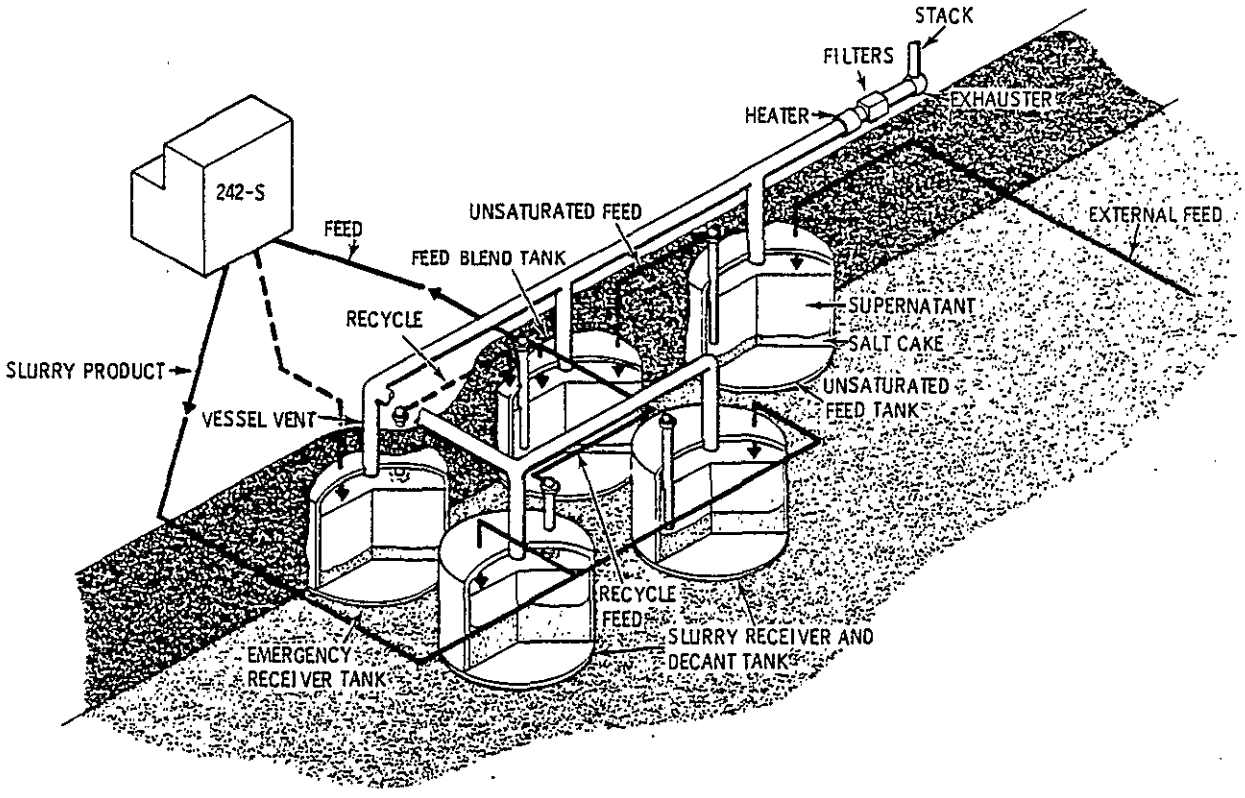


FIGURE II.1-49 242-S BOTTOMS TANK SYSTEM

pumped-out salt cake. As the salt cake then warms up from the energy released because of radioactive decay, a tendency for concentration by evaporation will occur reducing further the volume of residual liquid. The current development programs involve determination of the limits of removal of interstitial liquid by pumping from the salt wells. This effort will test the predictions.

Upon failure of the carbon steel liners of tanks containing salt cake, the residual liquids will be subjected to potential leakage to the soils underlying these tanks. Estimation of the volume of such leakage is difficult since much of the liquid will continue to be held in the salt cake by capillary action. The small volume which may leak would be held in the soils underlying the tanks and held there by capillary action, much as has been observed in the leakage which has previously occurred. Vertical monitoring wells and horizontal laterals under tanks would detect such leakage.

An underground storage tank which is filled with salt cake from one of the ITS systems, and which has the maximum amount of interstitial or residual liquor removed, is considered stabilized for interim storage. Until the waste is stabilized the integrity of the tank and process lines are of primary importance and under continual surveillance.

Liquid level measurements are taken in active tanks (having recent transfers to or from) twice per shift and in inactive tanks once per shift. Material balances are made every 2 hours during transfers, and a final material balance is made at the completion of the transfer and drain back from line holdup. In-tank temperatures in some tanks are monitored every shift.

A network of dry wells is in place or planned for every tank except those in the AY and AZ farms, which have internal leak detection systems as a part of their construction. Similar systems are associated with the AX farm tanks, but single-wall construction has predicated the additional protection provided by dry wells. The AX leak detection systems consist of a pattern of drain channels in the underlying concrete base slabs which route leakage to 60-ft deep wells situated adjacent to each tank. Each well is equipped with weight factor/specific gravity and radiation monitoring instrumentation and pumpout facilities. The AY and AZ farm tanks, being of double-wall construction, have the unique feature of leak detection and pumpout facilities within the annular space between the two steel walls. In addition, all A farm tanks and nine SX farm tanks (105, 107, 108, 109, 110, 111, 112, 114 and 115) have systems of three underlying laterals about

10 feet beneath the concrete bases. These dry wells and laterals are monitored for radiation increases on a frequency determined by the status of the tank, e.g., whether the tank is active, inactive, or in restricted use.

Subsequent to the stabilization of solid salt cake in a tank for interim storage, the plan is to core-drill, analyze, and characterize the salt cake. Then the tank will be isolated by cutting and blanking all process piping to and from the tank, blanking all risers and equipping the tank with a filtered ventilation system. Subsequent surveillance of a stabilized, isolated tank will consist of periodically obtaining in-tank photographs, sampling and analyzing the vapor space, monitoring the in-tank temperatures, and monitoring the dry wells and laterals.

II.1.1.2.2.4 Liquid Waste Streams and Transfer Lines

The 200 Area activities of fuels processing, waste partitioning and plutonium processing require the transfer of large quantities of high-level radioactive waste within and between the areas. The extensive systems and lines which show the sources and destinations of the radionuclides and available transfer lines are described in Appendix II.1-C, Parts 3 and 4.

Stainless steel underground waste transfer lines in concrete encasements are in place between the 200 East and 200 West Areas for transfer of radioactive liquid waste between these areas (Appendix II.1-C). These lines are used to transfer neutralized high-level wastes between 200 East and 200 West Areas for processing, underground storage, evaporation and solidification.

II.1.1.2.2.5 Cribs and Ponds [X.4]

Certain liquid effluents are released to the ground via underground structures called cribs. These effluent streams are primarily process and steam condensates which have a potential for releasing radioactivity upon process upset or equipment failure. The amount of radioactivity normally in these streams is very small; the concentration is generally less than 0.05 uCi/ml (except tritium). While some of these streams have been classified as intermediate-level liquid waste (5×10^{-5} to 10 uCi/ml), other streams have radioactivity concentrations well below ERDAM-0524 Table II guides for uncontrolled areas and have diversion capability if process upsets occur. All of these streams are within controlled areas.

A crib is constructed by digging a ditch about 20 feet deep and up to 1400 feet long, backfilling with rock and covering with an impermeable membrane and soil. A pipe running the length of the crib is designed to distribute the liquid uniformly along the crib length (Figure II.1-50). The released liquid percolates through the soil. The soil column between the bottom of the crib and the groundwater is 150 to 300 feet thick and contains up to 50% silts and sand, having some clay content. Since percolation rates through these materials are slow, the liquid spreads laterally and involves much more soil than that directly beneath the crib. Formerly, when aqueous waste

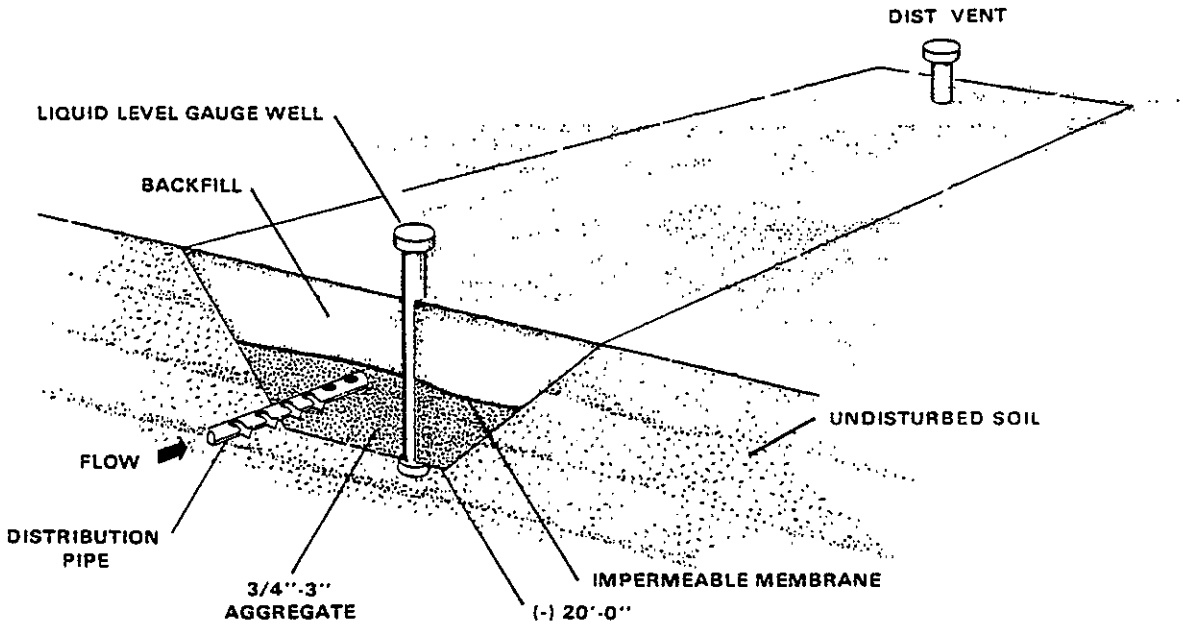


FIGURE II.1-50 TYPICAL CRIB FOR AQUEOUS WASTE

containing organic or complexing agents were discharged to the ground, the volume was limited to what was believed the soil could retain above the groundwater by capillarity.

A typical crib disposal site is shown in Figure II.1-51. While the coarse gravels have little capacity to sorb or filter radioactive materials, the clays have good ion exchange properties and make good filter beds. The soil columns in the 200 Areas exhibit cation exchange capabilities of 2.5 to 10 milli-equivalents/100 g of soil. The ion exchange capacity of the clays varies widely with the type of ion being sorbed (Figure II.1-52). For example, tritium and nitrate ions are only slightly sorbed, if at all. Ruthenium is held relatively well, but a fraction of the ruthenium is of such ionic form that little sorption takes place. The tritium, nitrate, and ruthenium then flow to the groundwater at essentially the same rate as the downward percolating water from the crib. These materials may at times enter the groundwater directly below a crib at concentrations above the appropriate limits for drinking water but are rapidly diluted below such limits. Cesium and strontium are tightly held by the soil, most being held within a few tens of feet below a typical crib. Plutonium is held very tightly by the soils, with essentially all of it held within 10 feet of the point of release.

An extensive network of wells is provided for sampling groundwaters. Groundwaters associated with waste disposal sites are routinely sampled and analyzed. About half of the wells are sampled quarterly and about half are sampled semiannually. Some sampling is done by lowering a container on a cable down the well to the water table; some is by pumping from the well with samples collected from the pumped water. Since sampling by the pumping method is preferred, wells are being modified and equipment is being installed to provide most sampling by this technique. Samples are analyzed under an audited quality control program. When long-lived radionuclides, such as ^{90}Sr, ^{60}Co, or ^{137}Cs, are detected in the groundwaters at concentrations approaching 1/10 of the concentration guide[4] for drinking water, the crib site is deactivated, and the process effluents are routed to a new crib. Only a few cribs were used to the point of reaching this limit. In those cases, the radionuclides are still observed to be bound to the soils near the point of entry to the groundwater system.

A total of 177 cribs have been provided for disposal of liquid waste since startup of the 200 Areas facilities. Of these, 144 have been deactivated, 8 have not been used, 10 are in standby, and 15 are currently being used for disposal of liquid waste from normal processing operations. The shutdown of most Hanford reactors and the resultant decrease in reactor fuels processing, coupled with additional waste treatment of several intermediate-level liquid waste streams, resulted in a major reduction in the quantity of radionuclides discharged to the ground via cribs during the past several years.

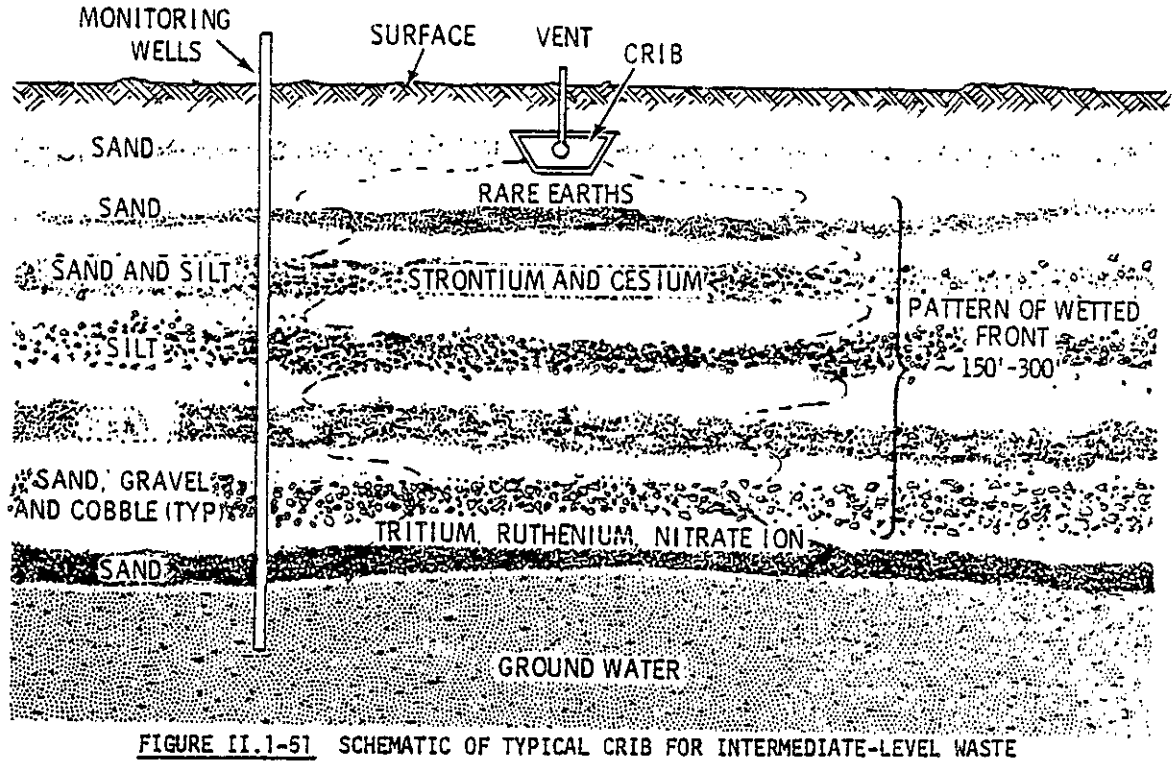


FIGURE II.1-51 SCHEMATIC OF TYPICAL CRIB FOR INTERMEDIATE-LEVEL WASTE

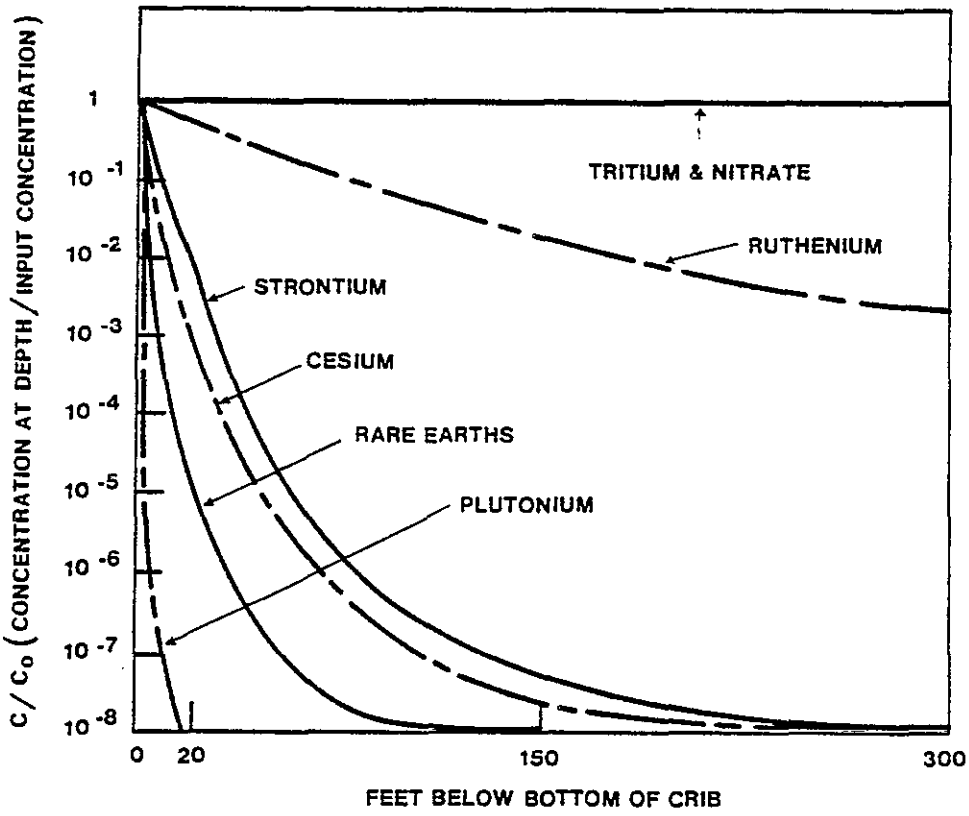


FIGURE II.1-52 APPROXIMATE SORPTION PATTERNS FOR TYPICAL HANFORD DISPOSAL CRIB

Approximately 80% of the process condensate overheads from concentration of Purex first cycle high-level waste is routinely recycled to the process. Total recycle of this stream is planned. Ammonia scrubber waste, previously routed to a crib, will be collected and routed to a waste evaporator for decontamination. Funds were requested to provide recycle of another Purex process condensate stream (from concentration of back-cycle waste) and to provide improved monitoring, diversion, and collection of Purex steam condensate for cleanup in the event this stream should become contaminated due to failure of process vessel heating coils. Process condensate overheads from the B Plant high-level waste concentrator will be batch collected, sampled, and analyzed prior to discharge, when the currently funded project is completed in CY-1975. If above discharge limits, this waste stream will be recycled. Improved monitoring, diversion, and collection of B Plant steam condensate for cleanup will also be provided by this project.

Process condensate overheads from the self-boiling 241-A, AX, and AY waste storage tanks are treated via an ion exchange column to remove ^{137}Cs and ^{90}Sr. Process condensate overheads from the ITS units 1 and 2 are also treated via an ion-exchange to remove ^{137}Cs prior to discharge.

Process condensates from the 242-T Waste Evaporator are batch collected and monitored; they can be recycled, if necessary. Liquid waste from the operation of Z Plant, containing essentially all of the plutonium-bearing liquid waste from that operation, is routed to underground waste storage tanks via the 242-T Waste Evaporator. Currently no appreciable quantity of plutonium is discharged directly to the ground. The plutonium discharged to ground in the 200 Areas with the Purex Plant processing about 900 tons of uranium per year is currently estimated to be 13 g/yr. The actual plutonium discharged to ground during the first 6 months of CY-1974 was less than 5 grams (based on limits of analytical detection). Process condensates from the new 242-S Waste Evaporator-Crystallizer are treated via ion-exchange to remove ^{137}Cs prior to discharge. All waste from this facility meets surface discharge limits. When currently funded plant modifications are in place, the total quantity of radioactive materials discharged to the ground via cribs should be reduced to less than 100 curies and 13 grams of calculated plutonium

9 1 1 1 8 9 1 0 4 9 3

annually.* Conceptual design of facilities are proceeding to reduce total annual discharges to less than 60 curies (except tritium) and alternatively to meet drinking water standards for all discharges.

The chemical processing operations use very large quantites of water, most of which never come in contact with radioactive materials. This low-level aqueous waste, which is primarily cooling waters with some steam condensates, is discharged to ponds for evaporation and/or percolation through the ground to the groundwater. The upper limit of contamination of such discharges is set at 5×10^{-5} μCi/ml of mixed fission products or alpha emitters.** Radiation monitoring instruments, with alarms, are installed on most effluent streams flowing to pond discharge points to alert operating personnel to any abnormal radioactive release. Currently, radiation monitors on two streams (AR Vault steam condensate and cooling water and B Plant cooling water) will, in the event of abnormal levels, activate diversion valves routing the wastewater to unlined ditches instead of the larger pond areas. Funds are now available to line these ditches for containment and rerouting of the contaminated wastewater for future decontamination should diversion occur. Funds were requested in FY-1975 budget to provide similar capability for the Purex Plant wastewater.

Approximately, 130 billion gallons of cooling water and steam condensates have been discharged to 30 surface ponds and ditches in the 200 Areas since the start of chemical processing operations. Approximately, 360 acres of land have been used for these waste disposal operations, with about 180 acres of this total still in use.

Radionuclides discharged to these sites, primarily from accidental releases due to equipment failures, are filtered or sorbed and held in the soil beneath the pond or ditch area except for ^{106}Ru and tritium. Where ponds or ditches were removed from service, contaminated sediments were either removed or buried in place. Liquid levels in currently used ponds minimize exposure of any contaminated sediments to plant and animal life. (Figure II.1-53 shows a typical pond.)

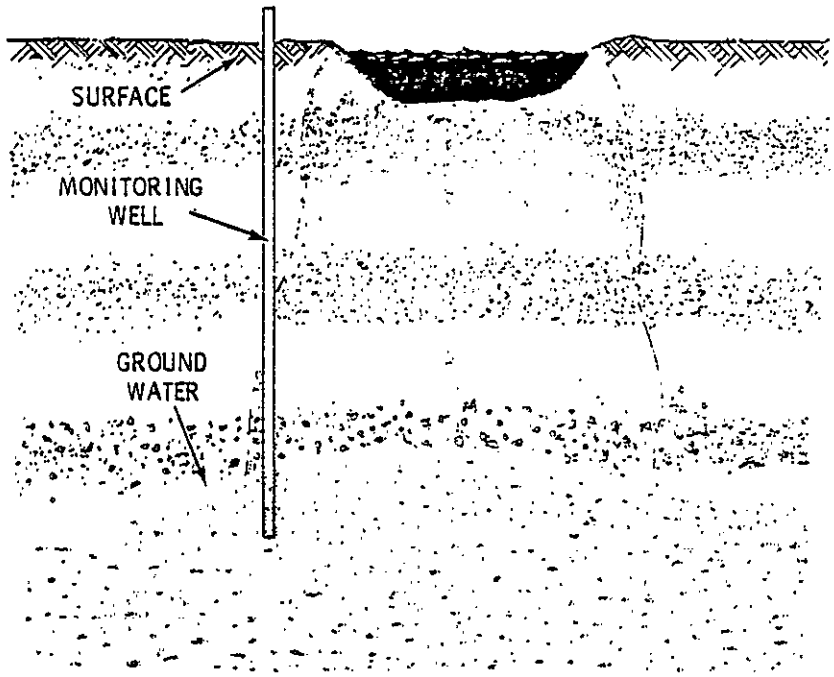


FIGURE II.1-53 SCHEMATIC VIEW OF TYPICAL POND RECEIVING LOW-LEVEL AQUEOUS WASTE

* The quantity of plutonium released is based upon the detection limit for plutonium. Therefore, the quantity reported is a hypothetical number determined by multiplying the plutonium concentration detection limit by the volume of liquid effluent discharged to the cribs in 1 year.

** In this context, "mixed fission products" signifies fission products having concentration ratios approximating those present in Hanford reactor fuels from 6 to 12 months subsequent to reactor discharge.

II.1.T.2.2.6 Buried Storage [X.24]

More than 5 million ft^3 of contaminated solid waste of widely diverse nature and contaminated to varying degrees with radioactive materials have been buried on the 200 Area plateau since 1944. This waste was buried in 19 sites using approximately 155 acres of land. Prior to 1968, essentially all of the waste buried at these sites was generated by the 200 Areas operating facilities. Since 1968, waste generated by 300 Area operations was also buried in the 200 Areas sites. Beginning in December 1973, waste from reactor operations in the 100 Areas was sent to the 200 Areas for burial. Small volumes of solid waste, generated by offsite AEC operations, were and will continue to be buried there.

Solid radioactive waste buried in the ground is considered to be in long-term storage. An exception is that waste buried after April 30, 1970, which contains or is suspected of containing transuranium nuclides; this is considered to be in interim storage (20 years). Large items of solid waste, such as failed equipment from locations where the presence of transuranium nuclides can be safely ruled out, are packaged in concrete boxes and buried in industrial waste burial trenches. Small items of failed equipment and trash-type contaminated waste, from locations where the presence of transuranium nuclides can be safely ruled out, are packaged in cardboard cartons, wood boxes, or steel or fiber drums and buried in the so-called "dry waste" trenches. (A schematic drawing of the solid waste burial trenches is shown in Figure II.1-54.)

The various waste containers used provide containment of nontransuranic radioactive contamination and minimize radiation exposure to personnel during temporary storage, handling, shipment, and burial operations. Once buried, no reliability is placed on the containers for confinement or retrievability of these materials. Although burial of the waste containers by backfilling the trench is normally done at the close of the day's receipt of solid waste, waste trenches are immediately backfilled whenever the dose rate at the edge of the trench reaches 100 mR/hr. Solid waste is normally covered with 10 to 20 feet of earth to prevent uptake of radionuclides by plant life or disturbance by burrowing animals. An exception, waste contained in concrete boxes or small drums, may have a minimum dirt cover of 4 feet provided that radiation levels at grade are less than 1 mR/hr. Periodic routine surveillance of filled burial trenches is provided to assure that the burial grounds are maintained to meet existing standards.

Solid waste, containing or suspected of containing transuranium nuclides buried after April 30, 1970, is packaged and buried in compliance with ERDAM-0511. This directive states that "such wastes shall be segregated from other solid wastes and shall be packaged and buried so that they can be readily retrievable, as contamination-free packages, within an interim period of 20 years."

Formerly, the waste was packaged in iron drums and iron or concrete boxes and buried in special trenches. Subsequent evaluation of iron drums directly buried in Hanford soils indicated that failures could occur in less than 20 years and retrieval, as contamination-free packages, might not be possible. Two alternates to direct burial were implemented on a test basis, either of which will protect the containers from direct contact with the soil and will permit ease of retrieval.

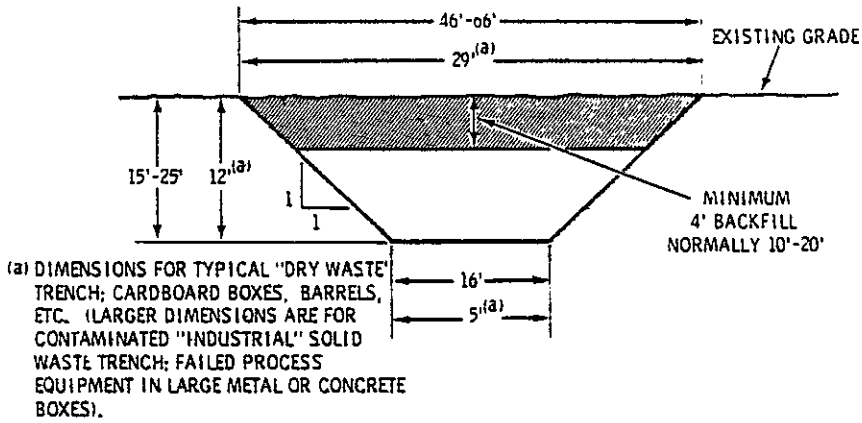
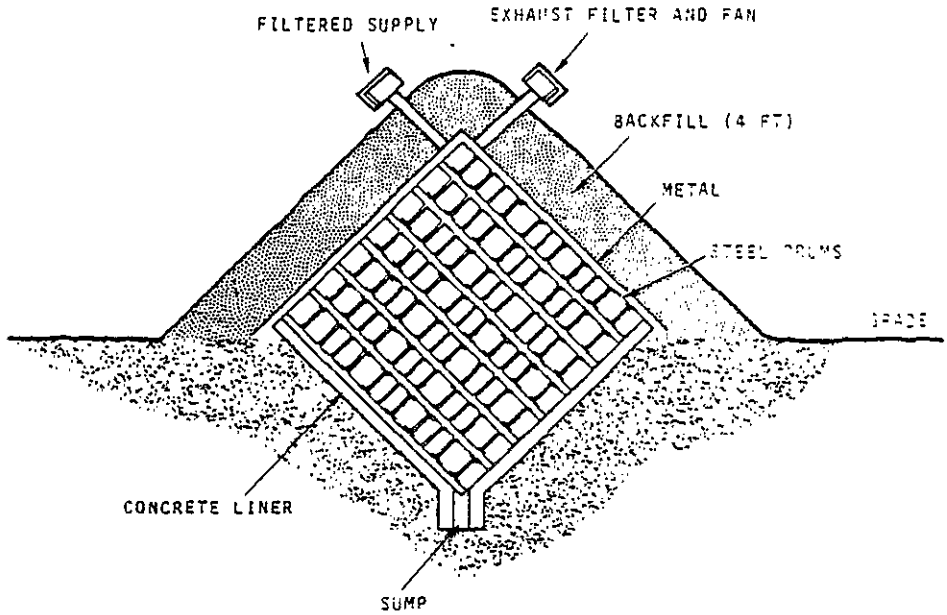


FIGURE II.1-54 SOLID WASTE BURIAL TRENCHES

A prototype concrete V-trench was built and filled with transuranic-bearing waste drums, as shown in Figure II.1-55. A metal cover and several feet of earth cover isolate the drums from the environment. This alternate provides protection of the drums from the soil and allows sampling of the storage trench atmosphere for radioactive materials and combustible gases, either of which would indicate drum failure.

Currently, a simpler alternate, pad storage, is being tested. The transuranic-bearing solid waste is segregated as combustible and noncombustible at the point of origin and placed in labeled drums. The segregated waste drums are placed on the storage pad in a stack four drums high; each layer of drums is separated by plywood treated with fire retardant. When drums are stacked to a volume of 24 feet by 24 feet by 12 feet, the stack will be covered with plywood and plastic-reinforced nylon sheeting prior to covering with 4 feet of earth. Capability for sampling the storage atmosphere is also provided. (A schematic of this storage alternate is shown in Figure II.1-56.)



ADVANTAGES
- PROTECTS DRUMS FROM SOIL
- STORAGE CONDITIONS CAN BE MONITORED

FIGURE II.1-55 CONCRETE LINED V-TRENCH USED FOR RETRIEVABLE TRANSURANIC WASTE STORAGE

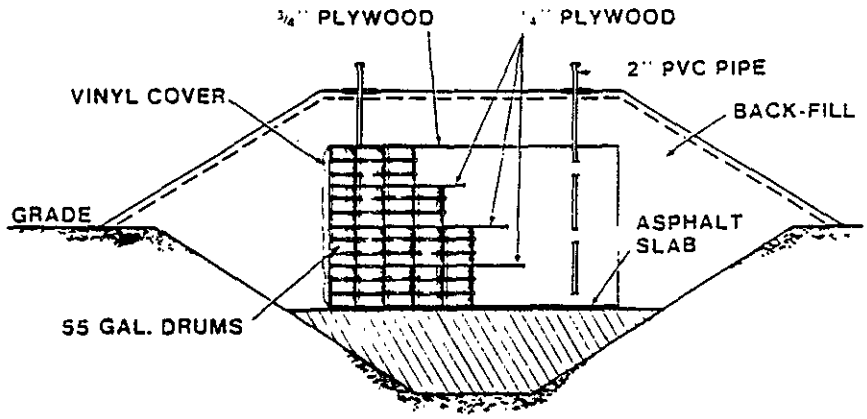


FIGURE II.1-56 THE TRANSURANIC SLAB (Alternate Method for Retrievable Transuranic Waste Storage)

Small items of transuranic-bearing solid waste, containing fission products capable of generating high dose rate gamma emissions, are packaged and shipped in shielded casks. This waste is discharged from the casks to caissons, as shown in Figure II.1-57, and the caissons can be retrieved.

Some of the Purex processing equipment is so large and becomes so contaminated in service, that its transport to a burial ground would require abnormally high exposure of operating personnel. Such equipment is placed on flatcars and pushed into the solid waste storage tunnels appended to the Purex Plant. A schematic of a Purex solid waste storage tunnel is shown in Figure II.1-58. An inventory of stored waste is given in Appendix II.1-C, Part 6.

Currently, two methods for reducing the volume of solid waste are being practiced. Some waste from the laboratories and from the 234-5-Z Building plutonium finishing operation is compacted prior to storage to provide a volume reduction of approximately four to one.

II.1.1.2.2.7 Ventilation Equipment

Gaseous effluents from the 200 Areas facilities are limited to airstreams containing relatively low concentrations of radionuclides, either in gaseous or entrained particulate form. Multiple filtration is relied upon to remove particulate matter, while a "silver reactor" and/or wet scrubbers are used to remove radionuclides such as radioiodine and oxides of nitrogen. Figure II.1-59 shows a typical ventilation flow pattern for a chemical processing plant. Air is drawn through a washer and filter and supplied to a processing area. The air flows, sequentially, from less contaminated to more contaminated zones. After passing through the most contaminated zone, the air flows through an exhaust duct to HEPA filters and then through a stack to the atmosphere. (A wide variety of HEPA filters is used, as indicated in Table II.1-5.)

Filtration of exhaust gases is not provided near the location where radioactivity enters the air at each hood, cell, or glove box if central exhaust filtration is provided, as in the 202-A and 234-5 Laboratories. Filtration is not provided where moisture or corrosive fumes must be removed from the exhaust to protect the integrity and efficiency of the filters, but the

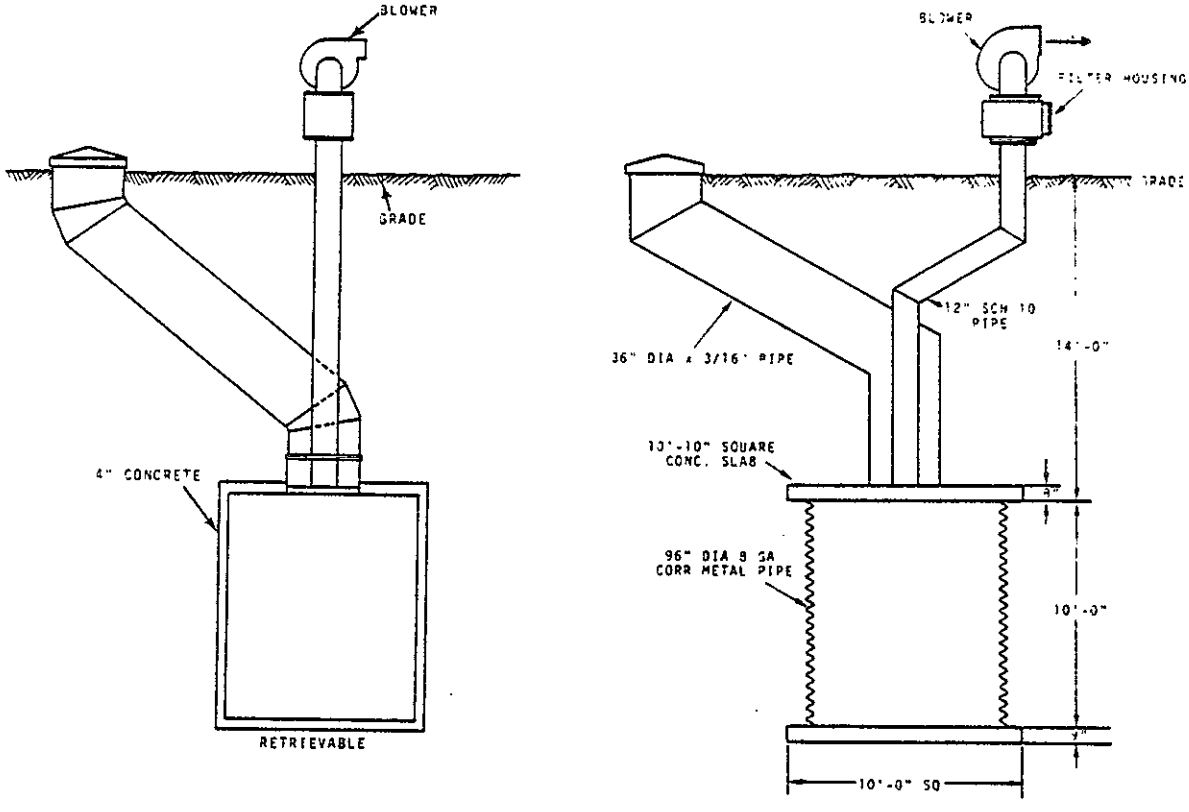


FIGURE II.1-57 SOLID WASTE BURIAL CAISSONS

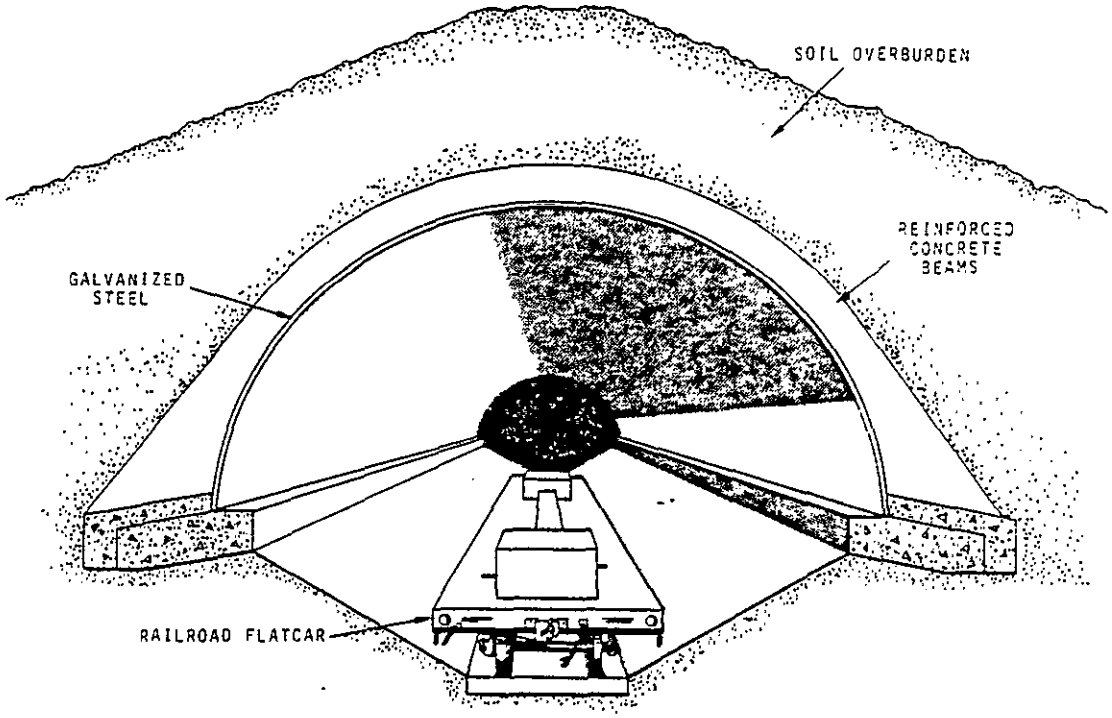


FIGURE II.1-58 TUNNEL FOR STORAGE OF RADIOACTIVE EQUIPMENT

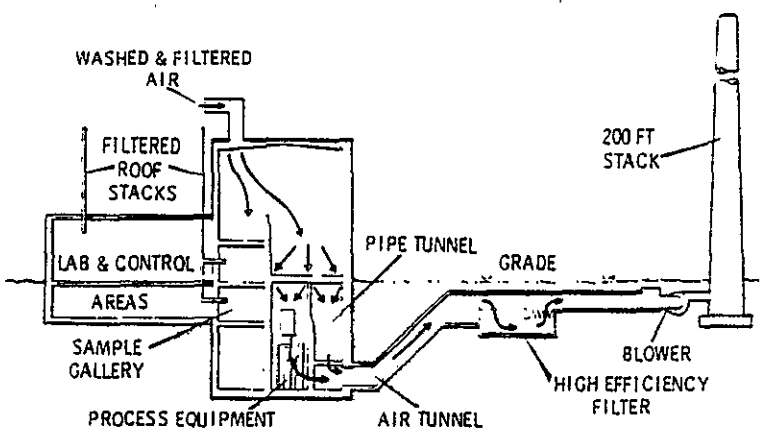


FIGURE II.1-59 SCHEMATIC OF VENTILATION OF TYPICAL SEPARATIONS PLANT

TABLE II.1-5

VENTILATION FILTERS

Type	Plant	Rated Efficiency, %[a]
Three-Stage Glass HEPA[5]	Z Plant	99.99+
Two-Stage Glass HEPA[5]	B Plant, AR Vault	99.99
Two-Stage Glass Fiber[6,7]	Purex	99.9
Sand[6]	T Plant, U Plant, B Plant Backup	99.5

(a) For 0.3 μm particles.

filtration is provided as near as practical to the source. The design limitations which affect the location of such filtration include the space available, ease of changing filters and protection of filters from fire through distance. The important fact is that all exhaust gases from hoods, glove boxes, and cells are filtered before release to the environment.

In the large canyon-type processing building, the cell exhaust gases are collected in structurally integrated tunnels because of the large quantities of air necessary for directional-flow contamination control. It is more practical to combine all of these gases and provide a separate shielded structural filter facility. Where especially toxic or radioactive off-gases from processes are encountered, special off-gas systems with gas treatment and filtering equipment within the cells are provided. These are usually mixed with the main exhaust system before the final filters.

Process chemicals and radioactive contaminants are entrained by air that comes in close contact with process materials. These gases are segregated into separate vent systems according to process requirements and compatibility of the process gases. The gases are processed for removal of noxious materials in a variety of ways:

- by Iodine Absorber (Purex)
- by Ammonia Scrubber (Purex, B Plant)
- by NO_x Absorber (Purex, UO_3 Plant)
- by HF Scrubber (Z Plant)

Once the noxious materials are reduced to within acceptable levels, the process vent gases are exhausted to the ventilation system for additional filtration and return to the atmosphere.

II.1.1.2.3 300 Area

II.1.1.2.3.1 Radioactive Waste Management [X.4]

The 300 Area liquid waste handling systems provide for retention of some liquids containing above trace amounts of radioactivity for transport to and subsequent treatment in the 200 Area or the 100-H Area. Other liquids containing only trace amounts of radioactivity are discharged to ponds. The 183-H solar evaporation basin was first used in 1973 on an intermittent basis and will be fully operational in 1975. It will accommodate that portion of the fuel processing effluent (except for water rinses and scrubbers) containing uranium, copper, fluorides, nitrates, chromium+6, and sulfates. The plutonium and fission product waste is generated in laboratories and test facilities conducting research and development work on separation processes, waste solidification and reactor fuels.

Solid and liquid radioactive wastes are now sent to the 200 Areas for disposal, except for 1) some low-level uranium-contaminated liquid waste sent to the 183-H basin or to 300 Area ponds and 2) slightly contaminated animal waste sent to 300 Area ponds. Radioactive airborne effluent wastes in the 300 Area are filtered and monitored prior to release through stacks, except for a uranium fume exhaust from 333 Building that passes through a water scrubber unit before being sampled and discharged to the atmosphere.

Radioactive Waste Liquids[8]

All radioactive liquid waste generated in the 300 Area is retained and shipped to 200 Areas for disposal, with two minor exceptions noted above (Appendix II.1-E, Part 3). Some effluents contaminated with uranium are released to the process water ponds. Discharges to ponds during 1972 were about 2.8×10^6 gpd, consisting of about 11,000 gpd from the life sciences facility and the remainder from the fuel fabrication area and the systems shown on Figures II.1-60 through II.1-62.

Temporary storage of radioactive liquids prior to shipment to the 200 Areas is provided by the 340, 340-A, and 340-B Waste Retention and Neutralization Facility (Figure II.1-63). The three buildings, constituting a total area of 3800 ft^2, provide facilities also for chemical neutralization and transfer of the radioactive waste into tankers. The main building houses a large rectangular concrete pit 21 feet deep containing two stainless steel, 15,000-gal neutralization tanks, valves, and transfer pumps. The pit area, which is covered by removable concrete blocks, adjoins the operation gallery and sampling room. The annex building, 340-A, contains six 8,000-gal stainless steel waste storage tanks. Three 5,000-gal tanker trucks can be accommodated in the load-out addition. Two 20,000-gal tank cars can be accommodated in 340-B, a railroad tank car load-out facility.

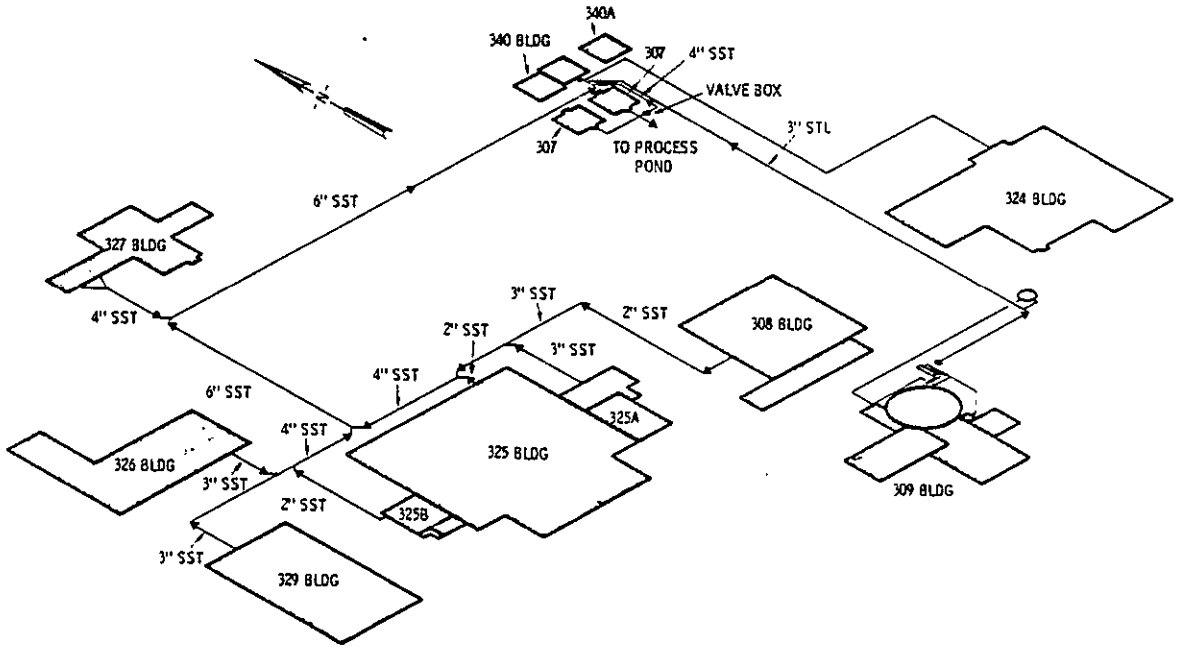


FIGURE II.1-60 CONTAMINATED LIQUID WASTE COLLECTION SYSTEM

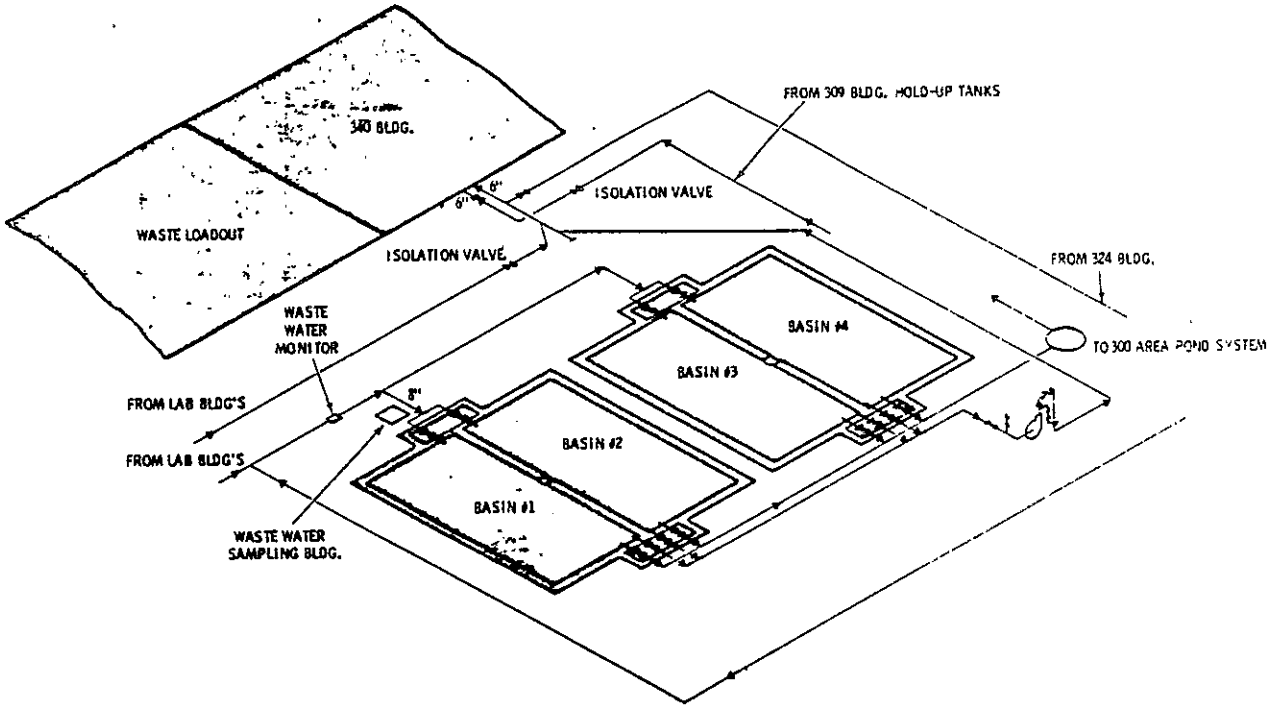


FIGURE II.1-61 RETENTION WASTE SYSTEM (307 Basins)

A separate underground waste sewer from a limited number of sinks and drains in Buildings 308, 309, 324, 325, 326, 327 and 329 serves this system. The line is a cathodically protected underground network of stainless steel piping leading directly to the 340 Waste Management Facility (Figure II.1-60).

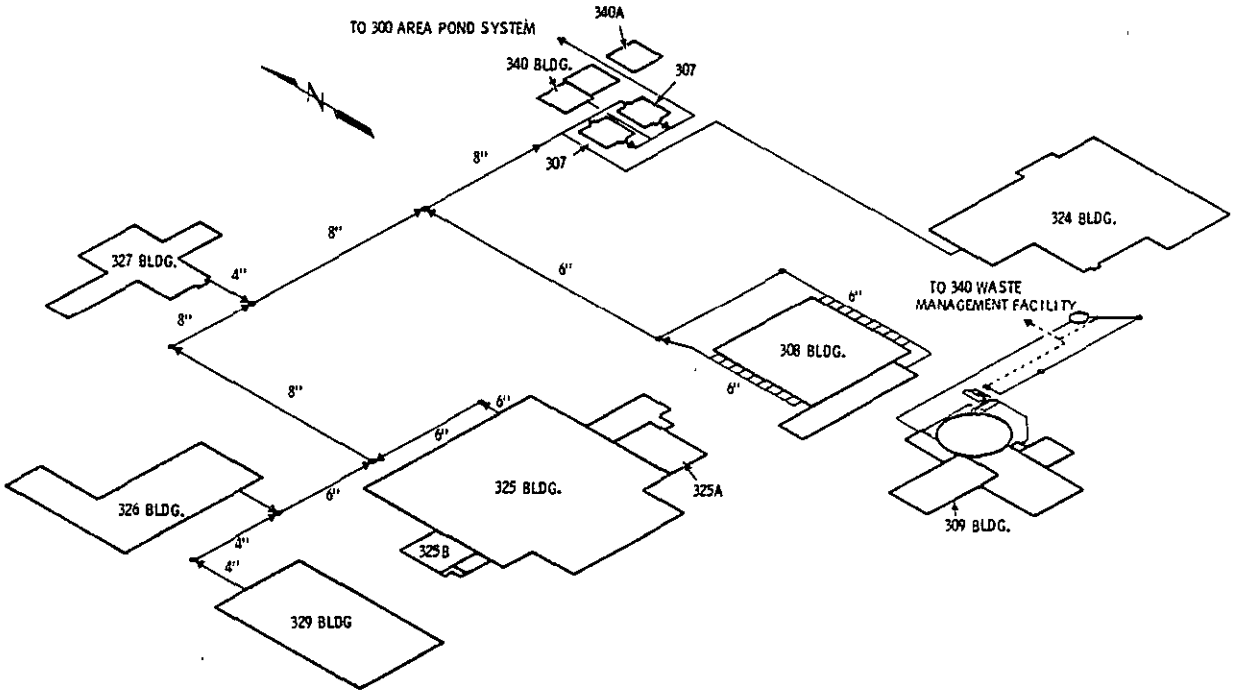


FIGURE II.1-62 300 AREA NORMALLY UNCONTAMINATED WASTE SYSTEM

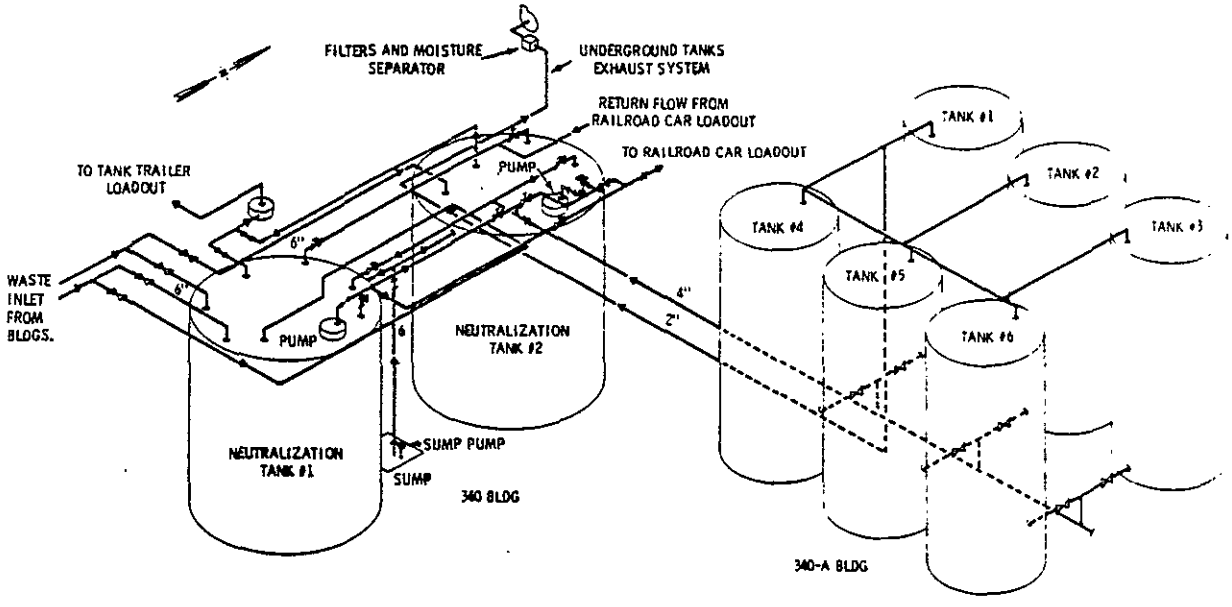


FIGURE II.1-63 340 AND 340-A BUILDING INTERMEDIATE-LEVEL WASTE STORAGE TANK

Normally Uncontaminated (Retention) Liquid Waste

A second liquid waste retention system, the 307 Retention Basins, provides a collection point for normally uncontaminated liquid waste from laboratories which may, inadvertently, contain low-level radioactive waste material. The four basins are of reinforced concrete construction with the tops just above grade. Capacity of each is about 50,000 gallons. Basins 1 and 2 are provided with a neoprene lining to simplify decontamination if required. Basins 3 and 4 have bare concrete surfaces and are used only in case of emergency. A continuous in-line β/γ liquid effluent monitor samples the waste stream just ahead of the influent into the 307 Basins. This

monitor signals an alarm in the nearby 325 Building equipment room and automatically shuts off the basin's discharge pump to a pond when a radionuclide concentration is detected.

Basins 1 and 2 are provided with a series of baffles which form a serpentine flow path. The time for free flow through the basin by the serpentine route is sufficiently long to allow an adequate counting interval for the sample in the monitor. The discharge pump can be shut down automatically by this equipment prior to any release of radioactivity to the ground. Normally the contents of the basins are discharged to the ponds. (Figure II.1-62 is a schematic of the system.) A continuous sampler removes a representative sample from the influent lines to the basins. Samples are taken to the laboratory weekly for alpha and beta/gamma analysis for backup to the monitor.

Buildings 325-A and 324 on this system are provided with waste water diverter systems (similar to the waste water system described above). In these buildings, cooling water from equipment containing large quantities of radioactive materials is monitored by the waste water diverter system monitor prior to release to the retention waste system. If a rupture in a cooling coil should allow contamination of the cooling water, the waste water diverter will signal an alarm and divert the contaminated water to a 20,000-gal underground catch tank for verification and appropriate disposal without taxing the 307 basin waste management complex. Underground piping connects the normally uncontaminated process waste from Buildings 308, 309, 324, 325, 326, 327, and 329 in a second separate sewer system discharging into the first of the four 307 Facility retention basins (Figure II.1-61).

High-Level Radioactive Liquid Waste

High-level radioactive liquid process waste is retained, using shielded stainless steel casks, for transfer to the 200 Areas. Cask capacities range from half liter to 500 gallons. Normally these are transported directly from the laboratory generating the waste via the highway to the 200 Areas for disposal. Special vehicles are required, as the large casks weigh up to 17 tons.

Radioactive Solid Waste

Active facilities for long-term management of solid radioactive waste do not exist in the 300 Area as no solid radioactive waste is now buried or incinerated in this area. All radioactive solid waste is transferred via truck and highway from the laboratories or facility where radiation work is performed to the 200 Areas for disposal. Each transfer of solid waste to the 200 Areas is performed according to written procedures and is permanently recorded.

All radioactive solid waste is divided into transuranic and nontransuranic solid waste as it accumulates. Since transuranic waste contains some radioactivity from elements whose atomic number is greater than 92, this waste is handled separately and in special disposal containers. Since the nontransuranic waste does not contain radioactivity from transuranic elements, packaging varies from low-level radioactive waste sealed in plastic-lined cardboard containers to high-level radioactive waste requiring large concrete casks for containers.

Retired Solid Waste Storage Facilities

Approximately 7.5×10^5 ft^3 of solid waste containing approximately 10 Ci of uranium contamination have been placed into the 300 Area burial sites since fuel fabrication began at Hanford. Thorium contaminated waste is less than 0.5 Ci and is segregated from uranium (i.e., a different trench). Most of the 300 Area contaminated waste is in a matrix of bonding materials on fabrication components, scrap material and equipment as surface contamination.

Of the approximately 7.5×10^5 ft^3 of solid waste, approximately 90,000 ft^3 are surface contaminated metallic, concrete, and asphalt materials. The remaining approximately 6.6×10^5 ft^3 occupy approximately 1×10^5 ft^3 of underground space. The volume reduction occurs as a result of the weight of the solid waste and the soil overburden.

The burial sites are listed in Appendix II.1-E, Part 2, along with the size, date of deactivation, general description of the contents and the depth to the water table. Figure II.1-64 shows their location.

Radioactive Gaseous Waste

Each laboratory or facility in which radioactive materials are handled or processed is equipped with its individual exhaust treatment system. Wherever practical, airborne radioactive materials are removed from exhaust gases near the hood, glove box, or cell in which they are generated. For glove boxes and manipulator hot cells, all recent new designs have provided for

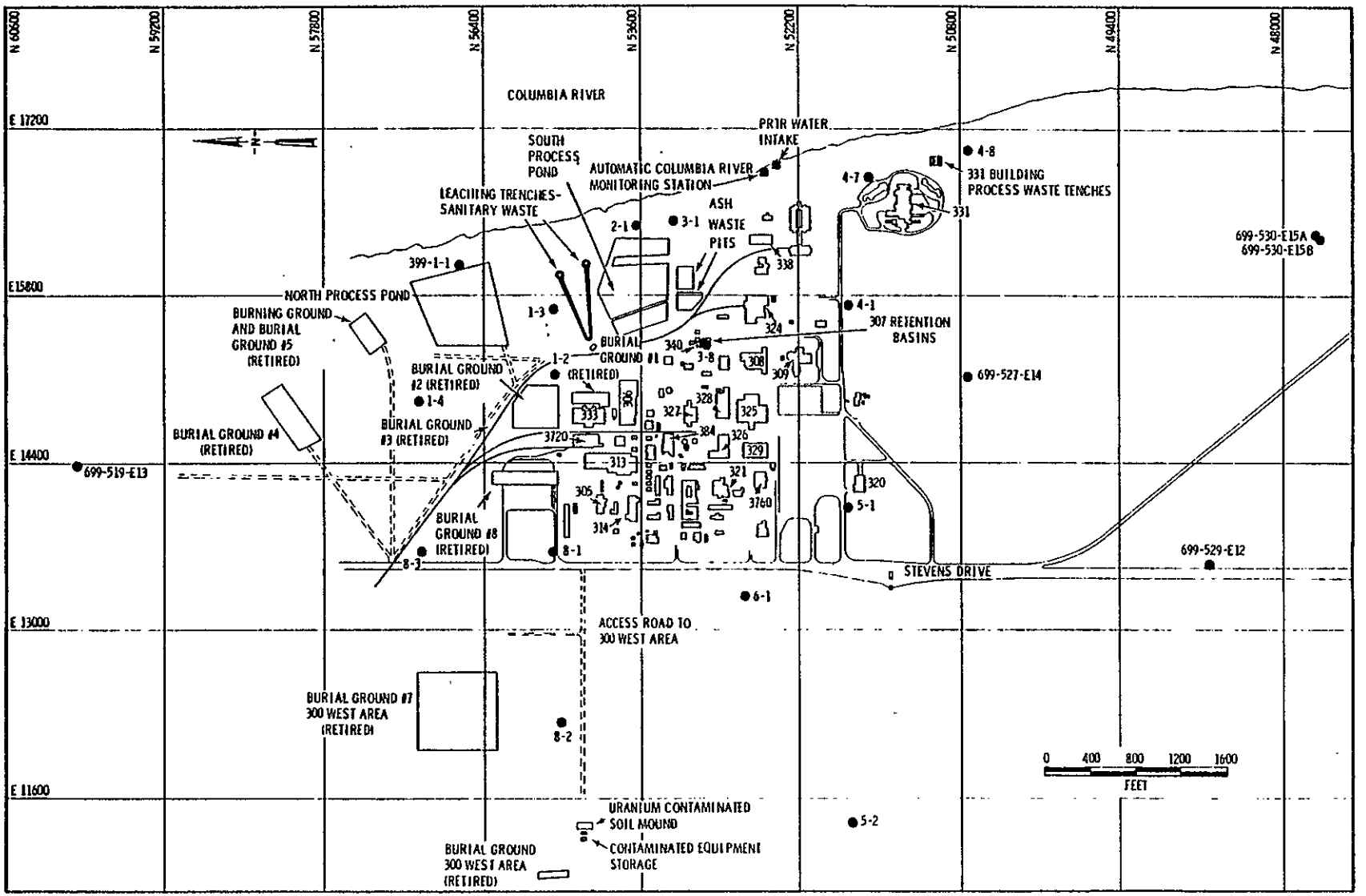


FIGURE II.1-64 300 AREA WASTE STORAGE AREAS

filters directly at the air exhaust outlet from the compartment. Some were installed years ago on the duct work between the glove box and the first filter where the contamination has not been enough of a problem to warrant a modification.

The exhaust treatment systems in every facility, except 333 Building, utilize HEPA filters which are tested to meet at least a 99.97% efficiency for particles 0.3 μm and greater in diameter. The filters are tested following installation and on a scheduled frequency thereafter. Filters are scheduled for an annual routine dyoctyl phthalate (DOP) test but are checked promptly if any indication of filter malfunction occurs. Over many years, two filter failures have been experienced and resulted in local contamination with no activity released offsite. Occasionally, filters are replaced because of plugging, which reduces air flow below acceptable levels. Where required, a charcoal absorber is used as a collector for radioactive iodine. All gaseous streams are sampled daily and are also constantly monitored if the air stream has a potential for becoming highly contaminated. Plutonium contaminated exhausts are double or triple filtered with sampling provided between the filters and sampling or monitoring after the final filter. An alarming device is part of the monitoring system and would give immediate notification of release due to loss of filter integrity. Failure of any major filter system in active status would be detected within a short time (less than an hour). All expended filters from the facilities or laboratories in which radioactive materials are handled or processed are treated as radioactive solid waste.

The wet uranium fume exhaust from the abrasive cut-off saw in the 333 Building passes through a water scrubber unit before being sampled and discharged to the atmosphere. The water from the scrubber unit is sent to the 300 Area process ponds.

II.1.1.2.4 Waste Management Facilities and Activities Planned and Under Construction FY-1973 Through FY-1975

The current program has as its continuing objective the reduction of radioactivity in all effluent systems to the lowest technical, economical and practical levels and includes the following action:

II.1.1.2.4.1 100 Areas

N Reactor Control Rod Coolant Dump System $75,000

Valves and piping will be provided in the N Reactor control rod coolant system to assure discharge of this stream to the 1301-N Crib, thus further reducing the potential for discharging small amounts of radioactivity to the river.

N Reactor Gravity Drain and Disposal Basin $445,000

An emergency disposal basin will be installed east of the existing 1301-N Crib to provide an adequate emergency cooling water disposal capacity in case of 1) an emergency dump of the N Reactor primary loop to the dump tank followed by once-through cooling, and/or 2) a cooling system break inside the 105-N or 109-N Buildings and a concurrent drain pump failure. Emergency drainage sufficient to prevent direct overflow of contaminated water to the Columbia River and to prevent possible water damage to the 105-N and 109-N Buildings will be provided. The basin will provide a soil column 25 to 30 feet deep between the bottom of the basin and the average groundwater level for absorption of radioactivity.

N Reactor Ventilation Loop Seal Improvement $325,000

A redundant confinement valving system will be installed in the N Reactor building ventilation system to provide positive reliable secondary closures in the vent openings and thus assure containment of vapors and gases which would only be generated under unlikely conditions.

II.1.1.2.4.2 200 Areas

In-Tank Solidification Systems, Auxiliaries $2,500,000

Additional liquid waste routing facilities will be provided to permit transfer of slurries from the 242-S Evaporator to existing tanks in the 241-U Farm.

Waste Management Effluent Control (B Plant) $1,000,000

Four waste effluent streams, 1) 244-AR cooling water, 2) B Plant cooling water, 3) B Plant steam condensate and 4) B Plant process condensate will be provided with lined trenches, monitoring, and automatic diversion facilities such that in event of accidental contamination of these streams, they will be contained and recycled rather than released.

Contaminated Soil Removal Facility $1,000,000

Plutonium-containing soil will be removed from the underground disposal crib 216 Z-9 for packaging and restorage in facilities affording retrievability provisions.

Purex Ammonia Scrubber Waste Concentration Facilities $405,000

The amount of radioactivity in the Purex Ammonia Scrubber waste which is discharged to a covered trench will be reduced significantly by providing for routing of all of this stream to an existing concentrator system. The decontaminated condensate will be routed to a crib and the concentrated radioactivity will be routed to underground tanks.

Additional Waste Concentration and Salt Cake Storage Facilities $30,000,000

To be provided are: a waste evaporator system, additional underground storage tanks for cumulative capacity of at least 3 million gallons of highly radioactive waste, routings for new tanks and existing underground storage tanks, underground lines, encasements, pumps and auxiliaries, which are needed for the waste concentration program and for minimizing the potential for leakage of radioactive liquids to the ground.[9]

Provision of the proposed facilities will allow acceleration of the waste solidification program. The liquid waste in 30 of the older waste tanks, some of which are associated with the existing waste concentration systems, can be emptied at least 1 year sooner for solidification by evaporation-crystallization. Also, most of the liquid waste can be stored in single-wall 200 East Area waste tanks of later improved design or the new double-wall waste tanks provided by this project instead of the older tanks which otherwise would be utilized. This will reduce the potential for future leaks.

Purex Condensate Recycle $450,000

This project will provide for recycling condensates from the 1) backcycle concentrator as extractant for the first uranium cycle and as the scrub solution for the first decontamination cycle, and 2) first uranium cycle concentrator as the final uranium cycle extractant.

With the proposed facilities all process condensates except the final uranium concentrator condensate, which is well within release limits established by the ERDA, would be recycled within the Purex Plant. This will provide for a significant reduction in the amount of radioactive material discharged to ground.

Groundwater Monitoring Wells $100,000

Additional wells will be drilled at selected strategic locations to enhance the existing routine groundwater monitoring capability.

Encase Waste Lines 232-Z to 241-Z $115,000

A short run of existing piping which transports incinerator scrubber waste from the plutonium incinerator building to a sump will be replaced with an encased pipeline thus affording double containment provisions.

Waste Management Effluent Control $3,500,000

Facilities will be provided to maintain and to extend protection against the accidental release of radioactivity in certain effluent streams from the Waste Fractionization Facility (B Plant) and the Chemical Processing Facility (Purex Plant). The facilities include: 1) a replacement ventilation filter for B Plant, including an underground concrete filter cell equipped with replaceable prefilters and two stages of HEPA filter banks and a corrugated metal instrument building above the cell; 2) improvements, including prefilters and HEPA filters for treating ventilation air from the sample gallery, the organic treatment cell, and the acid fractionization cell of the Purex Plant; 3) diversion facilities to detect contamination which may accidentally enter normally nonradioactive cooling water streams and steam condensate from the Purex Plant

0 1 5 0 1 6 3 1 1 6

and to divert such an affected stream to either a lined and covered reservoir or to existing waste tanks for decontamination; 4) replacement Purex Plant ventilation air filter designed for a flow rate of 125,000 ft^3/min and consisting of a prefilter and secondary high efficiency filters in a concrete cell with a corrugated metal instrument building above the cell.

B Plant Vent System Ventilation Improvements $475,000

This project will provide new ventilation exhaust fans and single-stage, HEPA filters for the ventilation exhaust from the B Plant operating, pipe and electrical galleries and would provide sampling facilities for the filtered vessel vent exhaust.

These additions will reduce the potential risk of releasing radioactive materials from the operating areas to the environment. The vessel vent exhaust sampling system will provide for detecting filter failure. The gallery ventilation filters will protect the environment from potential release of contamination from the operating areas.

242-T Evaporator Effluent Improvements $200,000

In order to reduce the risk of releasing radioactive materials to the environment, the 242-T Building process cells (feed, evaporator, and condensate) will be provided with filtered supply and exhaust ventilation systems consisting of 1) supply air: preheater, two stages of roughing filters, and ductwork, and associated service piping, instrumentation and controls; and 2) exhaust air: preheater, prefilter, parallel two-stage, HEPA filters, parallel exhaust fans, stack, ductwork and associated service piping, instrumentation and controls.

222-S Laboratory Exhaust Ventilation Improvements $485,000

A new bank of HEPA filters will be installed in a new enclosure to further protect the environment by providing additional filtration of the exhaust air ventilation from contaminated and potentially contaminated zones of the 222-S Laboratory Building. New ductwork, fans, stack and accessories will also be provided.

II.1.1.2.4.3 300 Area

325 Building Ventilation Exhaust Addition $485,000

The 325 Building Laboratory will be provided with new local exhaust filter plenums containing HEPA filters, fire detection sensors and fire suppression equipment, thus adding a second stage of filtration to the existing single stage system. Improved reliability will result and the potential for release of radioactivity via the ventilation system will be correspondingly reduced.

300 Area Liquid Waste Disposal $190,000

The existing process waste system will be provided with new leaching trenches, a sampling station and two monitoring wells. The new leaching trenches will replace the existing process ponds, thus eliminating the possibility of leaching to the river of minerals which have accumulated over the years. There will also be longer flowpaths to the river from the new trenches.

Replace and Upgrade 300 Area Contaminated Waste Line $400,000

The existing entire radioactive contaminated sewer system consisting of a 6-in. trunk line fed by smaller 3- and 4-in. lines will be replaced and upgraded to eliminate the possibility of line deterioration resulting in the release of radioactivity to the ground.

II.1.1.2.4.4 P-11 Facility Cleanup $300,000

The objective of this project is to clean up the P-11 site and restore the area so that it will not pose an environmental hazard to people or animals, thus allowing alternative uses of the land area, if so desired.[10] The P-11 Facility (location shown in Appendix II.1-A) served as a laboratory for plutonium criticality studies prior to 1952. It consisted of two buildings: the 123 Building (a converted original Hanford area residence) and the 120 Building. The 123 Building, which served as the control house, is already razed and involved no plutonium contamination. The 120 Building, which is a single-story metal building about 32 feet by 42 feet in plan, contained a critical assembly room, a small chemistry laboratory, storage and tank room, and a change room. Work in this facility was discontinued in 1952 after a fire destroyed a part of the interior of the structure.

II.1.1.2.5 Decontamination and Decommissioning [RPB, X.11, X.18, X.24, X.25]

Many Hanford facilities including waste disposal areas and equipment have been retired from service. Some of these are contaminated either with relatively short half-life radionuclides such as most fission and activation products and/or with long half-life materials such as plutonium. Contaminated facilities are secured to prevent release or spread of contamination; monitoring and surveillance are provided to assure that any releases will not go undetected. A program has begun to formulate decontamination and decommissioning (D&D) and to carry out plans to ultimately dispose of the retired facilities. Special containment, packaging and storage may be an acceptable decommissioning action for fission and activation product contaminated facilities, while radionuclide recovery and treatment for ultimate disposal will be required for facilities contaminated by long half-life radionuclides.

The objectives of the D&D program are:

- Prepare an overall plan for D&D
- Conduct several demonstration operations
- Adopt and utilize a D&D program to lead to ultimate disposal of retired facilities.

Current planning suggests that movement of contaminated materials to a centralized location on the 200 Area plateau would be the first step. This location provides good protection against dispersal of radioactive materials. A centralized location would eliminate the need for surveillance at many individual sites. The cost of moving the material needs to be reviewed in view of the low potential for dispersal at most current facilities locations. In any event, the Hanford D&D program is intended to determine the various alternatives available and provide the information needed to determine appropriate actions.

The initial emphasis of the D&D plan is to establish priorities based on:

- Maintenance needs of retired facilities
- Surveillance requirements
- Potential hazards
- Half-life of the radionuclides
- Location
- Potential personnel exposures
- Overall knowledge to be obtained
- Complexity of D&D
- Budget limitations
- Contamination characterization knowledge
- Volume reductions achievable
- Availability of interim storage facilities.

The initial program is divided into six categories:

1) Disposition of Retired Contaminated Facilities
2) Disposition of Contaminated Equipment
3) Characterization of Retired 100-Area Facilities
4) Solid Waste Burial Ground Recovery; initially characterization of 300-North and WYE Burial Grounds
5) Plutonium recovery
6) Fission Product recovery.

II.1.1.2.5.1 Disposition of Retired Contaminated Facilities at Hanford

Objectives - The objective of this program is to prepare an overall plan and to demonstrate technology for decontaminating and decommissioning retired contaminated facilities at Hanford.

Status - The objective will be achieved through the following major tasks:

- Establish methods, costs, and priorities for the disposition of retired (excessed) Hanford facilities. Alternative levels of residual contamination to permit unrestricted use, conditional public use, or continued use for nuclear activities, are to be considered.

- Formulate definite plans, schedules, costs and an environmental assessment for a project to accomplish permanent disposition of a specific Hanford facility. The planning and project selection are to be such as to permit demonstration of techniques and establish the feasibility of application to other retired nuclear facilities.

- Identify required R&D for disposition projects.

To accomplish the tasks outlined above, the program has been divided into the following key task areas:

- Compilation of Data on Past D&D Activities - A comprehensive listing of reports and documentation of previous D&D related activities containing over 600 references has been compiled and is available for use in the form of a computer print-out.

- Documentation of Disposition Activities - Information derived from work carried out directly under the program, as well as information resulting from other programs, will provide inputs to the documentation. Its key function will be to act as a central basis of information for determining the priorities and incentives for future D&D activities on all Hanford retired and contaminated facilities.

  The Disposition Document will contain, as a minimum, the following information on all Hanford retired and radioactively contaminated facilities: 1) a description and history of uses, 2) a complete characterization of radioactive and chemical contaminants, 3) description of salvageable equipment, 4) priority and incentives for decommissioning, 5) criteria for acceptable residue contamination levels, 6) disposal options, 7) requirements for additional site characterization, R&D, and safety and environmental analysis, and 8) estimated D&D project costs and schedules. In addition, a current tabulation will be maintained on all radioactively contaminated facilities that are scheduled for retirement.

- D&D Demonstration Facility - The Redox Plutonium Concentration Building, 233-S, was selected as the first Hanford facility for demonstrating of existing D&D technology, performing R&D, and testing of new technologies.

Currently, five options for disposition are being studied: 1) enclose buildings in protective shell that would withstand all credible accidents for 100 years, 2) entomb structure with concrete, 3) decontaminate concrete structure and leave standing and remove equipment and metal structures, 4) completely dismantle entire building and contents, package, and bury, and 5) use building as a graveyard for other contaminated facilities. Option 4) is presently favored as yielding the most information return on the investment.

II.1.1.2.5.2 Contaminated Equipment Volume Reduction

Objectives - The objective of this project is to develop and demonstrate volume reduction technologies on contaminated metallic equipment. Treatment is required to reduce the size of the equipment and to reduce the mobility of the associated radionuclides. Thus, storage of the final material will be safe and less costly and will require a minimum of surveillance.

Status - The present approach is to develop remotely controlled size-reduction techniques which can reduce any and all metallic equipment to pieces suitable for charging electric furnaces. Final volume reduction is proposed to be achieved through meltdown. The resulting ingots will be suitable for long term, retrievable storage. Decontamination is being investigated for possible use as a precursor step to simplify size reduction and meltdown. The following processes are currently being investigated under this program:

- Cost evaluation study of decontamination by chemical cleaning.

- Size reduction by electric arc plasma furnace torch, burning bars and other techniques which permit remote operation.

- Materials handling for equipment or equipment sections using cranes, mechanical conveyors, and rotating arm rakes.

- Bulk volume reduction by melting of fragmented equipment in the following types of furnaces: graphite-electrode electric arc, plasma arc, and vacuum induction.

- Techniques providing overall simplicity and maximum integrity of the final product.

- Fume control techniques to insure total containment of the radionuclides.

- Redistribution of surface contaminants during meltdown of laboratory-sized radioactively contaminated metal samples.

II.1.1.2.5.3 Characterization of the 100 Areas

Objectives - Confirm radionuclide inventories and concentrations in the retired 100 Area facilities including reactor buildings, solid and liquid disposal sites, and liquid waste discharge areas.

Status - The program has been segmented into the following key task areas:

- Review documentation to locate, review, and analyze records of solid and liquid waste disposal activities in the 100 Areas.

- Establish special surface mapping techniques and conduct field surveys to define more precisely each underground radioactive disposal site.

- Conduct in-place sampling of all underground disposal sites with well drilling equipment. Sample reactor graphite cores and thermal shields with specially designed equipment.

- Confirm quantities and types of radionuclides contained in all contaminated sites and facilities in the 100 Areas. These data will form the basis for all future D&D plans for the 100 Area.

II.1.1.2.5.4 Characterization of 300 North and Wye Burial Grounds

Objective - This study is designed to evaluate the present status of waste materials disposed to the 300 North and Wye Burial Grounds (318-10 and 318-14, respectively) and to evaluate the alternatives of designating the sites for permanent storage and/or removal of all or part of the materials.

Status - The objectives of this program will be achieved via the following tasks:

- A records review will be conducted to locate, review, and analyze records of solid and liquid waste disposal activities in the 300 Area.

- The precise boundaries of the waste disposal sites will be determined by dimensional surveys and the possible use of magnetometer, metal detector, seismic, and radar equipment.

- Data on radionuclide quantities, types, and migration rate within the disposal sites will be determined using sample drilling and instrument wells.

- Based on these data, future D&D plans can be formulated for this area.

II.1.1.2.5.5 Plutonium in Soils [X.18]

Research and development programs to demonstrate the ability to recover plutonium from cribs and trenches are in progress. A demonstration program to recover plutonium from the 216-Z-9 Crib is planned. This recovery effort will 1) provide the practical knowledge on recovery methodology, and on potential and actual problems and 2) indicate directions for supportive recovery research. Recovery of plutonium from the Hanford soil storage locations is necessary to avoid the need for ultra-long-term surveillance, land control, and to avoid consequences of potentially disruptive climatic and geological changes that might occur in the Hanford area in the next 100,000 to half-million years. The practical level of recovery needed is yet to be determined. Studies are in progress at Hanford and at other ERDA facilities to determine an acceptable cleanup level. EPA has held a hearing to receive comments on the subject of acceptable levels for plutonium in the environment and presumably will issue guidance on this subject. The degree to which plutonium cleanup from waste disposal sites will be needed will be factored into the

9 1 1 3 9 1 0 5 1 4

development of the ultimate disposal plan for Hanford waste. Recovered plutonium can be used as product, repackaged for interim storage or packaged for ultimate disposal, depending on the actual time of recovery and the status of the ultimate disposal program.

II.1.1.2.5.6 Fission Products in Soil

The ultimate disposal plan must consider the possible recovery of fission products from cribs and trenches. Current plans are based on leaving fission product materials that are not associated with plutonium in their cribs and trenches for decay. For plutonium associated fission products, the shorter half-lives of the fission products of prime interest, ^{90}Sr and ^{137}Cs, as compared to plutonium, will be considered when the ultimate disposal options for fission product recovery are developed. Monitoring and surveillance programs to indicate status of soil disposed fission products will need to be continued for some time, but probably not longer than a few hundred years even if no fission product recovery is required as part of the ultimate disposal plan. Any unacceptable movement of the fission products or any changing environmental condition that might lead to movement of the fission products would require a recovery plan and ultimate disposal action. The ultimate disposal environmental impact statement will need to analyze, evaluate, and present the consequences of the various ultimate disposal options developed for fission products in the soil.

II.1.1.2.5.7 Future Plans

The long-range objective of the D&D program is to identify generic types of contaminated facilities (buildings, reactor, disposal areas, etc.) and develop disposition plans which can be used to direct physical decontamination and/or decommissioning of the facilities. The results of the demonstration project at the 233-S facility will be applied to similar classes of facilities. Studies will progress to treatment of more complex facilities such as reactors, burial grounds, etc. Table II.1-5a outlines the projected schedule of D&D at Hanford.

TABLE II.1-5a

PROJECTED SCHEDULE OF D&D AT HANFORD

DISPOSITION OF RETIRED CONTAMINATED FACILITIES

- First demonstration facility selected in early FY-1975
- Second demonstration facility selected mid-FY-1976
- Operations on first demonstration facility begun late FY-1976
- Third demonstration facility selected mid-FY-1977
- Issue final report on first demonstration facility late FY-1977

CONTAMINATED EQUIPMENT VOLUME REDUCTION

- Laboratory investigation of contaminated metal meltdown begun mid-FY-1975
- Nonradioactive size reduction demonstration conducted by end of FY-1976
- Nonradioactive meltdown demonstration conducted by mid-FY-1977

CHARACTERIZATION OF THE 100 AREAS

- Field survey of disposal sites begun late FY-1975
- In-place sampling of liquid waste disposal sites completed mid-FY-1976
- In-place sampling of solid waste disposal sites and facilities completed late FY-1976
- Final report and disposal site maps completed and issued early FY-1977

TABLE II.1-5a (Continued)

CHARACTERIZATION OF 300 NORTH AND WYE BURIAL GROUNDS

- Field survey of waste disposal sites begun late FY-1975
- Drilling of current series of sampling wells completed late FY-1976
- Estimate of any migration of radionuclides based on available data completed early FY-1977
- Final report and disposal site maps completed and issued late FY-1977

PLUTONIUM RECOVERY

- Detailed schedules will be developed based on the results of the 216-Z-9 Crib plutonium recovery program.

FISSION PRODUCT RECOVERY

- No schedule for recovery has been established.

II.1.1.3 Plant Water Usage

Sanitary and process water for the Hanford Reservation operations are supplied from a number of different locations (Table II.1-6). The 100-B pumphouse, with the 100-D as backup, supplies water to 100-B-C, 100-D, 100-H, 100-F, and 200 Areas. (All of these areas are shown on Figure II.1-1.) A water plant at 100-N Area supplies sanitary and process water to both 100-N and the WPPSS generating station located adjacent to 100-N. The 300 Area pumphouse supplies all water needs for the 300 Area. The City of Richland water supply system is intertied to the 300 Area system as an emergency backup. Various wells in the 600 Areas on the site supply both sanitary and process water.

An average of 440 cfs (0.4% of annual average flow) of Columbia River water is continuously withdrawn, mainly for cooling purposes. Most of this water is discharged directly back to the river as nonradioactive disposal. In addition, approximately 34.7 cfs (less than 0.03% of the total annual average flow) of Columbia River water is withdrawn and discharged to the ground as sanitary and industrial wastes. Wells supply approximately 73,000 gal/day for sanitary and minor irrigation use which is almost entirely discharged to the ground.

II.1.1.4 Waste Inventories [X.18]

Multiple disposal sites for radioactive waste have been used at Hanford during its 30-yr history. The choice of disposal site is based on many factors including half-life and toxicity of the elements involved, quantity of material to be discarded, proximity to water table and/or the Columbia River, and optimum personnel radiation exposure and contamination control. The use of many of these sites has been terminated.

The waste inventory data reported subsequently and in greater detail in Appendix II.1-C for cribs, burial grounds, ponds, ditches, specific retention sites, and unplanned releases are subject to variations in sample collection and analysis.

High-level waste streams are analyzed for plutonium, uranium and neptunium. Fission product content is calculated from irradiation history. The total contents of all waste tanks are known with fair precision, although the contents of individual tanks and, to some extent, of individual tank farms are less certain because of transfers among tanks and farms.

Discharges to cribs, specific retention sites, ponds and ditches are based on line samples. Since the concentration of radionuclides in these streams is often low, accuracy is low and considerable uncertainty is involved. In some cases, particularly for discharges to ponds and ditches, the radioactivity is below limit of detection and the results are therefore reported as "less-than" figures.

Unplanned releases of liquids to grounds are based on estimates of volumes involved and of concentrations of the radionuclides in the stream. Gaseous releases are based on stack samples.

TABLE II.1-6

PLANT WATER USE

Plant or Facility	Source of Supply	Primary Use
100-B	Columbia River 100-B Pumphouse	Process water
100-D	Columbia River 100-D Pumphouse	Process water
100-K	From 100-K Pumphouse	Process water
100-N	Columbia River-100-N Pumphouse	Process, sanitary and cooling water
100-F	From 100-B Pumphouse	Process water
200 Areas	100-B Pumphouse Well 299-E26-6 Wells 299-E28-11 and 15	Process and cooling water Emergency cooling water supply Emergency process supply
300 Area	Columbia River 300 Area Pumphouse	Process and sanitary 331 Fish Ponds
FFTF	Wells 699-S0-7 699-S0-8 699-S1-7B	Construction and Sanitary
Atm. Physics	100-B Pumphouse	Sanitary
609 Fire Sta. (100 Area Central)	100-B Pumphouse	Sanitary
609 A Fire Sta. (200 Area Central)	100-B Area	Sanitary
6652C (Aeronomy)	Rattlesnake Springs	Sanitary
6652I (Ale Hq)	Well 699-26-89	Sanitary and Irrigation
Emergency Relocation Ctr.	Well 699-S18-51	Sanitary
BY Telephone Exchange	Well 699-50-28A	Sanitary
Hanford Road Maintenance	Well 699-Han-9	Industrial and Sanitary
Vernita Park	Wells 699-72-101A, B and C	Sanitary and Irrigation

Reported quantities of radioactivity in burial grounds or storage tunnels are estimates based on operating history and radiation levels of the equipment or waste buried. Generally, these data are of greater uncertainty than liquid and gaseous streams since there is no practical method by which a representative sample, particularly of large equipment pieces, can be obtained.

Overall, however, the accuracy of the inventory total is believed to be within a factor of two, probably within 50% or better. The reported inventories in this final environmental impact statement have been adjusted to a single significant figure to reflect the uncertainties in the data.

II.1.1.4.1 Contained Solids and Liquids

II.1.1.4.1.1 Disposal Sites

The approximate inventories of solid waste disposal in the 100 Areas through 1972 summarized below are shown in Appendix II.1-B, Part 3. These inventories are corrected for decay through the end of 1972.

Radionuclide	Quantity (Ci) (decayed through 1972)
Long Half-Life (>1 Year)	
^{60}Co	30,000
^{90}Sr	30
^{239}Pu	0.4
Short Half-Life (<1 Year)	
^{65}Zn	1,000
^{54}Mn, ^{95}Zr	4,000

The approximate inventories of solid waste disposal in the 200 Areas through 1972 summarized below are shown in Appendix II.1-C, Part 6.

Radionuclide	Quantity
U	6×10^8 g
^{239}Pu	4×10^5 g
^{90}Sr	1×10^4 Ci
^{106}Ru	3×10^3 Ci
^{137}Cs	1×10^4 Ci
Other radioactive materials	4×10^5 Ci

II.1.1.4.1.2 Facilities [X.4, X.24]

Inventories of radioactive materials estimated to be contained in nonoperating reactors and reactor facilities through 1972[3] as summarized below are shown in Appendix II.1-B, Part 3.

Radionuclide	Quantity (Ci)
Reactors	
^{60}Co	70,000
Reactor Facilities	
^{90}Sr, ^{137}Cs, ^{239}Pu, ^{152}Eu	800
^{60}Co	2,000
^{59}Fe	150,000

Inventories of radioactive materials estimated to be contained in the two Purex equipment storage tunnels through September 1973 as summarized below are shown in Appendix II.1-C, Part 6.

Radionuclide	Quantity
Mixed Fission Products	30,000 Ci
^{90}Sr	1,000 Ci
^{106}Ru	8 Ci
^{137}Cs	1,000 Ci
^{60}Co	20,000 Ci
^{239}Pu	<500 g

The estimated decayed inventory of radioactive materials stored in tanks in the 200 Areas through 1980[11] and 2000 are summarized below.

Radionuclide	Quantity (Ci) 1980	Quantity (Ci) 2000
^{90}Sr	5×10^7	3×10^6
^{137}Cs	3×10^7	2×10^6
^{239}Pu	2×10^4	2×10^4

II.1.1.4.2 Liquid Discharges to Soil

The estimated radioactive material inventories in the 100-N Area crib at the end of 1972[3] as summarized below are shown in Appendix II.1-B.

Radionuclide	Quantity (Ci)
^{60}Co	2,000
^{54}Mn	800
^{137}Cs	400
Misc. nuclides	500

The estimated radioactive material inventories in the 100-F animal waste leaching trench at the end of 1972[12] as summarized below are shown in Appendix II.1-B.

Radionuclide	Quantity (Ci)
^{90}Sr	4
^{239}Pu	0.08

The estimated radioactive material inventories in 200 Area ditches, ponds, and cribs at the end of 1972[13] (decayed) as summarized below are shown in Appendix II.1-C, Part 6.

Radionuclide	Quantity 200 Area	Radionuclide	Quantity 200 Area
Beta	2×10^5 Ci	^{60}Co	$<2 \times 10^2$ Ci
^{90}Sr	3×10^4 Ci	^{233}U	$<1 \times 10^3$ g
^{106}Ru	3×10^3 Ci	U_{nat}	1×10^8 g
^{137}Cs	4×10^4 Ci	^{239}Pu	2×10^5 g

II.1.1.4.3 Radionuclides Stored Beneath Selected 200 Area Cribs [X.4, X.24]

A detailed study of radioactive waste beneath a specific disposal site (216-S-1 and 2 Cribs) was made in 1956. In 1966, the site was again evaluated as part of a larger study which involved the drilling of 30 wells totaling 4988 feet to explore the soil sediments beneath 11 major and typical waste disposal sites.[14,15]

Both of the above studies concluded that the major amount (greater than 99% of the long-lived radionuclides) is stored in the subsoil within a few tens of feet below the bottom of the disposal facilities and well above the water table. The details of the exploration of radionuclide distributions beneath these waste disposal sites are summarized in Appendix II.1-C, Part 5.

Exploratory wells were drilled in 1966 at the following sites:

- 216-A-5 crib
- 216-A-8 crib
- 216-A-24 crib
- 216-B-3 ponds
- 216-S-7 cribs
- 216-S-9 crib

- 216-A-25 ponds
- 216-B-C cribs and trenches
- 216-BY cribs
- 216-T-28 crib
- 216-Z-9 cribs
- 216-Z-12 cribs

Summaries of the results are also presented in Appendix II.1-C, Part 5.

During 1971, data from the 1966 drilling were used to define an empirical relationship from which the quantities of ruthenium, cesium and strontium in the lowermost 50 feet of the vadose zone were estimated. Forty-two cribs were identified where possible quantities of these long-lived radionuclides might exist. The total inventory calculated for the lowest 50 feet of the vadose zone was about 2000 Ci of ruthenium and about 400 Ci of strontium plus cesium.[16]

On the basis of the concentration measurements for gross beta (calculated as ^{106}Ru) and tritium and nitrate ion plumes, an order of magnitude estimate was made of the total curies or kilograms in the unconfined groundwater aquifer. The concentration measured at the water table was assumed to be constant over the saturated thickness of the unconfined aquifer, an assumption which has not been verified but which should produce a conservative estimate. After the aquifer area was divided into 1000-ft square cells (yielding about 10,000 cells), the amount of contaminant in each cell was summed. The results were as follows:

Gross Beta (as ^{106}Ru)	6400 Ci
Tritium	3.5×10^7 Ci
Nitrate	2.2×10^8 kg

The radiological status of the groundwater near the surface of the unconfined aquifer is monitored regularly. The results are reported annually. The gross beta (ruthenium) plumes and the tritium plumes are mapped in Figures II.1-66 and II.1-67 for the latter half of 1973. The tritium plumes correspond to the nitrate plumes of Figure II.1-68 that emanate from the 200 Areas and the 100-N Area. The remainder of the tritium-contaminated groundwater in the northern part of the Reservation is due to previously operating reactors.

The major trends of the groundwater flow paths are illustrated by these plumes. Dispersion, radioactive decay, and a minor amount of sorption act to modify the convective transport of these contaminant "tracers." The gross beta activity plumes in Figure II.1-66 are not spread as far as the tritium or nitrate plumes, primarily because ruthenium (half-life of 1 year), which is the major beta emitter, is decaying faster than the current rate of travel away from the disposal sites.

Other radionuclides are observed in the unconfined aquifer in the immediate vicinity of the disposal sites at 100-N Area, 200 East and West Areas, and the 300 Area. At the 100-N Areas, the radioactivity in the groundwater from ground disposal of waste is predominantly tritium, ^{131}I, ^{106}Ru, ^{90}Sr, and ^{60}Co. At the 200 Areas, the groundwater activity in addition to ^{106}Ru and tritium is due to ^{60}Co, ^{90}Sr, ^{137}Cs, U, ^{99}Tc and ^{129}I.* At the 300 Area, the predominant radionuclide in the groundwater is uranium from fuel fabrication and laboratory waste disposal. Table II.1-7 shows the highest average concentrations of radionuclides other than tritium, ^{129}I and ^{99}Tc listed by disposal site for 1972.

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* Recently, more comprehensive analysis for ^{129}I (half-life 1.6×10^7 yr) was added to the groundwater monitoring program. Due to the low energy of the beta and gamma from ^{129}I, a special chemical separation is required and newly developed analysis methods are now available. Preliminary indication is that ^{129}I in the groundwater may have an environmental importance comparable to ruthenium and tritium. The first results for ^{129}I will be reported in the next annual monitoring report "Radiological Status of the Groundwater Beneath the Hanford Project." Groundwater concentrations of ^{99}Tc are found to be less than ^{106}Rh. The routine monitoring program has measured ^{106}Rh concentrations with special samples for ^{99}Tc on an intermittent frequency. The ^{106}Rh was considered to be a good measure of the position of the rapidly moving radionuclides other than tritium and ^{129}I.

0 2 5 0 1 6 3 1 1 6

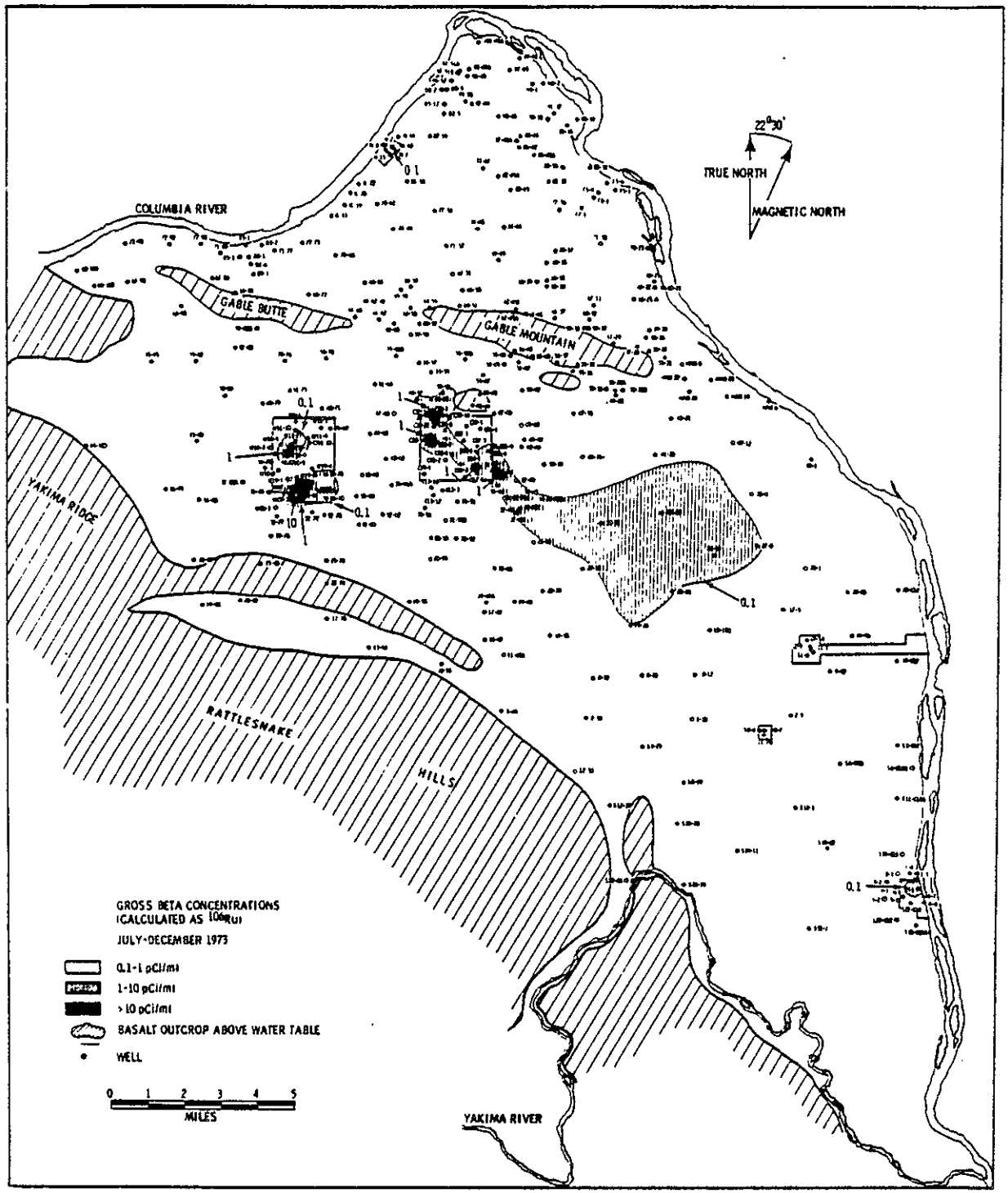

FIGURE II.1-66 AVERAGE GROSS BETA (As ^{106}Ru) CONCENTRATIONS FOR 1973 (Concentration Guide: 10 pCi/ml)

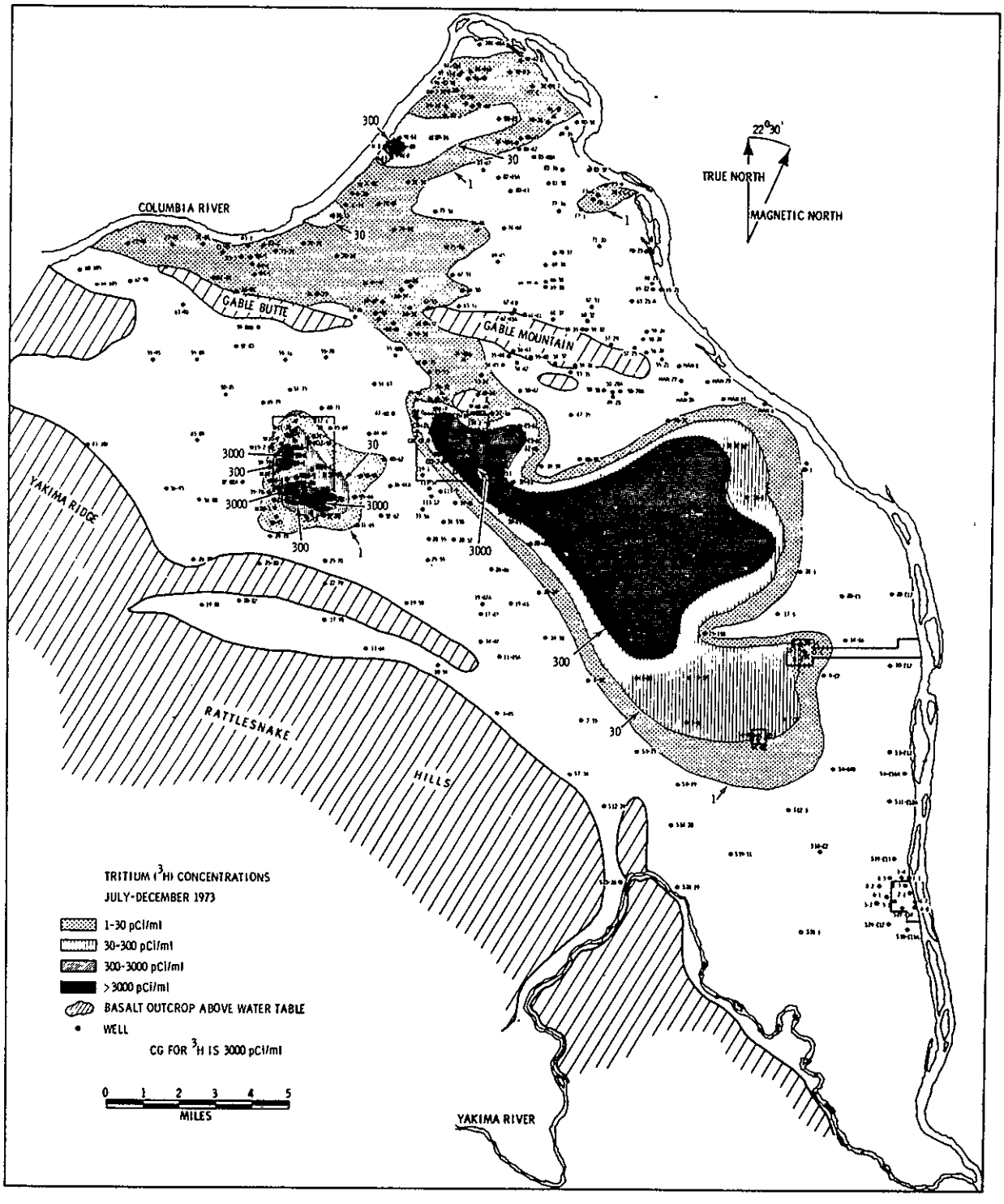

FIGURE II.1-67 AVERAGE TRITIUM (^{3}H) CONCENTRATIONS FOR 1973
(Concentration Guide: 3000 pCi/ml)

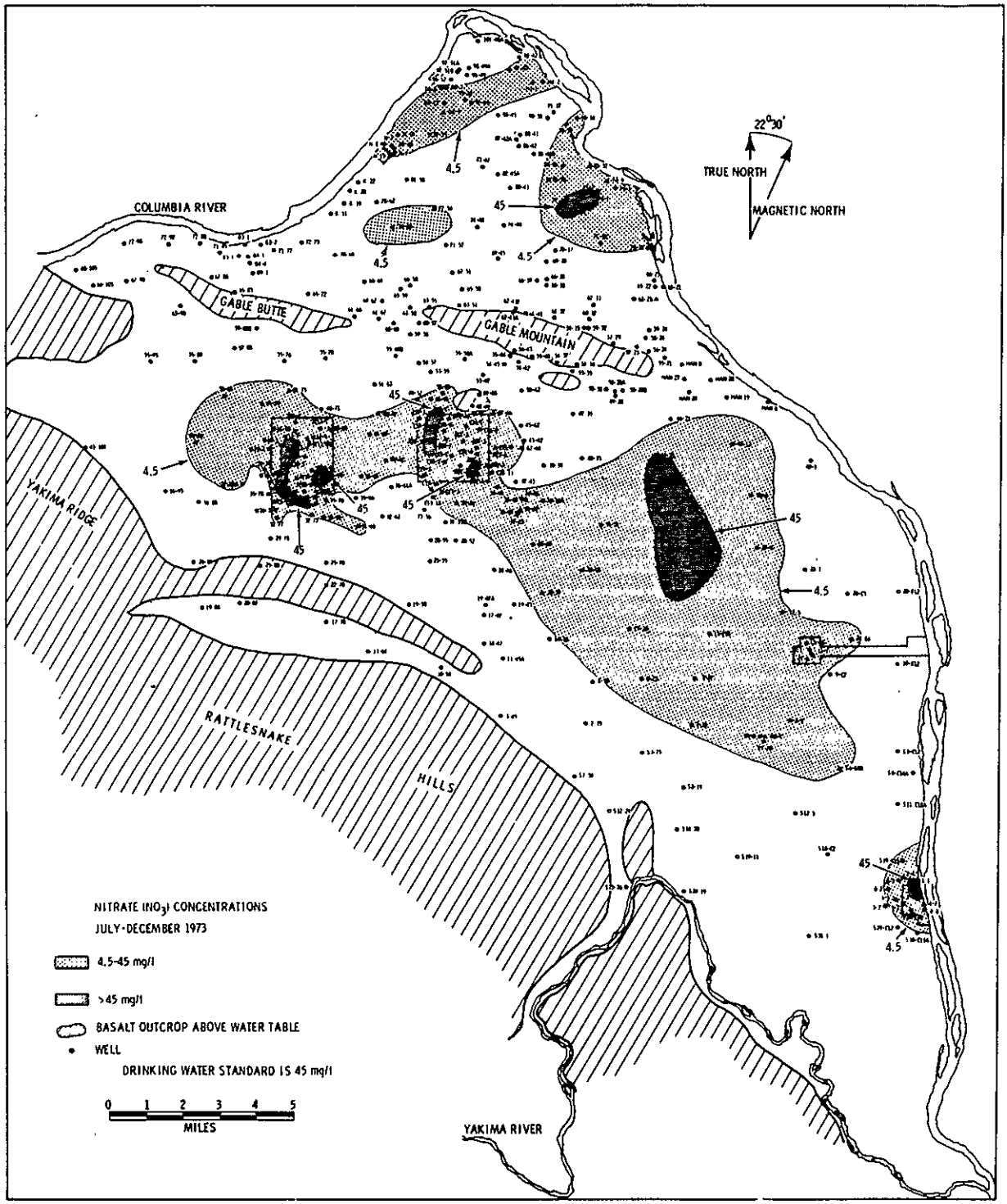

FIGURE II.1-68 AVERAGE NITRATE ION (NO_3^-) CONCENTRATIONS FOR 1973
(Drinking Water Standard: 45 mg/l)

TABLE II.1-7

HIGHEST GROSS BETA, ^{60}Co, ^{106}Ru, ^{90}Sr, ^{137}Cs, AND GROSS ALPHA CONCENTRATIONS IN THE GROUNDWATER UNDER THE AREAS LISTED BY DISPOSAL SITE

	Average Concentration (pCi/ml)			
	Jan-June 1972	July-Dec 1972	Analytical Limit	Concentration Guide
Gross Beta (as ^{106}Ru)			0.08	10
100 Areas				
Active Sites				
1301-N Crib	1.9	1.1		
Inactive Sites				
105, D/DR Crib, Storage Basin, Trenches	<0.08	0.12		
200 Areas				
Active Sites				
216-S-23	18	13		
216-B-50	3.9	4.3		
216-A-30	0.8	2.0		
216-A-36B	3.1	2.0		
Inactive Sites				
216-S-9	77	46		
216-S-1	23	26		
216-S-13	18	17		
241-BX-1,2	5.5	5		
241-BY-1,2	4.7	3.8		
300 Area				
Active Sites				
307 Retention Basin Transfer Line	6	0.32		
North Process Pond	<0.11	0.15		
^{60}Co			0.02	30
100 Areas				
1301-N Crib	0.054	<0.15		
200 Areas				
Active Sites				
216-B-50	9.0	10.3		
216-B-57	2.4	2.9		
Inactive Sites				
216-Z-7	2.3	1.5		
^{106}Ru			0.06	10
100 Areas				
1301-N Crib	0.18	0.07		

9 6 1 1 1 6 1 0 5 2 4

TABLE II.1-7 (Continued)

	Average Concentration (pCi/ml) Jan-June 1972	July-Dec 1972	Analytical Limit	Concentration Guide
200 Areas				
Active Sites				
216-S-23	17	15		
216-A-30	0.8	2.3		
216-A-36B	3.1	2.1		
Inactive Sites				
216-S-9	76	56		
216-T-26	3.3	3		
Gross Alpha (as ^{239}Pu)			0.02	5
200 Areas				
Inactive Sites				
216-S-13	1.41	2.57		
216-S-21	0.07	0.06		
216-A-27	0.04	0.035		
300 Area				
North Process Pond	0.1	0.09		
^{137}Cs			0.02	20
100 Areas				
1301-N Crib	<0.02	<0.11		
200 Areas				
Active Sites				
216-B-46,50	0.64	0.55		
216-A-36-B		0.042		
Inactive Sites				
216-A-24	0.076	0.15		
216-S-9	<0.07	<0.06		
^{90}Sr			0.03	0.3
100 Areas				
1301-N Crib	0.12	0.13		
200 Areas				
Active Sites				
216-A-36-B	0.064	0.064		
216-A-10	<0.032	0.033		
Inactive Sites				
216-S-1	19.2[a]	19.3[a]		
216-S-2	0.15	0.12		
216-A-5	<0.032	0.042		

(a) Appendix II.1-C, Part 5.

II.1.1.4.4 Plutonium Movement in Hanford Soil Systems [RPB, X.23, X.25]

The retention of plutonium solutions by Hanford soils is well documented.[37-52] (A discussion of these studies is presented in Appendix II.1-H.) Field observations and laboratory studies show that the bulk of the plutonium in waste solutions at near-neutral pH is removed from the solutions by sediments relatively close to the disposal point. The removal mechanism is 1) a plutonium-sediment exchange reaction or 2) plutonium precipitation for neutral to slightly acid waste solutions. Plutonium is adsorbed most effectively by high surface area, high cation exchange capacity sediments, with little effect from competing salts. Soil column studies show that little plutonium adsorption by sediments occurs from tenth normal acidic solutions, or higher acidities, at pH 10 from alkaline solutions.

Plutonium mobility in sediments in connection with 216-Z-9 covered trench investigations was studied.[47] Laboratory scale diffusion and leaching experiments showed that about 0.1% of the plutonium from surface sediments in 216-Z-9 covered trench was mobilized by groundwater. According to the study, plutonium migration into lower sediment layers was 10,000 times less than the transporting solution velocity. Plutonium movement by diffusion was negligible in a ten half-life period (8.5 cm in 2.4×10^5 years).

A study was made of the reactions of organic waste containing plutonium with Hanford sediments. Percolation of organics through the sediments had little effect on soil permeability for subsequent filtration of high-salt aqueous waste. Hanford waste disposal practices have avoided disposal of plutonium contaminated organic waste streams to sediments. Organic plutonium contaminated waste streams are stored in waste tanks.

Studies[45] have shown that only small amounts of ^{239}Pu are translocated from the sediments to plant leaves during plant growth. Leaf to soil ratio for ^{239}Pu was about 0.0001 on the average for barley grown on Milville silt loam, Cinebar silt loam and Ephrata fine sandy loam. Studies are in progress to determine the microbial alternatives of plutonium solubility in soils. The studies indicate that for the experimental conditions used, the solubility of plutonium in soil is influenced by the activity of the soil microflora. Research is directed toward determination of, 1) the uptake of plutonium by a broad range of plants from representative soil types containing plutonium at environmental concentration levels, with emphasis on root crops, 2) the potential for recycling of plutonium present in plant roots, and 3) the form and behavior of plutonium in soils and plants. These studies are fundamental in predicting and understanding the long term interactions of plutonium with soils, waters and plant growth.

II.1.1.4.5 Unplanned Releases

During the period 1945 through 1973 a number of unplanned radioactive contamination releases to the environment occurred. Details of many of these are abstracted in Appendixes II.1-B, Part 5, II.1-C, Part 8 and II.1-E, Part 5. These listings include unplanned releases which are known or believed to be in excess of 0.1 Ci of fission products or 0.1 g of plutonium. When possible, ground surface contamination was removed, covered or otherwise stabilized to preclude further spread in the environment.

Appendix II.1-B presents abstracts of unplanned environmental release incidents which occurred in the reactor (100) areas. Typical incidents included windborne radioactivity spread from dry cooling water retention basins and fuel element failures resulting in radioactivity releases from ventilation stacks. In excess of 2600 Ci of short-lived fission products are known to have been released to the environment as a result of incidents at Hanford reactor sites. Fire in a remote laboratory facility released about 4 g of plutonium.

The largest number of unplanned environmental release incidents occurred in the chemical processing (200) areas. The quantities of radioactive materials released are detailed in Appendix II.1-C. The typical incident involved leakage of waste solutions from tanks or lines or emission of gaseous or particulate radioactivity from stacks. In one incident, several hundred gallons of uranium solution soaked into the ground alongside a Hanford road after the overturn of a tank truck. This contamination has since been removed to the point that radiation control is no longer required. The largest release was the 106-T tank leak which released 40,000 Ci of ^{137}Cs, 14,000 Ci of ^{90}Sr and 4 Ci of plutonium to underground soils. No offsite or groundwater contamination resulted.

A number of environmental release incidents occurred in the 300 Area laboratory complex (Appendix II.1-E). 300 Area incidents resulted in the release of about 843 Ci of mixed fission products. Most of these incidents involved gaseous or particulate releases from stacks but the majority of radioactivity released occurred in a single incident which leaked fission products to the ground.

II.1.1.5 Waste Handling System and Operating Experience - Radioactive

II.1.1.5.1 Gaseous Radioactive Material Releases

The results of analyses of all exhaust air streams likely to contain radioactive materials are summarized below for 1972.[2]

Data for specific facilities are presented in Appendix II.1-C, Appendix II.1-D, and Appendix II.1-E.

100 Areas (1972)

	^{41}Ar	^{3}H	^{131}I
Total Release, Ci	1×10^{5}	2.7×10^{1}	1.3×10^{-2}
Average Concentration, µCi/ml	5.2×10^{-5}	1.4×10^{-8}	6.8×10^{-12}

	^{133}I	^{90}Sr	^{239}Pu
Total Release, Ci	5×10^{-2}	$<4.5 \times 10^{-6}$	$<3.7 \times 10^{-7}$
Average Concentration, µCi/ml	2.6×10^{-10}	$<6.6 \times 10^{-14}$	$<5.4 \times 10^{-15}$

200 Areas (1972)

	Alpha (Assumed Pu)	Alpha (Assumed U)	Beta	^{131}I
Total Release, Ci	5.2×10^{-3}	9.1×10^{-5}	8.7×10^{-1}	2.1×10^{-1}
Average Concentration, µCi/ml	3.9×10^{-13}	1.7×10^{-12}	6.5×10^{-11}	1×10^{-10}

300 Areas (1972)

	Alpha	Beta	^{131}I
Total Release, Ci	$<6.6 \times 10^{-5}$	$<3.4 \times 10^{-3}$	$<1.2 \times 10^{-2}$
Average Concentration, µCi/ml	$<1.1 \times 10^{-14}$	$<5.8 \times 10^{-13}$	$<2.5 \times 10^{-12}$

II.1.1.5.2 Liquid Radioactive Material Releases to Columbia River [RPB, X.25]

The total quantity of radioactive materials released to the Columbia River at 100-N[2] as summarized below are shown in Appendix II.1-B, Part 4.

100-N Area (1972)

	^{3}H	^{24}Na	^{51}Cr
Total Release, Ci	7×10^{3}	5×10^{2}	2.5×10^{1}
Concentration, µCi/ml	2.5×10^{-3}	1.4×10^{-6}	6.8×10^{-8}

	^{56}Mn	^{239}Np	Misc.
Total Release, Ci	6×10^{2}	9.0×10^{1}	1.8×10^{2}
Concentration, µCi/ml	1.6×10^{-6}	2.4×10^{-7}	

Quantities released in 1972 to the Columbia River via the 102-in. discharge line at 100-N are as follows:

To Columbia River Via 102-Inch Discharge Line at 100-N

Radionuclide	Ave. Conc. pCi/ℓ	Peak Conc. pCi/ℓ	Total Released Ci
^{46}Sc	0.06	60	0.02
^{51}Cr	0.9	280	0.2
^{54}Mn	1.5	1000	0.4
^{58}Co	0.1	82	0.02
^{59}Fe	0.25	900	0.1
^{60}Co	4.0	1200	1.0
^{65}Zn	0.7	450	0.2
^{76}As	0.1	36	0.03
^{95}Zr	0.2	70	0.04
^{95}Nb	0.4	140	0.1
^{99}Mo	NRD	42	<0.1
^{99}Tc	NRD	23	<0.1
^{122}Sb	NRD	10	<0.01
^{124}Sb	NRD	29	<0.01
^{125}Sb	0.05	32	0.02
^{131}I	0.1	6	0.03
^{134}Cs	0.02	<6	0.01
^{137}Cs	0.2	<2	0.07
^{140}Ba	<0.1	1500	0.1
^{140}La	<0.04	4900	0.3
^{141}Ce	0.1	140	0.03
^{144}Ce	0.3	170	0.1
^{187}W	NRD	0.3	<0.01
^{239}Np	NRD	45	0.02
^{103}Ru	0.08	110	0.02
^{24}Na	4	5	1
^{56}Mn	19	34	5
^{133}I	NRD	0.8	--

II.1.1.6 Waste Handling Systems and Operating Experience Nonradioactive

II.1.1.6.1 Nonradioactive Gaseous Releases[16]

II.1.1.6.1.1 100 Areas

Three oil-fired boilers, that provide standby power at the 100-N Area, release SO_2 and NO_2 to the atmosphere via stacks from each unit. No scrubbers or separators are used. (The pollutants released to the atmosphere are summarized in Table II.1-8.) The 100-K Area central heating plant has been deactivated. Separate unit heaters are utilized at each facility in other 100 Areas except 100-D in which experimental work is conducted and electrical heat is used. In 100-D and 100-F Areas, oil-fired package steam boilers burning an estimated 250,000 gpy each, discharge directly to the atmosphere.

TABLE II.1-8

SOURCES AND EMISSIONS OF NONRADIOACTIVE POLLUTANTS TO THE ATMOSPHERE CY-1972

	200-E Power Plant	200-W Power Plant	300 Area Power Plant
Fuel	Coal	Coal	Coal
Combustion configuration	spreader stoker	spreader stoker	spreader stoker
Consumption (tons)	57,000	35,000	10,500
Sulfur Oxides (tons)	650	400	120
Nitrogen Oxides (tons)	430	260	80
Particulates (tons)	3,400	2,000	650
Aldehydes (pounds)	300	200	50

	100-N Power Plant		300 Area Power Plant	
Fuel (oil)	#6 Residual	#2 Distillate	#6 Residual	#2 Distillate
Combustion Configuration	Tangentially Fired	Tangentially Fired	Horizontally Fired	Horizontally Fired
Consumption (gallons)	8,500,000	94,000	2,200,000	1,100,000
Particulates	100 tons	1,400 pounds	25 tons	8 tons
Sulfur Dioxide	1000 tons	2,000 pounds	250 tons	25,000 (pounds)
Sulfur Trioxide (pounds)	25,500	30	6,500	350
Carbon Monoxide (pounds)	1,700	20	450	200
Hydrocarbons (pounds)	25,500	300	6,500	3,300
Nitrogen Oxides (tons)	170	1.88	90	40
Aldehydes (pounds)	8,500	200	2,200	2,200

Exhaust Gas Flow for Main Heating Plants

100-N	$1. \times 10^{10}$ ft^3/year
200-E	3.4×10^{10} ft^3/year
200-W	2.1×10^{10} ft^3/year
300	2.3×10^{10} ft^3/year

	200-E Steam Plant	100-D Steam Plant	100-K Steam Plant	100-F Steam Plant	400 Area Steam Plant	3000 Area Steam Plant
Fuel	#2 Dist	#2 Dist	#2 Dist	#2 Dist	#2 Dist	#2 Dist
Combustion Configuration	Horiz. Fired	Horiz. Fired	Tang. Fired	Horiz. Fired	Horiz. Fired	Horiz. Fired
Consumption (gallons)	54,000	250,000	290,000	270,000	11,000	120,000
Particulates (pounds)	800	3,800	4,300	4,000	160	1,800
Sulfur Dioxide (pounds)	1,200	5,700	6,500	6,000	250	2,700

TABLE II.1-8 (Continued)

	200-E Steam Plant	100-D Steam Plant	100-K Steam Plant	100-F Steam Plant	400 Area Steam Plant	3000 Area Steam Plant
Sulfur Trioxide (pounds)	20	80	90	90	5	40
Carbon Monoxide (pounds)	10	50	60	50	2	20
Hydrocarbons (pounds)	160	750	860	800	30	360
Nitrogen Oxides (pounds)	4,300	20,000	11,500	21,600	900	9,600
Aldehydes (pounds)	100	500	600	540	20	240

333 Building
Metal Etch Line

Nitrogen Oxides - 14 tons

II.1.1.6.1.2 200 Areas

One major heating and power plant is operating in the 200-E Area and another is operating in the 200-W Area. In addition, a portable steam generator is operated in the 200-E Area tank farms. Atmospheric releases are summarized in Table II.1-8.

The Btu/hr heat input rating of all fossil fuel combustion equipment is:

Btu/hr heat input	39.5×10^6 at 30 m/hr*
	65.7×10^6 at 50 m/hr
	79×10^6 at 60 m/hr
	92×10^6 at 70 m/hr
	105×10^6 at 80 m/hr

The Btu/hr value and sulfur and ash content, where relevant, for all fuels are:

Coal Analysis

Continental (Hiawatha)		Pit	
Btu/lb	12650	Btu/lb	11250
Ash	6.5%	Ash	10%
Sulfur	0.7%	Sulfur	0.7%

The hourly fuel use rate for each unit is:

Fuel use rate Hiawatha

30 m/hr = 1.5 tons per hour
40 m/hr = 2.0 tons per hour
50 m/hr = 2.5 tons per hour
60 m/hr = 3.0 tons per hour
70 m/hr = 3.5 tons per hour
80 m/hr = 4.0 tons per hour
Pit coal add 10% more consumption per hour at each load rating.

Stack height and internal exit diameter for all release points are:

Stack height 250 ft - 9 ft ID at top.

Exit velocity and temperature for all stack effluents are:

*m/hr = 1000 pounds steam per hour.

9 1 1 3 9 1 0 5 3 0

Velocity and temperature

30 m/hr = 204 fpm at 183°F
50 m/hr = 283 fpm at 204°F
60 m/hr = 330 fpm at 232°F
70 m/hr = 377 fpm at 246°F
80 m/hr = 425 fpm at 262°F

II.1.1.6.1.3 300 Areas [X.24]

A central powerhouse in the 300 Area provides up to 365,000 lb/hr of steam for building heat and limited process heat in some facilities. The four oil-fired units normally in use are supplied from a large underground storage tank. Three of these discharge through individual ducts at roof level.

The two coal-fired units now being returned to routine service are fed from an uncovered large surface supply maintained by railcar shipments. The two coal-fired and one oil-fired units are discharged through a cyclone separator and a 150-ft high stack to the atmosphere.

II.1.1.6.2 Nonradioactive Liquid Disposal

II.1.1.6.2.1 Sanitary Waste

100 Areas

Each area includes several sanitary waste systems including separate septic tanks draining into tile fields. The rates of sanitary sewage discharged to the ground for 1972 are listed in Table II.1-9.

TABLE II.1-9

SEWAGE DISPOSAL TO GROUND FROM 100 AREAS

Plant	gpd
100-N	22,500
100-K	2,750
100-B-C	180
100-D	2,400
100-F	2,700

200 Areas

All facilities in the 200 Areas with sinks, rest rooms, showers, or lunchrooms are on a sanitary sewer system discharging into septic tanks which overflow into tile fields. The rate of sanitary sewage discharge to the ground for 1972 is 99,000 gpd.

300 Areas

Sanitary waste is liquid waste from change rooms with sinks and showers, restrooms, toilet facilities, janitor sinks and lunchrooms. All permanent 300 Area buildings with one or more of these accommodations are on a separate sewer system delivering sewage to septic tanks with a total volume of about 8,500 ft^3 (Figure II.1-69). The effluent from the septic tank flows to one of two leaching trenches approximately 600 feet long and 10 feet wide.

Flow through the sanitary sewer system varies from 350,000 gpd in the winter to 600,000 gpd in the summer. A weir between the septic tank and the leaching trench measures the volume of sewage. This is continuously recorded and the record inspected daily. Samples are taken routinely between the trenches and the river and analyzed for coliform, BOD and turbidity.

Miscellaneous Facilities

The rates of sanitary sewage discharged to the ground via tile fields adjacent to facilities for 1972 are summarized in Table II.1-10.

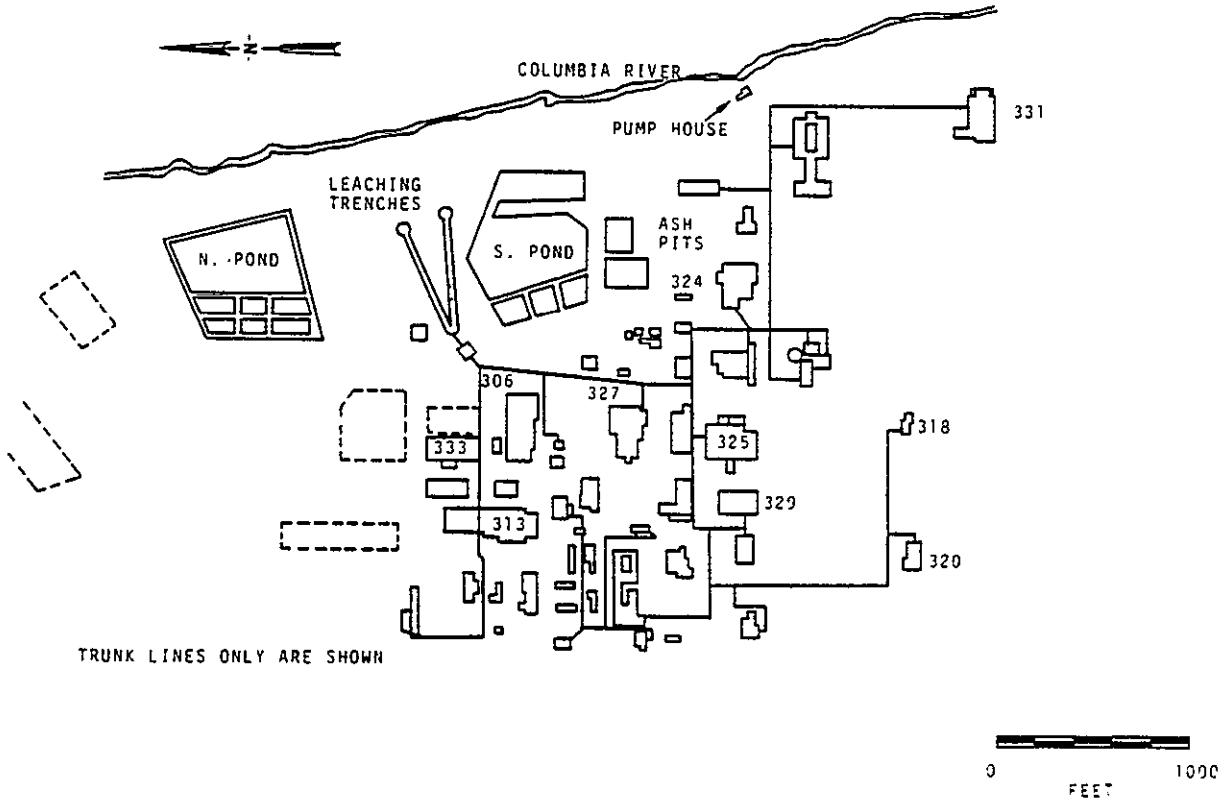

FIGURE II.1-69 300 AREA SANITARY SEWER SYSTEM

TABLE II.1-10

OTHER SEWAGE DISPOSAL TO GROUND

Plant	gpd
609 Bldg. Fire Station	1,250
609-A Building Fire Station	800
Hanford Road Maintenance	200
600 Area (Atmos. Physics)	2,900
6652-C Aeronomy	900
6652-I (ALE)	900
BY Telephone Exchange	6
FFTF	60,000
WPPSS-N Area	10,000

II.1.1.6.2.2 Industrial Liquid Waste [X.24]

100 Areas

Four of the 100 Areas discharge water directly to the river. For 14 discharge points, a discharge permit application was filed with the Corps of Engineers who, in turn, transferred it to EPA. The application has not been processed by the EPA. (The discharge applications are shown in Appendix II.1-D) No waste abatement is applied to any discharge as essentially no chemicals or radionuclides are released. Table II.1-11 and the figures in Appendix II.1-D describe these releases.

TABLE II.1-11

DIRECT DISPOSAL TO THE COLUMBIA RIVER

Plant	gpd
100-N	283,000,000
100-K	4,530,000
100-B-C	755,000
100-D	792,000

Approximately 2,000,000 gpd of industrial waste which contains minor amounts of chemicals, shown in Table II.1-12, and radioactive material (discussed in previous section) are discharged to the ground at the 100-N Area via 1301-N Crib. No industrial liquid waste is discharged to the ground in the deactivated 100 Areas.

TABLE II.1-12

1301-N CRIB - 1972

Volume Released 7.6×10^6 ℓ/d

Sulfate	3.5 mg/ℓ	Nitrate	0.1 mg/ℓ
Aluminum	80 μg/ℓ	Ammonia	1.8 mg/ℓ
Calcium	13 mg/ℓ	Nitrite	0.140 mg/ℓ
Chromium	10 μg/ℓ	Strontium	80 μg/ℓ
Iron	50 μg/ℓ	pH	7.7
Magnesium	2 mg/ℓ	Total Solids	67 mg/ℓ

200 Areas

Approximately 16,800,000 gpd of industrial waste are discharged to the ground in the 200 Areas via ponds and cribs. (The discharge points are described in Appendix II.1-C.) These discharges, primarily cooling waters containing minor amounts of chemical and radioactive pollutants, are controlled between pH of 7.0 and 8.0.

300 Areas

Industrial waste includes cooling water, process water and other nonsanitary waste. Discharge of uranium and small qunatities of radioactive waste containing less than 5×10^{-5} uCi/cm^3 is permitted. The average concentration is about 1×10^{-7} uCi/cm^3. Each facility in the area with significant quantities of process and cooling water is connected to the separate process sewer system which discharges directly into one of two retention ponds (Figure II.1-70). These ponds, covering approximately six acres each, are used alternately, the North Pond being currently used. The North Pond comprises three smaller divided bays and one large bay. Water enters the ground through percolation at the bottom of the pond. The first bay (nearest the influent) of the pond contains an oil stop to permit the recovery of spilled oil. A representative weekly sample of pond water is obtained at the pond inlet. Discharge to the ponds averages about 3,000,000 gpd. The average concentrations of chemicals released to the ponds in 1972 are summarized in Table II.1-13. A new trench with a bottom area of 15,000 ft^2 is under construction and will replace the retention ponds by August, 1974.

Three locations in the 300 Area discharge directly to the river. These discharge points are covered by a permit application (shown in Appendix II.1-D). These discharges include 27,000 gpd of filter backwash from the 300 Area water treatment plant and 1,150,000 gpd of 331 Building fish pond effluent. The 309 Building drain discharges air conditioning water.

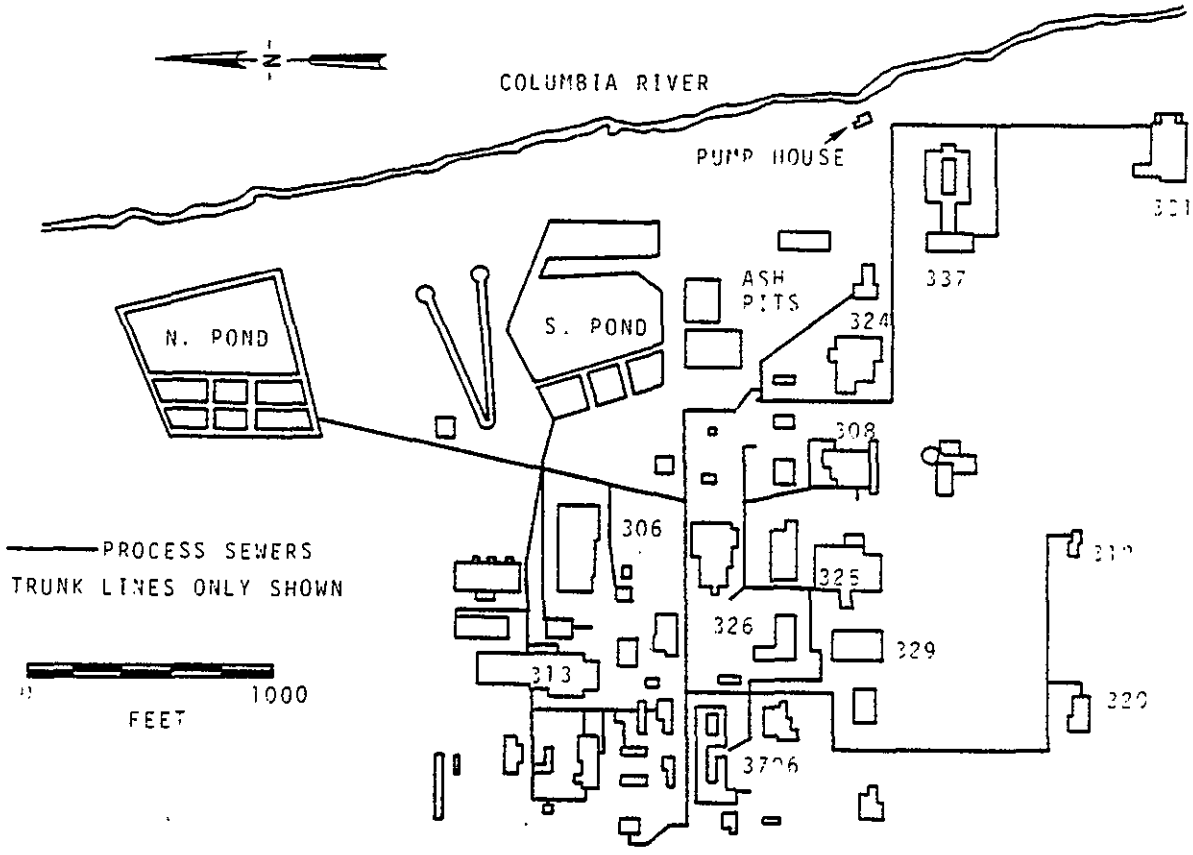

FIGURE II.1-70 PROCESS SEWERS AND RETENTION PONDS

TABLE II.1-13

NONRADIOACTIVE CHEMICALS RELEASED

300 Area Process Pond - 1972

Volume Released 3 x 10^6 gpd cooling water at pH 7.8

Chemical	Average Concentration for 1972, ppm
Chlorine	12.0
Copper	2.1
Iron	0.11
Fluorides	2.1
Nitrates	61.0
Sulphates	28.0
Chromium+6	0.011
Uranium	0.130

II.1.1.6.2.3 Oil and Chemical Waste

At Hanford, approximately 23,000 gallons of nonradioactive contaminated waste oil from machine and automotive operations are generated annually (Table II.1-14) and are used to stabilize dust on plant roads and parking areas. No other disposal is considered for this waste oil as dust stabilization is a necessary activity.

9 1 1 1 3 1 0 5 3 4

Approximately 450 gallons of waste oil contaminated with radioactive materials are generated annually. The oil is immobilized with absorbent material in areas and buried in approved burial grounds.

TABLE II.1-14

DISPOSAL OF USED OIL

Contractor	Gal/yr Non-radioactive Contaminated Used Oil	Gal/yr Radioactive Contaminated Used Oil	Disposal Method	Disposal Cost Contaminated Dollars/yr	Disposal Cost Non-Contaminated Dollars/yr
BNW	100		A		43.00
		250	B	200.00	
		150	C	500.00	
UNI	1160		A		240.00
		770	D	-0-	
HEDL	6600		A		1200.00
		50	B	37.50	
ARHCO	13000		A		520.00
JAJ	2200		A		32.00
TOTAL	23060	450/770	B/D	737.50	2035.00

A. Use to stabilize dust on plant roads and parking areas.

B. Put in barrels with absorbent and buried.

C. Put in double containers with absorbent and buried.

D. Used in solidification agent and shipped offsite

An additional 700 gallons of cutting oil, containing about 98% water and contaminated with uranium, are used in concreting uranium scrap for disposal or offsite shipment. Several installations (100-N, 100-B, 100-K, 100-F Areas and 300 Area) along the Columbia River use and store oil and other potentially hazardous pollutant chemicals. However, spill prevention and control measures are incorporated into the design and operation of the storage and handling facilities so that existing controls would either prevent or limit the flow of these materials to the river, thus presenting no hazard to the public or the environment.

Routine evaluation of water quality upstream of N Reactor shows that the river burden, in tons per day, includes:

Chemical Measured	Daily River Burden (ton/day)
SO_4	4,300
NO_3	130
Cl	180
Na	400
TOTAL	5,010

Procedures have been defined to minimize the quantity of any accidental spills of chemicals or fuel oils. These include the following:

- Control of filling, discharge, inspection, and maintenance of storage vessels is to be accomplished by trained operators and vendors who follow precautionary operating procedures.

- Complete records are to be maintained on all orders, receipts, and use of chemicals. Quantities, concentrations, laboratory analyses, delivery dates, costs, etc., are to be kept on all chemicals received.

- Measurements are to be taken before and after vessel loading, with physical inspection of the vessels also to be made at that time. Once each year, a complete physical inspection of chemical and oil storage vessels is to be made. Valves are to be inspected on a routine preventive maintenance schedule.

- Equipment Maintenance Standards require an internal inspection of diesel fuel storage tanks and day tanks every 3 years. Since these tanks, if ruptured, pose the largest single potential threat to navigable water, this requirement is deemed to be preventive. In addition, the dikes for diesel fuel and the open trench at 100-N between the river and the tanks (to collect such a loss) are to be maintained as preventive systems.

- Once each year, audits are to be made by a site Environmental Engineer to insure that inventory control requirements were met. These audits are to include review of records and physical systems as described above.

Systems for preventing accidental spills into the Columbia River from operations at Hanford are built into the design, operation, and maintenance of the facilities. Although confident that a spill of oil and other potentially hazardous pollutant chemicals will not reach the river in amounts that represent a hazard to the public or the environment, the ERDA has maintained extensive procedures for many years for coping with any emergencies that might arise at the site, including such things as liquid spills. The procedures detail the actions to be taken and the requirements for internal and external notification. In the case of accidental spills to the river, the procedures require notification to downstream water users and, as appropriate, Federal and State pollution control agencies, the Coast Guard, and the Corps of Engineers.

Numerous potentially hazardous chemical substances, listed in Appendix II.1-F, are in the 200 Area waste streams. Several of these are discharged to the atmosphere as gases, including liquid nitrogen, carbon dioxide and ammonia. In addition, a portion of the nitric acid is discharged to the atmosphere as oxides of nitrogen. Fumes, mists and vapors from chemical makeup tank vents probably contain traces of most of the process chemicals listed.

The aqueous chemical sewer streams contain varying amounts of all the process chemicals. Since many of these materials can be expected to interact in a dilute aqueous solution, prediction of all of the potential products is a formidable task. Oxidizing agents such as potassium permanganate or sodium nitrite will react with materials such as ferrous sulfamate or hydrazine to form more stable compounds. Acids and bases will react to form salts. The vast bulk of these chemicals are retained in the process waste streams, so that the reaction products enter the underground waste tanks.

II.1.1.6.3 Nonradioactive Solid Waste Disposal

II.1.1.6.3.1 Toxic Waste [X.24]

Toxic nonradioactive waste includes harmful chemicals such as beryllium, asbestos, mercury, carcinogens, cyanides, dichromates, cobalt, selenium, cadmium and arsenic. Beryllium waste is disposed of in the same manner as transuranic waste. Combustible toxic waste is disposed of by high-temperature incineration in small combustion chambers which are followed by dual scrubbers. Nonburnable solid or liquid toxic materials are packaged and buried in the 200 Areas in controlled areas.

II.1.1.6.3.2 Pyrophoric Waste

This waste category includes the alkali metals, phosphorus, hydrides, and finely-divided zirconium alloys. Alkali metals are stored under inert gas and are disposed of by burning at the 3718-F Building in the 300 Area. Each of the others is separately stored in oil or liquids prior to conversion to nonpyrophoric oxides.

II.1.1.6.3.3 Salvageable Scrap

Salvageable scrap including lumber, metal turnings, and similar materials, plumbing parts and fixtures, electrical wiring, conduits and fixtures, and certain other building fixtures and materials are surveyed for radioactive contamination and if clean are collected in appropriate containers throughout the plant. Periodically these containers are transported to Central Stores excess yards where the salvaged materials are processed for public sale.

II.1.1.6.3.4 Trash

Solid waste generated in offices, lunchrooms and laboratories throughout the plant includes paper products and food scraps, but excludes material contaminated with radioactive nuclides or noxious chemicals. The combustible dry waste is placed in portable containers conveniently located at buildings housing personnel. This waste is determined to be approximately 90% paper products and is 97% combustible. The waste volume is reduced by a factor of three by compaction, and the reduced volume of waste is buried in a centralized sanitary landfill facility operated by ARHCO. The total compacted volume for the waste is forecast to be 360,000 ft^3/yr.

II.1.1.6.4 Sanitary Sewage and Industrial Waste (Future Plans)

The sanitary sewage disposal quantities are anticipated to remain relatively constant over the next 5 years.

II.1.1.6.4.1 200 Area

The new 242-S evaporator will add approximately 1 billion gallons of water per year to the ground in 200-W Area for a period of approximately 3 years. A proposed evaporator would discharge a like amount of cooling water for the same period to the ground in the 200-E Area.

II.1.1.6.4.2 300 Area

Chemicals from the 300 Area fuel fabrication facility (except for water rinses and scrubbers) are collected in plastic tanks, neutralized and transported to 100-H Area and deposited in large concrete basins. Solar evaporation reduces the slurry to a sludge which is retained for possible future recovery of copper and uranium. This operation was instituted in 1973 on an intermittent basis and will be fully operational in 1975. As a consequence of this action, the concentration of the following ions in the 300 Area process waste ponds is expected to be reduced by about 80%: chromium +6, copper, fluoride, nitrate, and uranium. Since the uranium is the principal radionuclide in the ponds, the radioactivity is expected to be reduced by a similar amount.

Changes in laboratory operations are anticipated as work on the Liquid Metal Fast Breeder Reactor (LMFBR) program progresses. Among those changes is installation of an alkali metal cleaning facility which will affect waste water discharged to the 300 Area process pond slightly. An increase in volume of 215,000 gal/month (0.2% of current flow) and very slight increases in sodium ion and sulfate ion concentrations are anticipated.

II.1.1.6.4.3 400 Area

Present plans include construction of a Radiation and Repair Engineering Facility (RAREF) in the Fast Flux Test Facility. It is estimated that the RAREF will discharge up to 40,000 gallons of water once every 3 weeks to the 400 Area Leaching pond. The RAREF effluent will be monitored to ensure that it is free of radioactivity but will contain 10 mg/l sodium ion from nonradioactive cleaning operations.

II.1.2 Environmental Measurements and Monitoring Programs

II.1.2.1 Operational Programs - Radiological [X.4, X.24, X.25]

The Hanford Environmental Surveillance program is a multifaceted operation, performing several different tasks both onsite and offsite. The primary task is the computation of dose to local population groups from all exposure pathways that may show the presence of radioactivity from Hanford operations, in order to determine compliance with ERDAM-0524[17] radiation dose standards. Measurement is made of the radionuclide concentrations in local air, water and foodstuffs, along with direct radiation measurements. Onsite and offsite monitoring also provide estimates of radiological impacts on the biosphere, in addition to providing indications of unusual results or trends which might indicate loss of control of radioactive waste disposal operations. A major groundwater monitoring program also provides continuing information on movement of contaminants in the groundwater beneath the site. Waste disposal sites, both active and retired, are monitored for any changes of conditions.

The data collected are available in routine reports issued by the Environmental Evaluation staff. Groundwater data and evaluations are reported in the series, "Radiological Status of the Groundwater Beneath Hanford Project for ..."[18] Data from locations within the plant boundaries are presented in the annual "Environmental Status of the Hanford Reservation for..." report series.[19] Data from offsite locations are presented in the annual "Environmental Surveillance at Hanford for..." series of reports.[20,21]

A summary of the Hanford Environmental Surveillance program is given here; the complete surveillance schedule for CY-1974 can be found in BNWL-B-323,[22] with frequency and required analyses of all the samples taken. The bulk of the radioactive analyses are performed by the United States Testing Company, with the remainder being done by BNW. Table II.1-15 is a summary listing of the program.

A quality assurance program is applied to the environmental sample collection and evaluation program. The sampling programs are designed to put emphasis on samples that are more significant in estimating exposure or assessing contamination control practices. Frequent and multiple samples or continuous monitoring are provided as part of the environmental evaluation program for these samples. For exposure pathways with little or no exposure potential, fewer samples are taken. The program is designed to provide a quality of sample collection or continuous monitoring commensurate with the potential exposure.

The majority of the routine environmental radioanalyses for the Hanford program are performed by the U.S. Testing Company in Richland, Washington. Analytical limits are specified in a services contract between U.S. Testing and ERDA. The term "analytical limit" is defined as the concentration at which the laboratory can measure a radionuclide with an accuracy of ±100% at the 90% confidence level given the required volume of sample material. The detection limit for a specific radionuclide varies with sample type, sample size, counting time, and amounts of interfering radionuclides present. The "analytical limits" represent upper bounds to the fluctuating detection limits.

U.S. Testing maintains an internal quality control program consisting of routine instrument calibration and background counts to insure the integrity of results. U.S. Testing also participates in the Interlaboratory Comparison program of the Environmental Protection Agency involving the analysis of several environmental media (milk, water, air, food, and soil) and a variety of radionuclides of interest. A number of different environmental samples, containing known amounts of one or more radionuclides, are prepared and routinely distributed to all laboratories in the program. These laboratories perform the required analyses (three separate determinations) and return their results to EPA for comparison with the known value and the results from the other laboratories. The results from the different laboratories should form a consensus around the correct value. In this manner, the program enables a laboratory to document the precision and accuracy of their results relative to the other laboratories and to take any needed corrective action.

Forty-four air samplers both onsite and offsite provide samples of airborne particulates routinely analyzed for gross beta; samples from 15 of these locations are also counted for total alpha. These air samplers are composited in 13 different groups (by geographical sector) for specific nuclide analysis on a monthly basis. In addition, 38 of these sampler locations are monitored for airborne ^{131}I using charcoal cartridges. One tritium monitoring location is in current operation, with an increase in number of locations expected as site operations warrant.

External penetrating radiation is measured at 64 locations, both onsite and offsite, using thermoluminescent dosimeters. The dosimeters are changed bi-weekly or monthly depending upon their location. External radiation is also measured with portable instruments at selected points on the shoreline of the Columbia River on a weekly or monthly basis. Exposure from penetrating radiation from immersion is measured in the Columbia River upstream and downstream of plant facilities with the thermoluminescent dosimeters. A sensitive dose-rate monitor continuously measures the radiation level at the river water surface and includes an automatic alarm and safety features.

Soil and vegetation samples are taken at 36 locations on an annual basis. River sediment samples are taken at two locations, also annually. The soil and vegetation are analyzed for uranium, ^{90}Sr, ^{239}Pu and are given a gamma scan for specific radionuclide identification. The sediment samples are sectioned and each layer given a gamma scan.

Surface water samples are taken from the Columbia River at several points, as well as from the wastewater ponds and ditches on the Hanford site. The Columbia River measurements are made on three integrated and three grab samples. Drinking water samples are taken at Richland, plus two onsite locations. The river water integrated samples are analyzed for ^{3}H, total beta, total alpha, ^{131}I, ^{239}Pu, and for specific nuclides by gamma scan. The river water grab samples are analyzed for ^{3}H and total beta. The sanitary water integrated samples are given total alpha, total beta and gamma measurements.

The groundwater is routinely measured[22] at numerous wells for tritium and gross beta. Other specific radioanalyses are made at several locations. Sampling frequency varies from monthly to semi-annually depending on the location of the well. In general, only the shallower, unconfined aquifer is sampled, but the deeper, confined aquifers are sampled at a few wells.

TABLE II.1-15

ROUTINE ENVIRONMENTAL SURVEILLANCE SCHEDULE CY-1974

Type of Sample	Type of Analysis	Cont	D	SW	W	SM	M	BM	Q	SA	A
			Frequency(a)								
WATER											
Columbia River Water	Radioactivity	1			1		4		1		
	Chemical		1		3		8				
	Biological						4				
Sanitary Water	Radioactivity				3						
	Chemical				2(b)						
Waste Water	Radioactivity				1		10				
	Biological						1				
Groundwater Wells	Radioactivity						2	2	133	94	
	Chemical						2	42	139	77	
AIR											
Filters	Radioactivity				15	29					
Charcoal Cartridge	Radioactivity				3	7					
Tritium Cartridge	Radioactivity					1					
OTHER											
Waste Disposal Sites	Radioactivity								23	70	1
Radiation Level	Dose Rate		1			17	47				
Shoreline Survey	Dose Rate				1	1	18				
Ground Control Plot	Radioactivity		1			1	14	13	12	4	
Road Survey	Radioactivity						7		8		
Aerial Survey	Radioactivity									3	
Railroad Survey	Radioactivity										1
Milk	Radioactivity					4	2				
Fish Columbia River	Radioactivity					1					
Wild Fowl	Radioactivity								9		80
Mammals	Radioactivity						1		3		35
Soil	Radioactivity										26
Vegetation	Radioactivity										26
Foodstuffs:											
Meat	Radioactivity						1			1	
Eggs	Radioactivity						1			1	
Chicken	Radioactivity								1	1	
Produce	Radioactivity										14
Oysters	Radioactivity										1

(a) Samples were taken continuously, daily, semi-weekly, weekly, semi-monthly monthly, bi-monthly, quarterly, semi-annually or annually.

(b) Samples routinely analyzed and reported by the Hanford Environmental Health Foundation.

Selected fauna are sampled onsite, with a frequency depending on the type collected and location. Whitefish are collected from the Columbia River and samples are composited bi-weekly, with measurements by gamma scan and specific analysis for ^{32}P and ^{90}Sr. Deer, three collected during each hunting season, are analyzed for ^{90}Sr, ^{239}Pu and gamma emitters. Rabbits, muskrats and mice as available are collected at the liquid waste disposal sites and are analyzed for ^{90}Sr, ^{239}Pu, natural uranium, and gamma emitters. Ducks, geese, and pheasant are collected along the Columbia River during hunting seasons; flesh samples are analyzed for ^{90}Sr and gamma emitters. At wastewater ponds, ducks are collected during the year; the particular analyses depend on the location where the samples were collected, but always include ^{90}Sr and a gamma scan.

Foodstuffs are collected from local farms and commercial establishments. Leafy green vegetables are collected during the growing season and are given a gamma scan plus a ^{90}Sr analysis. Eggs, chickens, and beef are collected when available and given the same analyses as leafy green vegetables. Oysters from a commercial source at Willapa Bay, Washington, are analyzed by gamma scan on an annual basis.

Milk samples are taken at two grocery stores and at four local farm sources. The two commercial sources get milk from different milksheds, one in eastern, the other in western Washington. These samples are collected bi-weekly at the farms and monthly from the commercial sources. The milk is analyzed for ^{131}I, ^{90}Sr, and given a gamma scan. Cattle forage, hay, or pasture grass is collected with each milk sample but is only analyzed when other positive results suggest it.

Potential surface contamination from Hanford operations is monitored by four different methods. Forty-five special ground plots are surveyed with a portable beta-gamma monitoring instrument (GM counter) for changes in background measurements. All of the major Hanford roadways are monitored monthly for particulate contamination with a truck-mounted gamma scintillator. The unit has a linear response to exposure rates over the range of 1 to 100 μR/hr with lower level discriminator set at 300 keV. The detection level at about 1 foot is 0.1 μCi of ^{131}Ba or 0.2 μCi ^{137}Cs as point sources. Using the same detector, the railroad right-of-way is monitored on an annual basis. An annual aerial survey, using sensitive scintillation gamma monitoring instrumentation, is made on controlled flight patterns around the site.

In addition to the routine surveillance program, additional sampling and monitoring capabilities are provided to the Hanford site in cases of unusual operating conditions or releases. As a minimum, the response includes an intensified sampling schedule plus additional samples for detailed analysis.

A special aerial survey was made to determine whether aerial gamma surveys could adequately measure the activity of high specific activity gamma emitters contaminating large surface areas. The survey successfully measured the ^{137}Cs activity and the total gross gamma activity over areas from less than 1 km^2 to 20 km^2. Also ^{241}Am was successfully measured over areas wherein the ^{137}Cs was sufficiently low. Microcuries per square meter was measured as low as 0.1 for ^{137}Cs and ^{241}Am. Other radionuclides such as ^{60}Co were also detected. An aerial neutron survey was tried, though its efficiency limited detection to areas having more than 10 kg plutonium per 4,000 m^2.

As privately owned nuclear facilities increase operations at Hanford, the routine program will be modified further to provide additional information required to differentiate the effluents from the ERDA contractors and the private facilities. Typically these modifications to the program would be increased air sampling between the different facilities, external gamma dosimetry, and surface or groundwater sampling, if these media are involved.

The states of Oregon[35] and Washington[36] have maintained statewide radiological surveillance programs, including some measurements pertinent to Hanford operations. Included are sampling of Columbia River water, shellfish, milk from milksheds in adjacent counties, groundwater near the WNP-2 reactor site, and more recently, ambient radiation measurements in the city of Richland. Published reports of the results of these activities in general confirm results reported from the Hanford surveillance program.

II.1.2.2 Operational Programs - Ecological

Prior to the government acquisition 30 years ago of the land area known as the Hanford Reservation essentially no data was available concerning the ecology of the area. St. John and Jones in 1928 published an annotated list of the vascular plants of Benton County and provided a general description of major vegetation types in relation to soil and topography.

Studies of local aquatic populations and potential radiation effects began at Hanford under the sponsorship of the Manhattan Engineering District before the first reactor was in operation. A broad spectrum of ecological studies, both aquatic and terrestrial, continued on a greatly expanded basis under the AEC. With some exceptions, these studies were of limited duration and were pursued more for general scientific knowledge than for strict application to the Hanford site. In the course of this work, however, a mass of ecologically-related data accumulated that not only provides baseline information but also is used to guide the biological sampling portion of the radiological program.

Continuing ecologically-oriented monitoring programs under the ERDA are at present concerned with the censuses of waterfowl onsite and of salmon spawning beds in the Columbia River within and adjacent to the site boundaries. These programs are expected to continue indefinitely. Examples of current studies of more limited duration are included on the following pages.

0 4 5 0 1 6 8 1 1 6

II.1.2.2.1 Aquatic Ecology

II.1.2.2.1.1 Columbia River Studies

Anadromous Fish

Since 1947, the Columbia River from Richland to the vicinity of Priest Rapids has been surveyed from the air to estimate the size of the salmon spawning population in this area.[23,24] A number of factors influence the population changes observed since 1947. In general, the number of spawning chinooks in this reach of the river increased until 1969 after which they fell off slightly in 1970 and 1971, quite markedly in 1972 and increased again in 1973. These studies were instigated to determine if the Hanford operations adversely affected this population. The greatest increase occurred during the time the most reactors were in operation, but there is no evidence that this increase was the result of Hanford activities.

Radionuclide Decline

When the last plutonium production reactor was shut down in January 1971 (except for the dual purpose N Reactor), a study was initiated to investigate the decline and retention of Hanford produced radionuclides in the Columbia River ecosystem. Radionuclide concentrations in most segments of the ecosystem declined quite rapidly compared to previous years where the single pass reactors were in operation. Continuing studies reveal the virtual disappearance of ^{46}Sc, ^{54}Mn, and ^{137}Cs in the biota and the presence of extremely low levels of ^{60}Co and ^{65}Zn.[25,26] Studies are in progress to describe the cycling of these elements in the food-web. Laboratory studies are being conducted to examine 1) the uptake and retention of radionuclides by periphyton from the water and 2) the transfer of radionuclides from the sediments into the water and periphyton.[27,28]

II.1.2.2.1.2 Radioactive Waste Pond Studies

Gable Mountain Pond

Ecological studies in Gable Mountain Pond were initiated in 1972 to define the potential for offsite movement of radioactivity via the aquatic food-web. The body burdens of radionuclides in controlled populations of goldfish and waterfowl are being measured to obtain the levels and rates of radionuclide accumulation. The spatial distribution of radioactive materials in the pond sediments is also under investigation. Over 85% of the gamma radioactivity is in the upper 2 inches of sediments, with ^{137}Cs accounting for over 90% of this activity.

U Pond

The distribution of ^{239}Pu and ^{241}Am is being studied in the aquatic biota in U Pond, which has received low-level processing waste for more than 30 years. Initial efforts are being made to measure the levels of these transuranics in the sediments, water and in the benthic, plankton, and nektonic communities. To establish the current ecology of this pond, a number of limnological parameters are being measured including temperature, pH, dissolved oxygen, alkalinity, insolation, water transparency, and primary productivity. Sampling is based on a statistical blocking design which will allow for analyses of variance, regression, and correlation of the radioecological and limnological data.

II.1.2.2.2 Terrestrial Ecology

Ecological measurement and monitoring programs are expected to continue on the Hanford Reservation. The ALE Reserve provides a place for long term studies of the dynamics of secondary plant succession and related changes in animal populations. Studies aimed at estimating primary productivity in climax and seral plant communities will also measure environmental variables such as precipitation, soil moisture, air and soil temperatures and the details of mineral uptake by plants and transfer to animals. The ALE Reserve will continue to play an important role in evaluating the long term response of plants and animals to induced environmental stresses such as cattle grazing, added increments of moisture, selective herbicides, fires, and ionizing radiation to selected components of the shrub steppe ecosystem.

Terrestrial ecology studies at Hanford relevant to management and storage of radioactive waste include the following list, several of which are discussed subsequently:

- floristic and faunistic lists of important biota
- identification of rare and endangered species

- mapping of major plant communities
- seasonal migration patterns of waterfowl use of the Columbia River and ponds
- successional trends in plant communities' response to fire and plowing and other kinds of soil disturbance
- tagging mule deer fawns to determine the dispersal patterns from the Hanford Reservation
- population dynamics of Columbia River Canada Goose populations
- primary productivity and mineral uptake by plants from soil in climax and seral plant communities
- population dynamics of rodent populations
- the abundance and role of microorganisms and invertebrate fauna in the steppe ecosystem
- food webs of the steppe ecosystem
- uptake of radionuclides by plants from soils in field conditions.

II.1.2.2.2.1 Radionuclide Behavior in Experimental Field Plots

Small field plots treated with ^{137}Cs and ^{90}Sr in 1962 and 1954 respectively[53] were observed for movement of radionuclides downward into the soil profile and for determining the uptake of radionuclides from soil by crop plants and associated weeds.

Over the years, ^{90}Sr moved downward to depths of 10 inches while ^{137}Cs is mostly confined to the surface inch or two. After 18 years, the nuclides are still available to plants. These studies are continuing to ascertain the long-term effect of aging and weathering on radionuclide uptake by plants and the rate of movement in the soil profile.

II.1.2.2.2.2 Ionizing Radiation, $LD_{50/30}$, Doses to Small Mammals

The $LD_{50/30}$ doses of acute ionizing radiation were determined for the small mammals (mice and moles) characteristic of the Hanford Reservation; values range between 500 and 900 rads. The great basin pocket mouse is the most radioresistant while the grasshopper mouse is the most radiosensitive.

II.1.2.2.2.3 World Wide Fallout on the Hanford Reservation and Surrounding Area

Radionuclides derived from nuclear weapons tests are present in small quantities and ubiquitously spread over the land water surfaces of the earth. The accumulation of fallout ^{137}Cs in the steppe plant communities of the Hanford Reservation is about five times less than forest communities in the nearby Cascade Mountains. Studies of fallout have value in assessing environmental radioactivity associated with waste management practices as compared to adjacent areas without nuclear facilities.

II.1.2.2.2.4 Population Dynamics of the Canada Goose

The nesting success of the Canada Goose has been documented for a quarter of a century. Over the years the number of nesting pairs of geese has fluctuated, but at Hanford the hatchability of eggs is currently as high or higher than areas without nuclear facilities. Studies of the Canada Goose are continuing and will provide a valuable base for ecological monitoring involving power reactors presently being constructed on the Hanford Reservation.

II.1.2.2.2.5 Use of Waste Ponds by Ducks and Geese

Waste ponds on the Hanford Reservation are attractive to migratory flocks of ducks and geese. A surveillance of transient populations indicates that mixtures of species including puddle and diving ducks and fish-eating ducks regularly use the ponds during autumn months. As many as 1100 ducks and geese rest on the ponds on a particular day. The role of ducks and geese in transferring radionuclides from waste ponds offsite is a part of the aquatic studies program.

II.1.2.2.2.6 Laboratory Studies that Support Field Surveillance

The uptake of plutonium, americium, curium and neptunium by plants from soil, especially plants that are common in waste management zones, are studied in the laboratory. The uptake of these

radionuclides in decreasing order is Np > Am > Cm > Pu; however, this order can be changed by changing the chemical form of the nuclides. Generally, tumbleweed accumulates more radionuclides than cheatgrass.

II.1.2.2.3 Hydrology [X.18]

II.1.2.2.3.1 Columbia River

Surface water samples are taken from the Columbia River at Vernita, 100-F Area, 300 Area, North Richland and Richland, as well as from the wastewater ponds and ditches on the Hanford site.[22] The Columbia River measurements are made on four integrated and two grab samples weekly. Drinking water samples are taken at Richland, plus two onsite locations. The river water integrated samples are analyzed for ^{3}H, gross beta, gross alpha, ^{131}I, ^{239}Pu, and for specific nuclides by gamma scan. The river water grab samples are analyzed for ^{3}H and gross beta. The sanitary water integrated samples are given gross alpha, gross beta and gamma measurements.

River flow rates are obtained from continuous USGS river stage measurements at a gauge station immediately downstream from Priest Rapids Dam. The river elevations are available immediately onsite via telemetering. Continuous temperature monitoring is also done at the Priest Rapids gauge station and by telemeter at Richland. Water quality measurements on the Columbia River water samples include pH, dissolved oxygen, turbidity, coliform, enterococci, BOD, and nitrate ion, (Table II.1-15). State Water Quality Standards[29] are applicable to the Hanford reach of the Columbia River (Appendix II.1-G, Part 2).

Surface water monitoring data and discussion are presented in the annual "Environmental Status of the Hanford Reservation for CY-1972"[19] and the annual "Environmental Surveillance at Hanford for CY-1972" report series.[20,21]

II.1.2.2.3.2 Groundwater

The periodic hydrological measurements on the groundwater system of the unconfined and confined aquifers consist of water quality analyses, water level measurements and water temperature profile logging. Water quality analyses are made on semiannual samples from six wells on the Reservation. Water level measurements are made quarterly at about 330 wells on the Reservation covering both the unconfined and uppermost confined aquifer. Water table maps for the unconfined aquifer are prepared from these measurements, as in Figure II.3-15. Temperature logs of the wells are made at intervals that average 5 years apart. Figure II.3-18 shows the latest groundwater temperature distribution measured.

The groundwater is routinely measured[22] at numerous wells for tritium and gross beta. Other specific radioanalyses are made at several locations. Sampling frequency varies from monthly to semiannually depending on the location of the well. In general, only the shallower, unconfined aquifer is sampled, but the deeper, confined aquifers are sampled at a few wells. Groundwater data summaries, contamination maps, and evaluations are reported in the series, "Radiological Status of the Groundwater Beneath Hanford Project for ..."[18]

Water quality measurements of the unconfined and confined aquifers are obtained routinely by utilizing test wells on the Hanford Reservation. Maps of the nitrate ion concentration near the surface of the unconfined aquifer are regularly published. (The map for 1973 appears in Figure II.3-17.) Since the nitrate ion is not absorbed on the soil, the extent of wastewater movement is shown, thus indicating where radionuclides contained in the wastewater should be found. In Figure II.1-68, the major plume is from the 200 Areas disposal operations. However, plumes are also beneath the 300 Area and emanating from the 100-N Area. The plume at the 100-F Area is presumably from continued disposal of BNW Animal Lab waste. The isolated plume south of 100-N and east of 100-K Area is probably due to previous reactor operations. A residual nitrate background of up to 6 mg/liter in the groundwater north of Gable Mountain and Gable Butte is due to pre-Hanford operations agricultural activities. Similarly, occasionally detectable nitrate ion is in the groundwater between the Yakima River and the Columbia River.

In 1973 Atlantic Richfield Hanford Company authorized an independent review of the surveillance program in hydrology.[54] Details of the recently completed review are contained in Appendix II.3-D.

II.1.2.2.4 Meteorology

The principal onsite meteorological monitoring program is operated at the Hanford Meteorology Station (HMS). This station is centrally situated on a plateau of the Hanford site at an elevation of 733 ft MSL (Figure II.1-71). Other onsite meteorological monitoring programs were conducted for limited periods.

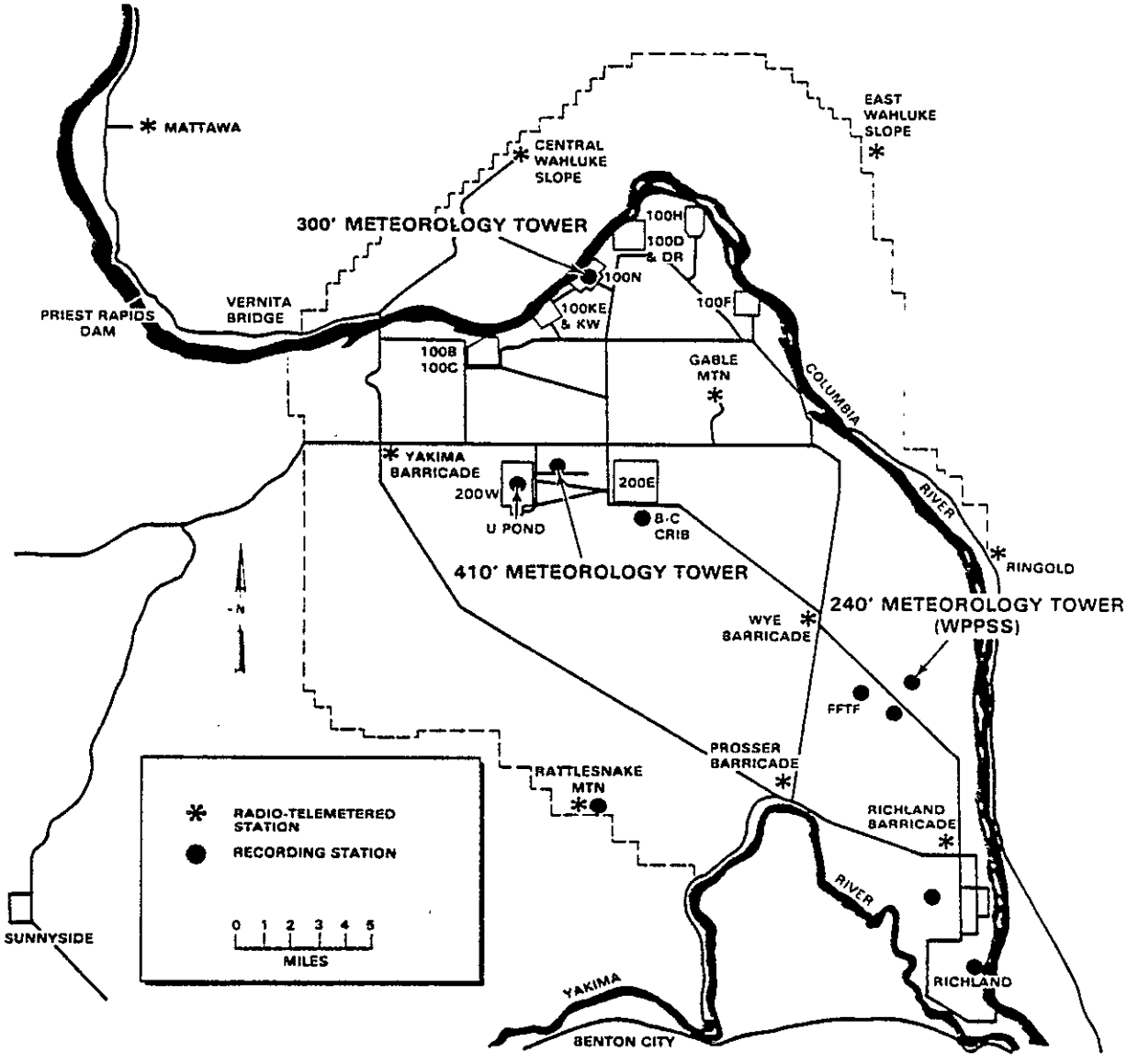

FIGURE II.1-71 HANFORD METEOROLOGICAL SENSOR FACILITIES

II.1.2.2.4.1 Hanford Meteorology Station

Records have been kept at the HMS from 1944 to the present.[30] The data include standard surface observations as specified in Federal Meteorological Handbook No. 1[31] as well as other measurements specifically taken to describe the atmospheric diffusion climatology of the Hanford site.

This monitoring program includes eight levels of wind measurements and ten levels of air temperature measurement from a 410-ft steel tower. Surface observations of temperature and humidity are taken about 75 feet northwest of the tower. About 1500 feet west of the tower is a pyranometer, a precipitation gauge, and an instrument shelter with maximum and minimum thermometers. Table II.1-16 shows current (1973) sensor height information for the HMS.

At the HMS site, upper level wind measurements have been made by the standard pilot balloon-theodolite method (Pibal) for over 25 years. Some of these observations are summarized for climatological use. Pilot balloon data are presently taken twice a day at 1200 and 2400 PST.

TABLE II.1-16

INSTRUMENT HEIGHT LOCATIONS

Instruments	Surface (ft) 3	Surface (ft) 7	Tower Levels (ft) 20	50	100	150	200	250	300	350	400
Humidity	X										
Wind Speed and Direction		X		X	X	X	X	X	X		X
Air Temperature	X		X	X	X	X	X	X	X	X	X

With the exception of precipitation, all instrumentally measured parameters are recorded on charts at the HMS. These data are transferred to computer punch cards as hourly averages, where appropriate, and transferred and stored on magnetic tape from which data summaries are tabulated as required.

II.1.2.2.4.2 Arid Lands Ecology (ALE) Reserve Meteorological Data

The ALE Reserve comprises approximately 120 square miles located along the north and northeastern slopes of Rattlesnake Mountain. Since March 1968 to the present, and on a continuing and expanding basis, BNW has been recording various climatological data on ALE with the types of instruments currently in use listed[32] as:

Soil temperature:

- Weathermeasure two-point thermometers, mercury in plastic sensors
- Kahlsico two-point thermometers, mercury filled bulb sensor

Air temperature and relative humidity:

- Bendix-Friez standard hygrothermographs
- Weathermeasure standard hygrothermographs

Precipitation:

- Taylor visual gauge, 5-in. capacity
- Weathermeasure propane-heated tipping bucket recorders

II.1.2.2.4.3 Hanford Radio-Telemetered Automatic Weather Station Network

A ten-station* network of radio-telemetered automatic weather stations is installed and continuously operated on the Hanford Reservation, with approximately 10-mile spacing between stations. Meteorological parameters measured are wind speed and direction, and temperature. The central station programmer and data acquisition equipment are housed at the HMS. This network is operated primarily as a real time information base for accident assessment capabilities, although data from the network were used in several studies (Figure II.1-71).

II.1.2.2.4.4 N Reactor Meteorological Tower System

A second fully instrumented micrometeorology tower system is operated by UNI. This tower is located about 8 miles north of the HMS and is about 300 feet lower in base elevation. The data system[33] consist of a central station near the control room of the N Reactor and a remote station near the river bank approximately 450 feet northeast of the 100-N Area exclusion fence.

The remote station comprises a 300-ft tower, sensors, digitizing electronics, and a microwave transmitter. Four boom levels are on the tower: near the surface and nominally at 50, 200, and 300 feet. Each boom supports a horizontal wind-speed sensor, a horizontal vane slightly above the boom, and an aspirated platinum resistance temperature detector slightly below. All sensors have essentially a 5-second time constant. The placement of all sensors is shown in Table II.1-17.

* The actual number of stations in operation has varied during the history of the operation.

TABLE II.1-17

SENSOR HEIGHTS WITH RESPECT TO BASE

Nominal Level	Wind, Speed and Azimuth	Temperature
Surface	8.0 ft	5 ft[a]
50 ft	51.5 ft	48.5 ft
200 ft	201.5 ft	198.5 ft
300 ft	301.0 ft	298.0 ft

(a) Actually approximately 4 feet above ground surface directly below sensor.

The central station consists of a microwave receiver, demodulating and timing electronics, data formatting circuits, real-time data displays, and an incremental digital tape recorder. The real-time data displays include analog meters, strip printer and a nixie data display. A digital clock monitors the timing accuracy of the system.

II.1.2.2.4.5 Washington Public Power Supply System Nuclear Plant No. 2

The WPPSS Nuclear Plant No. 2 (WNP-2) site is located about 15 miles ESE of the HMS. Since March 1972 to the present, and on a continuing basis, WPPSS has been recording meteorological data including wind direction, wind speed, temperature, and relative humidity. The WNP-2 site is equipped with a three-cup anemometer and vane as well as primary and redundant instrumentation for measuring dry bulb temperature and relative humidity.

WPPSS is erecting a 240-ft (70 m) meteorology tower from which humidity, and wind data will be recorded on a permanent basis. The meteorological Data Recording System will consist of an array of tower mounted sensing instruments, a group of continuously operating strip chart recorders, a magnetic tape recorder and supporting power supplies and controls. The variables and their location to be measured are:

Wind speed at 240 feet aboveground (100 m)
Wind direction at 240 feet
Wind speed at 33 feet (10 m)
Wind direction at 33 feet
Wind speed at 7 feet (2 m)
Wind direction at 7 feet
Air temperature difference between 33 and 240 feet
Air temperature difference, 7 to 33 feet
Air temperature difference, 7 to 240 feet
Ambient air temperature at 240 feet
Ambient air temperature at 33 feet
Ambient air temperature at 7 feet
Dew point temperature at 7 feet
Precipitation at ground level
Wind direction sigma at 240 feet (tape only)
Wind direction sigma at 33 feet (tape only)
Wind direction sigma at 7 feet (tape only)

II.1.2.2.4.6 Fast Flux Test Facility (FFTF)

An onsite wind speed and direction measurement system is operated at the FFTF located about 17 miles southeast of the HMS at an elevation of approximately 550 feet MSL. This consists of a Weather Measure Sensor system #W1034 mounted on a 13-ft mast.

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II.2 ANTICIPATED BENEFITS

The Hanford facilities were designed, built, and originally operated to produce plutonium for nuclear weapons. The waste management programs initially established were the first in the world to cope with massive quantities of radioactive materials and were established under conditions of expediency during time of war. Since that time, a continuing research and development program has provided new technology and new waste management equipment and materials. Throughout all programs, a prime concern has been the isolation of radioactive materials from man's environment. Today large quantities of radioactive waste exist which cannot prudently be abandoned. Therefore, waste management in some form is required. Waste to be generated by the projected operation of N Reactor and Purex will not add substantially to the current total inventory. Discontinuing N Reactor and/or Purex plant operations would not alter the need for a continuing radioactive waste management program.

The anticipated primary benefit from the Hanford Waste Management Operations is to continue isolation from man's environment of the already generated and yet to be generated radioactive materials. New technologies and new equipment are added to the Hanford waste management facilities, as practicable, to reduce even further the amounts of materials released to the environment. The waste management programs provide manpower and facilities to perform research and development not only for the long-term disposal of Hanford generated waste, but also for the nuclear power industry. Also, the operation of the Hanford waste management program makes possible production of plutonium for the U.S. defense needs, Research and Development, and provides steam to the Washington Public Power Supply System for the generation of 860 megawatts of electricity for the Northwest power pool. The waste management activities also support a variety of ecological and biological studies on the movement of radionuclides in the environment.

In addition to the benefits of providing improved technologies for future waste management programs, extensive technology in monitoring and evaluating the movement of radioactive materials in the environment was and is being developed at the Hanford site. Particularly, instrumentation to measure minute tracer quantities of materials in air, water, and soils were developed and are being used to identify transfer mechanisms of radionuclides between various components in the environment. Specific attention is paid to such factors as bioconcentration, particle resuspension, absorption factors in the human body for various modes of radioactive material intake, and related data that permits complete evaluation of the radiological consequences of the Hanford Waste Management Operations. Benefits from all of this work during the past 30 years are available and are being used directly by the private power industry and by those interested in monitoring and evaluating environmental pollution and environmental control practices.

II.3 CHARACTERIZATION OF THE EXISTING ENVIRONMENT

II.3.1 Plant Location

The Hanford site covers approximately 570 square miles located in the Pasco Basin, a semiarid region of southeastern Washington State in the rain shadow of the Cascade Range. This section of the State has a sparse covering of natural vegetation primarily suited for grazing, although large areas near the site have gradually been put under irrigation during the past few years. Most irrigated farms near the Hanford site obtain water from the Yakima River or from the Columbia River.

The Hanford Reservation boundaries lie between 46° 18' and 46° 48' north latitude and 119° 17' and 119° 52' west longitude[1] mostly within Benton County, with portions of Franklin and Grant Counties also included. The Columbia River flows through the northern edge of the Hanford site and forms part of the eastern boundary. The western-most boundary is approximately 30 miles due east of Yakima, Washington, while the closest population center, Richland, Washington, is located about 3 miles from the most southern portion of the boundary.

II.3.2 Regional Demography

The 1970 estimate of the population distribution varies from 160,000 to 250,000 people within a 50-mile radius of three separate points within the Reservation boundaries. These points are:

- the Hanford Meteorological Station (HMS) located between the 200 East and 200 West Fuel Reprocessing Areas
- the 100-N Reactor Area
- the 300 Laboratory and Fuel Fabrication Area.

Figure II.3-1 shows the 1970 U.S. Census Populations of nearby communities with the circle of a 50-mile radius from the HMS superimposed. Estimates have been made for 1973, 1977, 1981 and 2000,[2-7] based upon 1970 census information, current birth rate trends, and an estimate of net migration into or out of the state as economic and employment opportunities change over the forecast period. The forecast does not reflect the population expansion which would result from the creation of a nuclear park or a more intensive utilization of nuclear energy for power generating and other purposes. It is assumed that the Hanford Reservation will remain under the control of the U.S. Energy Research and Development Administration (ERDA) and that no persons will reside within the Reservation boundaries. The population residing in the unincorporated area was calculated on the basis of population density in the portion of a specific census district within the site area. This assumes an even distribution of population throughout the unincorporated areas of each census district. It was further assumed that the rate of population growth was the same for both incorporated and unincorporated areas.

In 1970, an estimated 246,000 people were living within a 50-mile radius of the HMS; 227,000 within 50 miles of the 100-N Area; and 162,000 within 50 miles of the 300 Area. The distribution of this population appears in Figures II.3-2, -3 and -4, and also in Appendix II.3-A, Part 1 with the projected populations to the year 2000.

II.3.3 Land Use

Before the arrival of Europeans, the native Indian tribes lived largely on fish from the Columbia River and on natural plant products. The earliest use by white immigrants of the Hanford site was for stock-grazing in a seasonal pattern. In the first decade of the twentieth century, several small, privately-irrigated farms were put into cultivation. The Hanford Irrigation Project, taking water from the river above Coyote Rapids (upstream from 100-K Area), supplied a small but flourishing irrigated orchard and farm economy along the river as far downstream as the Hanford townsite until the government purchased the land to construct the Hanford Engineering Works.

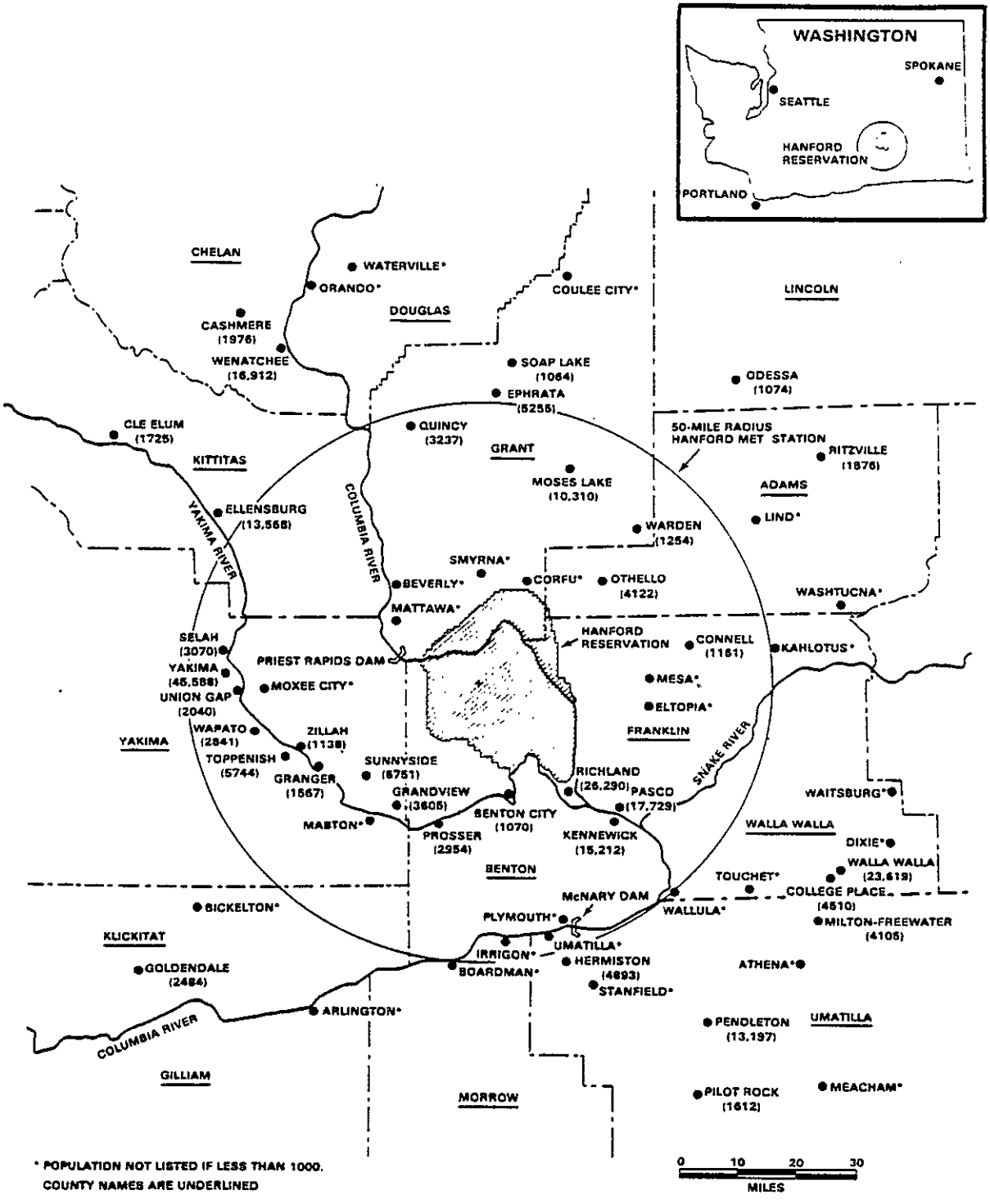

FIGURE II.3-1 1970 U.S. CENSUS POPULATIONS OF COMMUNITIES IN THE HANFORD SITE VICINITY

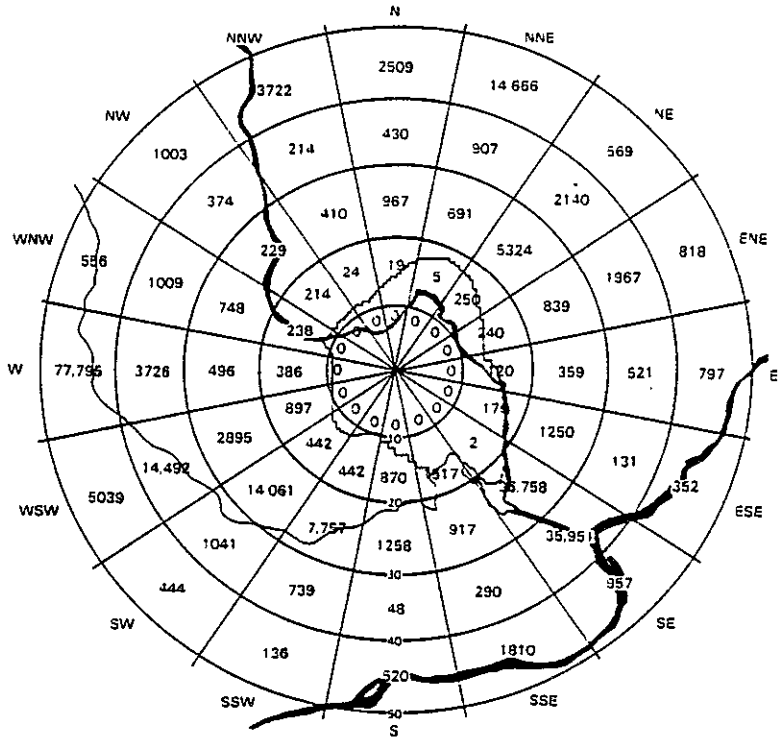

FIGURE II.3-2 ESTIMATED GEOGRAPHIC DISTRIBUTION OF THE 1970 POPULATION (246,000) WITHIN A 50-MILE RADIUS OF THE HANFORD METEOROLOGICAL STATION

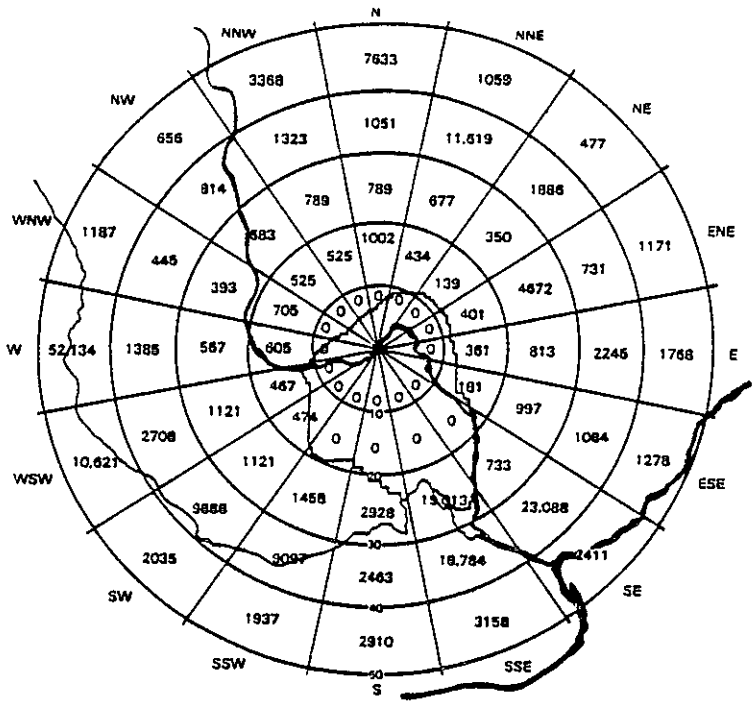

FIGURE II.3-3 ESTIMATED GEOGRAPHIC DISTRIBUTION OF THE 1970 POPULATION (227,000) WITHIN A 50-MILE RADIUS OF THE 100-N AREA

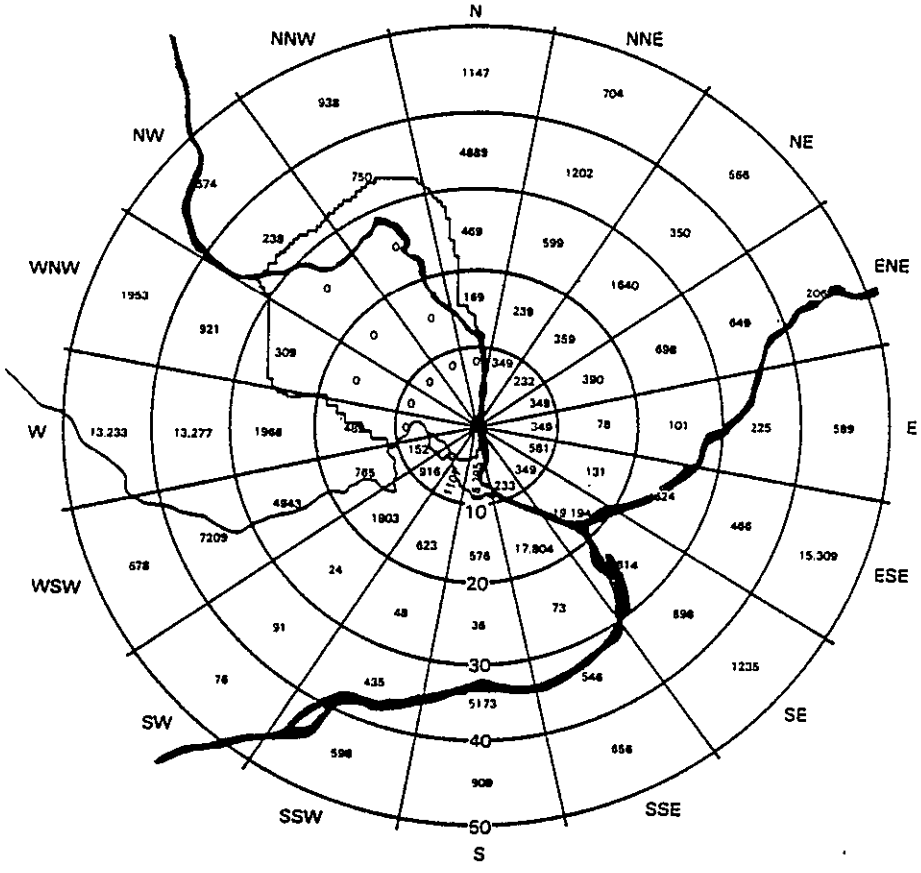

FIGURE II.3-4 ESTIMATED GEOGRAPHIC DISTRIBUTION OF THE 1970 POPULATION (162,000) WITHIN A 50-MILE RADIUS OF THE 300 AREA

The nature and extent of present land use is discussed here on the basis of arcs described from the HMS. Land areas included in a 50-mile radius from the other two site areas are also covered.[8] Figure II.3-5 is an aerial photograph in which the general pattern of agricultural usage is visible as the darker, regular-shaped areas.

Figure II.3-6 shows the Hanford site map with sector markings overlaid. Starting from a line directly north from the HMS, the 0- to 10-mile zone is entirely within the Hanford site boundaries. The area south of the Columbia River is under ERDA control and is a limited access area. Land north of the river is controlled by the Bureau of Sport Fisheries and Wildlife as a game refuge. All of this zone between the 0- and 150-degree radials is limited access area under control of ERDA. Most of the zone between the 150- and 270-degree radials consists of the Arid Lands Ecology (ALE) Reserve, which is also limited access ERDA land under the control of Battelle, Pacific Northwest Laboratories. Between the 270-degree radial and the starting radial, land south of the Columbia River is ERDA-controlled limited access while north of the river the game refuge is again encountered.

Again starting from the 0-degree radial, the 10- to 20-mile zone is a continuation of the game refuge with some areas open for fishing, shotgun and bow hunting during daylight hours. Further north, this zone includes the eastern-most portion of the Wahluke Slope and the Saddle Mountains. Between the Wahluke Branch Canal and the Columbia River, the zone consists of lands in the Columbia Basin Project which are irrigated or are being developed for irrigation. The area west of the river is limited access Hanford site. Leaving the site boundary, the land is mainly unirrigated land used for grazing cattle and sheep. South and west of the Columbia River, in the vicinity of Priest Rapids Dam, is the U.S. Army Yakima Firing Range which is undeveloped, unpopulated land. Northwest of Priest Rapids Dam and Reservoir is the Wahluke Slope portion of the Columbia Basin Project. This area is partially irrigated with the rest (outside the Hanford Reservation) expected to be irrigated in the next 10 years.

FIGURE II.3-5 AGRICULTURAL USAGE OF THE HANFORD SITE

The 20- to 30-mile zone on the 0-degree radial is north of the Saddle Mountains and is irrigated farmland, part of the Columbia Basin Project. (The estimated percent of acreage by crop in all irrigated areas within a 50-mile radius of 100-N Area is presented in Table II.3-1.) The area from lower Crab Creek to northwest of Othello is generally undeveloped. From Othello south to the Columbia River, the land is irrigated farmland. On the west side of the river is the city of Richland. West from Richland, the 20- to 30-mile zone includes the Yakima River and the towns of Prosser, Sunnyside, Grandview and Mabton. Land along the Yakima River is primarily in orchard use. Higher land away from the valley floor is used primarily for grazing livestock

with some land used for grain crops. At approximately the 270-degree radial, the Yakima Firing Range is again encountered. At 320 degrees is the Gingko Petrified Forest, a registered natural landmark.

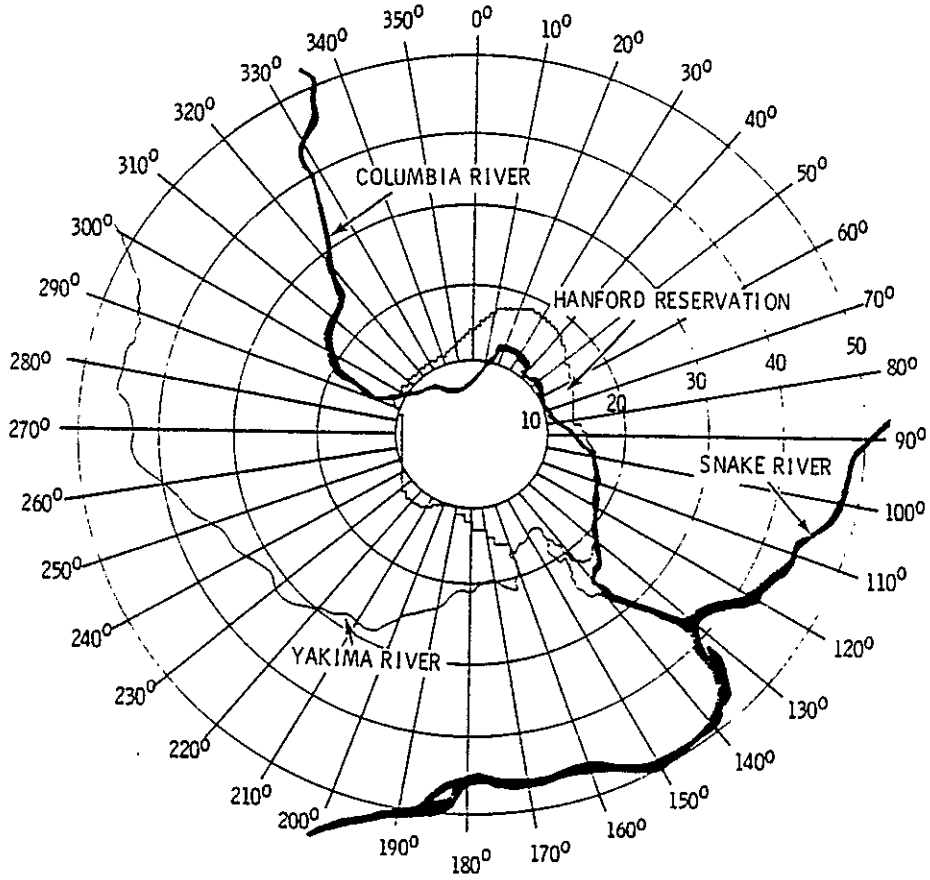

FIGURE II.3-6 HANFORD SITE LAND USE

At the 0-degree radial, the 30- to 40-mile zone consists of an undeveloped area of sagebrush and sand dunes. At 20 degrees, the Potholes Reservoir, a recreation area surrounded by sand dunes, is located south of Moses Lake. Between 30 and 50 degrees, this zone encompasses a major portion of the Columbia Basin Irrigation Project. At approximately the 130-degree radial, the Columbia River is encountered, with the city of Pasco on the north side and the city of Kennewick on the south side. South and west of Kennewick, the 30- to 40-mile zone runs south of the Horse Heaven Hills. Although this land is primarily used for dry-land wheat farming, there are about 88 sections (56,320 acres) where permits have been granted for private irrigation development. Crossing the Horse Heaven Hills, the zone includes part of the Yakima Valley containing the towns of Granger, Toppenish, Zillah and Wapato. This land is largely in orchards and other truck crops, with livestock grazing at the higher elevations. Northeast of Yakima is the Yakima Firing Range, east of which lies irrigated farmland of the Columbia Basin Project.

At the 0-degree radial, the 40-mile radius to the 60-mile radius includes the towns of Ephrata and Soap Lake; also included is the southern end of Grand Coulee, a national landmark. The land is primarily rangeland with some irrigated farmland around Soap Lake. The town of Moses Lake is in this zone at approximately the 20-degree radial. Between the 20- and 90-degree radials is a large portion of land planned for irrigation development as a part of the Columbia Basin Project.

At approximately 70 degrees between the 45- and 60-mile radius, the land is used for nonirrigated wheat production. Between the 90- and 120-degree radials and extending to the 75-mile radius, the land is used for nonirrigated wheat production. An exception is the area at the confluence of the Snake and Columbia Rivers where private irrigation projects are underway. The 40- to 60-mile zone also includes the town of College Place and part of Walla Walla. Moving west and

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south, the land is irrigated along the Walla Walla River and produces alfalfa and sugar beets. Land on both sides of the Columbia River below McNary Dam hold private irrigation projects totaling approximately 345 sections (220,800 acres). Between the 200- and 260-degree radials, the land is very rugged and, for the most part, undeveloped. At the 260-degree radial, the Yakima Valley is entered with the city of Yakima at 270 degrees. Crossing the Umtanum Ridge and the Manastash Ridge, the Kittitas Valley is entered. This is an area of both irrigated and dry-land farming and cattle production. At 330 degrees, a portion of the Wenatchee National Forest is found.

TABLE II.3-1

ESTIMATED PERCENT OF ACREAGE BY CROP IN THE IRRIGATED AREA WITHIN 50 MILES OF THE 100-N AREA[10] 1962-1968

Crop	Percent of Total Acres	Crop	Percent of Total Acres
Alfalfa Hay	30.26	Apples	0.24
Wheat	15.36	Lentils	0.20
Sugar Beets	7.92	Onions, Dry	0.20
Potatoes (Late)	5.84	Mixed Grain	0.18
Pea Seed	5.61	Radish Seed	0.13
Dry Beans and Edible	5.58	Asparagus	0.11
Irrigated Pasture	5.37	Cantaloupes	0.10
Potatoes (Early)	3.07	Carrots	0.10
Silage	2.41	Cherries	0.10
Barley	2.40	Grapes	0.10
Corn for Grain	2.11	Merion Blue Grass Seed	0.10
Alfalfa Seed	1.81	Nursery Stock	0.10
Corn, Sweet (Processing)	1.63	Orchard Grass, Seed	0.10
Peppermint	1.17	Pears	0.10
Oats	0.85	Rutabagas	0.10
Other Hay	0.76	Rye	0.10
Clover, Seed (All Kinds)	0.74	Sorghums	0.10
Peas, Green (Processing)	0.71	Soy Beans	0.10
Beans, Lima (Processing)	0.40	Watermelons	0.10
Spearmint	0.27	All Others	3.37

II.3.4 Water Use [X.18]

An estimated 200,000 acre-ft of water are taken annually from and near the Columbia River within 50 miles of the 100-N Area. This estimate is based on the best available source of data for wells and surface water pumpage. However, these are "paper water rights" and are therefore estimated to be twice the actual pumpage, even though not all of the wells in actual use are listed. Water rights received after 1969 are not reflected, and not all of the people who have been pumping ground and surface water have applied to the state for water rights. However, the data give an adequate upper limit to current water usage for 50 miles downstream of the 100-N Area. (Details of this data, taken from records of the Department of Ecology, State of Washington, Spokane, Washington, are available in Appendix II.3-A.)

In the next 65 miles of downstream flow, the Columbia River forms the border between Washington and Oregon. Private irrigation development is extensive on both sides of the river. Land which is now irrigated or expected to be irrigated in the next 5 to 10 years totals approximately 277,000 acres. Assuming that all of this land were put into a high water use crop such as alfalfa, an estimated 1,155,000 acre-ft or 372 billion gallons of water would be required each year during the normal irrigation period (April to October).[11,12,13] In comparison, the annual average river flow is about 87,000,000 acre-ft.

II.3.5 Historical and Archeological Sites and Natural Landmarks [X.18]

The National Register of Historic Places[14] currently lists three historical sites within approximately 50 miles of the Hanford site. These are:

- Marmes Rockshelter, located 1 mile north of Lyons Ferry on the west side of the Palouse River, Franklin County
- Olmstead Place State Park, 4 miles east of Ellensburg, near the Kittitas Highway, Kittitas County
- Whitman Mission National Historic Site, 6 miles west of Walla Walla, off U.S. 410, Walla Walla County.

The National Registry of Natural Landmarks[15] lists two sites which are within 50 miles of the Hanford site:

- Gingko Petrified Forest, located in Kittitas County 29 miles east of Ellensburg
- Grand Coulee, located in Grant County between the towns of Grand Coulee and Soap Lake.

Many archeological sites of significance are found in the Hanford area.[16,17] The Columbia River shoreline, from Vantage in the north downstream to Umatilla, is rich with Indian artifacts. Many campsites and fishing grounds within the Reservation boundary were traditionally used as wintering areas from prehistoric times until the area was evacuated in 1943. Registered archeological sites within a 50-mile radius of the HMS are identified in Figure II.3-7; the majority of these sites lie close to the Columbia and Snake Rivers. (Some of these sites are described in Appendix II.3-A.) Large portions of the land area at greater distances from the rivers have never been surveyed for archeological sites.

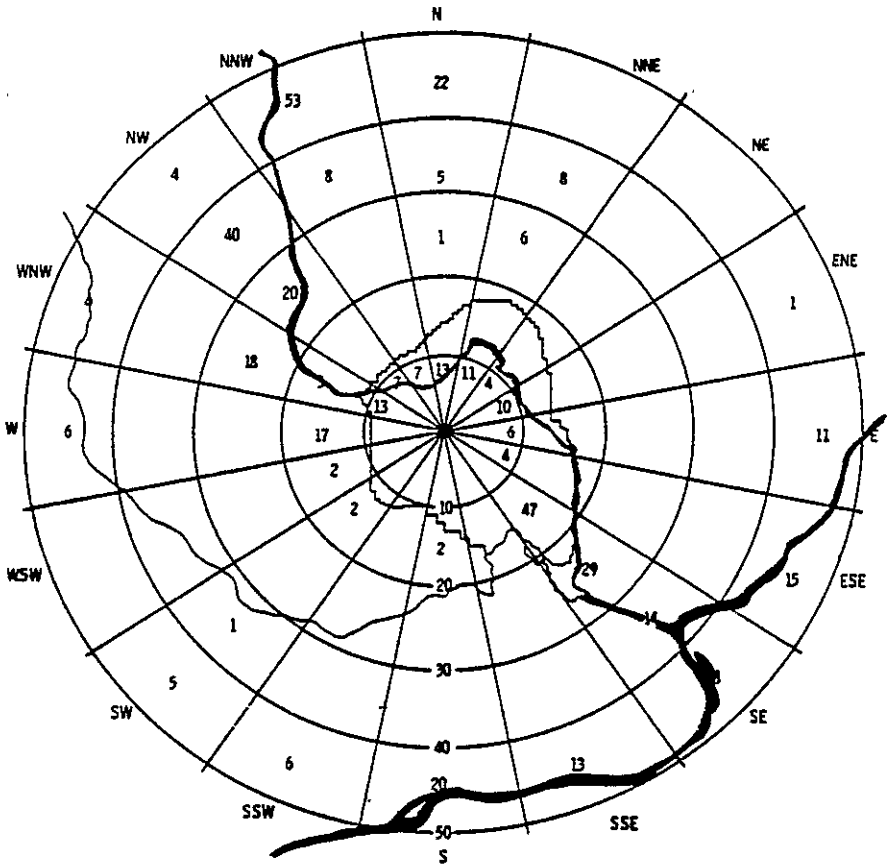

FIGURE II.3-7 NUMBER AND LOCATION OF KNOWN ARCHEOLOGICAL SITES WITHIN A 50-MILE RADIUS OF HANFORD METEOROLOGICAL STATION

The Columbia River was one of the most densely inhabited regions in aboriginal North America, and its inhabitants possessed one of the most interesting lifeways of the continent. With the exception of the sites located on the Hanford reach of the Columbia, evidences of this lifeway have been virtually erased. Therefore, the remaining sites assume great significance and are being evaluated. Field exploratory work is being conducted by Dr. D. G. Rice, an archaeologist formally from Washington State University, under a research grant.

Other natural landmarks in the area, which are not of national significance, include the Saddle Mountains immediately to the north. This range of hills running east-west includes Sentinel Mountain (2,625 feet) and Wahatis Peak (2,969 feet). The Columbia River, which flows through the northern portion of the Hanford site and then along the eastern boundary, provides another natural landmark as do the White Bluffs rising 200 to 300 feet along the eastern shoreline. The southwestern edge of the Reservation is marked by the Rattlesnake Hills and Rattlesnake Mountain (approximately 3,400 feet). Gable Mountain and Gable Butte, within the Reservation, are a marked geological feature. A parallel series of northwest-southeast trending ridges, notably Yakima and Umtanum Ridges, extend from the Reservation boundary to the foothills of the Cascade Range. Several major dry coulees open into the Reservation on the eastern boundary and in part serve as natural drainage channels from irrigated lands.

II.3.6 Geology[a]

Geology is the study of the origin and development, through natural processes, of the earth. When the geologic formations are adequately understood, the variations in their chemical and physical properties take on an identifiable pattern and become logically explainable. The permeability, transmissivity, effective porosity, and exchange capacity of the formations and their component units are the principal parameters affecting the disposal of radioactive liquid waste to the ground. Those parameters vary appreciably from formation to formation and within formations, but are predictable once the nature and extent of the formational units are understood. Consequently, values for those parameters often can be estimated even where specific measurements have not been obtained or cannot readily be obtained. Conversely, when data ("samples" of the area) are obtained and values calculated, the geologic information often permits a determination of the validity of the value and of how representative it may be of the formational unit.

Study of the geological history and development of an area often identifies operative but not obvious processes that may affect various activities. For example the past history of and projected reoccurrence of earthquakes, landslides, climatic changes, floods, volcanic eruptions and comparable natural catastrophes may become clear. Therefore, the geology of the Hanford Reservation is of interest in evaluating the overall safety and suitability of storage of radioactive waste on the Reservation.

Eastern Washington is dominated by the Columbia Basin geologic province, the northernmost extension of the Columbia River Basalt Plateau.[18] The basin, encompassing about 50,000 square miles of southeastern Washington and adjacent parts of Idaho and Oregon, is underlain by the vast field of flood lavas of the Columbia River Basalt Group. Today those lavas and the ground surface generally dip radially inward toward the Pasco Basin, which is the near-central, physiographic low of the larger Columbia Basin.

The Pasco Basin evidently was formed by slow and prolonged subsidence concomitant with filling of the basin by basaltic lavas.[19] Inauguration of uplift of the northern Cascade Range, possibly 15,000,000 years ago, probably combined with basining in south-central Washington to divert the ancestral Columbia River from a westward course to the ocean to a south-westerly course into and through the Pasco Basin.

Basaltic lavas were emitted largely peripheral to the basin. At least the latter ones advanced into the basin from a probably dominantly southeast source,[20] forcing the Columbia River westward. Continued downwarping resulted in a return of the river to the basin center. Developing volcanicity, accompanying the southward progression of uplift of the Cascades and the beginning of uplift of the anticlinal ridges in southern Washington, resulted in an increasing accumulation of volcanic debris, especially in the synclinal valleys. As the ridges rose, they were periodically buried by volcanic debris from the Cascades and the northwestward advancing lava flows. Ultimately the anticlines rose too high and locked the Columbia River into the Pasco Basin. The latest basalt flows then were emitted from local fissures into the lowest points of the Basin.[21]

(a) Appendix II.3-B provides a more detailed description of the geology of the Hanford Reservation.

At least some faults formed probably as an early phase of deformation.[22] Once the axes of tectonic activity developed, folding predominated. Faults, though common in the region, are largely restricted to the anticlinal ridges, showing minimal evidence of recent offset and apparently reflecting stress relief where folding was insufficient for that release.[23] A southward progression of uplift also appears to have occurred in central Washington with the more northerly anticlinal ridges (Umtanum Ridge and Saddle Mountains) rising earlier than those to the south (Horse Heaven Hills).[19]

The Horse Heaven Hills in time rose to obstruct the Columbia River course from the Cascades to the Blue Mountains. A flattening of gradient of the river caused the deposition of the sediments of the Ringold Formation, ultimately to an altitude of about 1000 feet. Then the Columbia River began to incise its channel through the Horse Heaven Hills at a rate faster than uplift. Once the Columbia River base level was lowered, the river eroded the Ringold Formation sediments beneath the Hanford Reservation and developed a land surface that sloped gently from an altitude of about 600 feet on the west to 400 feet on the east.[24] On this surface a thick deposit of caliche developed, attesting to the then semiarid climate.[25]

Late in the Pleistocene epoch, catastrophic floods emanated from glacial Lake Missoula and other glacier-dammed lakes and repeatedly scoured the Pasco Basin. The floods stripped much of the eolian silt and underlying caliche from the basin and left a series of interconnecting channels, resembling the Channeled Scabland, carved into the Ringold Formation surface beneath the Hanford Reservation.[24]

Two of the floods were gigantic by any standards, involving about 500 cubic miles of water with a calculated maximum flow rate between 9 and 15 cubic miles/hr. The first of these floods is dated at 18,000 to 20,000 years ago and the second at about 12,000 years ago.[26] Evidence suggests that the earlier flood rose to 1,200 feet above mean sea level and the latter to about 900 feet above sea level, the result of hydraulic damming in Wallula Gap and downstream constrictions.

Aggradation resulting from the floods reached a level of about 700 feet altitude in the basin center where the effective width is greatest and the water was most slowed. The deposits are generally graded, both vertically and laterally. The coarsest sediments are in the northern reaches of the Reservation. Finer sediments prevail southward in the wider parts of the basin, with the finest sediments on the basin margins and on the flanks of the enclosing hills. The deposits of each flood also tend to be finer-grained upward, reflecting the decreased velocity of the flood waters as they ponded.

The sediments coarsen toward Wallula Gap, where the water velocities were again greater because of the basin's narrowing cross sectional profile and because of the volumes of water, including the Snake River, entering the Pasco Basin at downstream points. The basin fill there accumulated to a maximum altitude of about 500 feet.

Subsequent to the deposition of the basin fill sediments, the Columbia River cut its way across the Reservation, shifting generally northeastward as it lowered its base level and its grade. Estimates of its lateral rates of shift range up to a foot per year. Today residual channels cross the northeast part of the Reservation attesting to that shift. In the process of eastward shifting and concomitant with down-cutting, several benches or terraces were modified. They are best displayed in the southern part of the Reservation south of the Hanford Wye road junction. There, the uppermost terrace lies at an altitude of 500 to 540 feet and the lower at 400 to 440 feet, with the escarpment or boundary between the two paralleling the Columbia River and about 4 to 5 miles from the river.

Subsequent to the river shift, wind action established two sets of dunes that now cross both terraces indiscriminately. The first set forms a belt that extends from the junction of Cold and Dry Creek Valleys to a point halfway to the Yakima Horn, thence east-northeast immediately north of the Hanford Wye road junction to the Columbia River. There a belt four miles wide is formed immediately south of the Hanford townsite to a point opposite Ringold on the east bank of the Columbia River. The dunes evidently originated in Cold Creek Valley by deflation of the valley and wind transport of the sands to the east-northeast.[26]

The second group of dunes focuses on the area between the Yakima Horn and North Richland, with the dune belt dying out to the northwest and southeast. The dunes trend northeastward. Their eastward convergence with the more northerly belt indicates a somewhat different direction of the prevailing winds at different locations. To a large extent this is topographic control, due to the presence of wind gaps and anticlinal ridges in the wind's path.

Both sets of dunes evidently developed 4000 to 8000 years ago in the dry and warm climate of the Altithermal geological interval and have in part stabilized as a result of subsequent climatic

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changes.[26] They also attest to the continued eastward migration of the Columbia River and to the lack of its presence on the Hanford Reservation in the time since dune emplacement. Otherwise, the dunes would have been breached.

The eastward shift of the Columbia River evidently is continuing in the northern reaches of the Reservation. Thus the northern reaches of the White Bluffs (north of the Hanford townsite) are being actively undercut. Landslides into the Columbia River have occurred and will occur as the bluffs are oversteepened.

II.3.7 Seismology[(a)] [RPB, X.4, X.18]

Eastern Washington is in a region of low to moderate seismicity lying between the western Washington and western Montana zones of considerably greater seismicity.[27,28] On the basis of the damage that has been experienced since 1840, the U.S. Coast and Geodetic Survey (ESSA) designated eastern Washington as Zone 2 seismic probability, implying the potential for moderate damage from earthquakes. Periodic revisions between 1948 (the date of first issuance of the risk map) and 1969 did not change the potential for eastern Washington, although damage potentials for other parts of the country were upgraded (Figure II.3-8). Currently western Washington and western Montana are in a Zone 3 category, implying the risk of considerable damage. The categories are incorporated in the Uniform Building Code.

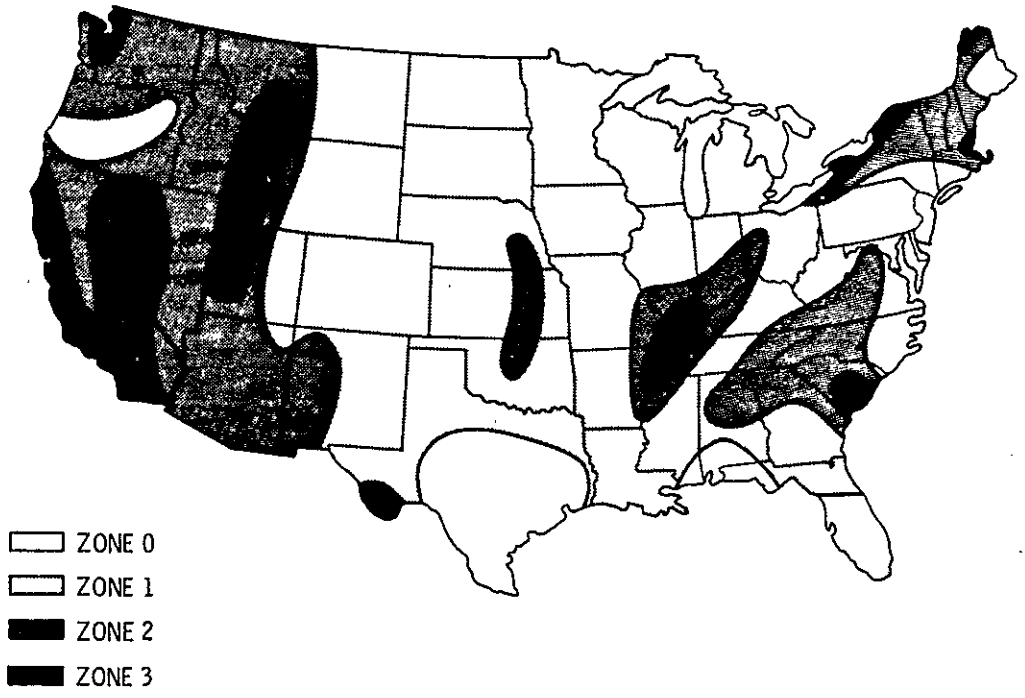

FIGURE II.3-8 SEISMIC RISK MAP

Hanford facilities are exposed to the possibility of earthquake damage from two sources: 1) the active seismic zones of western Washington and 2) closer shocks originating in the seismic zone that includes Walla Walla. However, the underlying sands and gravels in the Hanford Reservation provide excellent protection against damage. As far as can be determined, earthquake intensities greater than four on the Modified Mercalli Scale (MM-IV) have not assuredly occurred in the immediate Hanford area, although intensities as high as MM-V or MM-VI were observed at surrounding towns.[29]

The strongest shock of historic record to occur in western Washington was the 1949 earthquake originating in the Puget Sound channel just off Steilacoom, about 150 miles from Hanford. Intensities from MM-VI to MM-VII were experienced at distances of 150 miles.[29] Four shocks in western Washington between 1932 and 1946 had maximum intensities of MM-VII.

(a) Appendix II.3-C provides a more detailed description of the seismology of the Hanford Reservation.

The eastern Washington earthquakes occurring in historic times have not been as intense as those in western Washington, nor as frequent. In 1936, the Walla Walla area experienced an MM-VII shock. In 1934 at Ellensburg and in 1957 near Othello, "Seismic Swarms" of small shocks occurred. An intensity of MM-VI was reached in some of these, but the shocks were highly localized. The closest felt earthquake of historical record occurred at Corfu, 31 miles north of the 300 Area, in 1918. Goods fell from shelves and small landslides reportedly occurred.[30]

The great Alaska earthquake of 1964 and recent shocks in western Washington were not felt as strongly at Hanford as in surrounding localities. Moreover, Hanford is not located in a historically active seismic zone (Figure II.3-9). These considerations indicate that the area is one of the safest in the state.

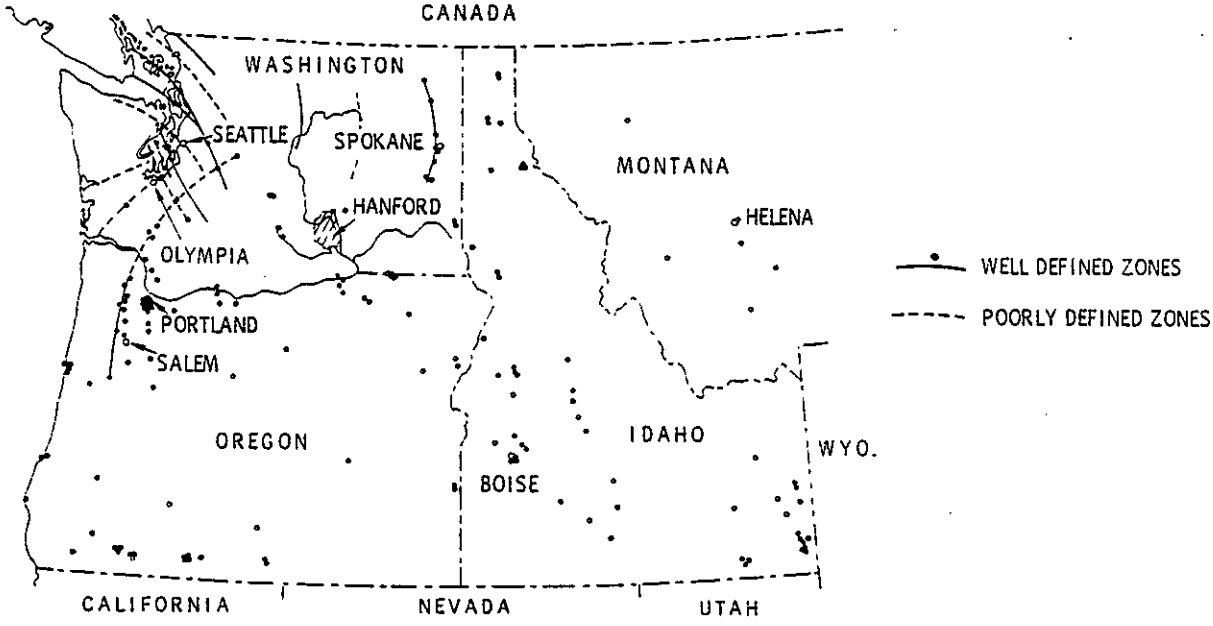

FIGURE II.3-9 EARTHQUAKE ZONES OF WASHINGTON

For building purposes, the Hanford area was included in Zone 2 in the seismic probability map adopted as part of the Uniform Building Code by the International Conference of Building Officials. It implies the potential of only moderate damage as deduced from the historical record. The seismic risk maps are based upon the worst damage that has been experienced; in most cases this has occurred on poorly consolidated and saturated sediments. Hence, a lesser damage potential is indicated for sites utilizing less earthquake-responsive ground. In compensation, the maps consider a historical record of about 100 years, during which the low population density of the area may have resulted in there being no record of some minor quakes and certainly no damage. The true earthquake potential then may be somewhat higher or lower than suggested by the Seismic Risk Map.

The U.S. Geological Survey has been actively engaged since 1968 in performing seismic research on and surrounding the Hanford area. The monitoring devices provided were considered as the best state-of-the-art instrumentation required to monitor microearthquakes and crustal movement.

This research includes three basic activities:

- A network of 32 seismometers strategically located from the Oregon-Washington border south of the Hanford Reservation to Grand Coulee Dam north of the Hanford Reservation. The seismometer network provides continuous, real time surveillance of seismic activity within the grid established by the network. The information is telemetered to either the USGS in Menlo Park, California, or the University of Washington in Seattle. Interpretative efforts by the seismic authorities at these locations identify any trends in seismic activity which may disclose "fault lines" if they exist.

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- Trilateration measurements are performed between 17 benchmarks to measure crustal motion. The initial base data were developed 3 years ago, with additional measurements at 6 months, 12 months, and 36 months from that time.

- Tiltmeters are installed at three locations on the Hanford Reservation. These pieces of equipment provide continuous geographic coverage of crustal motion. The output is telemetered to Menlo Park for interpretation.

Figure II.3-9 shows the active earthquake zones in Washington deduced from earthquake activity. East of the Cascades the trends are largely north-south, parallel to the Cascades, and divide the state into separate geographical, structural and tectonic provinces.

In eastern Washington, clearcut relationships of epicenters to specific surface faults or structures capable of faulting are not yet recognized. The suggested low rate of tectonic deformation for more than 10 million years[19] does not indicate any cause for concern. Much of the stress resulting from the continuing low rate of tectonic deformation appears to be dissipated from random epicenters along joints and bedding planes.

On the assumption that an MM-VII quake (magnitude 5.5) were to occur at the northwest end of the Rattlesnake-Wallula fault zone, ground acceleration of 13% g could be expected beneath most of the Hanford Reservation.[31] A design basis of 25% g on the Hanford Reservation thereby allows for an MM-VIII intensity quake (magnitude up to 6.8) for an earthquake epicentered at the same site. No such quake has ever been recorded in eastern Oregon or Washington.

The siting of nuclear facilities over the synclinal troughs assures the maximum distance from all hypothesized faults capable of earthquake generation. If, in addition, the Ringold Formation and Pasco Gravels are compact and undisturbed, the site is certain to pose few problems. An appreciable to high degree of conservatism appears present by acceptance of the MM-VIII quake (magnitude 6.8) and the resulting 25% g acceleration for facility design purposes.

II.3.8 Hydrology[(a)] [RPB, X.18, X.25]

II.3.8.1 Surface Water

The surface water bodies located within the boundaries of the Hanford Reservation consist of the Columbia River, various ditches and ponds in and near the 200 Areas and three ponds located in the 300 Areas (Figure II.3-10). Two ephemeral streams, Cold and Dry Creeks, appear for a short time only after heavy rainfall or snowmelt. The Yakima River borders part of the Reservation's southern boundary.

II.3.8.1.1 Columbia River

The river reach from Priest Rapids Dam (river mile 397) to the head (approximately river mile 351) of the reservoir behind McNary Dam is the last free-flowing reach of the Columbia River within the United States. The main channel is braided around the island reaches, and submerged rock ledges and gravel bars cause repeated pooling and channeling. The riverbed material is mobile, dependent on river velocities; it is typically sand, gravel, and rocks up to 8 inches in diameter. Small fractions of silts and clays are associated with the sands in areas of low velocity deposition, becoming more dominant approaching the upstream face of each river dam.[32,33,34]

The Columbia River in this reach has widely varying flow rates due to regulation by the power producing Priest Rapids Dam just upstream (Figure II.3-11). Flows during the summer, fall and winter vary from a low of 36,000 cubic feet per second (cfs) to as much as 160,000 cfs each day. The long-term annual average flow at Hanford is about 120,000 cfs,[35] but during low flow periods, daily flows average 80,000 to 90,000 cfs. The mean annual flow rate for 1972 at Hanford was 159,500 cfs. In recent years, peak flows during the spring runoff have ranged from 160,000 to 550,000 cfs; the maximum flood peak of record is 693,000 cfs in 1948.

The river width in the Hanford reach varies between 400 and 600 yards depending upon flow rate and position along the river.[36] The depth at the deepest part of the measured cross-sections varies approximately from 10 to 40 feet, with an average around 25 feet. Daily fluctuations in depth caused by Priest Rapids regulation can be as much as 10 feet above Vernita and 5 feet at Hanford. The maximum velocities measured vary from less than 3 feet per second (fps) to over 11 fps, again depending upon the river cross-section and flow rate.

(a) Appendix II.3-D provides a more detailed description of the hydrology of the Hanford Reservation. In 1973 Atlantic Richfield Hanford Company authorized an independent review, recently completed, of the hydrology program.

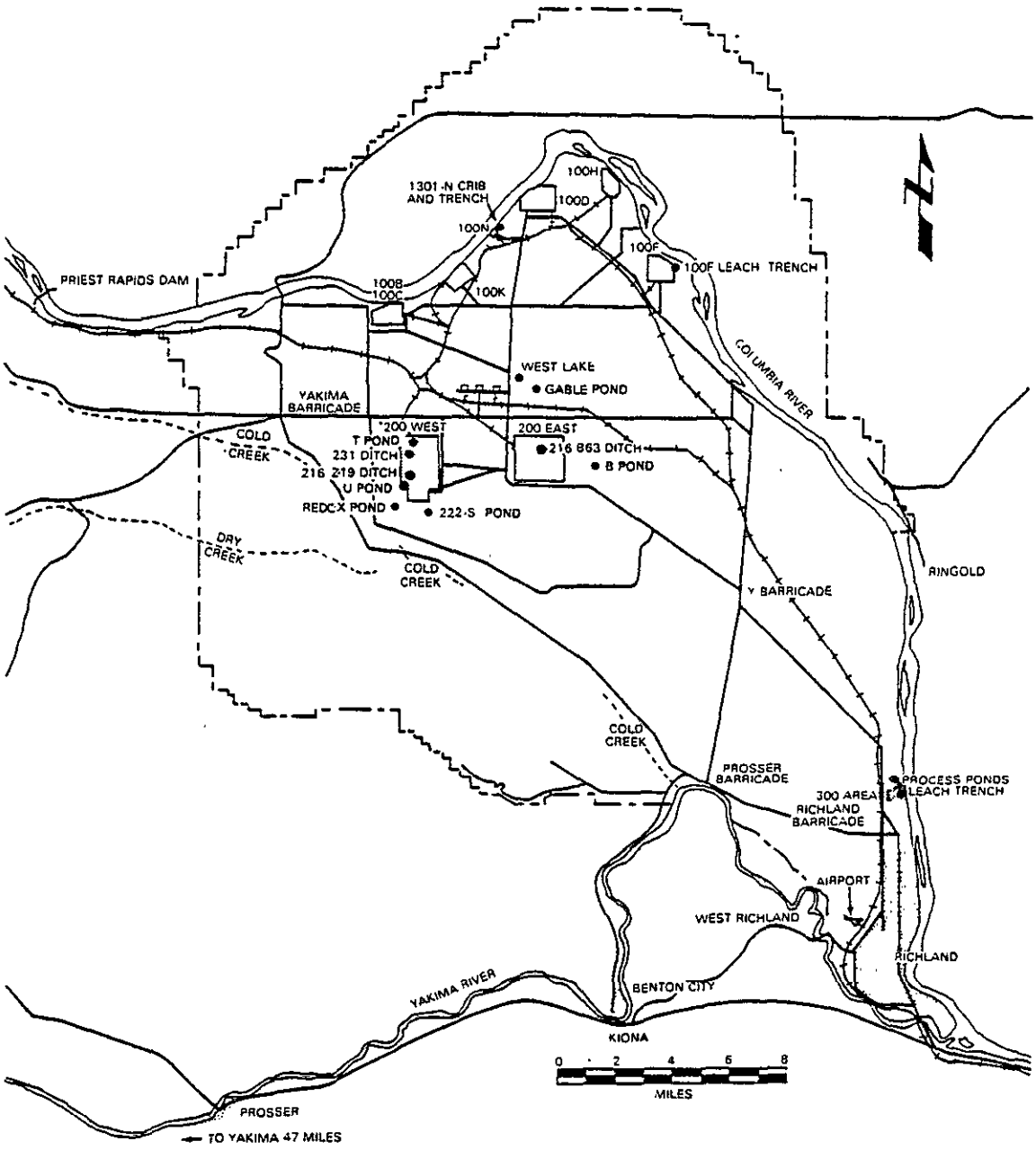

FIGURE II.3-10 SURFACE WATER AREAS ON HANFORD SITE

Temperature measurements of the Columbia River have been continuously recorded both above and below the Hanford Reservation for many years. Figure II.3-12 shows the temperature data just below Priest Rapids Dam and at Richland for 1972.[37] The maximum daily temperature for 1972 was 19.3°C (66.7°F). The annual average was 10.9°C (51.6°F) below Priest Rapids Dam and 10.1°C (50.2°F) at Richland. The maximum river temperature of record at Priest Rapids was 20.7°C (69.3°F) in August, 1958. The annual mean temperature for 1960-69 was 10.8°C (51.4°F).

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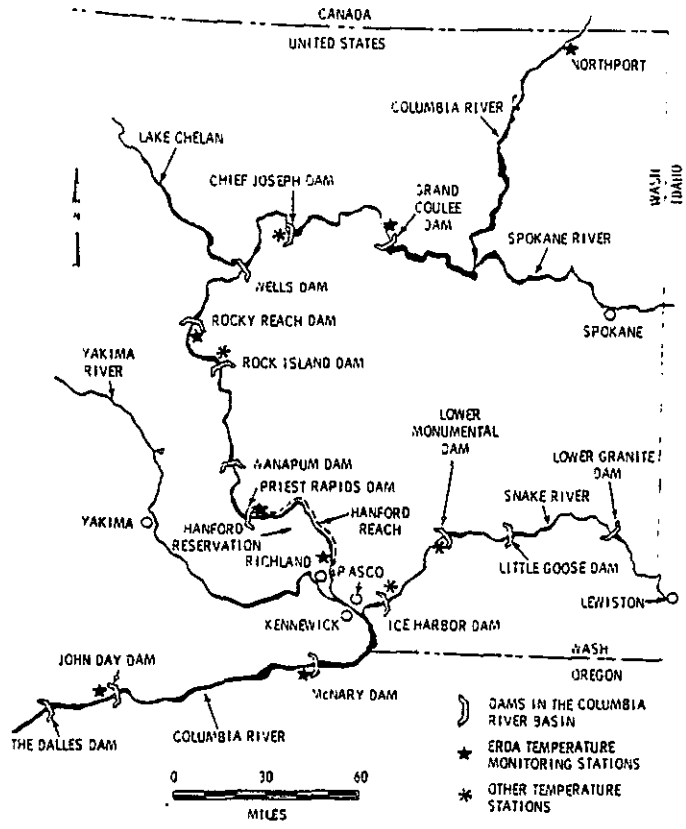

FIGURE II.3-11 A PORTION OF THE COLUMBIA RIVER BASIN

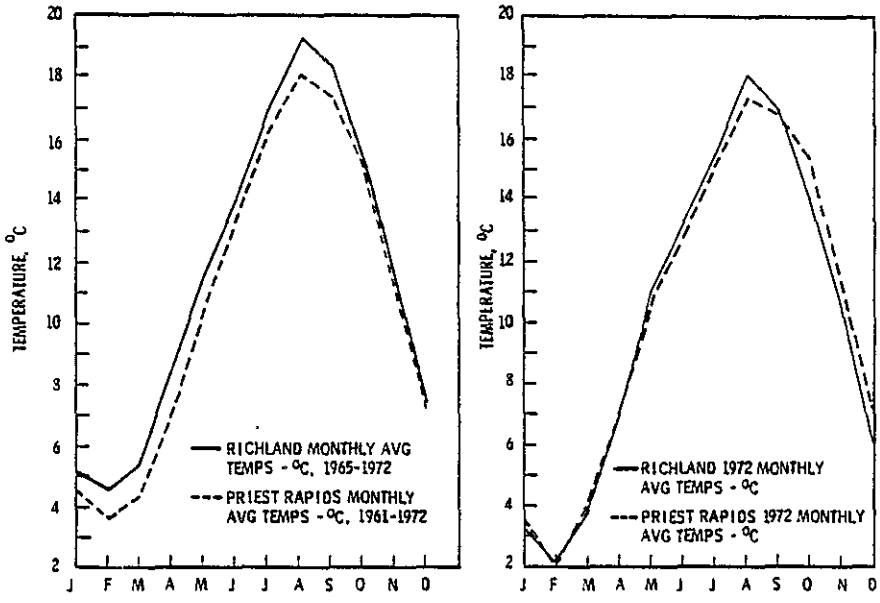

FIGURE II.3-12 1972 MONTHLY AVERAGE TEMPERATURE COMPARISON FOR PRIEST RAPIDS DAM AND RICHLAND

Samples for chemical analysis are taken routinely at Priest Rapids Dam, at Vernita, the 300 Area, and at Richland.[38] Table II.3-2 gives annual summaries of this data for 1972 at the Priest Rapids location. A study[39] on the effect of reactor effluent on chemical quality of the water includes analyses of river samples taken semimonthly at Vernita (downstream of Priest Rapids Dam but upstream from the Hanford Reservation) and within the Hanford boundaries but downstream of reactor effluent discharges. Statistical comparison of the mean sample values showed no significant differences at the 90% confidence level in any of the species except hexavalent chromium.

TABLE II.3-2

AVERAGE CHEMICAL CONCENTRATIONS IN THE COLUMBIA RIVER AT PRIEST RAPIDS DAM, OCTOBER 1971 TO SEPTEMBER 1972

Chemical	Concentration		Chemical	Concentration	
Calcium	19.	(mg/ℓ)	Ammonia Nitrogen	.07	(mg/ℓ)
Magnesium	4.3	(mg/ℓ)	Nitrite	.006	(mg/ℓ)
Sodium	2.1	(mg/ℓ)	Nitrate	.26	(mg/ℓ)
Potasium	1.4	(mg/ℓ)	Ortho-Phosphorus	.013	(mg/ℓ)
Chromium	0 [a]		Total Phosphorus	.037	(mg/ℓ)
Copper	2.6[a]	(μg/ℓ)	Total Alkalinity	59.	(mg/ℓ)
Lead	8.0[a]	(μg/ℓ)	Hardness	66.	(mg/ℓ)
Total Mercury	0.9[a]	(μg/ℓ)	Non-Carbonate Hardness	06.8	(mg/ℓ)
Zinc	32.0[a]	(μg/ℓ)	Specific Conductance	158.	(micro-ohms)
Bicarbonate	72.	(mg/ℓ)	pH	7.8	(units)
Sulfate	13.	(mg/ℓ)	Dissolved Solids	107.	(mg/ℓ)
Chloride	1.5	(mg/ℓ)	Color	15.	(Platinum - Cobalt units)
Kjeldahl Nitrogen	.29	(mg/ℓ)			

(a) partial data only

II.3.8.1.2 Yakima River

The Yakima River is a small river with annual flow rates between 1,300 and 20,000 cfs. This river passes near the borders of the Hanford Reservation on the southern side. It is of little importance to the Hanford operations since no direct water withdrawal or disposal is made. However, its entrance into the Columbia River at Richland diverts the main river away from the southern shore from the mouth of the Yakima to Kennewick. Past Horn Rapids, the Yakima River loses water continually through its bed and banks until it joins the Columbia River.

Continuous flow data in the vicinity of Hanford are available from a water stage recorder located at Kiona (approximately 20 miles west of Richland). Data from this station show a minimum and maximum flow of 1,420 cfs and 20,200 cfs, respectively for 1972. The mean flow for 1972 was 6,696 cfs.[35] Water quality measurements are routinely made on the Yakima River at Kiona.[37]

II.3.8.1.3 Ponds and Ditches

The Hanford Reservation contains a number of man-made ditches and ponds which are used for the disposal of low-level radioactive liquid waste, certain industrial waste, and cooling waters from various processes. (A complete list of these ditches and ponds, together with physical dimensions and radioactive inventory, is included in Appendix II.1-C, Part 2.)

Besides these man-made ponds, one natural pond, West Lake, exists (also shown in Figure II.3-10). The size of this pond is a direct function of the elevation of the groundwater in that area; the average size is about 10 acres. No waste is being discharged to this pond.

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The 300 Area ponds receive manufacturing process and cooling water from fuel fabrication processes and small amounts of laboratory waste, including waste from the 331 Building laboratories and effluent liquor from the animal pen septic tanks (Figure II.3-10). Sanitary waste from laboratory, office, and manufacturing facilities is routed to a septic tank, with overflow to leach trenches. No intermediate- or high-level radioactive waste is routed to any of the 300 Area ponds.

II.3.8.2 Water Below the Surface [RPB, X.18]

II.3.8.2.1 Background

The subsurface of the Hanford Reservation is underlain by various geologic units having widely different water-bearing properties (Appendix II.3-D). The rock types include: unconsolidated silts, sands, and gravels; semiconsolidated lake and stream sediments; and dense basalts with interbeds separating individual flows. From a hydrologic standpoint the most permeable horizons are the sands and gravels of the Upper Ringold Formation and the Pasco Gravels. The water table over the western portion of the Hanford Reservation lies at the top of the Ringold Formation. However, between the high terrace plateaus and the Columbia River, the water table rises above the Upper Ringold and intersects the overlying Pasco Gravels.

Above the water table lies the unsaturated or vadose zone. Any waste that percolates into the subsurface within the 200 Areas of the Hanford Reservation must flow through a thick section of unsaturated glaciofluviatile sediment prior to reaching the water table. Waste-soil interactions in the unsaturated zone result in maximum sorption of radionuclides in this zone and minimum migration of radionuclides to the water table below.

The uppermost aquifer (water-bearing formation) lies between the water table and the silts and clays of the Middle and Lower Ringold Formation. In general, groundwater in these unconsolidated and semiconsolidated sediments occurs under unconfined or water table conditions, although locally confined zones exist. Some semiconsolidated gravels and sands are locally found in the Lower Ringold Formation. These beds are usually separated from the overlying unconfined aquifer by a layer of silt and clay of variable thickness. These sands constitute the uppermost confined aquifer.

The Ringold Formation overlies a warped and severely deformed layer of basalt. The Columbia River basalt series has, in general, a saucer-shaped synclinal structure. It is an accordantly layered sequence of flows which were extruded as highly fluid lava in Miocene and early Pliocene time. Narrow zones of rubbly, permeable scoria somewhat similar to flow breccia occur at the top of a few flows and may be quite permeable. Some of these permeable zones in the basalt may constitute rather good confined aquifer systems.

During the past 30 years, wells have been drilled at Hanford through all the above-mentioned formations:[40]

- for water supply
- to provide quantitative data for evaluating the chemical and physical properties of the underlying material
- for measuring the hydrological characteristics of the various sediments
- for foundation engineering design
- for monitoring waste disposal facilities
- for monitoring the radiological status of the groundwater.

Figure II.3-13 shows the location of the wells currently available for hydrological measurements.

The aquifers in the Hanford Reservation have been studied extensively using data from existing wells, predictive mathematical studies, and regional hydrologic studies. All these data have been used in preparing the subsequent sections.

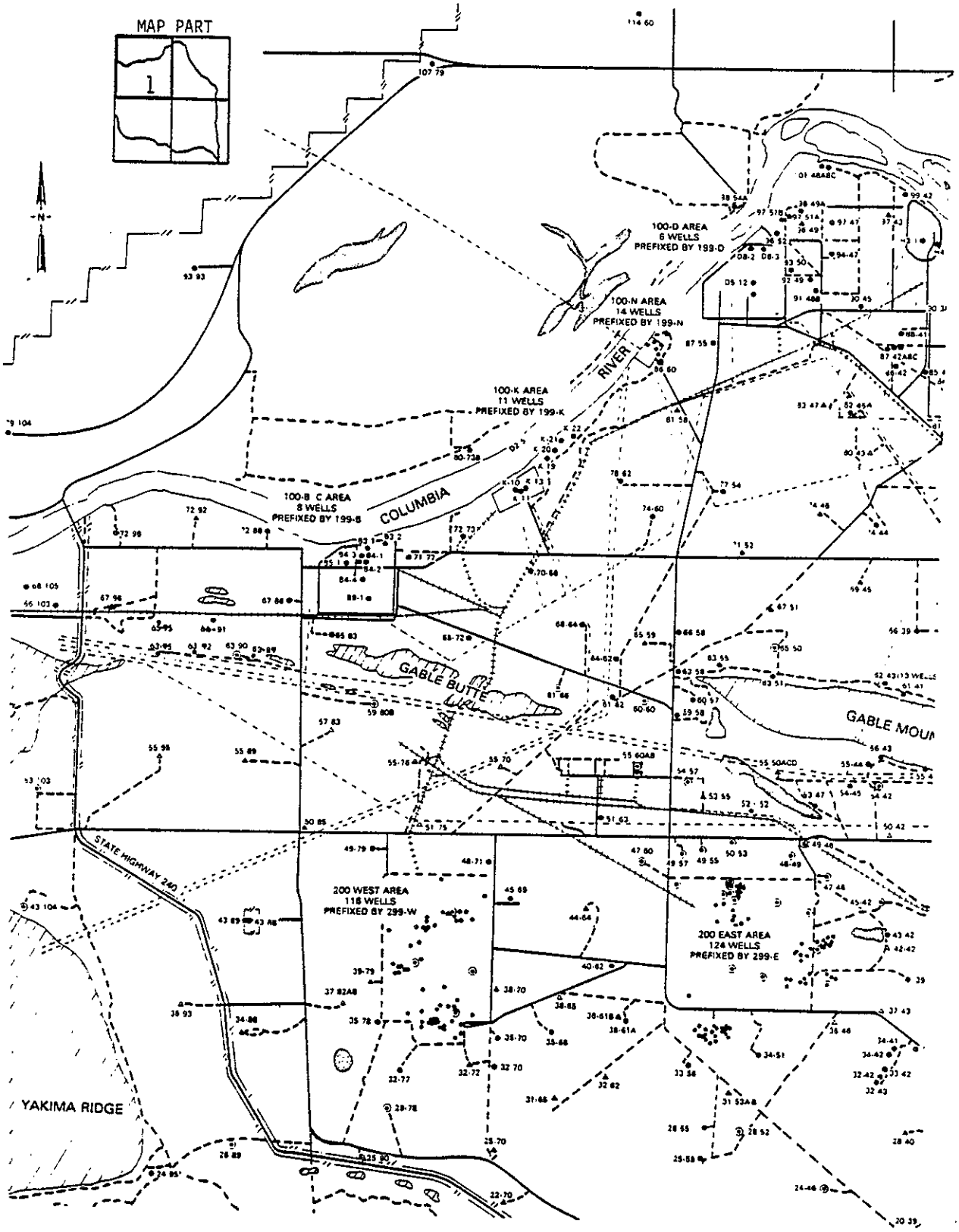

FIGURE II.3-13a HANFORD RESERVATION WELL LOCATION MAP (Part 1)

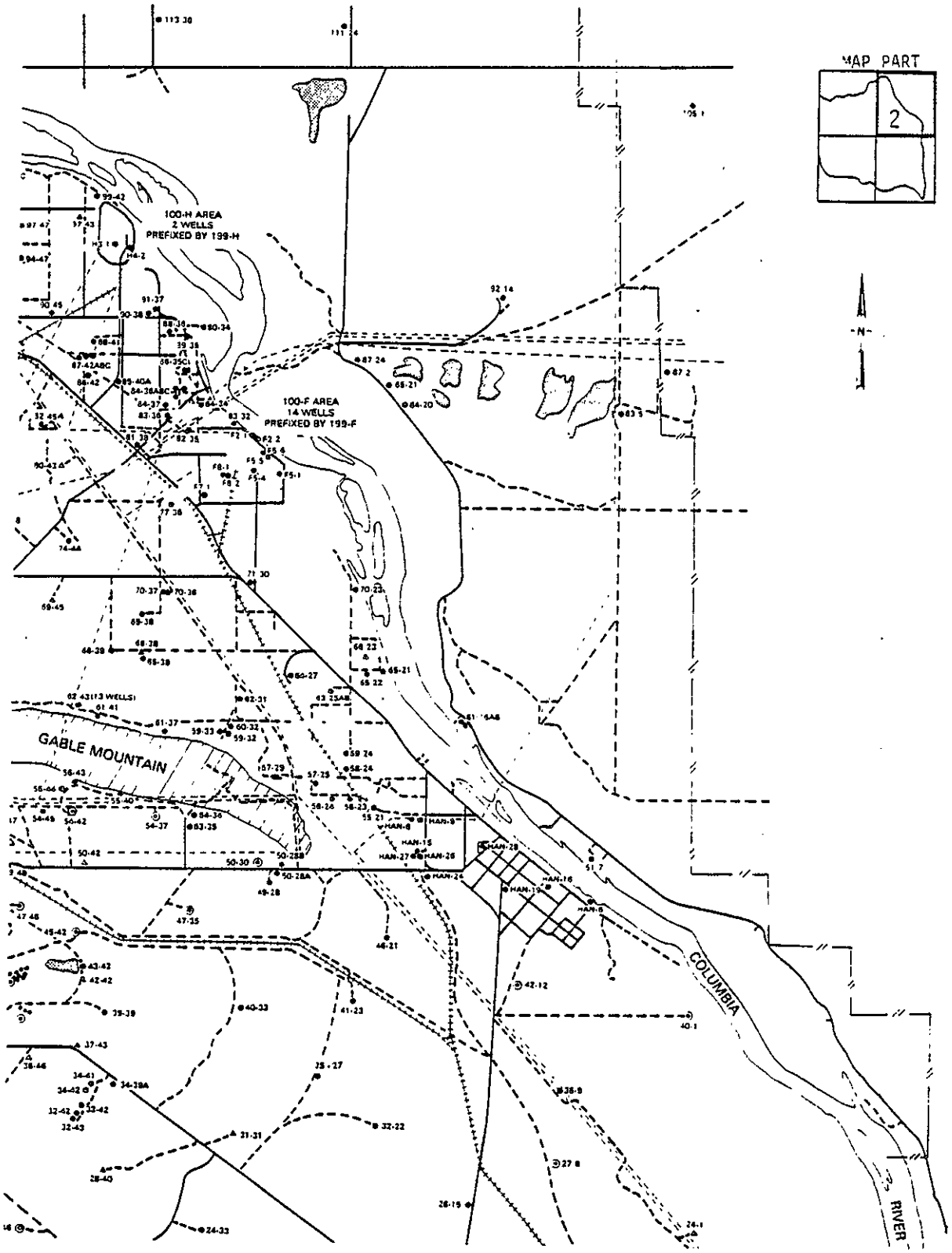

FIGURE II.3-13b HANFORD RESERVATION WELL LOCATION MAP (Part 2)

0 7 3 0 1 6 9 1 1 6

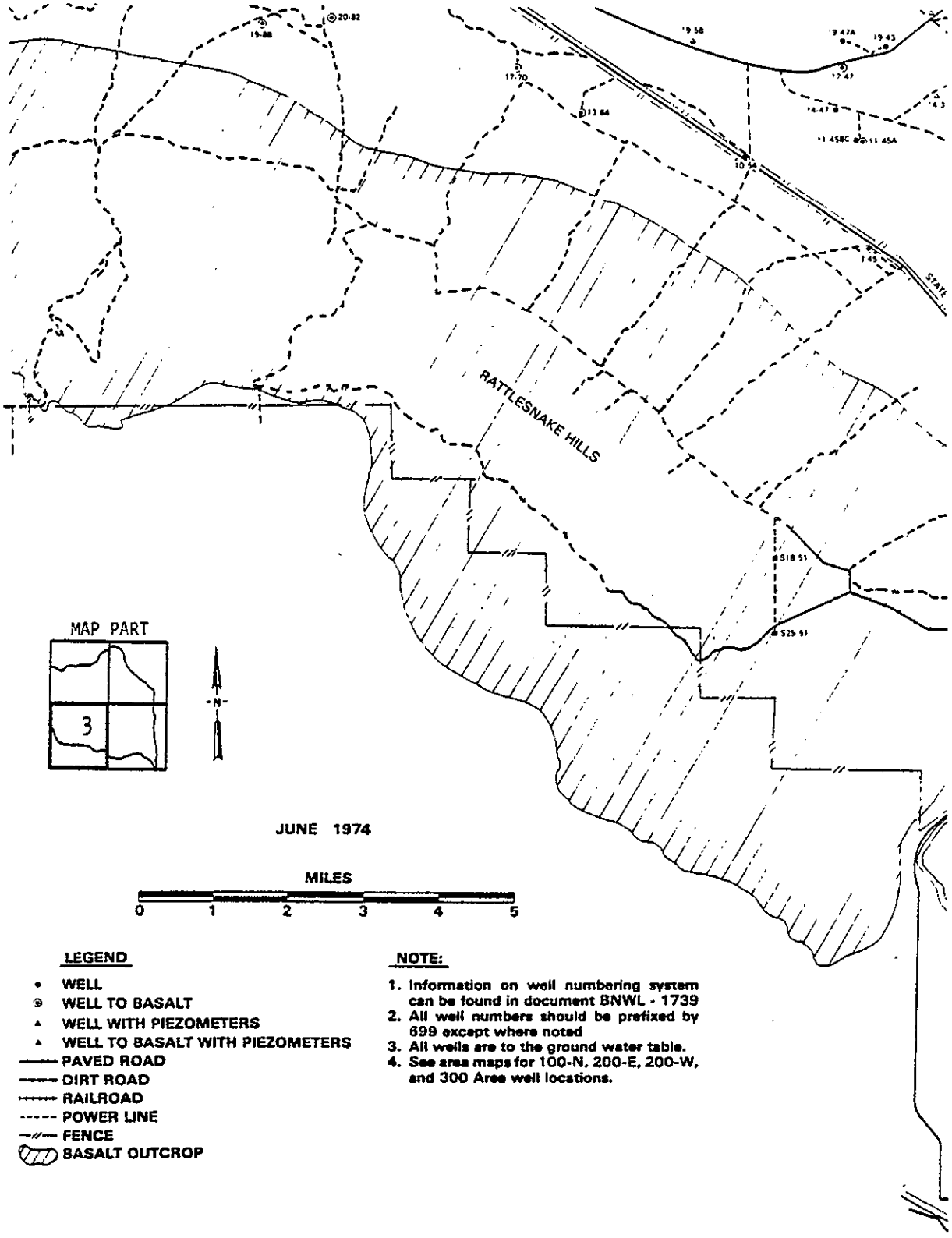

FIGURE II.3-13c HANFORD RESERVATION WELL LOCATION MAP (Part 3)

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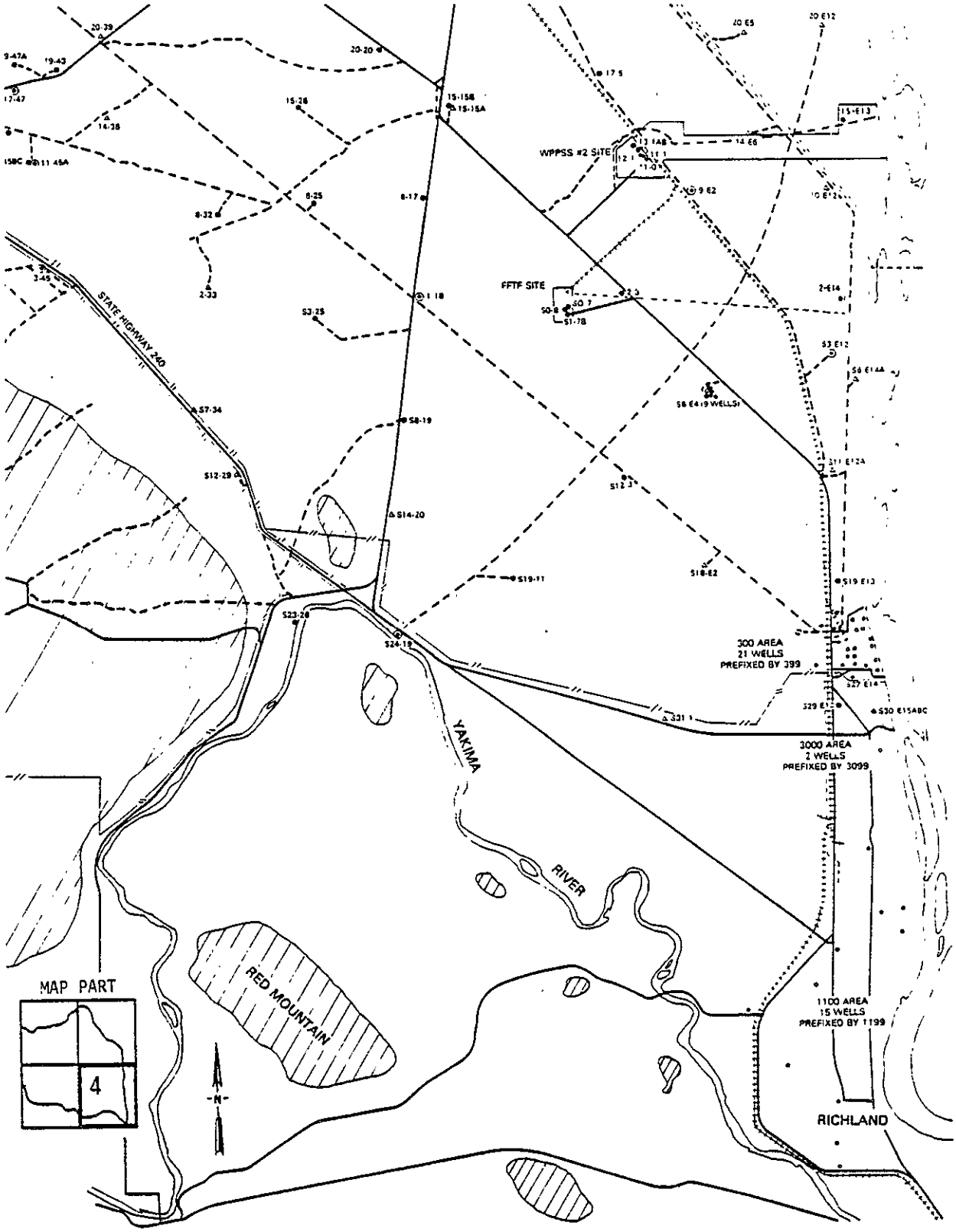

FIGURE II.3-13d HANFORD RESERVATION WELL LOCATION MAP (Part 4)

II.3.8.2.2 The Unconfined Aquifer [X.18]

The unconfined aquifer consists of both glaciofluviatile sand and gravel deposits and the Ringold silts and gravels. Since these materials are very heterogeneous, often greater lithologic differences appear within a given bed than between beds. The aquifer bottom is the basalt bedrock in some areas and silt/clay zones of the Ringold Formation in other areas. The impermeable boundaries of the unconfined aquifer within the Hanford Reservation and vicinity are the Rattlesnake Hills, Yakima Ridge, and Umtanum Ridge to the west and southwest. Gable Mountain and Gable Butte, as well as other small areas of basalt outcrop above the water table, also impede the groundwater flow. The Yakima River recharges the unconfined aquifer along its reach from Horn Rapids to Richland. The Columbia River forms a hydraulic potential boundary which is mainly a discharge boundary for the aquifer. However, the groundwater flow from 1 to 3 miles inland from the Columbia River is affected by seasonal river stage fluctuations.[41] The flow pattern that originally prevailed in the unconfined aquifer prior to waste discharges was primarily to the east and northeast with discharge into the Columbia River (Figure II.3-14). Natural recharge occurs at the foot of Rattlesnake Hills and Yakima Ridge. Surficial flow sinks into the floor of the valley at the foot of and paralleling Rattlesnake Hills. Probably, the underflow is to a great extent interrupted by a buried extension of Yakima Ridge which parallels Rattlesnake Hills at a distance of about 2 miles and which rises above the water table.

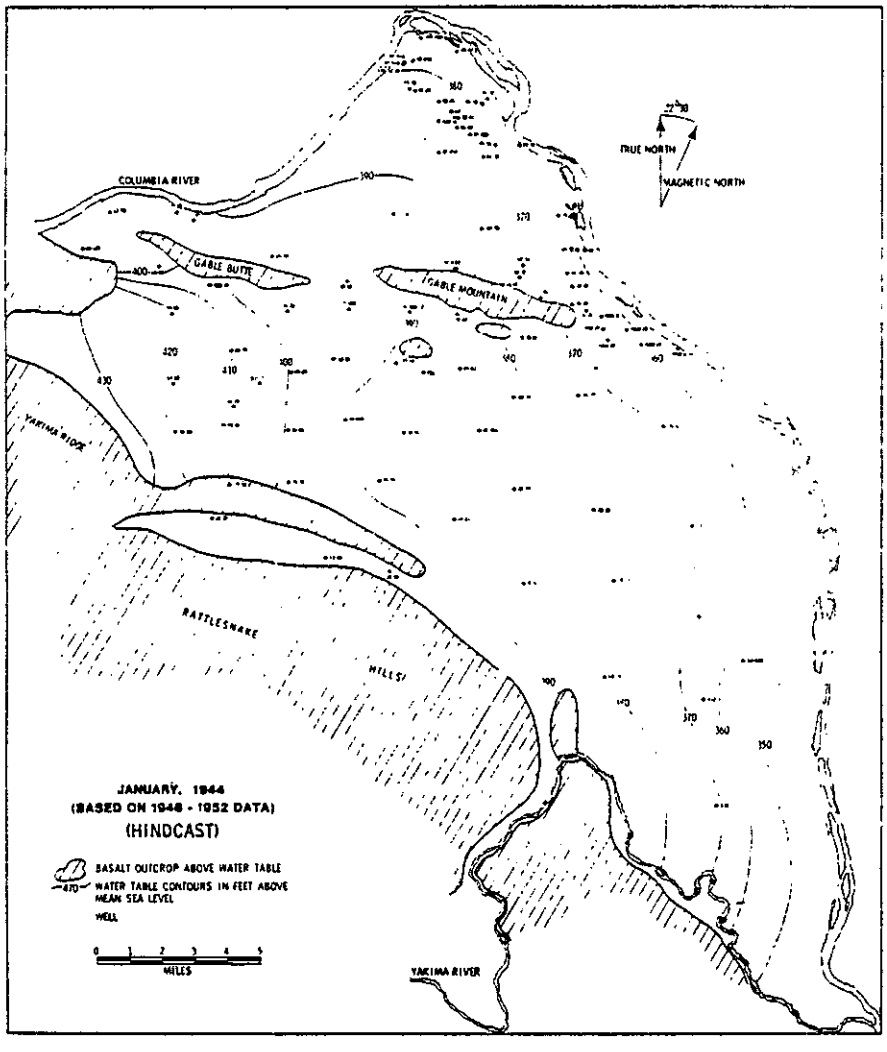

FIGURE II.3-14 HANFORD RESERVATION WATER TABLE MAP JANUARY, 1944 HINDCAST

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The regional water table is largely within the Ringold Formation and to a lesser extent in the Pasco Gravels. Geologic work[42] has pointed to the existence of highly permeable sediment on portions of both the northern and southern flanks of Gable Mountain. A filled erosional channel southeastward from the western side of Gable Mountain toward the Columbia River permeable zones parallel the river.

In 1944, before waste operations at Hanford began (Figure II.3-14), the hydraulic gradient in all but the south-westernmost portion of the Hanford Reservation was about 5 feet/mile. By 1975, plant discharges had created two mounds in the vicinity of the 200 West and 200 East Areas. Waste disposal raised the water table in the recharge sites and altered the existing hydraulic gradient. Today, groundwater flows radially outward from the mounds under the influence of an average gradient of about 30 feet/mile in the 200 West Area and 15 feet/mile in the 200 East Area. The water table has been raised 75 feet at the 200 West mound and 20 feet at the 200 East mound. Other local groundwater mounds formerly existed at each reactor site along the Columbia River. The mound at the still active 100-N Area is the only one of these remaining. A minor recharge mound exists under the 300 Area. The 1975 water table map is shown in Figure II.3-15.

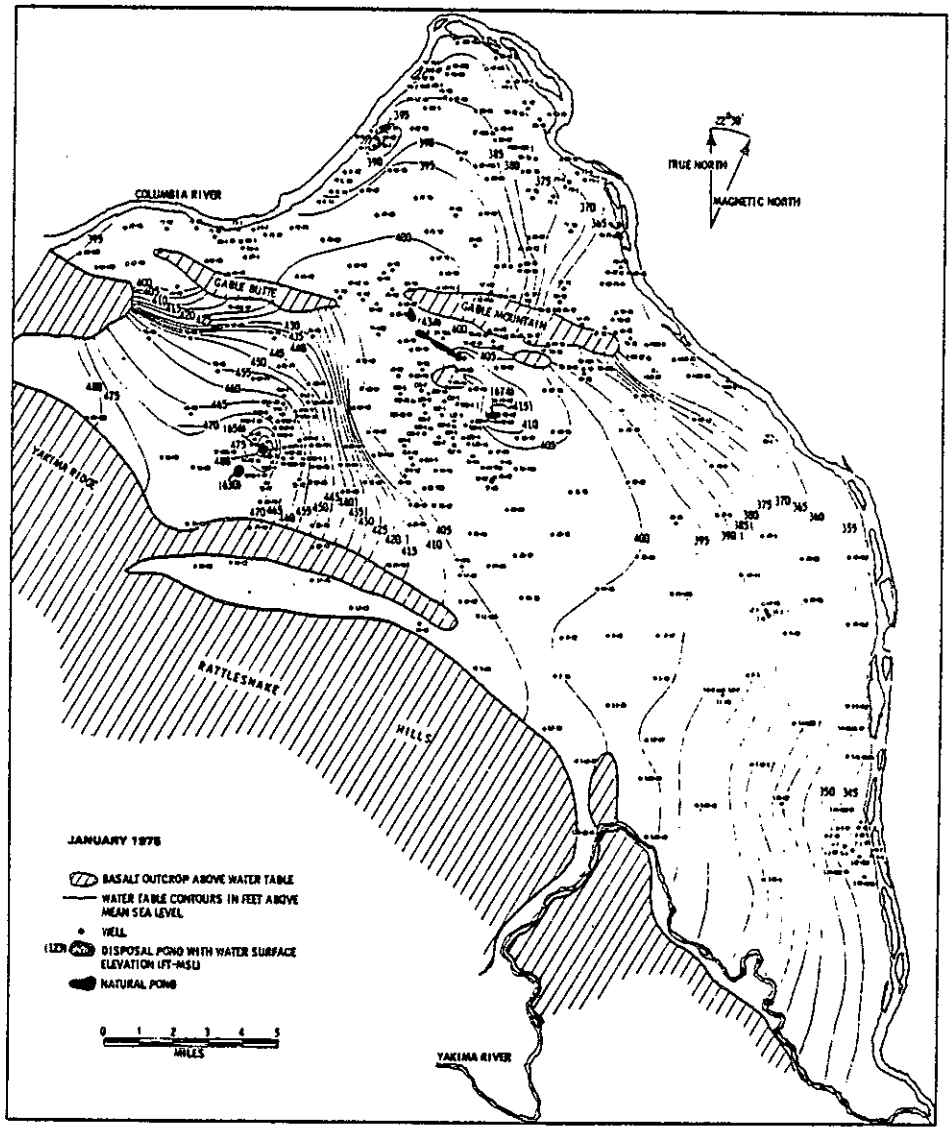

FIGURE II.3-15 HANFORD RESERVATION WATER TABLE MAP JANUARY, 1975

The natural recharge due to precipitation over the lowlands of the Hanford Reservation is not measureable since the evaporation potential during the summer months greatly exceeds total precipitation. Data on migration of moisture from natural precipitation in deep soils (below 30 feet) show movement rates less than 1/2 in./yr at one measurement site.[43,44,45]

To hydrologically describe an aquifer, four parameters need to be considered. These are:

- hydraulic conductivity: a quantity having the units of velocity that relate the flux of groundwater to the hydraulic gradient
- aquifer thickness: the thickness of permeable sediment lying between the water table or an upper confining bed and a lower confining bed
- effective porosity: the fraction of porous media capable of transmitting water
- storage coefficient: the volume of water that a unit decline in head releases from storage in a vertical column of aquifer of unit cross-sectional area.

For an unconfined aquifer, the storage coefficient approaches the effective porosity. Therefore, to describe the unconfined aquifer underlying the Hanford Reservation, measurement is needed of the hydraulic conductivity, aquifer thickness and storage coefficient.

Qualitatively, the hydraulic conductivity and storage coefficient distributions are a function of the different geologic formations in the unconfined aquifer. Ancestral Columbia River channels incised in the Ringold Formation are filled with more permeable glaciofluviatile sediments. Channels of permeable sediments have been identified[46,104] and are reflected in the groundwater flow pattern of the region.

Quantitative measurements of the hydraulic conductivity were made at several locations over the Hanford Reservation using a variety of techniques.[46,47,48] Excluding clay zones, the values obtained for the Ringold Formation range from 10 to 700 ft/day. Hydraulic conductivities of glaciofluviatile sediments range from 1,000 to 12,000 ft/day. The hydraulic conductivity distribution has been obtained using pumping test data and information from driller logs. As noted in Appendix II.3-D, the results of these studies agree well.[48,105]

Storage coefficient values can be measured in the field by using pumping tests. For unconsolidated sediments, the storage coefficient ranges between 0.05 and 0.3. However, few measurements of the storage coefficient have been made to-date at Hanford.[47] A pumping test program to produce these measurements is presently underway. The bottom of the unconfined aquifer has been determined throughout the Reservation using data from wells. Figure II.3-16 shows a map of the unconfined aquifer bottom. The surface depicting the aquifer bottom corresponds to basalt bedrock in some areas and silt-clay zones of the lower Ringold Formation in other areas.

Predictive models and regional studies use the data discussed above to predict the fate of any waste that may reach the water table. Radioactive contaminants are convected in the direction of groundwater movement upon reaching the water table.

Thus, the site of infiltration is of critical importance in evaluating the fate of any radioactive waste that gets into the groundwater. Ultimately, all groundwater in the unconfined aquifer flows into the Columbia River except for that small amount which is lost to the atmosphere by evapotranspiration.

The chemical quality of the groundwater in the unconfined aquifer is measured semiannually at seven locations. Sodium, calcium, and sulfate ions are measured as well as pH. Water from wells in the 300 Area is analyzed for chromium and fluoride ions associated with fuel manufacturing operations. Nitrate ion, which is a waste product from the manufacturing and chemical separations operations, is monitored over the entire Hanford Reservation. Maps of the nitrate ion concentration near the water table of the unconfined aquifer are published semiannually. The map for 1973 appears in Figure II.3-17.[52] Since the nitrate ion is not sorbed on the soil, the map indicates the direction and the extent of wastewater movement.

The temperature of the groundwater in the unconfined aquifer has been measured on an intermittent basis. Figure II.3-18 shows the distribution of the groundwater surface temperature under the Reservation for January 1974. Local thermal anomalies may be caused by vertical flow within a well casing. At one time, reactor groundwater mounds contained water on the order of 70-90°C.[53] The residual heat from these mounds can be seen in Figure II.3-18 under the northern part of the Reservation.

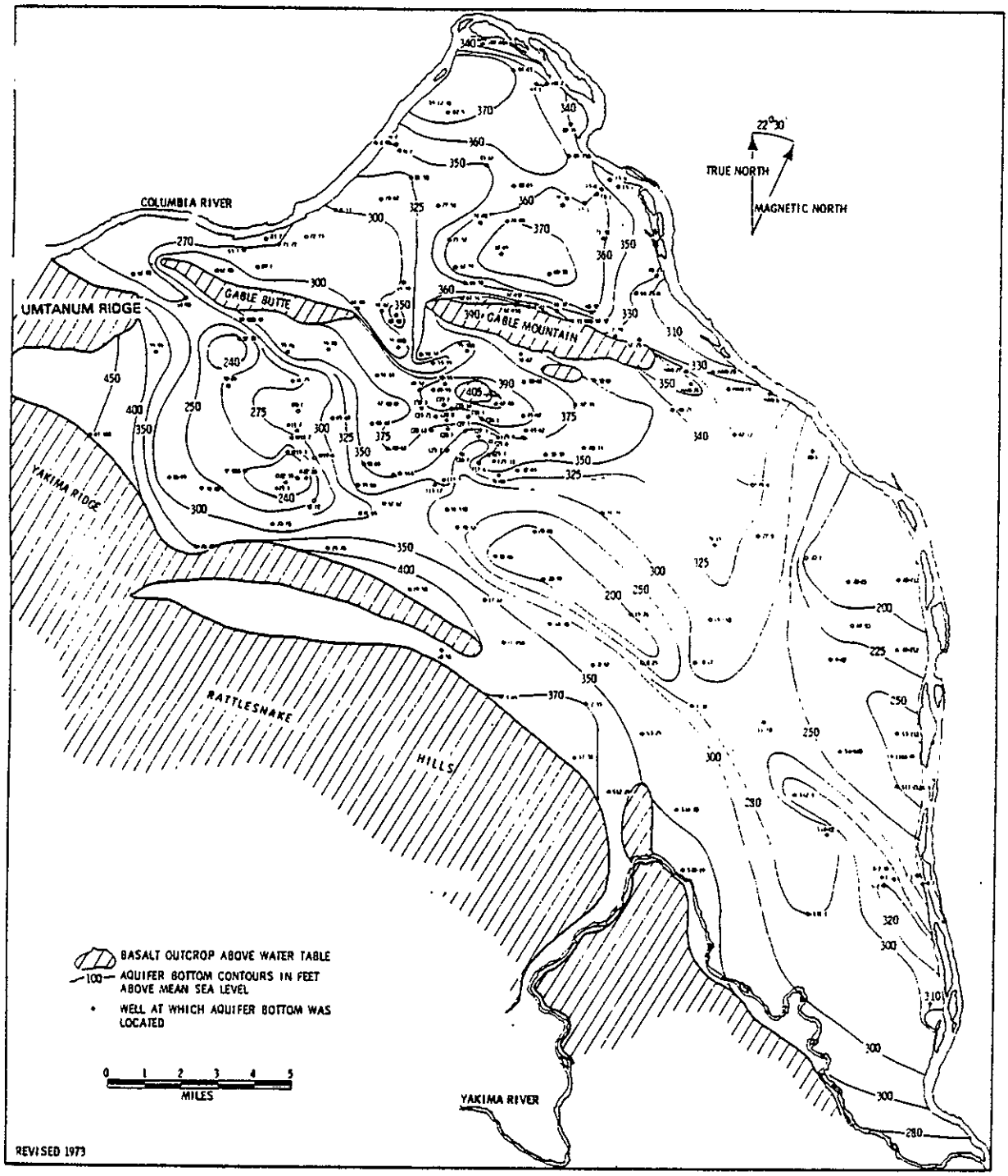

FIGURE II.3-16 HANFORD RESERVATION UNCONFINED AQUIFER BOTTOM MAP

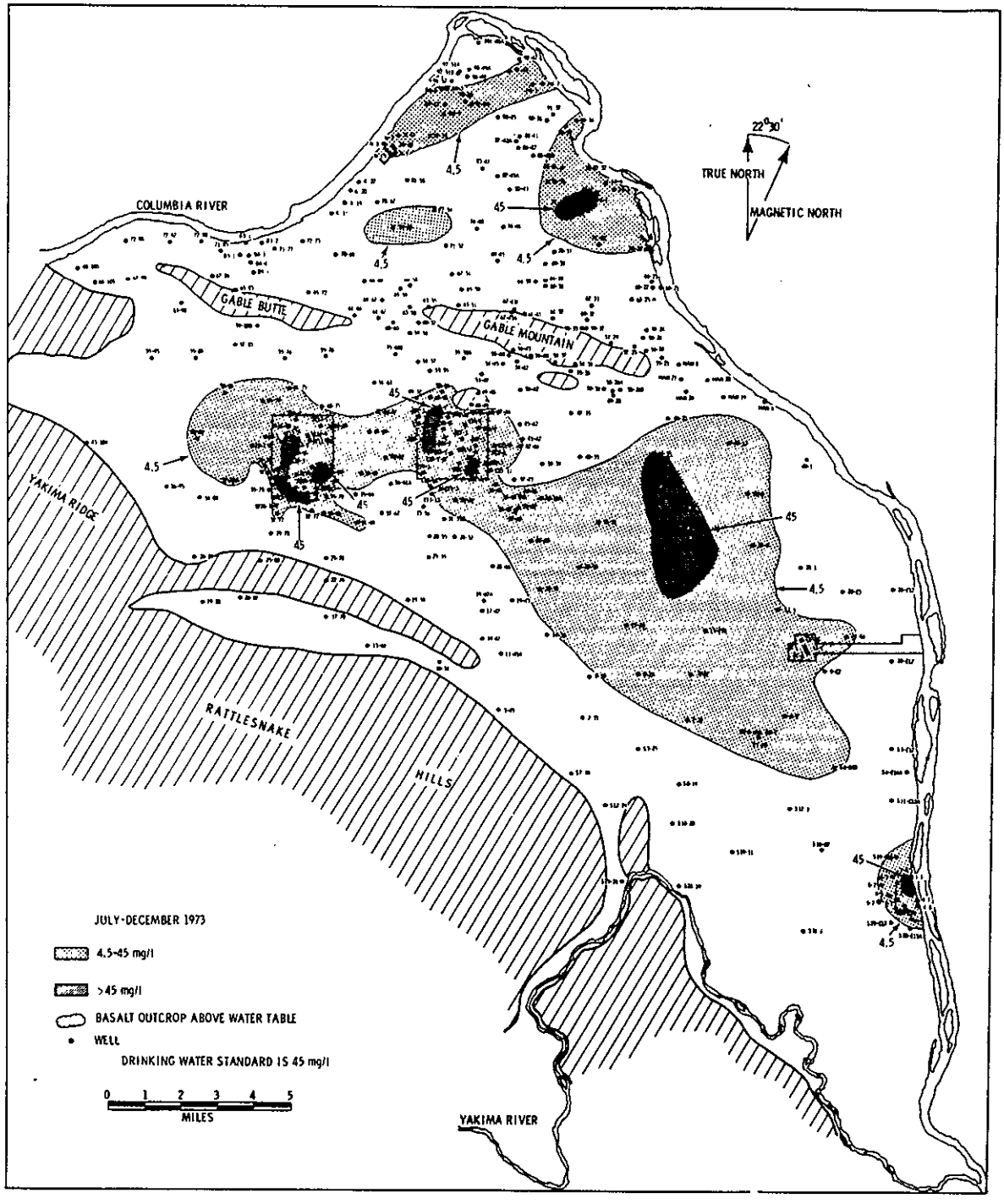

FIGURE II.3-17 AVERAGE NITRATE ION (NO_3) CONCENTRATIONS FOR 1973
(Drinking Water Standard: 45 mg/l)

9 1 1 1 8 9 1 0 3 7 7

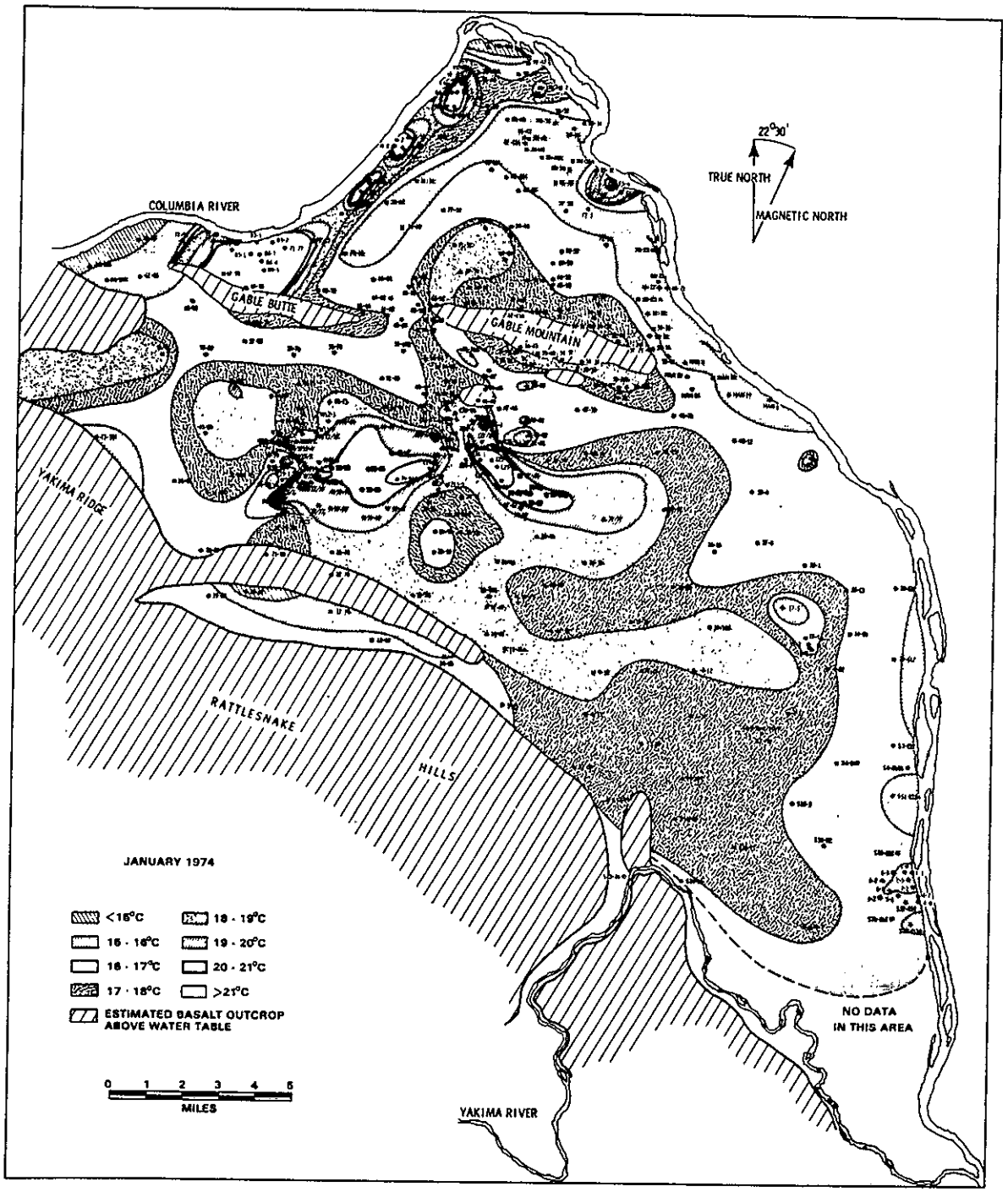

FIGURE II.3-18 GROUNDWATER TEMPERATURES AT THE SURFACE OF THE UNCONFINED AQUIFER

The radiological status of the groundwater near the top surface of the unconfined aquifer is monitored regularly and reported semiannually. The gross beta (ruthenium) plumes and the tritium plumes are shown in Figures II.3-19 and II.3-20 for 1973.[52] The major trends of the groundwater flow paths are illustrated by the contaminant plumes. Dispersion, radioactive decay, and sorption act to modify the convective transport of these tracers.

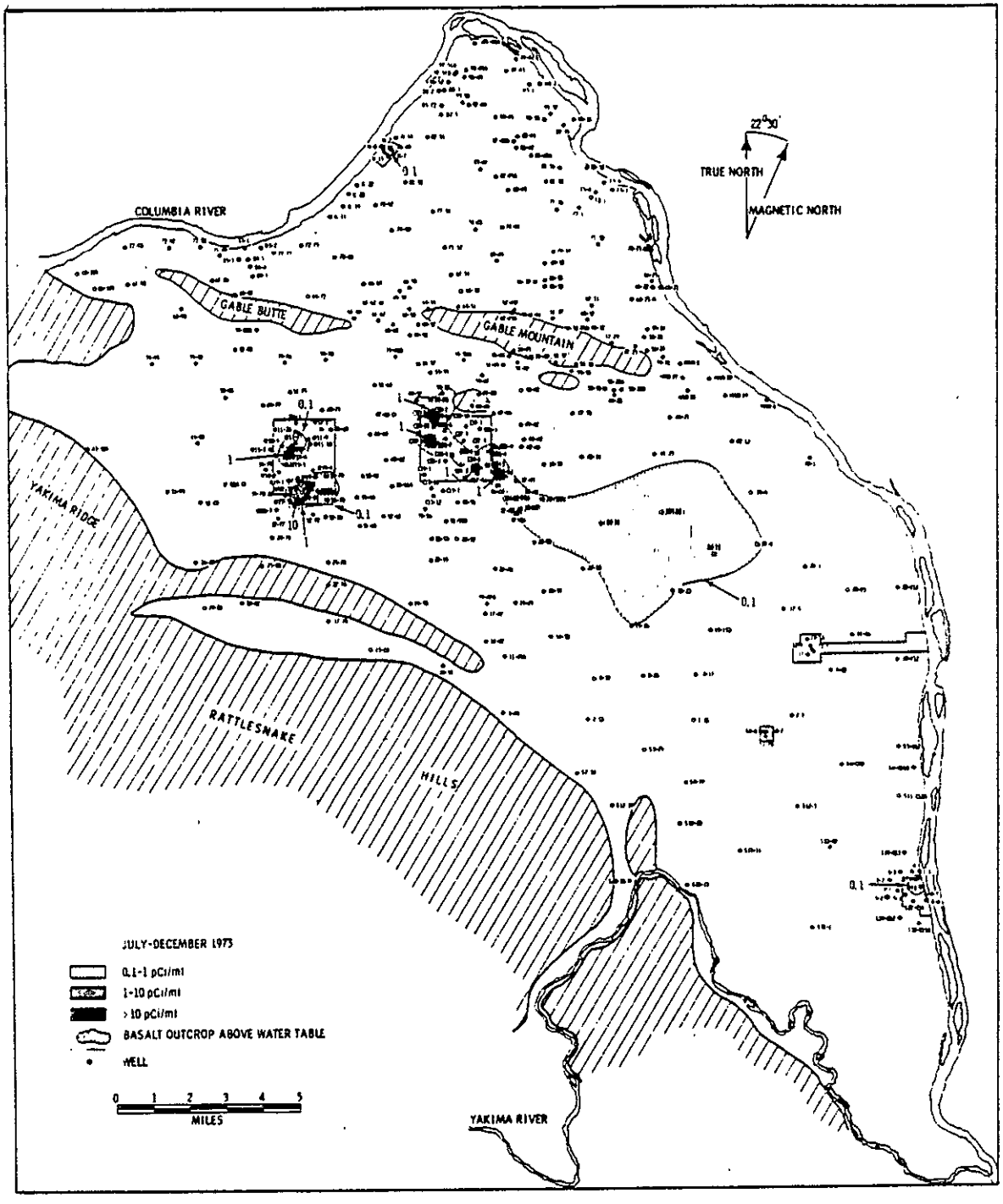

FIGURE II.3-19 AVERAGE GROSS BETA (As ^{106}Ru) CONCENTRATIONS FOR 1973 (Concentration Guide: 10 pCi/ml)

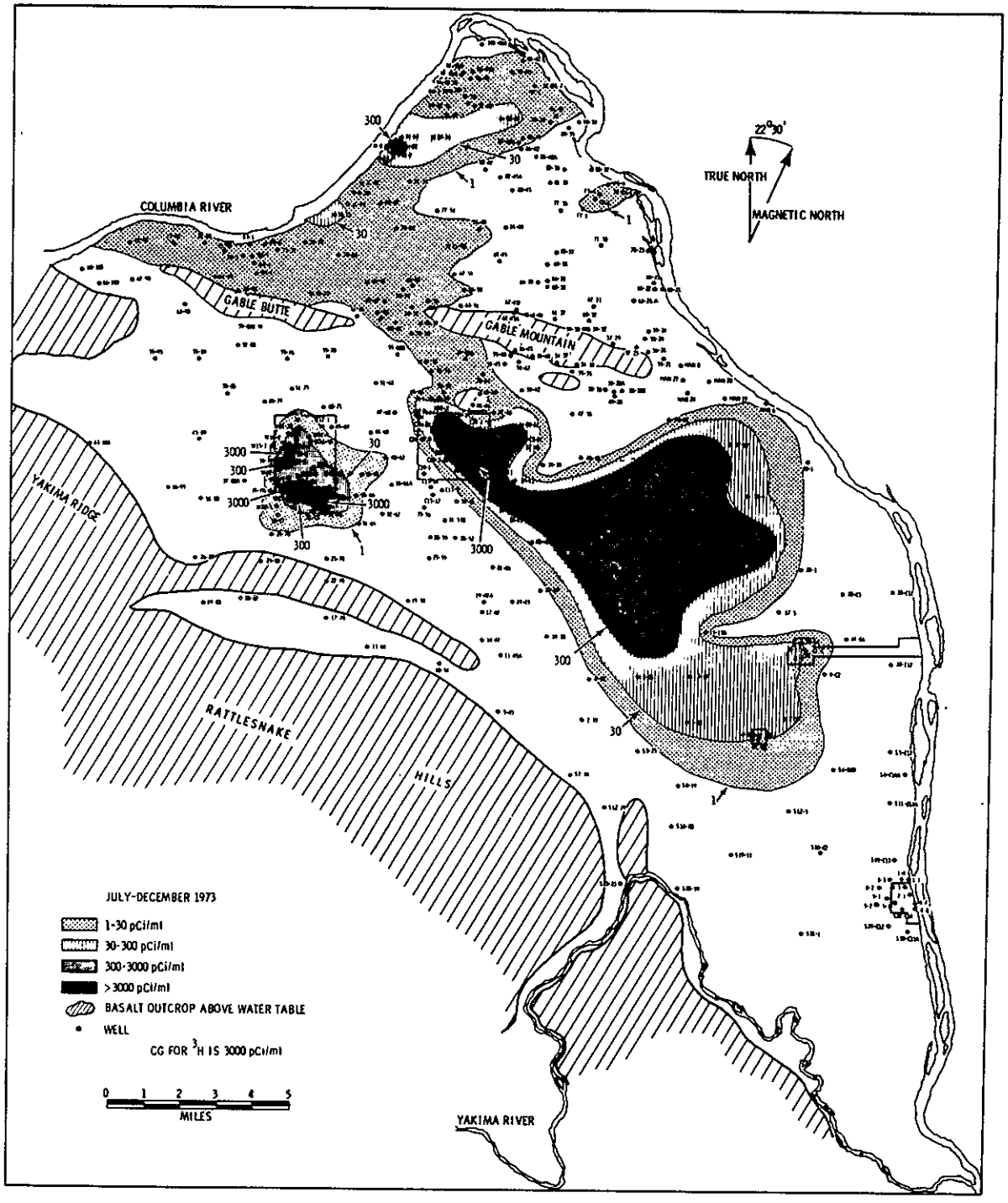

FIGURE II.3-20 AVERAGE TRITIUM (^{3}H) CONCENTRATIONS FOR 1973
(Concentration Guide: 3000 pCi/ml)

II.3.8.2.3 The Confined Aquifers [X.18]

A confined aquifer is one where the water-bearing stratum is overlain and underlain by relatively impermeable beds. Confined aquifers in the Hanford Reservation include 1) permeable sands and gravels in the lower part of the Ringold Formation overlain by thick silts and clays and 2) extensive basalt interbeds confined by individual basalt flows. The confining beds include sequences of individual basalt flows, where they are continuous and greater than about 50 feet thick, and the silts and clays of the lower part of the Ringold Formation. Within the basalt sequence, groundwater is transmitted primarily in the interflow zones, either in sedimentary beds or in the scoria and breccia zones forming the tops and bottoms of the flows.[54] Some of the basalt flows in the Pasco Basin have been eroded, particularly in the anticlinal ridges. In some locations, the basalts are highly jointed and contain breccia, pillow and palagonite complexes through which groundwater can move. The lower-most Ringold Formation silts and clays are of various thicknesses, and distinct hydraulic potential differences have been observed below the silts and clays. About 90 wells on the Hanford Reservation have been drilled to basalt. Most of these wells only barely penetrate the top basalt flows. Thus, data on the confined aquifers in the basalt flows are scarce and much more data must be gathered to fully characterize these aquifers. The piezometric surface of the confined bed between the lower Ringold clays and the top basalt flow is shown in Figure II.3-21 based on measurements made in 1970. In general, the hydraulic potential observed in the confined aquifer zones above the basalt is greater than in the overlying unconfined aquifer. The main exception is in the vicinity of the 200 Area recharge mounds which have raised the potential in the unconfined aquifer. Groundwater flow in this confined aquifer is also to the southeast with possible discharge into the Columbia River somewhere below Lake Wallula. However, the flow rates are expected to be quite small due to the low transmissivity range of this water-bearing zone.

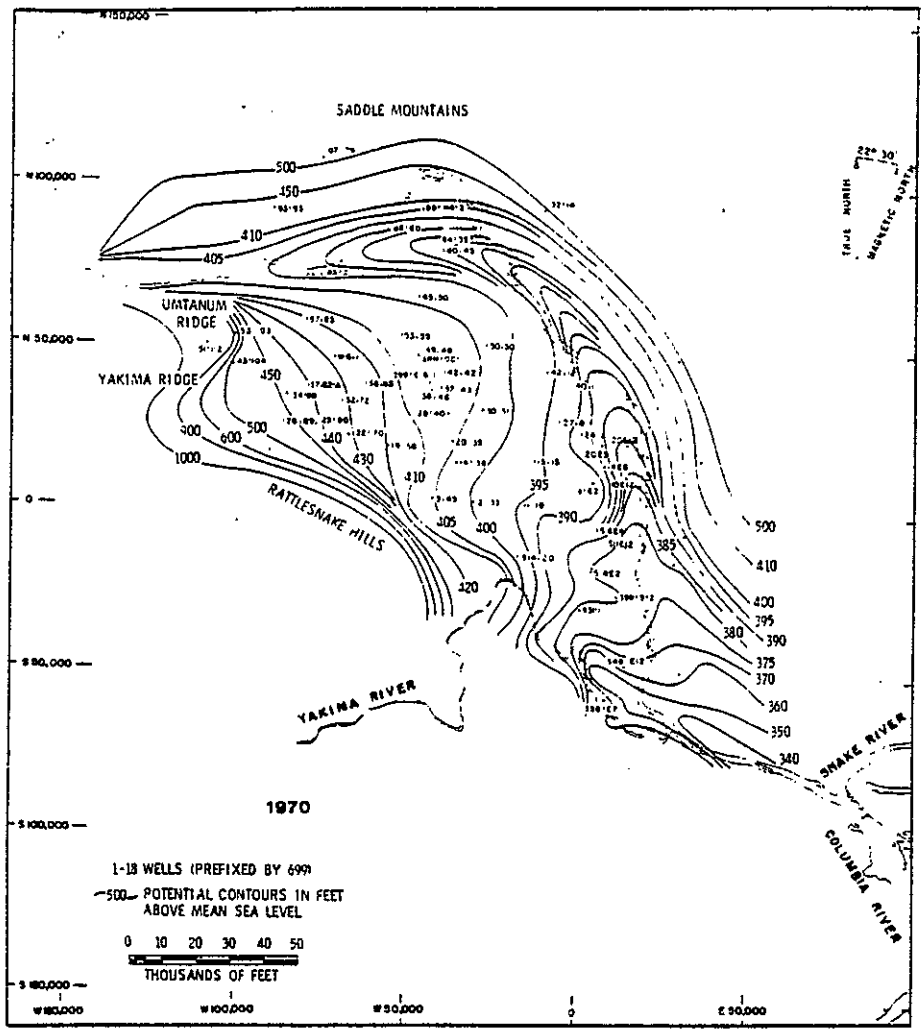

FIGURE II.3-21 PASCO BASIN UPPERMOST CONFINED AQUIFER POTENTIAL MAP - 1970

In 1970 and 1971, 23 wells penetrating the sands in the lower Ringold Formation and the first few basalt flows and interbeds were pump tested and transmissivity values calculated.[106] From these tests, values of transmissivity ranging between 2 and 8 ft^2/day were obtained for the confining beds and values between 50 and 2,000 ft^2/day for the permeable horizons. The hydraulic conductivity of the confining beds ranges between 0.02 and 0.2 ft/day and that of the aquifer, ranges between 2 and 30 ft/day.

Some data on the aquifer properties of the various confined aquifers are available from the ARHCO deep drilling project well ARH-DC-1.[107] This well was drilled to a depth of 5661 feet and is located near well 699-49-48 in Figure II.3-21. At this well the basalt from 362 to 1200 feet depth has a transmissivity of 695 ft^2/day. A sedimentary unit contained in this zone from 830 to 936 feet has a transmissivity of 355 ft^2/day. A dense basalt zone from 960 to 1090 feet depth has a transmissivity of 0.2 ft^2/day. There is one significant water-bearing zone, 10 feet thick, occurring at 3230 feet depth with a transmissivity of 68 ft^2/day.

Water-bearing sedimentary interbeds are centered at 500, 650, and 900 feet and range from 25 to 100 feet thick. The bed at 900 feet is about 100 feet thick consisting of well-sorted medium sand of moderate permeability. Its hydraulic conductivity is about 3.5 ft/day, making it the most productive aquifer penetrated by this well.

Data on the storage coefficients on the basalt aquifers are very inconclusive. All evidence so far suggests that the storage coefficient in these aquifers is approximately equal to the compressibility of water. This suggests that these aquifers behave as elastic bodies.[106]

Additional tests are needed to elucidate the characteristics of the confined aquifers and the possible interconnection between various flows. The interconnection between the uppermost confined aquifer and the unconfined aquifer must also be clearly established throughout the Reservation. The water quality and radiological status of the groundwater in the confined aquifer above the basalt have been measured with less detail and regularity than for the unconfined aquifer. The well sampler system is susceptible to cross-contamination and vertical flow between aquifers. Sample results are inconsistent. A program is being developed for improved sampling of this confined aquifer. The most extensive measurements have been for the tritium content. Table II.3-3 gives the results of the 1968-1970 measurements. Most values are below the routine tritium detection limit for water samples from the unconfined aquifer (500 to 700 pCi/ℓ). In addition to tritium, measurements for ^{129}I have recently been added to this program. Recent advancements in the capability to analyze ^{129}I at very low levels has made this possible.

TABLE II.3-3

TRITIUM IN HANFORD WELLS TAPPING THE CONFINED AQUIFER ABOVE THE BASALT

Well Number	Samples Results[a] (pCi tritium/liter)	Volume Pumped Prior to Sampling (gallons)	Well Number	Samples Results[a] (pCi tritium/liter)	Volume Pumped Prior to Sampling (gallons)
199-H4-2	600 ± 70	NM	699-14-E6-P	550 + 77	2,000
	730	95,000		610 - 35	NM
299-W11-2-P	3,900 + 320 - 640	500	699-14-38-P	640	NM
			699-15-15A	540	NM
699-S11-E12A	610 ± 29	Flowing Well			
			699-20-E12-P	<500	NM
699-2-33-P	<500	NM			
			699-20-E5-P	<500	NM
699-10-E12-P	<500	NM		<500	NM
	1,500 ± 56	1,600			
	<500	700	699-24-1-P	760	NM
	<500	700		<500	NM

(a) The Concentration Guide for public drinking water, as given in the ERDAM 0524 Appendix, Table 2, is 3×10^6 pCi/ℓ

NM - Not Measured
Detection limit 500 to 700 pCi/ℓ

In conclusion, a major barrier to investigation of the confined aquifers under the Hanford Reservation is a lack of suitable well structures that are capable of yielding reliable hydraulic potential measurements and representative confined groundwater samples. New and improved well structures are being built.

II.3.8.2.4 Aquifers North and East of the Columbia River

Very little data are available on the groundwater aquifers to the north and northeast of the Columbia River. The confined basalt aquifers underlie this area as well as the present Hanford Reservation. The unconfined aquifer exists only under the parts of the Wahluke Slope between the higher bluffs and the Columbia River. The Ringold Formation and glaciofluviatile sediments form this aquifer.

The Saddle Mountains form the northern boundary to the confined aquifers and are a potential recharge site from precipitation due to basalt flow outcropping. The Columbia River behind Priest Rapids Dam and Wanapum Dam and the Columbia Basin Irrigation Project are other probable recharge areas. The Columbia River forms the primary discharge boundary for the unconfined aquifer. Seasonal river-bank storage and discharge occur as on the Hanford side of the river.

The remaining sources of recharge to the unconfined aquifer are the irrigation wasteways and ponds that have been created. There are no observation wells monitored by ERDA to record the recharge effects of these ponds. The water table elevations in the unconfined aquifer near the Columbia River range from 370 to 405 feet MSL at the four available observation wells. The hydraulic potentials in the wells that penetrate the confined aquifers average about 50 feet higher. These wells are also perforated in several basalt aquifers precluding representative potential measurements.

The limited amount of information available indicates that the groundwater in the unconfined aquifer across the Columbia River moves toward the river and discharges into it. Some evidence indicates that groundwater in the confined aquifer may be flowing under the present riverbed to a trough of low potential. This flow, mixed with confined aquifer groundwater from under the Hanford Reservation, then moves downstream, with some discharge into the Columbia River through the unconfined aquifer, controlled by the hydraulic conductivity of the confining beds.

Water quality data for the groundwater across the Columbia River consist only of nitrate measurements for the confined aquifers. No nitrate concentrations above the routine detection limit (0.5 mg/ℓ) have been observed. Analyses for gross alpha, gross beta, and tritium have been made. The measurements of radionuclides in the confined aquifers have shown no detectable concentrations.

II.3.8.3 Hanford Hydrology Program Review [X.18]

In 1973 the AEC authorized an independent review (conducted between 1973 and 1975) of the groundwater management and environmental monitoring programs at the Hanford Reservation. Recommendations made by the consultants were used in preparing the preceding sections and are discussed in further detail in Appendix II.3-D. The consultants' recommendations have been considered in the development of new programs in the area of hydrology.[104,105,106,108,109]

II.3.9 Meteorology[a]

II.3.9.1 General Climate [RPB, X.18]

The Hanford climate is mild and dry, with occasional periods of high winds. Summers are generally hot and dry; winters are not as dry and are relatively mild for this latitude. Table II.3-4 contains a condensed summary of climatological observations at the HMS (Figure II.3-22), located between 200 East and 200 West Areas (Figure II.1-1). Both averages and extremes are included in this table. (Reference 57 contains this and much of the following data.)

The average maximum temperatures in July and January are 91.8°F and 36.7°F. The average minimum temperatures for the same months are 61.0°F and 22.1°F. The average relative humidity varies from a low of 31.8% in July to a high of 80.4% in December. The minimum diurnal temperature in winter seasons ranges from -27°F to 22°F, compared to diurnal maximum temperatures in summer seasons which vary from 100°F to 115°F.

(a) A more detailed description of the meteorology of the Hanford Reservation is given in Appendix II.3-E.

TABLE II.3-4

AVERAGES AND EXTREMES OF CLIMATIC ELEMENTS AT HANFORD
(Based on all Available Records to and Including the Year 1970)

	TEMPERATURE (°F) 1912-1970 AVERAGES							TEMPERATURE (°F) 1912-1970 EXTREMES								DEGREE DAYS (BASE 65°F) 1945-1970 TOTALS				
								DAILY MAXIMUM				DAILY MINIMUM								
	DAILY MAXIMUM	DAILY MINIMUM	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	RECORD HIGHEST	YEAR	RECORD LOWEST	YEAR	RECORD HIGHEST	YEAR	RECORD LOWEST	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR
Jan.	36.7	22.1	29.6	42.5	1953	12.1	1950	66	1968	-2	1950	51	1921	-23	1937+	1094	1640	1950	694	1953
Feb.	45.3	27.1	36.2	44.5	1958	21.8	1929	71	1924	3	1950	55	1932	-23	1950	778	1147	1956	576	1958
Mar.	56.5	33.8	45.2	49.8	1926	39.4	1955	83	1960	24	1960	54	1942	6	1955	642	794	1955	476	1947
Apr.	66.3	40.1	53.2	59.6	1934	47.5	1955	95	1934	41	1945	60	1956	12	1935	381	522	1955	266	1947
May	75.5	48.0	61.8	68.8	1947	56.6	1933	103	1936+	49	1918	70	1956	28	1954	153	255	1962	36	1947
June	83.2	55.5	69.4	75.4	1922	63.0	1953	110	1912	55	1966	83	1924	33	1933	34	90	1953	3	1958
July	91.8	61.0	76.4	83.8	1960	72.4	1963	115	1939	59	1966	82	1925	41	1935	3	22	1953	0	1970+
Aug.	89.2	59.2	74.2	81.5	1967	69.8	1964	113	1963	63	1920	81	1961	40	1918	5	32	1960	0	1970+
Sept.	79.6	50.8	65.2	71.7	1967	58.8	1926	102	1950	52	1934+	72	1955	25	1926	67	122	1970	13	1967
Oct.	65.3	40.8	53.1	59.0	1952	48.8	1930	90	1933	31	1935	60	1945+	6	1935	373	479	1946	200	1952
Nov.	48.6	31.5	40.0	46.0	1954+	31.3	1955	73	1934	14	1955	52	1959+	1	1955	746	1008	1955	567	1954
Dec.	39.2	26.0	32.6	42.0	1933	18.5	1919	68	1933	-3	1919	53	1933+	27	1919	991	1224	1964	822	1957
Year	64.8	41.4	53.1	81.8	July 1960	12.1	Jan 1950	115	1939	3	1950+	82	1925	27	1919	5267	1640	Jan 1950	0	Aug 1970+

	PRECIPITATION (INCHES) 1912-1970 TOTALS																	
								SNOW, ICE PELLETS (SLEET)										
	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MINIMUM MONTHLY	YEAR	MAX. IN 24 HOURS	YEAR	MEAN MONTHLY	MAXIMUM MONTHLY	YEAR	MAX. IN 24 HOURS	YEAR	MAXIMUM DEPTH	YEAR
Jan.	0.93	2.47	1970	0.13	1962+	1.08	1948	5.2	23.4	1950	7.1	1954	12.0	1969
Feb.	0.62	3.08	1940	T	1967+	1.24	1916	2.3	26.0	1916	5.2	1959	10.0	1969
Mar.	0.36	1.86	1957	0	1942+	0.59	1949	0.3	4.2	1951	2.2	1957+	2.3	1957
Apr.	0.40	1.22	1969	0	1933+	0.53	1951	T	T	1968+	T	1968+	0	----
May	0.45	1.71	1948	0	1931	0.55	1948+	T	T	1960	T	1960	0	---
June	0.57	2.92	1950	0	1919	1.50	1934	0	0		0		0	--
July	0.14	0.81	1966	0	1939+	0.73	1914	0	0	-	0	-	0	---
Aug.	0.19	1.18	1920	0	1955+	0.57	1947	0	0	--	0		0	--
Sept.	0.30	1.34	1947	T	1961+	0.82	1947	0	0	-	0		0	---
Oct.	0.58	2.72	1957	0	1917+	1.91	1957	T	0.3	1957	0.3	1957	0.3	1957
Nov.	0.85	3.05	1926	T	1939+	0.78	1966	1.2	12.7	1955	4.8	1955	5.1	1946
Dec.	0.86	2.53	1931	0.11	1946	1.00	1958	3.7	13.4	1955	5.4	1965	12.1	1964
Year	6.25	3.08	Feb 1940	0	Aug 1955+	1.91	Oct 1957	12.7	26.0	Feb 1916	7.1	Jan. 1954	12.1	Dec 1964

	WIND (mph) 1945-1970 AVERAGES						PEAK GUST			RELATIVE HUMIDITY (%) 1946-1970 AVERAGES					RELATIVE HUMIDITY (%) 1946-1970 EXTREMES			
	PREVAILING DIRECTION	MEAN MONTHLY SPEED	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	SPEED	DIRECTION	YEAR	MEAN	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST	YEAR	LOWEST	YEAR
Jan.	NW	6.3	9.6	1953	3.1	1955	65	S	1967	75.7	88.8	1960	60.0	1963	100	1970+	13	1963
Feb.	NW	7.0	9.4	1963	4.6	1963	63	SW	1965	69.9	86.9	1963	54.0	1967	100	1970+	14	1962
Mar.	WNW	8.4	10.7	1964	5.9	1958	70	SW	1956	55.8	65.9	1950	44.0	1965	100	1970+	12	1965+
Apr.	WNW	9.0	11.1	1959	7.4	1958	60	WSW	1969	46.7	64.5	1963	36.9	1966	100	1963+	9	1954
May	WNW	8.8	10.5	1965+	5.8	1957	71	SSW	1948	42.2	62.4	1948	31.2	1966	100	1949+	7	1953
June	WNW	9.2	10.7	1949	7.7	1950+	72	SW	1957	39.6	53.5	1950	30.0	1949	100	1967+	10	1964+
July	WNW	8.6	9.6	1963	6.8	1955	55	WSW	1968	31.8	40.5	1955	21.9	1959	97	1963	6	1951
Aug.	WNW	8.0	9.1	1946	6.0	1956	66	SW	1961	34.8	43.8	1968	24.5	1967	100	1959	7	1951
Sept.	WNW	7.5	9.2	1963	5.4	1957	65	SSW	1953	40.6	55.1	1959	33.9	1952	100	1962+	10	1962+
Oct.	WNW	6.7	9.1	1946	4.4	1952	63	SSW	1950	57.8	74.2	1962	42.5	1952	100	1969+	10	1952
Nov.	NW	6.2	7.9	1945	2.9	1956	64	SSW	1949	72.9	80.5	1956	64.1	1959	100	1970+	16	1959
Dec.	NW	6.0	8.3	1968	3.9	1963+	71	SW	1955	80.4	89.9	1963	69.0	1968	100	1970+	28	1968+
Year	WNW	7.6	11.1	Apr 1959	2.9	Nov 1956	72	SW	June 1957	54.0	89.9	Dec 1963	21.9	July 1959	100	Dec 1970+	6	July 1951

	SKY COVER (SCALE 0-10) 1946-1970 AVERAGES (SUNRISE TO SUNSET)					SOLAR RADIATION (LANGLEYS) (a) 1953-1970 AVG DAILY TOTALS					SOLAR RADIATION (LANGLEYS) (a) 1953-1970 EXTREME DAILY TOTALS			
	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	MONTHLY	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR	HIGHEST MONTHLY	YEAR	LOWEST MONTHLY	YEAR
Jan.	7.8	9.0	1969	4.3	1949	118	135	1962	88	1955	277	1969	16	1970
Feb.	7.4	8.9	1963	5.9	1964	200	236	1960	164	1954	422	1958	37	1970+
Mar.	6.7	7.9	1950	4.9	1965	340	388	1965	305	1961	542	1968	71	1963
Apr.	6.4	8.1	1963	3.7	1951	470	526	1959+	374	1963	691	1958	115	1970
May	5.8	7.7	1960	4.5	1949	571	634	1970	511	1962	782	1959	67	1962
June	5.2	7.0	1950	2.8	1961	626	698	1960	563	1953	809	1957	112	1965
July	2.7	4.5	1955	0.9	1953	659	700	1969+	588	1955	769	1969	150	1955
Aug.	3.3	5.9	1968	0.6	1955	551	613	1955	475	1968	721	1957	107	1959
Sept.	4.1	6.1	1959	2.5	1950	418	457	1961	354	1959	591	1970	61	1957
Oct.	5.9	7.7	1950	3.9	1952	262	299	1958	227	1956	428	1958	38	1962
Nov.	7.5	9.0	1965	6.2	1957	135	180	1957	97	1964	283	1957	14	1969
Dec.	8.1	9.2	1962	6.8	1954	91	116	1970	57	1969	185	1960	14	1969+
Year	5.9	9.2	Dec 1962	0.6	Aug 1955	370	700	July 1969+	57	Dec 1969	809	June 1957	14	Dec 1969+

EXTREME AVERAGES OR TOTALS AND YEAR OR SEASON OF OCCURENCE

1912-1970 TEMPERATURE AVERAGES (°F)		
HIGHEST ANNUAL	56.2	1958+
LOWEST ANNUAL	50.2	1929
HIGHEST WINTER (D-J-F)	41.1	1933-34
LOWEST WINTER	24.2	1948-49
HIGHEST SPRING (M-A-M)	58.2	1947
LOWEST SPRING	48.0	1955
HIGHEST SUMMER (J-J-A)	78.2	1958
LOWEST SUMMER	70.3	1954
HIGHEST FALL (S-O-N)	56.6	1963
LOWEST FALL	49.6	1946
1912-1970 PRECIPITATION TOTALS (IN.)		
GREATEST ANNUAL	11.45	1950
LEAST ANNUAL	3.26	1967
SNOW, ICE PELLETS (SLEET)		
GREATEST SEASONAL	43.6	1915-16
LEAST SEASONAL	0.3	1957-58
1945-1970 WIND SPEED AVERAGE (mph)		
HIGHEST ANNUAL	8.3	1968+
LOWEST ANNUAL	6.3	1957
1946-1970 RELATIVE HUMIDITY AVERAGE (%)		
HIGHEST ANNUAL	57.9	1950+
LOWEST ANNUAL	49.4	1967
1946-1970 SKY COVER AVERAGES (SUNRISE TO SUNSET, SCALE 0-10)		
HIGHEST ANNUAL	6.4	1966
LOWEST ANNUAL	5.1	1949
1953-1970 SOLAR RADIATION AVERAGE DAILY TOTAL (LANGLEYS)		
HIGHEST ANNUAL	385	1957
LOWEST ANNUAL	357	1967

TABLE II.3-4 (Continued)

NUMBER OF DAYS (1945-1970) (b)

	CLEAR					PTLY CLDY	CLOUDY					THUNDERSTORMS					HEAVY FOG (VIS 1/4 MI OR LESS)					PRECIP 0.10 INCH OR MORE					SNOW 1.0 IN. OR MORE				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan.	4	13	1949	0	1955+	7	20	27	1969+	6	1949	0	0		0		6	34	1965	0	1949	3	8	1970	0	1962+	2	10	1950	0	1967+
Feb.	5	9	1968+	1	1969+	6	17	26	1958	10	1951+	0	1	1962	0	1970+	3	11	1963	0	1967+	2	5	1961+	0	1967+	1	4	1959+	0	1970+
Mar.	7	12	1965+	2	1963+	9	15	22	1968	7	1948	0	1	1969+	0	1970+	1	5	1951	0	1968+	2	8	1957	0	1968+	0	2	1957+	0	1970+
Apr.	7	18	1955	1	1963	11	12	21	1963	3	1949	1	3	1948	0	1970+	0	1	1950	0	1970+	2	5	1948	0	1968+	0	0		0	-
May	8	14	1953	2	1960	12	11	19	1960	3	1949	2	7	1956	0	1965+	0	1	1958+	0	1970+	2	4	1967+	0	1968+	0	0		0	
June	11	21	1961	3	1966	10	9	15	1957	0	1949	3	8	1948	0	1963+	0	0		0		2	6	1950	0	1962+	0	0		0	
July	21	27	1953	14	1955	7	3	8	1955	0	1967+	2	5	1958+	0	1969+	0	0		0		1	3	1955	0	1970+	0	0		0	
Aug.	19	30	1955	11	1968	8	4	13	1968	0	1969+	2	8	1953	0	1969+	0	1	1959	0	1970+	1	3	1953	0	1970+	0	0		0	-
Sept.	15	21	1967	0	1969	8	7	13	1969	2	1952+	1	4	1959	0	1970+	0	1	1957	0	1970+	1	5	1959	0	1970+	0	0		0	-
Oct.	10	16	1953	3	1958+	9	12	18	1956+	3	1946	0	1	1968+	0	1970+	1	6	1962	0	1970+	2	8	1950	0	1969+	0	0		0	-
Nov.	5	10	1957	1	1965+	6	19	24	1965+	12	1948	0	0	-	0		5	13	1965	0	1960	3	7	1966+	0	1967	0	6	1955	0	1970+
Dec.	3	7	1954	0	1947	7	21	28	1962	14	1946	0	0	--	0	-	0	17	1950	2	1968+	3	9	1964	0	1949+	2	6	1964	0	1966+
			Aug		Jan.				Dec.		Aug			Aug					Dec					Dec.		Sept			Jan		
Year	115	30	1955	0	1955+	100	150	28	1962	0	1969+	11	0	1953+	0	---	24	37	1950	0		24	9	1964	0	1970+	5	10	1950	0	

NUMBER OF DAYS (1945-1970)

	3" OR MORE SNOW ON GRD.					PEAK GUST 40 MPH OR GREATER				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan.	5	23	1969	0	1967+	3	9	1953	0	1957+
Feb.	3	16	1950	0	1970+	2	6	1961+	0	1970+
Mar.	0	0	----	0	----	3	9	1956	1	1965+
Apr.	0	0	----	0	----	3	6	1959	0	1967+
May	0	0	----	0	----	2	6	1951	0	1963+
June	0	0	----	0	----	2	4	1970+	0	1967+
July	0	0	----	0	----	1	4	1962+	0	1969+
Aug.	0	0	----	0	----	1	5	1951	0	1970+
Sept.	0	0	----	0	----	2	4	1951	0	1970+
Oct.	0	0	----	0	----	2	8	1967	0	1957+
Nov.	1	18	1955	0	1970+	2	5	1961+	0	1969+
Dec.	2	14	1955	0	1969+	3	8	1957+	0	1969+
			Jan.					Jan.		
Year	11	23	1969	0	----	26	9	1953	0	----

NUMBER OF DAYS (1912-1970)

	MAX TEMP. 90 OR ABOVE					MAX TEMP 100 OR ABOVE					MAX. TEMP. 32 OR BELOW					MIN TEMP 32 OR BELOW					MIN TEMP 0 OR BELOW				
	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR	MEAN MONTHLY	GREATEST MONTHLY	YEAR	LEAST MONTHLY	YEAR
Jan.	0	0	----	0	---	0	0	--	0	----	11	29	1937	0	1967+	28	31	1960+	9	1953	2	14	1950	0	1970+
Feb.	0	0	----	0	----	0	0	---	0	---	3	19	1936	0	1970+	22	28	1944+	5	1958	1	9	1929	0	1970+
Mar.	0	0	----	0	----	0	0	---	0	----	0	2	1960	0	1970+	16	25	1944+	6	1968+	0	0	---	0	--
Apr.	0	4	1926	0	1970+	0	0	----	0	----	0	0	---	0	--	5	15	1935	0	1962+	0	0	--	0	----
May	3	11	1924	0	1965+	0	1	1966+	0	1970+	0	0	--	0		0	3	1938	0	1969+	0	0	----	0	----
June	9	20	1940+	0	1953	2	9	1970	0	1968+	0	0	--	0	---	0	0	----	0	---	0	0	----	0	----
July	21	29	1943	8	1963	7	16	1960+	0	1963+	0	0	--	0		0	0		0	---	0	0	---	0	----
Aug.	18	29	1915	7	1948	4	16	1942	0	1964+	0	0	---	0	---	0	0	-	0	---	0	0	---	0	----
Sept.	5	16	1938	0	1970+	0	2	1955+	0	1970+	0	0	---	0	----	0	4	1933+	0	1970+	0	0	----	0	----
Oct.	0	1	1933	0	1970+	0	0	---	0	----	0	2	1935	0	1970+	5	12	1916	0	1962+	0	0	----	0	----
Nov.	0	0	----	0	-	0	0	----	0	---	2	15	1955	0	1968+	17	30	1936	4	1949	0	1	1955+	0	1970+
Dec.	0	0	----	0	----	0	0	----	0	-	0	19	1914	2	1966+	26	31	1963+	14	1933	1	14	1919	0	1970+
			July					July					Jan					Dec					Jan.		
Year	56	29	1941+	0	---	13	16	1960+	0	-	24	29	1937	0	-	119	31	1963+	0	----	4	14	1950+	0	----

NUMBER OF DAYS

CLEAR (0-3 TENTHS SKY COVER, SR TO SS+)

GREATEST ANNUAL (1946-70)	143	1951
LEAST ANNUAL (1946-70)	85	1966

CLOUDY (8-10 TENTHS SKY COVER, SR TO SS)

GREATEST ANNUAL (1946-70)	183	1969+
LEAST ANNUAL (1946-70)	84	1949

THUNDERSTORMS

GREATEST ANNUAL (1945-70)	23	1948
LEAST ANNUAL (1945-70)	3	1949

HEAVY FOG (VIS 1/4 MILE OR LESS)

GREATEST SEASONAL (1945-70)	42	1950-51
LEAST SEASONAL (1945-70)	9	1948-49

PRECIPITATION 0.10 INCH OR MORE

GREATEST ANNUAL (1946-70)	39	1950
LEAST ANNUAL (1946-70)	10	1965

SNOW 1.0 INCH OR MORE

GREATEST SEASONAL (1946-70)	15	1955-56
LEAST SEASONAL (1946-70)	0	1957-58

3 IN. OR MORE SNOW ON GROUND

GREATEST SEASONAL (1946-70)	40	1964-65
LEAST SEASONAL (1946-70)	0	1960-61+

PEAK GUST 40 MPH OR GREATER

GREATEST ANNUAL (1945-70)	41	1961
LEAST ANNUAL (1945-70)	13	1958

MAX. TEMPERATURE 90 OR ABOVE

GREATEST ANNUAL (1912-70)	65	1960+
LEAST ANNUAL (1912-70)	37	1954

MAX TEMPERATURE 100 OR ABOVE

GREATEST ANNUAL (1912-70)	32	1942
LEAST ANNUAL (1912-70)	1	1954

MAX TEMPERATURE 32 OR BELOW

GREATEST SEASONAL (1912-70)	53	1955-56
LEAST SEASONAL (1912-70)	1	1937-38

MIN TEMPERATURE 32 OR BELOW

GREATEST SEASONAL (1912-70)	141	1916-17
LEAST SEASONAL (1912-70)	75	1957-58

MIN. TEMPERATURE 0 OR BELOW

GREATEST SEASONAL (1912-70)	18	1949-50
LEAST SEASONAL (1912-70)	0	1969-70+

REFERENCE NOTES

(a) CALORIES/cm^2

(b) SKY COVER AND PRECIPITATION OBSERVATIONS NOT BEGUN UNTIL 1946

0 LESS THAN 1/2

+ ALSO ON EARLIER YEARS

LOCATION AND HISTORY

PRESENT LOCATION 25 MILES NW OF RICHLAND, WASHINGTON

LATITUDE 46°34' N. LONGITUDE 119°36' W ELEVATION 733 FEET

OBSERVATIONS FROM 1912 TO 1944 WERE BY UNITED STATES WEATHER BUREAU COOPERATIVE OBSERVERS AT A SITE ABOUT 10 MILES ENE OF PRESENT LOCATION. SINCE 1944 OBSERVATIONS HAVE BEEN MAINTAINED ON A 24 HOUR-A-DAY BASIS BY THREE DIFFERENT CONTRACTORS

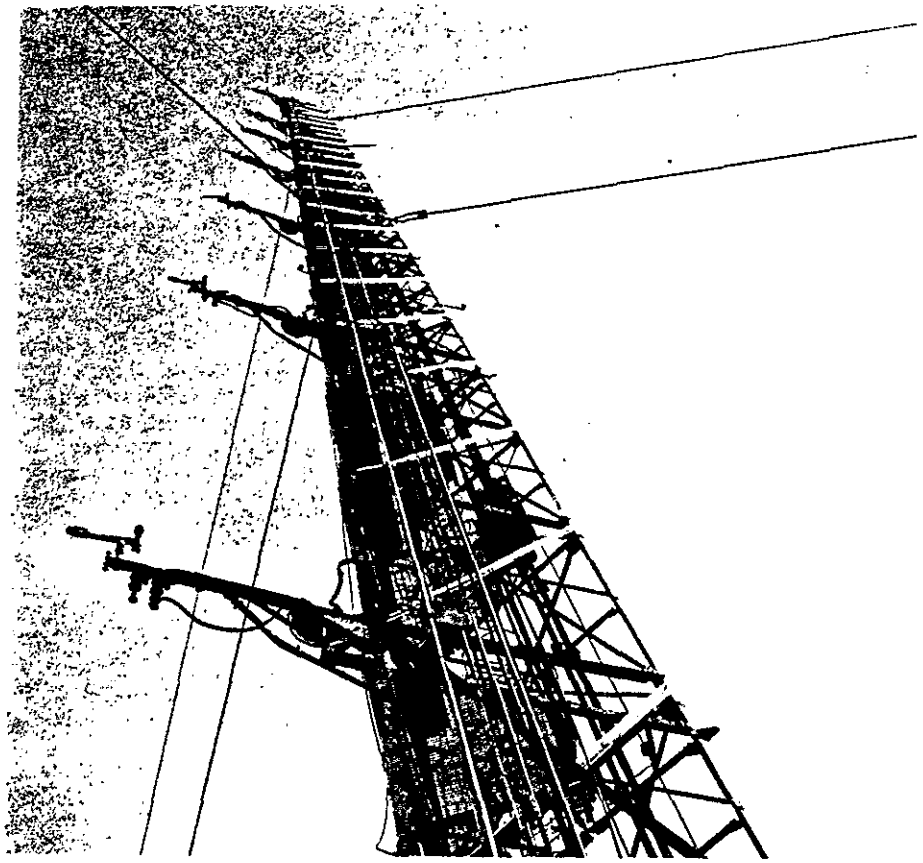

FIGURE II.3-22 410-FOOT TOWER AT THE HANFORD METEOROLOGICAL STATION

Average annual precipitation is 6.25 inches. November, December, and January contribute 42% of the total, whereas July, August, and September contribute only 10%. A slight secondary maximum in precipitation occurs in early summer. About 45% of all precipitation during the months of December through February is in the form of snow. A four to fivefold increase in annual rainfall for many years would be required to slowly move the 200 Area crib waste. The maximum expected rainfall over the next 1000 years is about 18 inches (a threefold increase for one year).

Mean monthly wind speeds range from about 9 mph in the summer to 6 mph in the winter. July hourly average wind speeds vary from a low of about 5 mph in midmorning to a high of 13 mph in the late evening. The corresponding speeds in January have the same trend, but have less than a 1 mph difference. The prevailing wind directions at the HMS are from the NNW through NW. The strongest winds tend to be from the SW. The highest observed peak wind gust at HMS was 72 mph from the SW. Winds with a peak gust of 40 mph or greater have been observed on the average of at least once in every month of the year, although the winter months tend to have a higher frequency of high wind periods.

The preceding description of climatology based on the observations at the HMS can be taken as representative of the Hanford site, although some local variations in climate may be expected as a result of the size of the site coupled with local topographical effects. No apparent climatological temperature differences exist among the low-level sites, although observations show that simultaneous differences up to 10°F and 15°F can occur. In studies on the slopes of the ALE Reserve on the northeastern slope of the Hanford site, average variations in temperature with change in elevation were found to closely follow the adiabatic lapse rate. This pattern is modified at higher elevations near the crest of the Rattlesnake Hills where the isotherms of minimum temperatures indicate a well-defined nocturnal temperature inversion reaching to 600 to 1000 feet above the valley floor. The inversion varies with season, intensifying in the spring and fall and diminishing in the winter and summer.

Tornadoes are relatively rare in this region and tend to be small, with little damage when they do occur. A single small tornado was observed onsite during 29 years of observation. No damage

from this tornado was reported. Fourteen tornadoes have been confirmed within 100 miles of the Hanford site between 1916 and the present. Data has been analyzed to determine the probability of a tornado hitting a particular facility onsite.[58,59] During any year, it was estimated that the probability is six chances in a million.

II.3.9.2 Diffusion Climatology

Drainage winds play an important role in local air circulation. The Cascade Mountains to the west of the Reservation exert considerable influence on the winds by serving as a source of cold air drainage. Differences in surface winds on the site can usually be attributed to differences in air flow associated with local topographical features (such as Rattlesnake Mountain and Wahluke Slope).

Joint wind speed, direction, and stability data are available from two locations onsite. The longest periods of data are from the HMS tower, in continuous operation since the mid-forties. Wind roses for each stability and for all stabilities combined, based on 15 years of HMS data, are given in Figure II.3-23. Included in these are groupings of the persistences by wind speeds for each direction. Figure II.3-24 presents wind rose summaries based on one year of data from the meteorology tower at the N Reactor site. These two locations cover the winds in the northern and central sections of the Hanford site. The definition of stability used in Figures II.3-23 and II.3-24, as well as in the Hanford diffusion model, is given in Table II.3-5.

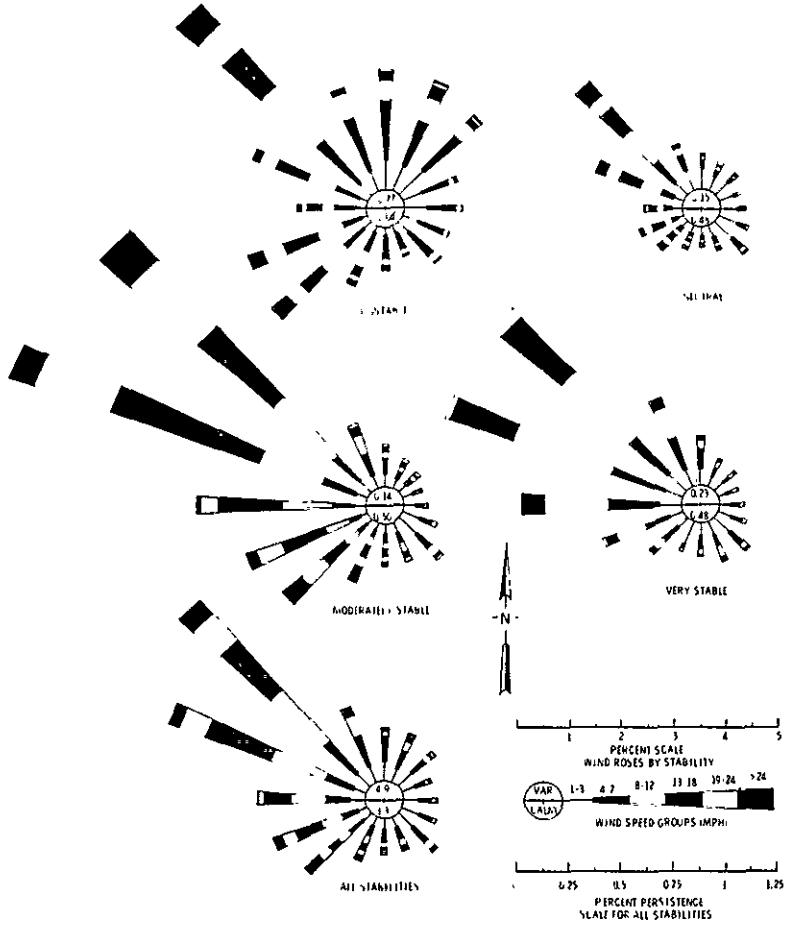

FIGURE II.3-23 WIND ROSES AS A FUNCTION OF STABILITY AND WIND SPEED AT HMS BASED ON WINDS AT 200 FT AND AIR TEMPERATURE STABILITY DEFINED BETWEEN 3 FT AND 200 FT FOR 1955 THROUGH 1970 (The points of the rose represent the directions from which the winds come.)

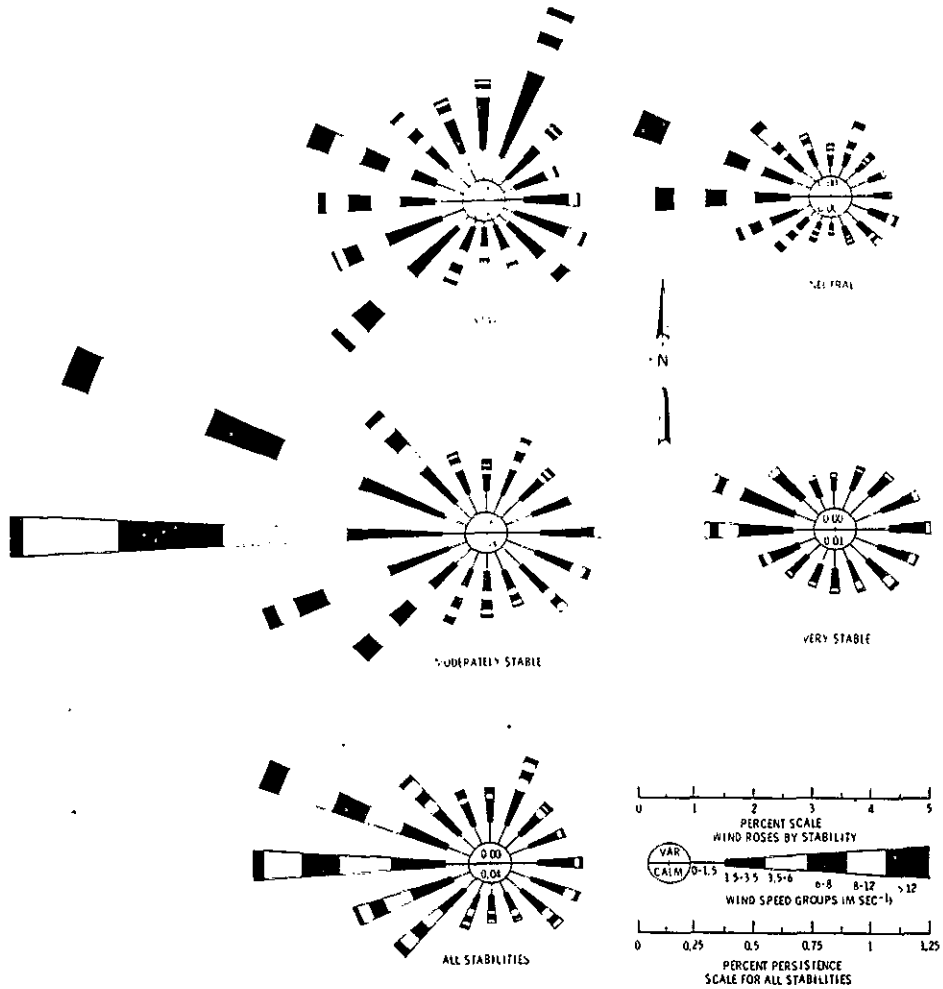

FIGURE II.3-24 WIND ROSES AS A FUNCTION OF STABILITY AT 100-N AREA BASED ON WINDS AT 200 FT AND AIR TEMPERATURES BETWEEN 3 FT AND 200 FT FOR JANUARY 29, 1970 TO JANUARY 28, 1971 (The points of each rose represent the directions from which the winds come.)

TABLE II.3.5

HANFORD ATMOSPHERIC DISPERSION MODEL
DEFINITION OF STABILITIES

Class	ΔT/200 ft in °F
Very Stable	≥ 3.5
Moderately Stable	-0.4 to 3.4
Neutral	-1.4 to -0.5
Unstable	≤ -1.5

Toward the southeastern section of the Hanford site, 16-point surface wind data summaries are available for the FFTF site and WNP-2 site. Annual wind roses for these sites are given in Figures II.3-25 and II.3-26. A tendency to greater north-south flow on this section of the Hanford site is evident.

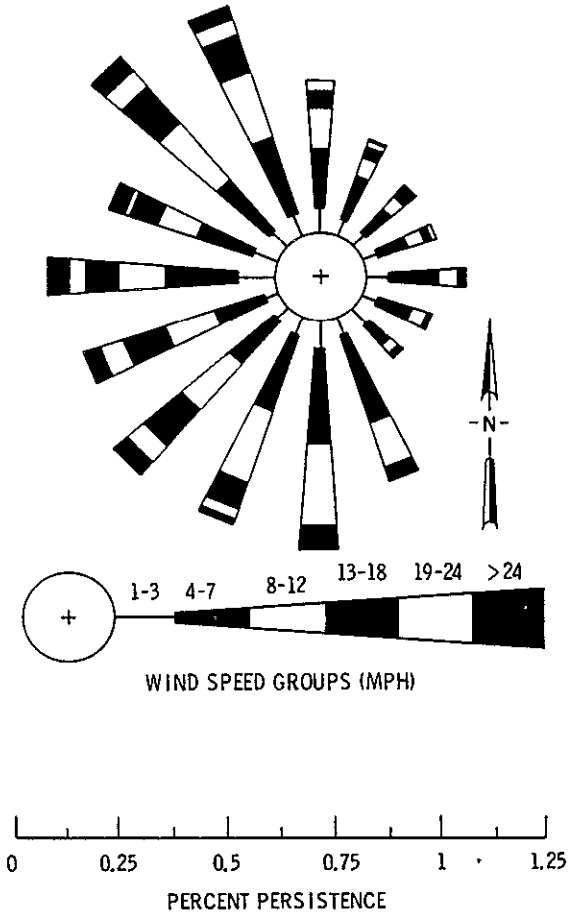

FIGURE II.3-25 WIND ROSE FOR THE FFTF SITE (At 13 ft, January 1, 1971 through July 1, 1973.)

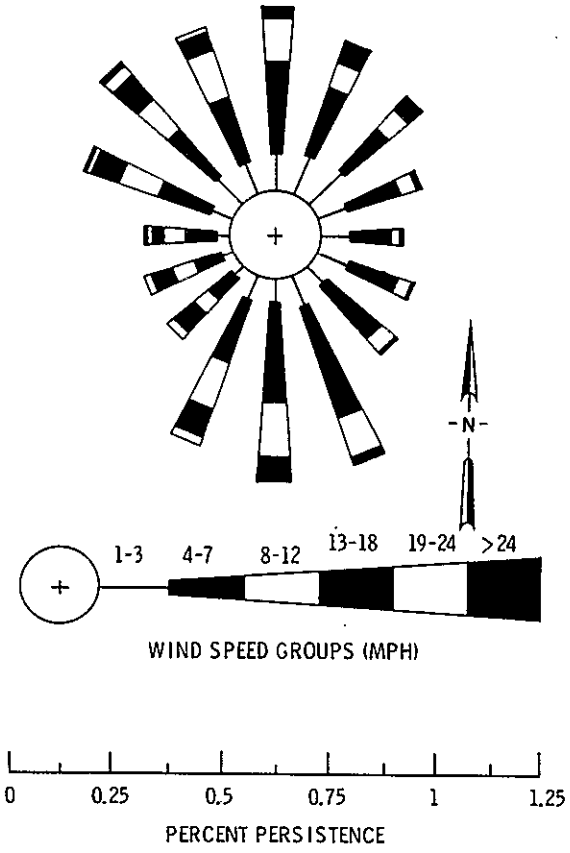

FIGURE II.3-26 WIND ROSE FOR THE WNP-2 SITE (At 23 ft, April 1972 through March 1973.)

Surface wind rose data based on an 8-point compass were compiled from a telemetered network of meteorology stations. A summary of these wind roses plotted on a map of the Hanford site is given in Figure II.3-27. These sensors were placed in locations to define local topographical effects on surface winds as well as to define the general surface flow of winds. A comparison of the telemetered data from the 300 Area with the FFTF data revealed only minor differences in the annual summaries. This suggests that the more detailed FFTF data may reasonably be considered representative of the 300 Area.

High-level winds over the site have been studied. Ground released balloon (Pibal) observations from the HMS show that at higher levels, winds tend to exhibit stronger westerly components than are observed in the surface wind observations.

II.3.10 Aquatic Ecology[a]

II.3.10.1 The Columbia River

The basic physical and chemical characteristics of the Columbia River were presented in previous sections of this report. References 60, 61 and 62 present additional data as well as the three most comprehensive evaluations of the ecological characteristics of the river, mainly in the Hanford to McNary Dam section.

(a) A more detailed description of the aquatic ecology of the Hanford Reservation is given in Appendix II.3-F.

9 1 1 1 8 6 0 1 3 0 9

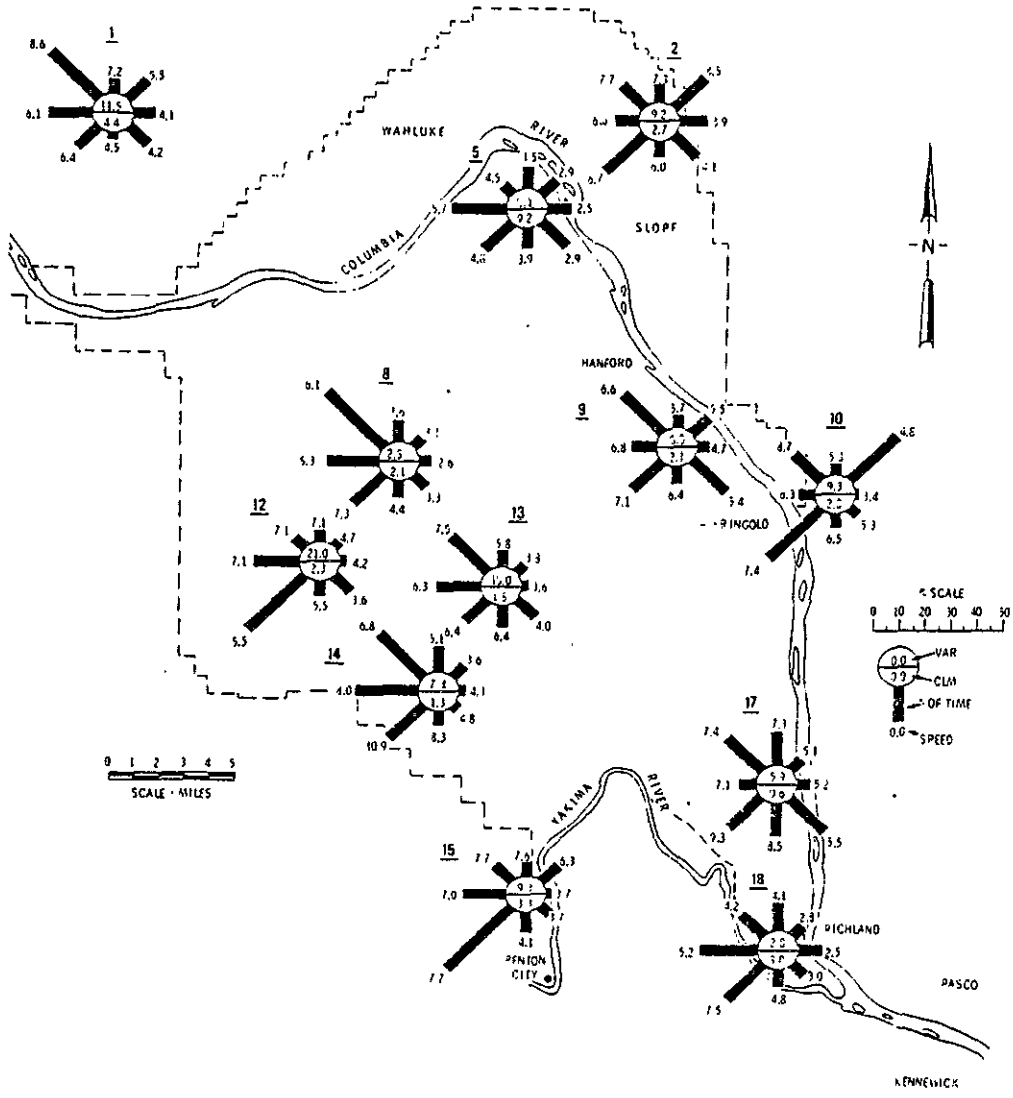

FIGURE II.3-27 SURFACE WIND ROSES FOR VARIOUS LOCATIONS ON AND SURROUNDING THE HANFORD SITE (The points of the rose represent the direction from which the winds come.)

Studies of the various aquatic organisms in the Columbia River, relating mainly to influence of the reactor operation, have been conducted for over 25 years; a bibliography with abstracts of these investigations was recently published.[63] The following paragraphs summarize the essential ecological characteristics of the major communities. Figure II.3-28 is a simplified diagram of the food-web relationships in selected Columbia River biota and represents the probable major energy pathways.

II.3.10.1.1 Phytoplankton

Diatoms are the dominant algae in the Columbia River, usually representing over 90% of the population. The main genera include Fragilaria, Asterionella, Melosira, Tabellaria, and Synedra. Lentic forms that originate in the impoundments behind the upstream dams are dominant in the Hanford section of the river. Peak biomass of net phytoplankton amounted to about 2.0 g dry wt/m^3 and winter values were less than 0.1 g dry wt/m^3.[64] A spring increase, with a second pulse in late summer and autumn, has been observed in other studies in the Columbia River.[65,66] Green algae and blue-green algae occur mainly in the warmer months, but in substantially fewer numbers than the diatoms.

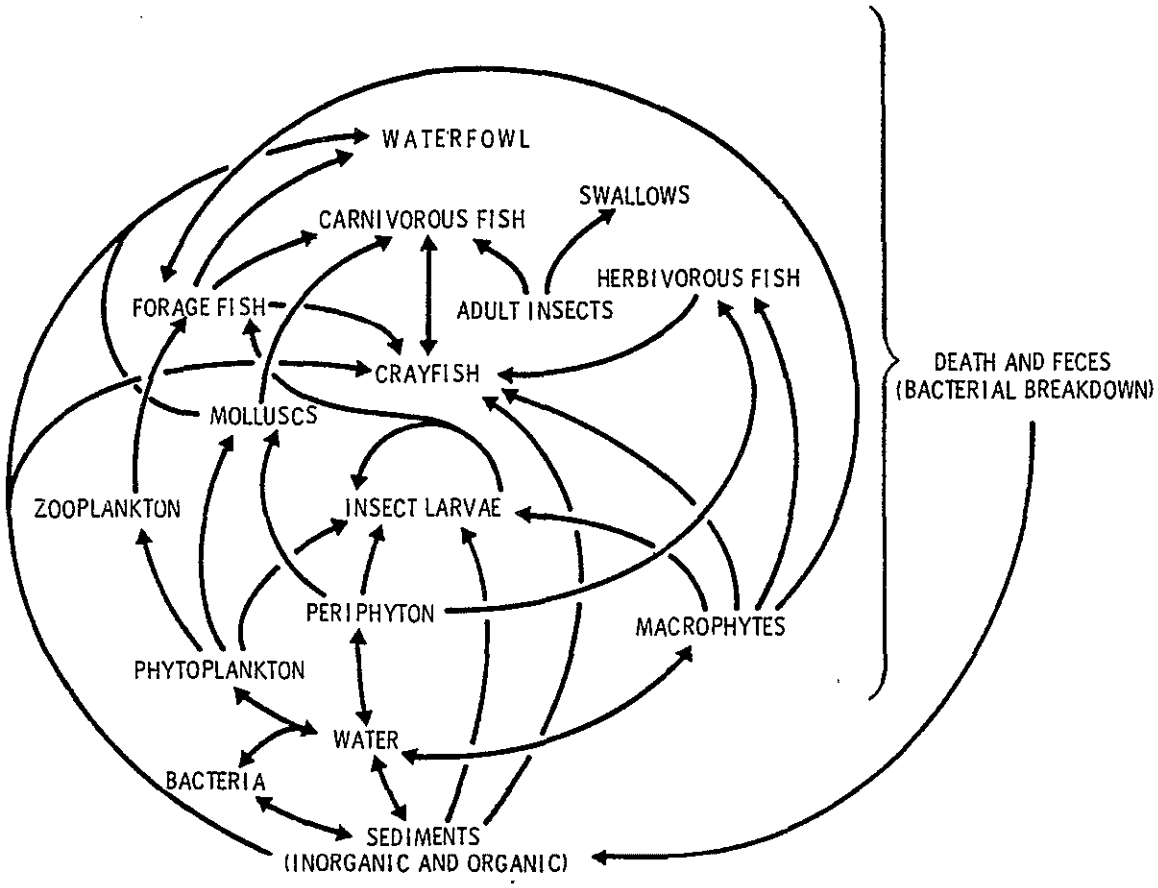

FIGURE II.3-28 FOOD WEB IN THE COLUMBIA RIVER

II.3.10.1.2 Periphyton

Periphytic communities develop on suitable solid substrates wherever sufficient light occurs for photosynthesis. Dominant diatom genera include Melosira and Gomphonema; in spring and summer, luxuriant growths of the filamentous green algae Stigeoclonium and Ulothrix occur. Net Production Rate (NPR), as measured from 14 day colonization of artificial substrates, varied from 0.07 mg dry wt/cm^2/day in August to less than 0.01 mg dry wt/cm^2/day in December and January.[67]

II.3.10.1.3 Macrophytes

Emergent macrophytic vegetation is extremely sparse and is usually found in slack-water areas. Some rushes and sedges occur in flooded areas.

II.3.10.1.4 Zooplankton

In the Hanford reach of the Columbia River zooplankton populations are generally sparse. They are associated with benthic deposits in slack-water areas near the edge of the river with cladocerans being more abundant than copepods.[68] Twenty-four species of Cladocera and Copepoda have been identified in McNary Reservoir.[69] This reservoir receives water from the Yakima, Snake and Walla Walla Rivers as well as from the Columbia, all of which may contribute to the zooplankton population.

II.3.10.1.5 Benthos

Benthic biota consist of organisms which are either attached or closely associated with the substrate. Dominant organisms presently found in the free-flowing Columbia include insect larvae, sponges, molluscs, flatworms, leeches, crayfish, and oligochaetes. The daily fluctuating water levels caused by the manipulation of flow by an upstream hydro-electric dam have destroyed a part of this fauna in the littoral zone. Near the old Hanford townsite, midge

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larvae (Chironomidae) and caddis fly larvae (Trichoptera) are the most numerous benthic organisms, averaging 121 and 208 organisms/ft^2, respectively.[60] Caddis fly larva and mollusc (Mollusca) are predominant in terms of biomass, averaging 2.24 and 1.23 g wet wt/ft^2, respectively. Total benthic organisms averaged 375/ft^2 and 3.59 g wet wt/ft^2 during 1951-52. These figures are approximations of these populations, due to the difficulty in sampling the entire bottom of a large river such as the Columbia. Sampling was restricted to the shallow shoreline and even there, variations between replicate samples were sometimes greater than seasonal variations.

II.3.10.1.6 Fish [RPB X.12, X.15, X.17, X.24, X.25]

The fish species of greatest importance in the Hanford reach of the Columbia River are the salmon and steelhead. These species live in freshwater during their early life stages, spend most of their life in the ocean, and as adults return to the river to spawn. The yearly number of adult anadromous fishes passing through the Hanford Reservation is indicated by the adult fish passage counts made at Priest Rapids Dam, the dam immediately upstream (Table II.3-6a). Adult salmonoid movement through the Hanford reach of the river occurs during all months of the year but greatest numbers pass during the spring to early fall period. Peak adult migration periods are generally as follows:

- Sockeye - July-August
- Chinook - May-September
- Coho - September-October
- Steelhead - August-October

Routes of migration through the area are generally along the north or east (left bank) side of the river opposite the reactors.[110] Fish more consistently pass through the left shore fish ladders of the dam downstream from Hanford than the right shore ladders.[111]

The fall run of chinook salmon spawn in the main stem Columbia River section from Ringold to Priest Rapids. Suitable salmon spawning areas are not available in the main stem river upstream and downstream of Hanford due to impoundments by the river dams. Spawning salmon have markedly increased in this last free-flowing stretch of the river, presumably, partly as the result of upstream displacement of populations that formerly spawned in the Columbia River downstream from Richland.[112] Estimates of the number of chinook salmon that spawn in the Hanford reach of the Columbia River have been made annually, by aerial survey, since 1947. In recent years, the locally spawning population has ranged from approximately 5,000 to 32,000 fish (Table II.3-6a), representing about 11% of the fall chinook spawning escapement to the river and nearly 30% of the fall run passing McNary Dam (River Mile 292).[112] An estimated 10,000 steelhead trout also spawn in the Columbia River near Hanford.[113] About 40% of the total adult fall chinook escapement to the Columbia River passes through or spawns in the Hanford reach of the river.

TABLE II.3-6a

ADULT ANADROMOUS FISH PASSAGE AT PRIEST RAPIDS DAM[(a)]
AND ESTIMATED CHINOOK SALMON SPAWNING NEAR HANFORD

Species	Number of Fish								
	1966[(b)]	1967[(b)]	1968[(b)]	1969[(b)]	1970[(b)]	1971[(c)]	1972[(c)]	1973[(c)]	1974[(c)]
Chinook Salmon (*Oncorhynchus tshawytscha*)	66,915	48,918	48,314	40,786	43,934	32,535	32,321	34,418	32,397
Sockeye Salmon (*O. nerka*)	170,071	123,786	108,308	39,240	77,422	72,753	44,957	54,471	35,434
Coho Salmon (*O. kisutch*)	11,903	8,879	13,212	1,351	4,971	7,619	5,268	1,576	1,781
Steelhead Trout (*Salmo gairdneri*)	13,006	7,354	10,524	6,650	5,442	10,593	6,350	7,006	3,062
American shad (*Alosa sapidissima*)	716	239	300	3,440	7,163	1,423	2,370	12,691	8,151
Fall Chinook spawning near Hanford[(d)]	22,000	23,000	25,000	32,000	27,000	25,000	6,000	21,000	5,000

(a) Fish passage counts are for the period from April through October.
(b) Adult fish passage numbers from Priest Rapids Fish Passage Reports, Grant Co. PUD, Ephrata, WA.
(c) Adult fish passage numbers from Condensed Daily Fish Count Reports, U.S. Army Engineer District, Portland, OR.
(d) Based on a conversion factor of 7 fish/redd

Young salmon hatch during mid to late winter and emerge from the gravel in February and March. The numbers of young salmon and steelhead passing the upstream Priest Rapids Dam are shown in Table II.3-6b. Estimates are incomplete except for chinook salmon. Practically all of the young sockeye salmon are over one year of age when they pass to the ocean. From 10 to 15% of the chinook outmigration are fish one year and older which pass Priest Rapids Dam in May. The remainder of the young chinook are less than one year of age (0-age class). From 40 to 60% of the chinook juveniles migrated past Priest Rapids Dam in August during 1965 to 1967, an indication that the outmigration of the salmon produced in areas upstream from Hanford is delayed, presumably due to the creation of the reservoir complex upstream.[116] The chinook produced in the Hanford reach move out of the area during mid-April to mid-June, the normal time of emigration.

TABLE II.3-6b

ESTIMATED NUMBERS OF JUVENILE SALMONIDS
PASSING PRIEST RAPIDS DAM

	Numbers (millions)			
Year	Chinook Salmon	Sockeye Salmon	Coho Salmon	Steelhead Trout
1965[a]	1.62	2.63	0.22	0.27
1966[a]	1.35	4.10	1.17	0.24
1967[a]	2.07	0.95	1.17	0.26
1968[b]	1.43	--	--	--
1969[b]	1.60	--	--	--
1970[b]	1.09	--	--	--
1971[b]	1.21	--	--	--
1972[b]	1.49	--	--	--
1973[b]	1.14	--	--	--
1974[b]	1.05	--	--	--

(a) Juvenile salmon estimates from Reference 114.
(b) Juvenile chinook salmon estimates from Washington Department of Fisheries.

A special study of the local sport fishery conducted for a year in 1966 to 1967[117] gave an estimated annual catch of approximately 6,000 fish in the section of the Columbia River from Richland (River Mile 339) to Ringold (River Mile 354). Since the time of this survey, sport fishing intensity, particularly from boats, has probably increased, which would presumably make the present annual catch higher.

Factors influencing the thermal tolerance of salmon and steelhead include: exposure time, acclimation temperature, and life stages of the fish. Pacific Northwest fisheries agencies have recommended the following temperature ranges as "optimum" for salmonids:[118]

Migration:	7.2 to 15.5°C (45-60°F)
Spawning:	7.2 to 12.8°C (45-55°F)
Rearing:	10 to 15.5°C (50-60°F)

The Columbia River temperatures in the Hanford reach are usually well below the optimum maximum temperature during the rearing and migration period from March through June. The addition of small amounts of heat during this period is not expected to be detrimental and may be of benefit during the spring months when river temperatures are near the lower optimum limit.

The period from July through October is the time when addition of heat to the river is of greatest significance. Maximum river temperatures may reach 21°C (70°F) during this time, and the minimum temperatures are usually above the optimum for salmonids. During the warm summer months the Columbia River is a marginal habitat for salmonids with respect to temperature. Laboratory studies in which chinook salmon eggs were incubated and reared at several thermal increments above ambient Hanford Columbia River temperature showed no increase in mortality at about 3°F above a base river temperature of 54.6°F.[119] Excessive mortality occurred at 7°F above river temperature. Increased temperatures accelerated growth of larval chinook salmon; a 2°F increment increased growth by 40%.

Many of the juvenile salmon passing through, and all of those produced in the Hanford reach of the river, are of zero age class (young of the year) and do not possess the motile powers of older juveniles or adults. To some extent they passively drift with the river currents. The majority[120] of these fish, 50 to 60%, are found along the shore; the remainder are distributed in the river cross-section mostly in the upper 30 inches of water. From hydrodynamic considerations alone it may be physically impossible for these fish to even enter the N Reactor thermal plume near its point of submerged discharge. The exact time-temperature exposure to a fry passing through the N Reactor plume has not been determined. However, examination of the mortality and the characteristics of the plume with comparable physical and thermal characteristics indicates that even if fish pass directly through the plume centerline they probably would not encounter elevated temperatures for a time period long enough to be lethal to them or even cause a loss of equilibrium. The thermal exposure would also be less than the minimum calculated as necessary to cause increased predation.

Whitefish and steelhead are the species most fished for by sportsmen in the Columbia River in the vicinity of Hanford. From a creel census and household follow-up conducted from 1963 to 1968 in the section from Ringold just downstream of the plant boundary to the mouth of the Snake River, the Washington State Game Department calculated that the average annual catch of steelhead in this area was about 2700 fish. The whitefish are resident in the Hanford reach of the river and support a winter sport fishery.

Population estimates of resident coarse fishes, such as suckers and minnows, have not been made. The problems in effectively sampling a river the size of the Columbia preclude definitive measurements. The above-mentioned species constitute a large portion of the resident population; other common species include sculpin, dace, sturgeon, sticklebacks, and bass. Thirty-nine species of fish have been identified in the Hanford area of the Columbia River.

II.3.10.2 100-N Overflow Trench

Liquid waste from the N Reactor flows into a crib from which the overflow goes into a 1600-ft long dispersal trench. Water seeping from the trench passes through about 2000 feet of soil before reaching the Columbia River.

No ecological studies have been performed on this dispersal trench, although periphytic algae and associated microscopic organisms are probably present as well as possibly some insect larvae. The trench was occasionally used by waterfowl until it was partly screened and backfilled to prevent their access.

II.3.10.3 200 Area Ponds and Ditches

A number of ponds and ditches in the vicinity of the 200 East and 200 West Areas have received low-level aqueous waste since Hanford's inception. Ecological studies have been performed on some of the sites. The ditches generally have sand substrates with a rapid rate of infiltration. Vegetation grows abundantly along the shores.

Ecological studies have been in progress since June 1972 on Gable Mountain Pond and since July 1973 on U Pond. The shoreline vegetation around Gable Mountain Pond is predominantly cattails and rushes. Open sections are present near the inlet and at the northwest end where the overflow passes through a culvert in a dike. Figure II.3-29 represents the basic food web present in Gable Mountain Pond and U Pond. The biota is rich in terms of species diversity but additional work is needed to quantify the various populations. Quantitative sampling is in progress on the 22-acre U Pond. The daily thermal regime of the pond depends primarily upon the incoming water and secondarily on atmospheric and solar heat; however, the range within which the pond fluctuates is influenced by seasonal changes in solar and atmospheric heat. Primary productivity is closely related to seasonal changes in insolation and temperature, and striking pulses occur during the warmer months when wind and cloud cover are minimal. The pond supports a simple food web based mainly on detritus and sedimented organic matter. Primary producers are mainly phytoplanktonic green algae (Chlorococcales) and several emergent vascular plants. Benthic detritivores and scavengers include chironomid larvae, oligochaetes, amphipods, and mayfly and beetle larvae. Goldfish, an introduced species and the only fish in the pond, also scavenge the bottom. Dragonfly and damselfly larvae and backswimmers constitute the only known carnivores in the pond.

II.3.10.4 300 Area Ponds

Two ponds, totalling about 12 acres, receive low-level liquid waste generated in the 300 Area laboratories and reactor fuel canning complex. The south pond is presently dry but could receive water again. Since copper and uranium are usually present in the waste, a layer of copper hydroxide is on the bottom.

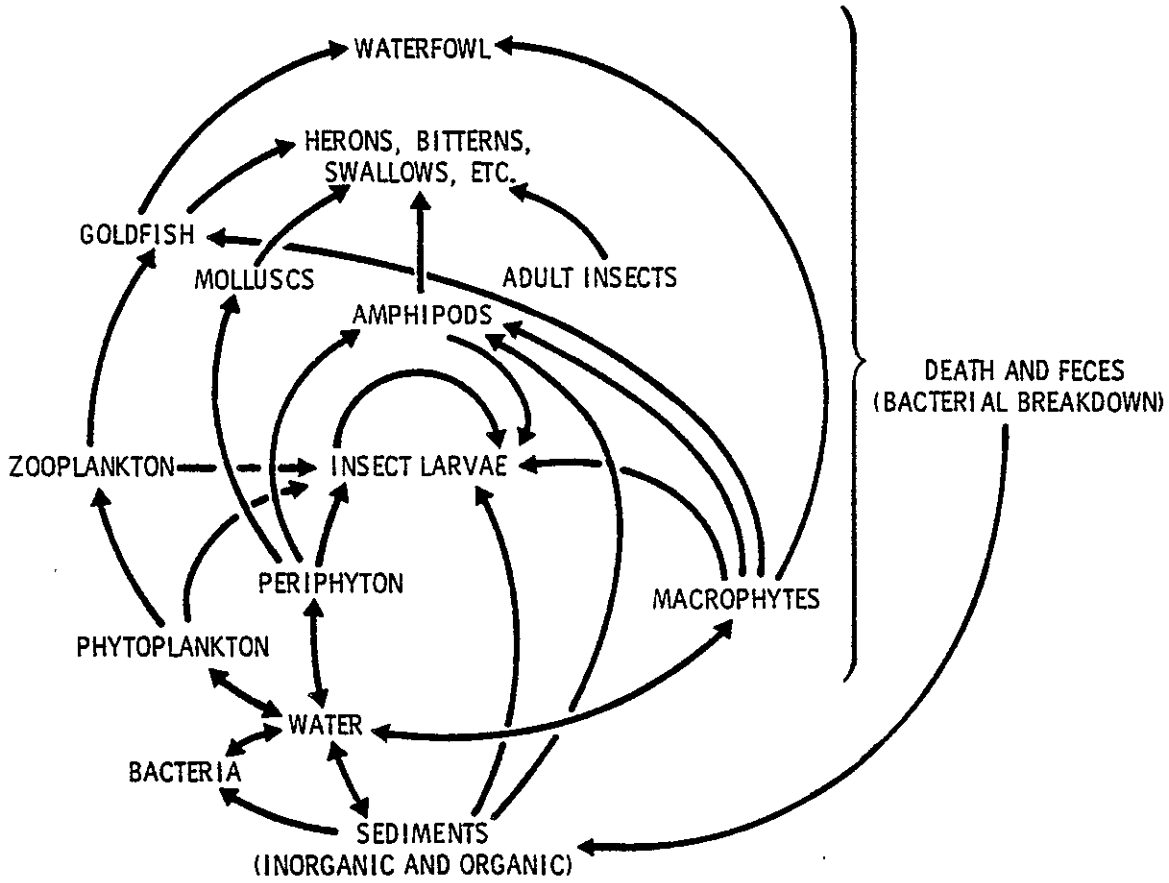

FIGURE II.3-29 FOOD WEB IN GABLE MOUNTAIN POND AND U POND

No ecological studies have been conducted on these ponds. Vascular plants grow down to the water's edge, but the pond proper is unsuitable for aquatic life. A few ducks frequent the ponds and the sanitary waste leach trenches alongside.

II.3.10.5 Rattlesnake Springs

Rattlesnake Springs, located on the Arid Land Ecology (ALE) Reserve, is a permanent spring which begins from groundwater seepage and is subsequently fed by small groundwater springs along its course. It flows for approximately 2 to 3 km, starting at about 0.43 cfs, and disappears into the ground. The stream bottom is composed of sand and gravel, with rubble in some areas. The biotic communities in the stream are subjected to periodic flash floods in winter, depending upon weather conditions. Despite these floods the stream supports a diverse flora and fauna.

II.3.10.5.1 Phytoplankton and Periphyton

Some 90 species of algae in Rattlesnake Springs were collected and identified. Slightly over half of the species are diatoms; in summer, green algae such as *Spirogyra* and *Cladophora* are the second most numerous group and are dominant in terms of biomass.

II.3.10.5.2 Macrophytes

Cattails and sedges occur along the stream, especially where it is not shaded, but the overwhelmingly dominant macrophyte is watercress, *Rorippa nasturtium-aquatica*. This seasonal plant occupies from 2 to 85% of the total stream area.[73]

II.3.10.5.3 Invertebrates

Several groups of invertebrates occupy the stream, although the species diversity is highly dependent upon the size of the winter floods, if any, and the resulting physiognomy of the

stream. No exhaustive taxonomic study has been made of the invertebrates; dominant forms present include midge larvae, blackfly larvae, and molluscs.

II.3.10.6 Other Springs on the ALE Site

Approximately 14 other permanent and intermittent springs occur on the ALE site. No ecological studies have been made on these springs, but qualitative collections were made for certain organisms. Algae was collected at a few sites, and the crayfish, Pacifasticus leniculatus, was collected for laboratory experiments.

II.3.11 Terrestrial Ecology[a]

II.3.11.1 Climatic Influences

A term frequently chosen to describe the Hanford region is "steppe", referring to its general resemblance to the steppeland of central Asia. The region is called a shrub-steppe[74] to differentiate it from true steppes having more grasses and fewer shrubs. Steppes have some characteristics in common: 1) little precipitation and 2) wide daily and annual temperature ranges. Aridity arises at Hanford from its geographical location in the rainshadow of the Cascade Mountains. Lying in the path of frequent winter storm tracks, the Hanford region is visited by many winter storms that bring clouds but little water. However, precipitation is relatively high during all winter months (about 2 or 3 cm per month). Although June exhibits a secondary maximum, the June precipitation is too little and too late to be of substantial importance to the vegetation, because the rains usually wet the soil only to a depth of 20 cm or less, well within the reach of evaporation by the high insolation intensities and warm soil temperatures of that season.[75,76] Consequently, the precipitation of importance to vegetation is that which is stored as soil water during the cool season.[77]

II.3.11.2 Vegetation

The vegetation mosaic of the Hanford Reservation (Figure II.3-30) consists of eight major kinds of shrub-steppe communities identified by the most conspicuous or most abundant plant species:

- Sagebrush/bluebunch wheatgrass (Figure II.3-31 and Figure II.3-32)
- Sagebrush/cheatgrass or sagebrush/Sandberg bluegrass (Figure II.3-33 and Figure II.3-34)
- Sagebrush-bitterbrush/cheatgrass (Figure II.3-35)
- Greasewood/cheatgrass-saltgrass (Figure II.3-36)
- Winterfat/Sandberg bluegrass (Figure II.3-37)
- Thyme buckwheat/Sandberg bluegrass (Figure II.3-38)
- Cheatgrass-tumble mustard (Figure II.3-39)
- Willow (Figure II.3-40)

Figure II.3-41 shows the location and direction of the view for each of the preceding photographs.

On the Hanford Reservation, the sagebrush/bluebunch wheatgrass vegetation-type occupies extensive acreage in the Rattlesnake Hills and is mostly confined to the ALE Reserve. Bluebunch wheatgrass is the most important livestock forage plant here. The most broadly distributed vegetation-type on the Reservation is the sagebrush/cheatgrass-bluegrass association. This vegetation-type occurs as a broad zone between the sagebrush/bluebunch wheatgrass type and the sagebrush-bitterbrush/cheatgrass type. Spiny hopsage and rabbitbrush may be intermingled with sagebrush shrubs. The general paucity of herbaceous cover tends to favor invasion by tumbleweed, with or without fire.

The sagebrush-bitterbrush/cheatgrass vegetation-type occupies the low elevations in the southeastern sector of the Hanford Reservation. Snowy eriogonum, a small shrub, is often locally abundant. The sagebrush-bitterbrush/cheatgrass vegetation-type occupies the sandiest soil short of dunes. The colonization of sandy soils in an arid environment is a slow process, especially

(a) A more detailed description of the terrestrial Ecology of the Hanford Reservation is given in Appendix II.3-G.

if large areas are affected--by fire, for example--and seed sources severely reduced (Figure II.3-32). The most efficient early invader of burned areas in the sagebrush-bitterbrush/cheatgrass vegetation-type is tumbleweed. Bitterbrush is an important forage plant for mule deer, especially in fall and winter.

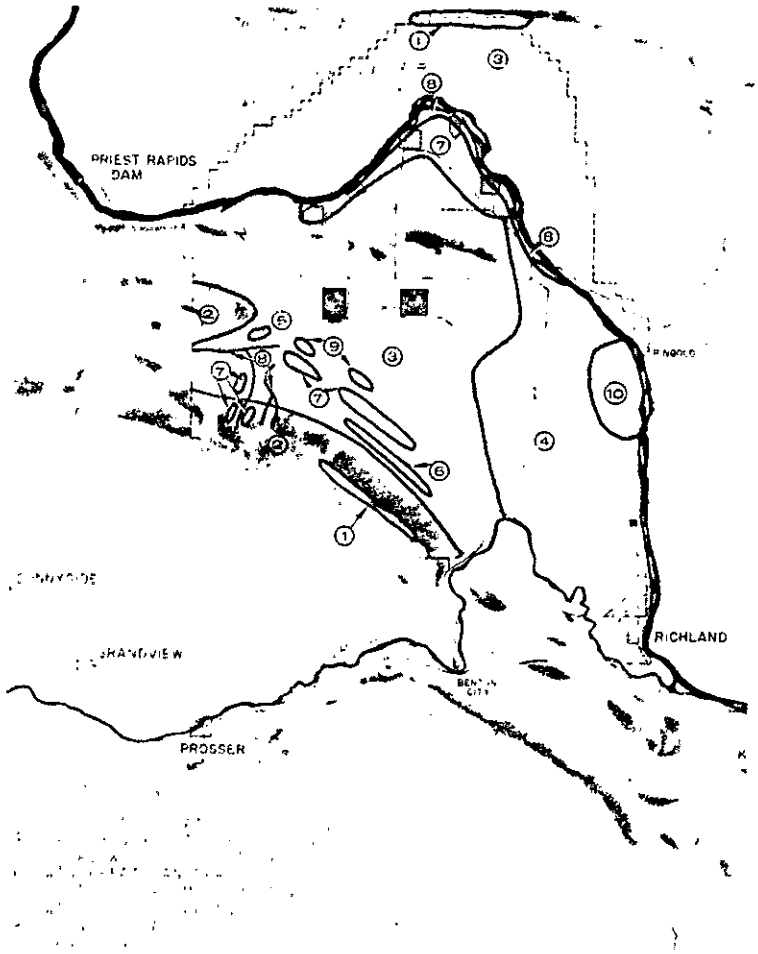

FIGURE II.3-30 DISTRIBUTION OF VEGETATION TYPES ON THE HANFORD RESERVATION

The greasewood/cheatgrass-saltgrass vegetation-type is restricted to a small area of about 100 acres in the vicinity of Rattlesnake Springs.[78] This vegetation-type is important because the geographic distribution of greasewood is determined by the presence of a relatively shallow water table.

The winterfat/Sandberg bluegrass vegetation-type occupies several thousand acres along the gentle lower slopes of the Rattlesnake Hills. For the most part, the geographic distribution of winterfat in the Pacific Northwest is restricted to the ALE Reserve.

The thyme buckwheat/Sandberg bluegrass vegetation-type occupies thin, stony soils along ridge crests in the Rattlesnake Hills and Gable Mountain areas. These communities have no potential for agricultural use and provide limited forage for livestock and wildlife, but they possess great aesthetic value because of the presence of many species with showy flowers.

The cheatgrass-tumble mustard vegetation-type occupies abandoned agricultural fields, especially in the 100 Areas and at Benson Ranch and Snively Ranch on the ALE Reserve. This vegetation-type consists mostly of alien annual plants, i.e., cheatgrass and annual mustards; it has, over the past 30 years, resisted invasion by native perennial grasses and shrubs and colonization by tumbleweed. Cheatgrass-tumble mustard communities in the absence of livestock grazing are effective in binding soil against wind and water erosion and have practical value in revegetation of highly disturbed soils.

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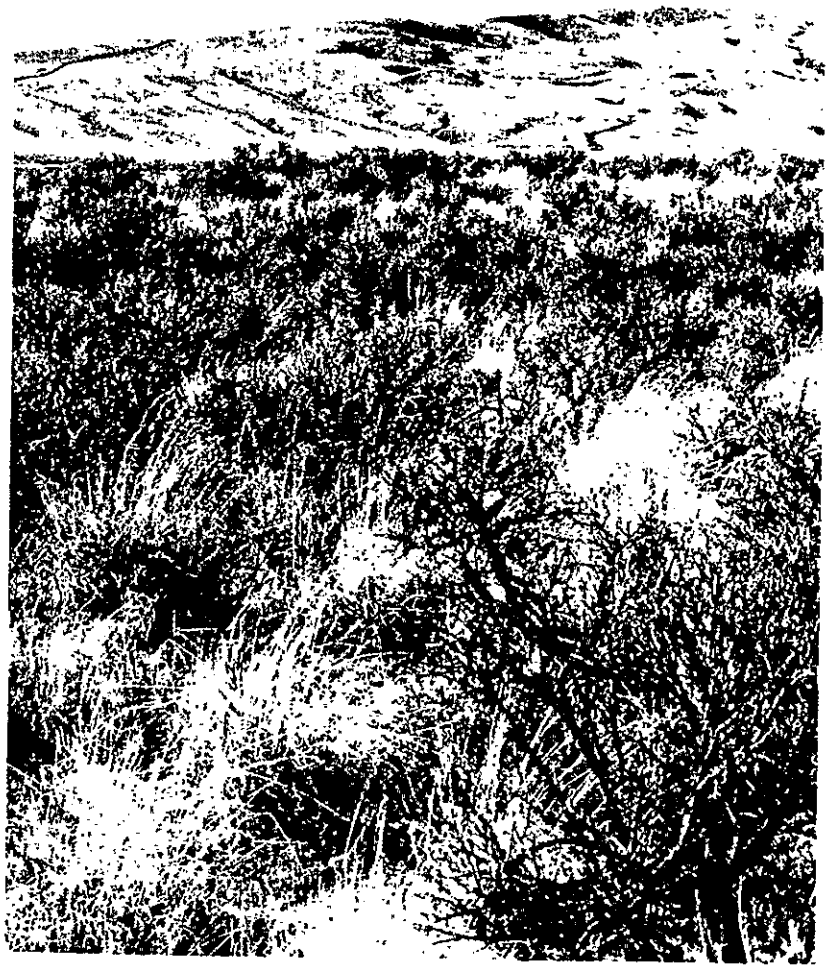

FIGURE II.3-31 SAGEBRUSH/BLUEBUNCH WHEATGRASS COMMUNITY (The shrub is big sagebrush and the large bunchgrass is bluebunch wheatgrass.)

FIGURE II.3-32 SAGEBRUSH/BLUEBUNCH WHEATGRASS COMMUNITY (Burned in 1957. The shrub in the foreground is rabbitbrush, a shrub that can sprout following fire damage; sagebrush is usually killed by fire.)

FIGURE II.3-33 SAGEBRUSH/CHEATGRASS COMMUNITY. (The shrub is big sagebrush, the dense grass understory is mostly cheatgrass, an alien weed introduced into the Pacific Northwest with the advent of livestock grazing and agriculture. These growths are prevalent on the low-elevations of the Hanford Reservation.)

FIGURE II.3-34 SAGEBRUSH/SANDBERG'S BLUEGRASS COMMUNITY. (The shrub is big sagebrush and the sparse understory is Sandberg's bluegrass.)

FIGURE II.3-35 SAGEBRUSH-BITTERBRUSH/CHEATGRASS COMMUNITY. (The light colored shrub is sagebrush and the dark colored shrub is bitterbrush. The understory is mostly cheatgrass.)

FIGURE II.3-36 GREASEWOOD/CHEATGRASS-SALTGRASS COMMUNITY. (The shrub clump in the foreground is greasewood, the understory grasses are a mixture of cheatgrass and saltgrass.)

FIGURE II.3-37 WINTERFAT/SANDBERG'S BLUEGRASS COMMUNITY. (The short-statured shrub in the foreground is winterfat.)

FIGURE II.3-38 THYME BUCKWHEAT/SANDBERG'S BLUEGRASS COMMUNITY. (Appearing at high elevations on the ALE Reserve, the low-growing cushion-like plants are thyme buckwheat.)

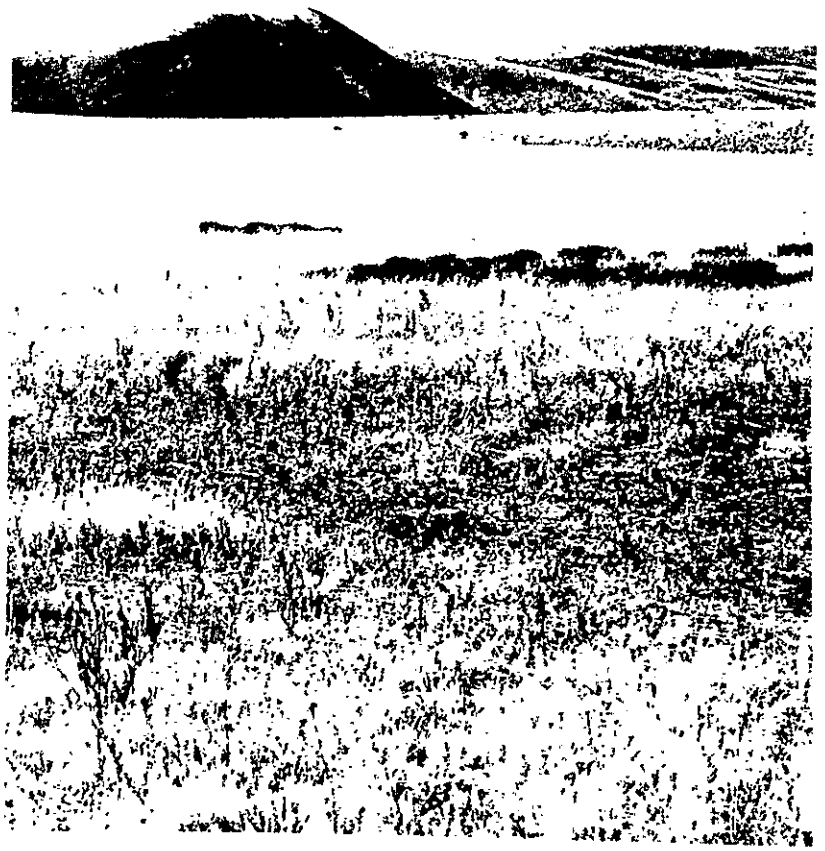

FIGURE II.3-39 CHEATGRASS-TUMBLE MUSTARD COMMUNITY. (This occupies a 30-year old abandoned wheatfield at midelevation on the ALE Reserve.)

FIGURE II.3-40 WILLOW COMMUNITY. (Located at Rattlesnake Springs on the ALE Reserve.)

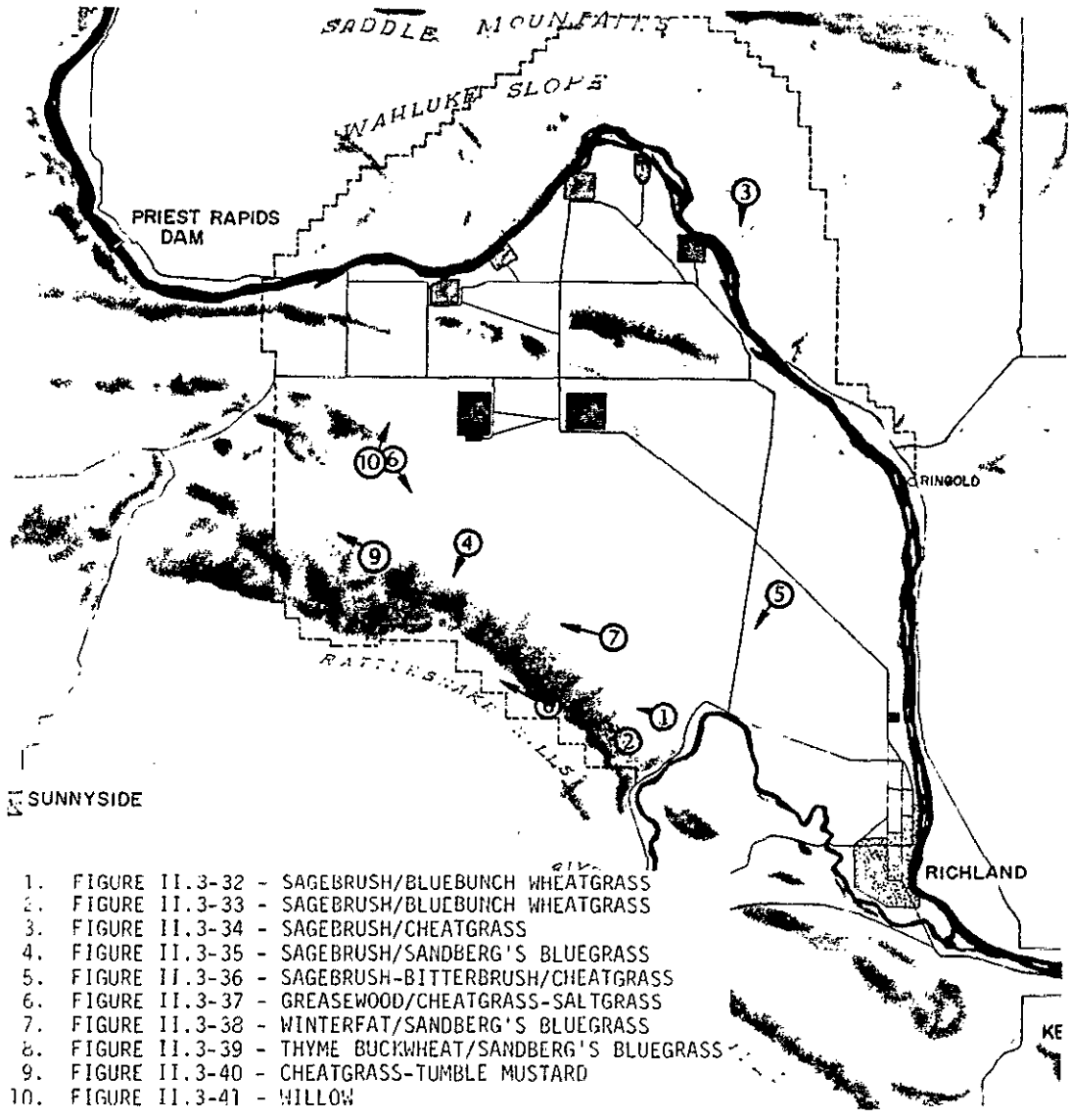

FIGURE II.3-41 LOCATION AND DIRECTION OF VIEW FOR PLANT COMMUNITY PHOTOGRAPHS

Willow vegetation occurs along the banks of the Columbia River, waste ponds in the 200 Areas, abandoned agricultural irrigation ditches in the 100 Areas and along permanent spring courses in the Rattlesnake Hills. Although the amount of acreage occupied by willow communities is small, their value to wildlife is large. Willows and associated deciduous trees, shrubs and herbaceous plants provide food and nest sites for game and song birds, summer forage, and cover for mule deer.

Miscellaneous vegetation-types occur throughout the Hanford Reservation. Of particular importance are deciduous trees around waste ponds,[79] abandoned homesteads and abandoned military installations that provide nesting and resting sites for raptorial birds of prey. Appendix II.3-G presents a current floristic list for the Hanford Reservation.

The historical pattern of plant succession in the steppe region of Washington was altered during the past century by the introduction of annual weeds from the steppes of Eurasia. One of the most agressive of these plants is cheatgrass. Cheatgrass is well adapted to the fall-winter precipitation regime of the area, its seeds are highly viable, and seedling growth is more

9 1 1 1 8 9 6 0 1 0 9 3

competitive than that of native perennial grasses.[80] Agricultural fields abandoned for 30 years continue to be dominated by cheatgrass; apparently the competition for soil, water and available essential mineral nutrients is sufficient to exclude other kinds of plants for long periods of time.

Tumbleweed, another exotic plant, has an effective method of seed dispersal. Tumbleweed is not as competitive as cheatgrass in most habitats, but it is the most successful colonizer of habitats where cheatgrass is suppressed by mechanical means or herbicides or in soils with heterogeneous texture. In the absence of physical disturbance, cheatgrass and tumbleweed are not effective in invading pristine steppe communities. Nevertheless, cheatgrass and tumbleweed will tend to become more important on the Hanford Reservation as more soil is disturbed by construction and waste burial sites.

II.3.11.3 Mammals

The mule deer is the only big game mammal found on the Hanford Reservation. Most of the mule deer on the Hanford Reservation live along the Columbia River, with smaller concentrations near Gable Mountain and the 200 Area, at Rattlesnake Springs, and on the Snively Ranch area in the Rattlesnake Hills.

The cottontail rabbit is the most abundant small game mammal, with small populations scattered throughout the Reservation area. The raccoon is probably the most abundant furbearing mammal on the Hanford Reservation, mostly confined to shoreline areas of the Columbia River and waste ponds in the 200 Areas. Beaver and muskrats occur in backwater areas of the Columbia River; muskrats are found also in waste ponds and ditches in the 200 Areas. Mink occur along the Columbia River while weasels are scattered throughout the Hanford area. The coyote is abundant on the Hanford Reservation as compared to adjacent land areas, although no accurate estimate of population density has been made. The bobcat and badger are present on the Reservation, but in low numbers.

The jackrabbit is widely distributed on the Hanford Reservation; however, it is less abundant in the sagebrush/bluebunch wheatgrass vegetation than in the sagebrush/cheatgrass and sagebrush-bitterbrush/cheatgrass vegetation-types. The jackrabbit is an important food item for coyotes and raptors.

The porcupine is widely distributed over the Reservation area but is especially abundant along the Columbia River. Porcupines occur in the 200 Areas and in the canyons and valleys of the Rattlesnake Hills.

Small mammals are abundant on the Hanford Reservation, particularly the Great Basin pocket mouse. Deer mice and ground squirrels are locally abundant, as is the pocket gopher. The kangaroo rat is not found on the Hanford Reservation although it is common in the steppe region of Oregon.

Appendix II.3-G presents a species list of the mammals (and other vertebrates) that occur on the Reservation.

II.3.11.4 Birds

The chukar partridge is the most important upland game bird on the Hanford Reservation. Most of the population is concentrated on the ALE Reserve, especially the Rattlesnake Hills, but there are local populations in the Gable Mountain area. Chinese ring-necked pheasants are present on the Hanford Reservation but in small numbers, and California quail are present as scattered local populations along the Columbia River. Mourning doves are migratory birds that nest throughout the Hanford Reservation area during the spring months.

Sage grouse are present in small numbers. In recent years, sightings generally occurred in the Rattlesnake Hills on the ALE Reserve. Over the years the sage grouse population has declined in southeastern Washington as pristine habitat was converted to dryland wheat and irrigated agricultural fields. The most abundant birds in steppe vegetation are the western meadowlark and the horned lark.[81]

The Canada goose is the most important of the nesting waterfowl on the Hanford Reservation; the nesting habitat is confined to islands in the free-flowing reach of the Columbia River.[82] The Columbia River also provides a resting sanctuary for migratory flocks of ducks and Canada geese. At peak migratory periods, 70,000 birds - mostly mallards - occupy the Hanford reach of the Columbia River.

Raptorial birds use the Hanford Reservation as a refugium from human intrusions, especially during the nesting season. Trees around abandoned farms in the 100 Areas and around abandoned military installations provide nesting habitat for red-tailed hawks, Swainson's hawks, and great horned owls. Prairie falcon nests are located on Gable Butte and along Umtanum Ridge.[83] The sparrow hawk is the most abundant of the raptorial birds. The marsh hawk nests on the Hanford Reservation (as does the burrowing owl), but the osprey is only an occasional visitor along the Columbia River. The golden eagle and the bald eagle are both winter visitors. The raptorial birds are of particular interest because their ancestral ranges are being steadily reduced by human encroachment. Relatively large areas of uninhabited land, such as the Hanford Reservation, provide a nesting and foraging ground for raptorial birds.

II.3.11.5 Snakes and Lizards

As compared to southwestern United States desert areas, the herpetofauna of south-central Washington is sparse. The most abundant reptile in low elevation steppe vegetation is the sideblotched lizard. The horned lizard is not common and the sagebrush lizard is scarce. The most abundant snake is the gopher snake, but the yellow-bellied racer and the Pacific rattlesnake are common. The coachwhip snake and the desert night snake are seldom observed. Snakes are an important food item for the Swainson's hawk.

II.3.11.6 Insects

A preliminary list of insect species known to inhabit this area is given in Appendix II.3-G. This list will probably continue to be updated for several years as additional specimens are found. It is probably safe to assume that the species which contribute significantly to insect abundance are contained in this list.

Leafhoppers (Cicadellidae), aphids (Aphididae) and plant hoppers (Fulgoridae) are all present, but members of the superfamily Coccidea are the most abundant. The Coccidea are primarily mealybugs (Pseudococcidae), most of which occur in association with bluebunch wheatgrass. Cicadas may periodically be conspicuously present in this area, primarily due to the buzzing "song" produced by the males.

The order Orthoptera contains the well known family Acrididae (grasshoppers) which are frequently very destructive members of grassland communities. The grasshopper possessing the greatest potential for outbreak in this area is the migratory grasshopper (Melanoplus sanguinipes). Localized concentrations have occurred at Hanford in the past[84] and will probably continue to do so in the future. These concentrations appear to occur only in the cheatgrass-tumble mustard vegetation.

The order Coleoptera (beetles) constitutes the largest insect order and contains nearly 50% of all known insect species. They are a very diverse group, inhabiting nearly all conceivable types of habitat. Some important predacious beetle families in this area are the ground beetles (Carabidae) tiger beetles (Cicindelidae), checkered beetles (Cleridae) and ladybird beetles (Coccinellidae). The weevils (Curculionidae) are probably the most important group of plant eaters in this order. Sixteen species of darkling beetles are known to occur in this area. Two species, Philolithus densicollis and Stenomorpha puncticollis, can be particularly abundant. Philolithus is very much more abundant in native grasslands than in cheatgrass swards, while Stenomorpha, somewhat less abundant than Philolithus, is less sensitive to vegetation type, but Stenomorpha does not occur at low elevations.

The order Hymenoptera (ants, wasps, bees) contains a great number of species that are either predators or parasites, as well as the plant pollinators essential for ensuring fertilization of many flowering plant species. The ants (Formicidae) can be an important component of natural systems, but they are not abundant on the Reservation. Ants apparently occur in all vegetation types. Members of the family Specidae are solitary wasps. The Ichneumonidae, another important Hymenopteran family, also attack a great variety of insect hosts. However, unlike the Sphecids (who paralyze and drag their prey to a burrow), the Ichneumonids are mostly internal parasites of immature stages of the host. Wasps are very mobile and occur in all vegetation types.

The collembola (springtails) play a dual role, some members feeding on decomposing plant material, others feeding directly on living plant tissue. Collembola are very common in any mulch layer but are frequently overlooked, due to their tiny size. The most abundant collembola species belongs to the family Sminthuridae, sometimes called the globular springtails.

In Appendix II.3-G is a distribution list of the abundant plants and animals in the several vegetation types, arranged in order of decreasing elevation. This listing demonstrates clearly that animals are more ubiquitous than plants.

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II.3.11.7 Rare or Threatened Species [X.18]

Three endangered or threatened species of vascular plants are known to occur on the Reservation: Balsamorhiza rosea, Erigeron piperianus, and Eriogonum thymoides. All occur on the ALE Reserve rather than the low lands where waste management activities are planned. In addition, Allium robinsonii may occur in the gravel bars along the Columbia River; it is also noted as a threatened species.[126]

The Hanford Reservation provides a refugium for several rare, threatened or indeterminate species.[85] The prairie falcon (Falco mexicanus) nests in several regions on the Reservation, with the number of nesting pairs probably in the dozens.[83] The American peregrine falcon (Falco peregrinatus anatum) apparently does not nest on the Reservation but does in neighboring regions, probably in small numbers. Species lacking specific data to attest to their status but considered to be possibly in some danger[85] include the ferrugionous hawk (Buteo regalis), which nests in several sites on the Reservation but in small numbers; the American osprey (Pandion haliaetus carolinensis), only a visitor; and the western burrowing owl (Speotyto cunicularia hypugaea), and the long-billed curlew (Numerius americanus), both of which nest on the Reservation in small but significant numbers.

II.3.11.8 Primary Productivity (Plants)

Arid and semiarid lands are not as biologically productive as humid or wet lands which can produce 2 or 3 kg/m^2 annually. In contrast, deserts produce about 70 g of herbage/m^2. Cheatgrass-tumble mustard communities on the ALE Reserve over the last 5 years produced herbage yields ranging between 110 and 330 g/m^2.[77] The annual productivity of pristine stands of sagebrush-bunchgrass was determined[74] to be about 100 g/m^2. On the ALE Reserve, annual production of herbage has been about 120 g/m^2 in a sagebrush-grass community.

There are pronounced differences in species diversity between cheatgrass communities and the sagebrush-grass communities. Nine species of plants, eight of which are annuals, contribute to the herbage yield of cheatgrass communities. About 20 species contribute to plant biomass in the sagebrush-grass community, and most of these are perennials of several different life forms.

Although herbage production is the visible output of plant growth, a root system is also produced each year. Less than 25% of the root biomass in the cheatgrass community penetrates deeper than 20 cm, compared to 50% for the sagebrush-grass community. The total root biomass is also greater in the sagebrush-grass community compared to the cheatgrass community, 1200 versus 800 g/m^2.

II.3.11.9 Mineral Uptake and Cycling

Herbage provides a source of energy, protein and essential minerals for herbivorous animals, but the amount of energy available to consumers is quite variable. The average heat of combustion (total heat release, or caloric content) varies from 3.8 kcal/g for cheatgrass leaves to 6.1 kcal/g for mustard leaves. Sagebrush leaves and native grasses fall in between. Although a crude measure of energy such as this does not measure usable energy, the relative contribution of the various species to digestible energy is probably similar.

Plants extract minerals from the soil solution for their own functioning, making these minerals available for consumer organisms. The amount of stable mineral elements that plants obtain from the soil in which they grow is important to radiation ecology, because some plants, such as greasewood,[86] accumulate mineral elements to significant concentrations.

Continuous maintenance of life requires that mineral nutrients currently bound up in plant and animal life eventually be returned to a common nutrient pool for use by succeeding generations. The rate of return is mostly governed by the activity of microflora and microfauna, organisms of decay which live on or in dead biotic material. The metabolic activity of these microbiota (measured by CO_2 evolution from the soil) is rather closely attuned to environmental conditions of temperature and moisture.[87] High levels of both temperature and water induce high levels of soil CO_2 evolution, but the climate of the Hanford Reservation precludes such coincidence in general. Consequently, soil CO_2 evolution is usually low, implying relatively little microbiotic activity compared to, say, a humid climate.

Measurements of loss from litter bags over a 2-yr period indicated that cheatgrass litter disappearance can be accurately thought of as an exponential process with a half-time of 6 ±1 year, much slower than the 1- or 2-yr half-time noted for bluebunch wheatgrass. Sagebrush casts about 90% of its leaf biomass in early summer, presumably a period of relatively slow decomposition, but weight losses[88] from litter bags imply a half-time of about one year, very much faster than cheatgrass leaves and stems. However, leaf and inflorescense litter - the annual portion of sagebrush biomass - represent only about half of 1% of the total standing crop. No

detectable weight losses of bark, branches, and buried roots occurred even after 2-1/2 years,[88] indicating that minerals in these portions of the sagebrush community remain unavailable for a relatively very long time.

II.3.11.10 Animal Populations

Most of the animals on the Hanford Reservation are nongame species having no direct link to man through the food he eats. However, these animals provide food for predators. Some of the most abundant animals on the Hanford Reservation in terms of biomass per unit area are darkling beetles, which have attained an estimated peak biomass of 2 g/m^2 (20 lb/acre) in cheatgrass communities.[89] These beetles can provide an important food supply for some predators in autumn when adult beetles are active on the soil surface for a few weeks.[90]

Coyotes are wide-ranging animals that have the potential for wandering on and off the Hanford Reservation boundaries in search of food. Coyotes have disrupted the nesting of Canada geese on Columbia River islands.[82] No studies have been made on the Hanford Reservation to determine the population densities or movements of the coyote, but an aerial patrol maintained for the ALE Reserve keeps casual coyote sightings recorded; the number of sightings doubled in recent years compared to 1969-1970.

The relative freedom from "people use" makes the Hanford Reservation an attractive nesting refugium for large raptors. A scarcity of suitable places to build nests is one of the reasons for low density nesting populations of Swainson's and red-tailed hawks.[83] Marsh hawks, sparrow hawks, prairie falcons, burrowing owls and great-horned owls are known to nest on the Hanford Reservation. The golden eagle, bald eagle and osprey frequent the Hanford Reservation in winter as a foraging ground.

The mule deer and the Canada goose are the most important game species that use the Hanford Reservation as a breeding ground. Both rely heavily upon the relative security of the islands in the Columbia River as a sanctuary for rearing young. Over the past four years 180 mule deer fawns were tagged near the Columbia River and released; 17 tags were returned from legal kills and road kills, etc., some from more than 40 miles from the tagging site.[91] A 21-yr history of Canada goose nesting on the islands was summarized recently.[82] A recent decline in numbers was attributed to coyote predation during nesting. Over the study period, Hanford's nesting geese had 97.4% fertility, equal to or better than other nesting areas.

II.3.11.11 Food Webs

The dynamic interplay of the many organisms in an ecosystem can best be grasped by considering the rates and routes of energy transfers between species--the "fate and effects" of food in the ecosystem. The following is a synthesis of ecological transfers on the Hanford Reservation, based on a few representative organisms and interactions, beginning with potential transfers to man, then considering a nonanthropocentric ecosystem.

II.3.11.11.1 Transfers to Man

Historically, the unmodified steppe ecosystem of southern Washington provided relatively little food to man. Indian tribes relied mostly upon the Columbia River fishes as a food base. Apparently, steppe vegetation did not support bison nor antelope herds.

Livestock grazing is not widely practiced; mule deer forage to some extent upon steppe vegetation but rely mostly upon riparian vegetation for food and cover. Since deer are mobile animals, some animals that are born on the Reservation are harvested off the Reservation by hunters. The chukar partridge is the most abundant upland game bird that can subsist on the food and cover provided by unmodified steppe vegetation. Although chukar partridges are not hunted on the Reservation, hunting is common in the Rattlesnake Hills, Yakima Ridge and the Saddle Mountains.

Ducks and geese are the more important biota with potential of contributing to the food chain to man. Hunting is not permitted on the Reservation, which serves as a refugium for ducks and geese during the hunting season. During the peak week of use in 1972, 1,100 ducks and geese were on ponds,[92] and 70,000 were on the Hanford reach of the Columbia River.

II.3.11.11.2 Food Webs in a Steppe Ecosystem

Figure II.3-42 shows a web of energy and nutrient transfers centering on cheatgrass. Although inadvertently introduced to the region, this grass is well adapted to the Hanford climate; physiologically, it is geared for growth under the cool conditions concurrent with Hanford's wet season. Consequently, green cheatgrass appears (as seedlings) when few perennials are growing, making it desirable forage for a wide variety of animals, including mule deer, coyotes, and

7 0 9 0 1 6 8 1 1 6

chukars. Mature cheatgrass seeds form important food sources for pocket mice and birds. The dead leaves and stems support a large number of microbiota, including mites, insects, nematodes and fungi. Figure II.3-42 demonstrates the motivation for discussing food webs rather than chains, because typically a consideration of "who eats whom" will result in many linked transfers rather than a simple linear cascade of matter and energy through the ecosystem. Similar webs could be constructed around each plant species on the Reservation.

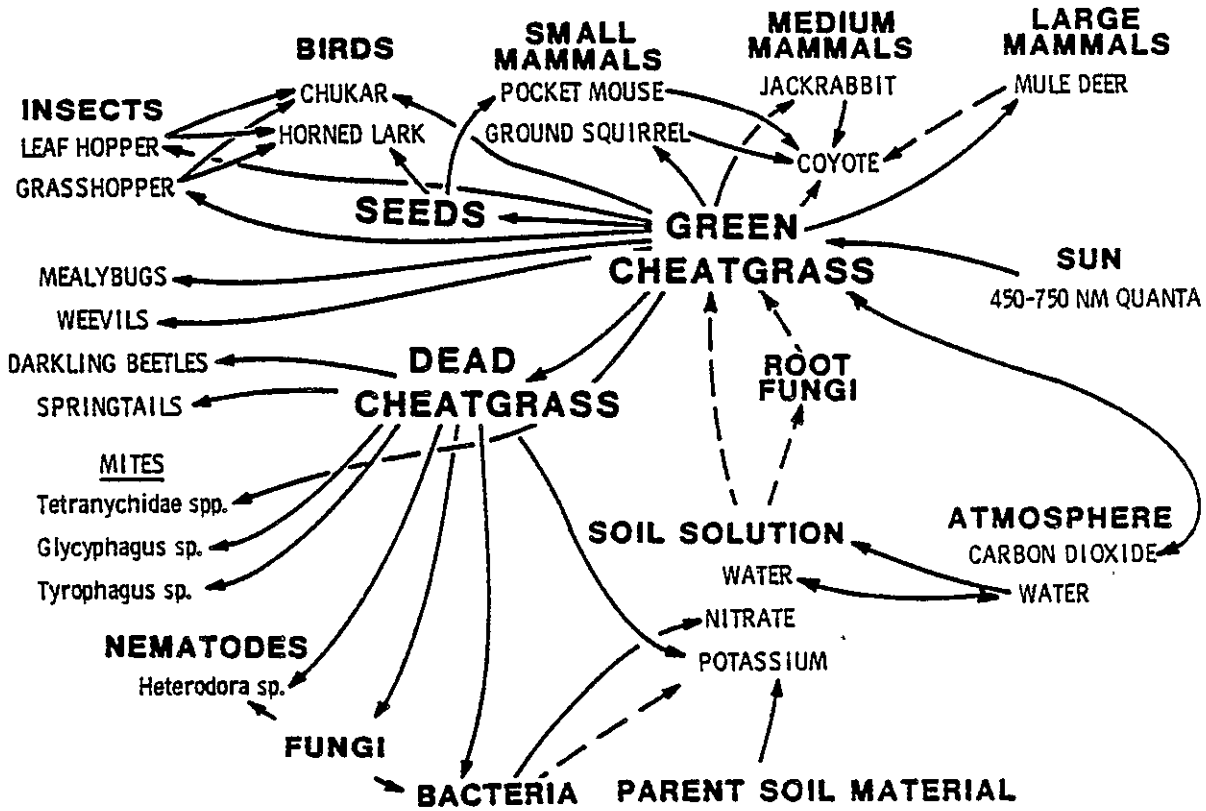

FIGURE II.3-42 FOOD WEB CENTERED ON CHEATGRASS

The edges of all food webs involve the same top carnivores--coyotes, eagles, owls, and so on --and all webs have a transfer into the microbiota, indicated by the transfer to fungi and bacteria. Microbiota are critical for continuous functioning of an ecosystem, but generally they are difficult to discuss with the same degree of concreteness as the larger organisms, because they are numerous, small, transient, hard to identify, and difficult to observe in action.

II.3.11.12 Ecological Research Results and Availability

The preceding pages summarized some aspects of the ecological systems of the Hanford Reservation; more could be written based on the many years of research at Hanford. A current and complete bibliography of journal articles, annual reports, Battelle documents and other writings by the staff of the Ecosystems Department is available.[93] Many of the references in that bibliography devolve directly from ecological research on the Hanford Reservation.

Good bibliographies of world-wide publications concerning ecological aspects of radioactive waste management are available, both for radioactive waste in general[94] and for transuranics[95] specifically.

II.3.12 Natural Radiation Background and Fallout Radioactivity

The natural radiation background has three components:

- naturally-occurring long-lived radionuclides, predominately ^{40}K, uranium, and thorium, and their radioactive daughters
- direct radiation from cosmic radiation and its secondaries
- nuclides formed by interaction of stable elements with high-energy radiation.

The latter occurs to a significant degree only with the lighter elements in the outer layers of the earth's atmosphere, but large scale atmospheric movements transport the radioactive species to the earth's surface. Tritium and ^{14}C are well-known products, but other nuclides such as ^{7}Be and ^{22}Na can readily be measured in ambient air. Superimposed on the natural radioactivity is residual fallout from atmospheric weapons testing, mostly tritium and fission products with half-lives of a year or more, (e.g., ^{90}Sr, ^{106}Ru, ^{137}Cs, U, and ^{239}Pu.) All of these radionuclides are undoubtedly present in all surface environmental media, but even unusually good radioanalyses will show measurable concentrations of only a few of the many possible nuclides. Direct radiation at the earth's surface also reflects the combined inventory from all the given sources.

Measurements of background radioactivity in air tend to be quite variable in space and time. (Variability and ranges of measurement are given in Table II.3-7.) Major factors affecting these measurements include:

- distance from soil or ore bodies containing uranium and thorium
- altitude (or depth)
- seasonal movements of large air masses
- occurrence of precipitation
- persistence of atmospheric stability.

TABLE II.3-7

CONCENTRATIONS OF RADIONUCLIDES IN SURFACE AIR AT RICHLAND, WASHINGTON, 1972

(Background, Fallout and Hanford Contributions)

Nuclide	(10^{-3} pCi/m^3)	Nuclide	(10^{-3} pCi/m^3)
^{7}Be	45-90	^{110m}Ag	0.002-0.05
^{22}Na	0.005-0.03	^{124}Sb	0.005-0.05
^{40}K	0.23-1.8	^{125}Sb	0.4-2
^{46}Sc	0.0005-0.01	^{129}I	3.8×10^{-5}-38×10^{-5}
^{54}Mn	0.04-0.22	^{134}Cs	0.03-2
^{57}Co	0.01-0.1	^{137}Cs	2-9
^{58}Co	0.005-0.5	^{140}Ba	0.05-9
^{60}Co	0.005-0.1	^{144}Ce	2-30
^{65}Zn	0.005-0.1	^{155}Eu	0.0005-0.005
^{88}Y	0.005-0.04	^{226}Ra	0.004-0.03
^{90}Sr	0.5-5	^{232}Th	0.01-0.2
^{95}Zr	1.4-45	^{238}Pu	0.01-0.2
^{103}Ru	0.5-32	^{239}Pu	0.01-0.2
^{106}Ru	2.2-14		

6 0 9 0 1 6 8 1 1 6

The Hanford site, at approximately 45° N. latitude and with elevations from about 300 to 700 feet above MSL, shows less than average (for the U.S.) cosmic radiation. Some indications of small, naturally-occurring uranium and thorium sources are present, mainly as elevated concentrations of radon and thoron daughters during atmospheric inversions. The arid climate tends to minimize the amount of fallout nuclides accumulated in local soils.

II.3.12.1 Direct Radiation

For the last several years the contribution of fallout to the direct radiation has decreased to the point where it constitutes on the average less than 7% of the total terrestrial exposure.[36] The whole-body external dose in the vicinity of Hanford was estimated recently[38] as 75 to 92 mrem per year.

II.3.12.2 Air

A particulate air sample collected in eastern Washington and counted immediately upon collection would yield predominately radon daughters; RaA, RaB, RaC, and RaC.[1] If allowed to decay for one week, the radon daughters would go through several half-lives and be much less dominant. Shown in Figure II.3-43 is the range of radionuclides measured in airborne particulates with a high-volume sample at Richland, Washington from 1962 through 1972. This chart also shows the timing of atmospheric tests of nuclear weapons in relation to the measured air concentrations at Richland, as well as the weapon yield in megatons. Plutonium-238 and $^{238}Pu/^{239}Pu$ ratios show the influence of a ^{238}Pu source contained in a space vehicle which burned in the atmosphere in 1967.

II.3.12.3 Columbia River

Table II.3-8 shows the background and fallout nuclides found[38] in the Columbia River upstream from Hanford at Priest Rapids Dam in 1972. Uranium concentrations in the river, for which the alpha activity concentrations are an approximation, may have been affected over the long term by such human activities as mining, dam construction, and irrigation, but the local record does not so indicate.

TABLE II.3-8

CONCENTRATIONS OF RADIONUCLIDES IN COLUMBIA RIVER WATER UPSTREAM FROM HANFORD, 1972

(10^{-9} µCi/ml)

Radionuclide	Analy. Limit	Vernita Max.	Vernita Min.	Vernita Avg.
Alpha	0.3	0.74	0.30	0.54
^{3}H	220.	1400	*	*
^{46}Sc	25	*	*	*
^{51}Cr	20	20	*	*
^{60}Co	15	0.30	*	*
^{65}Zn	2	2.0	*	*
^{90}Sr	0.5	2.8	*	0.50
^{131}I	1.0	5.2	*	1.2
^{137}Cs-^{137m}Ba	3.0	*	*	*
^{239}Pu	0.01	0.03	*	*

* Less than the analytical limit shown

II.3.12.4 Groundwater

Naturally occurring radionuclides noted in wells in the Hanford region are ^{40}K and members of the uranium and thorium series. Tritium in the groundwater can be detected near areas of surface recharge occurring since 1955, but in older groundwater, concentrations are less than 10 pCi/ℓ.

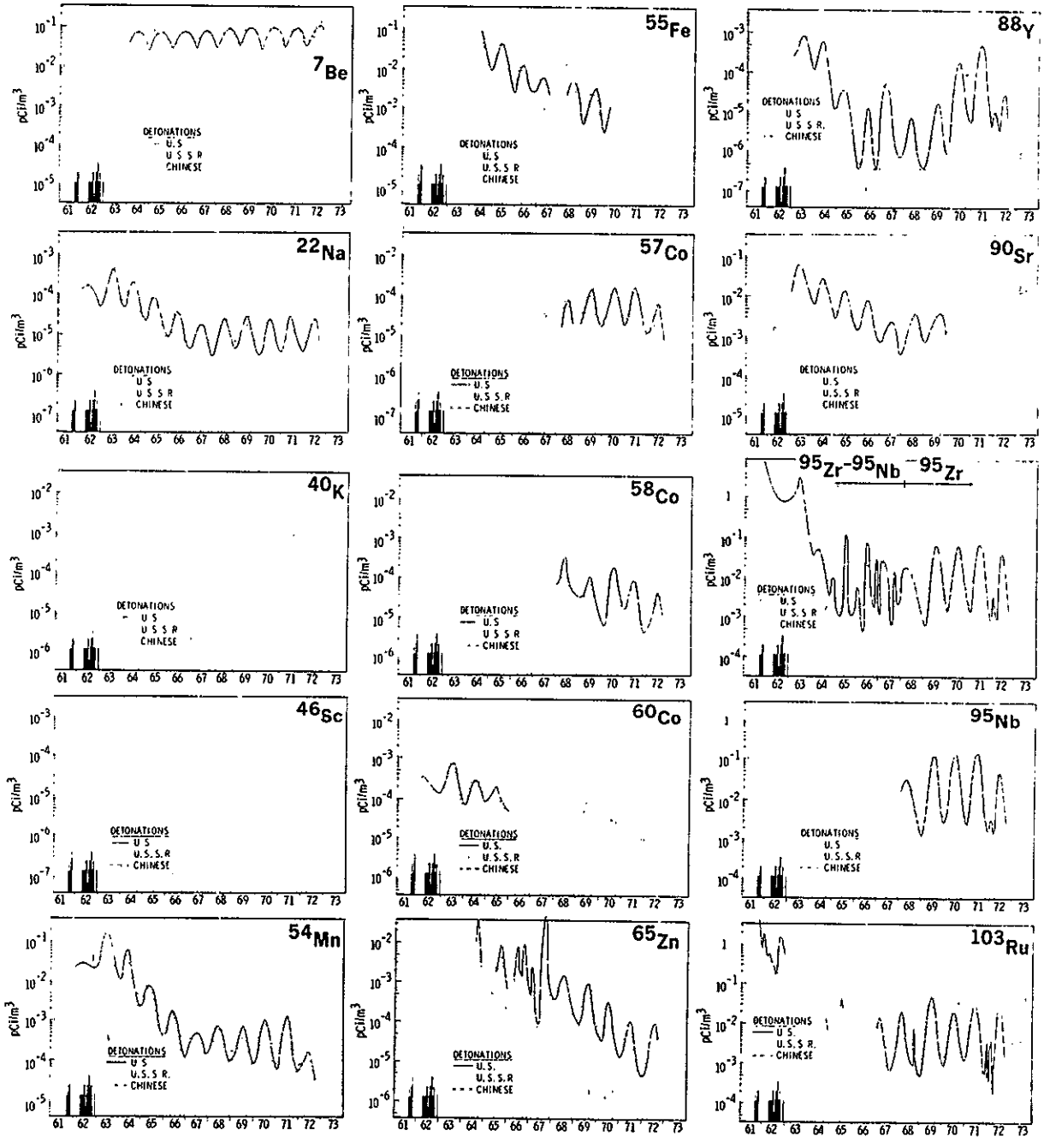

FIGURE II.3-43a RADIONUCLIDE CONCENTRATION IN SURFACE AIR AT RICHLAND, WASHINGTON. (Background, Fallout and Hanford Contributions)

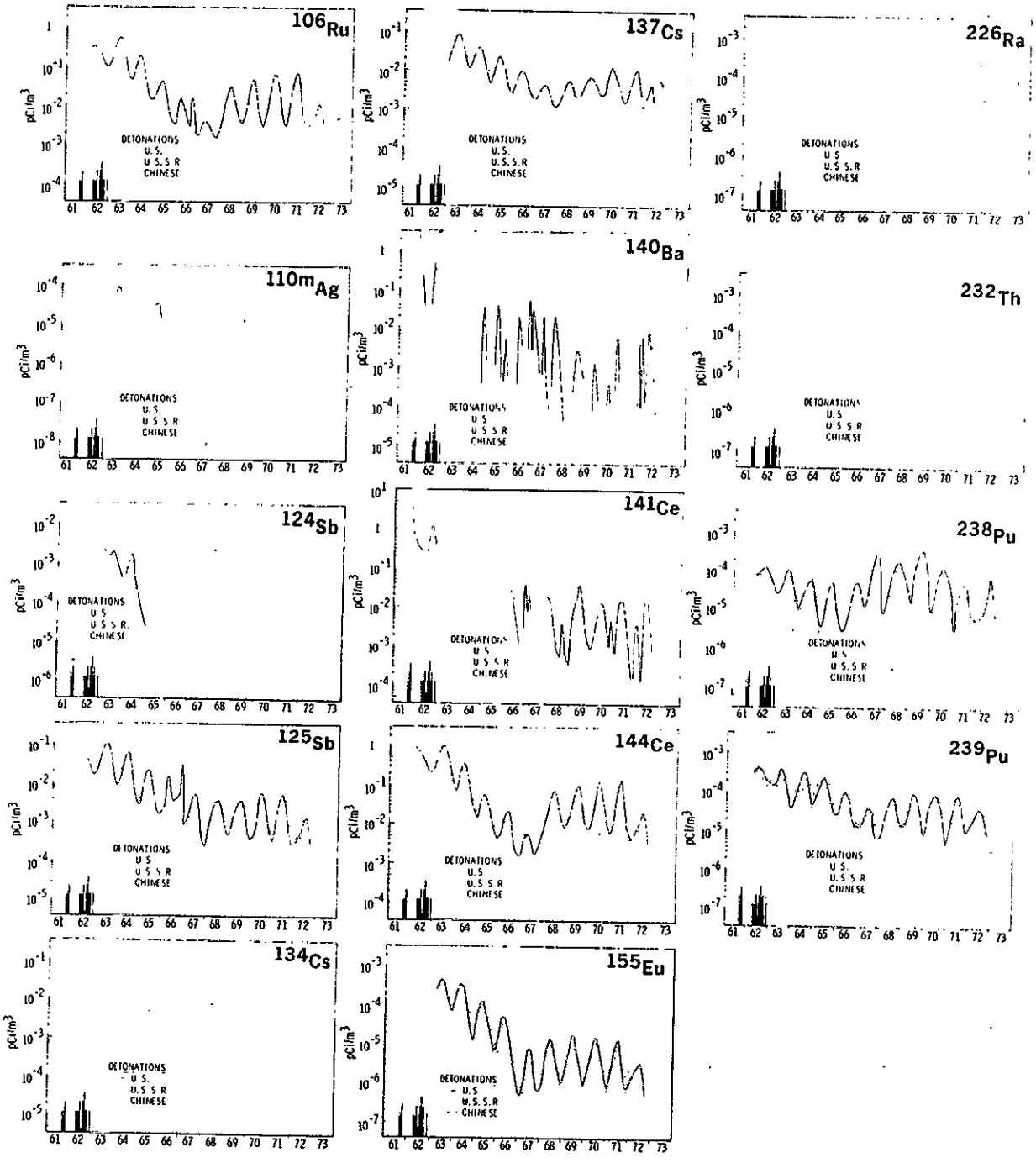

FIGURE II.3-43b RADIONUCLIDE CONCENTRATION IN SURFACE AIR AT RICHLAND, WASHINGTON. (Background, Fallout and Hanford Contributions)

II.3.12.5 Vegetation

For the purpose of this report the vegetation is split into two categories:

- food chains leading to man
- natural vegetation not normally eaten by local livestock.

Table II.3-9 gives the values for nuclides found in both categories during 1972 in the general Hanford area.[38]

TABLE II.3-9

RADIOACTIVITY CONCENTRATIONS IN VEGETATION NEAR HANFORD - 1972

(pCi/g - dry weight)

Nuclide	Leafy Green Composite	Natural Vegetation	Grass
^{40}K	24-5.0	2.7-21	1.6-19
^{54}Mn	NA	NA	<0.009-0.12
^{60}Co	NA	<0.04-0.09	<0.001-0.02
^{65}Zn	<0.08	NA	<0.03
^{88}Y	NA	NA	<0.008-0.02
^{89}Sr	0.004-0.008	NA	NA
^{90}Sr	0.008-0.003	0.02-2.1	NA
$^{95}ZrNb$	0.04-0.14	0.14-2.1	<0.1-4.3
^{106}Ru	<0.08-1.0	<0.4-5.7	<0.06-4.9
^{125}Sb	NA	NA	<0.04-0.71
^{137}Cs	<0.04-0.09	<0.24-5.8	0.14-4.7
^{144}Ce	<0.35	<0.4-4.4	<0.4-7.7
^{155}Eu	NA	NA	<0.01
^{226}Ra	NA	NA	0.1-0.5
^{232}Th	NA	NA	0.02-0.8
^{239}Pu	NA	0.001-0.010	NA
U_{nat}	NA	0.01-0.23	NA

NA - Not Analyzed

II.3.12.6 Sediments

Radionuclide concentrations are given in Table II.3-10 for samples collected near or on the Hanford site during 1972. The Columbia River sediment samples for which dates are given were collected behind Priest Rapids Dam upstream from the Hanford site.

TABLE II.3-10

RADIOACTIVITY IN THE COLUMBIA RIVER
SEDIMENT UPSTREAM FROM HANFORD - 1972

(pCi/g - dry weight)

Nuclide	Sediment
^{40}K	20 → 30
^{54}Mn	1
^{60}Co	1
^{65}Zn	1
^{137}Cs	1 - 6

II.3.12.7 Miscellaneous Foodstuffs

Miscellaneous foodstuff items[38] are collected locally and should be representative of the Hanford area. Radioactivity in gamebirds and food animals collected near Hanford in 1972 is given in Table II.3-11. Radioactivity for 1972 in milk and eggs, collected from both commercial sources as well as local irrigated farms, is shown in Table II.3-12; measurable radioactivity is attributed to non-Hanford sources.

TABLE II.3-11

RADIOACTIVITY IN GAMEBIRDS AND FOOD ANIMALS NEAR HANFORD, 1972

(pCi/g - wet weight)

Animal	^{32}P	^{40}K	^{60}Co	^{90}Sr	^{137}Cs	^{239}Pu
Whitefish	<1-1.8	26-4.9	<0.15-0.18	<0.002-0.003	<0.10-0.22	<0.003-0.008
Ducks	NA	<2.4-4.9	<0.15-0.24	<0.002-0.009	<0.10-1.2	<0.003-0.008
Geese	NA	2.4-4.7	<0.15	<0.002-0.017	<0.10-0.97	
Pheasant	NA	<1.8-3.2	<0.15	<0.002-0.006	<0.10-0.15	NA
Chicken	<1	2.0-2.8	NA	<0.002-0.004	<0.03-0.04	
Beef	NA	1.5-2.8	<0.15	<0.002-0.006	<0.02-0.08	NA

NA - Not Analyzed

TABLE II.3-12

RADIOACTIVITY IN LOCAL MILK AND EGGS, 1972[38]

(pCi/ℓ - milk; pCi/g - eggs)

Item	^{40}K	^{89}Sr	^{90}Sr	^{131}I	^{137}Cs
Milk	0.74-1.9	<0.002-0.002	<0.002-0.005	<0.002	<0.03-0.05
Eggs	0.8-1.4	NA	0.002-0.03	NA	<0.03-0.04

NA - Not Analyzed

II.3.13 Radiological Status of the Hanford Site and Environment

Radiological surveillance of the Hanford environment began with the first reactor startup in 1944 and has played a significant role, not only in evaluation the adequacy of waste management, but also in providing significant scientific data not otherwise available. Although the relative emphasis has shifted through the years and there has been significant interaction,

these two purposes have largely been met by a separate operational surveillance program and a series of special scientific studies. The latter have generally been published in the open literature[63] as well as in topical reports or in annual reports to sponsoring AEC (ERDA) Divisions. In recent years, the routine surveillance program results have been documented and published in a series of annual reports of radiological conditions in the site environment[38] and of the radiological status of the Hanford site;[97] the status of the groundwater beneath the Hanford site has been documented separately in semiannual reports.[52] The following sections include extracts from 1972 reports; data from the most recent report (1974) are included in Appendix III-G.

Although the emphasis here is on 1972 measurements, these data reflect the residual accumulated effects of almost 30 years of Hanford operations.

II.3.13.1 Columbia River

N Reactor, the only production reactor remaining in operation at Hanford during 1972, uses recirculating, demineralized water as a primary coolant. Wastewater containing some radioactive material is discharged to the ground in the 1301-N Crib. Many of the radionuclides are short-lived and disappear quickly due to radioactive decay before reaching the Columbia River; others are largely absorbed on soil particles and retained in the soil.

Some residual long-lived activity from previous single-pass reactor operation is still measurable where sediments are accumulated. Scouring by high river flows of these sediments, including those deposited in reservoirs behind each downstream dam, causes seasonal fluctuations in transport rates of those longer-lived nuclides associated with the sediments.

Table II.3-13 shows the maximum, minimum, and annual average radionuclide concentration in Columbia River water upstream of the Hanford site at Vernita and downstream at Richland for 1972.[38] The average radionuclide concentrations were less than 1% of the Concentration Guides (CG) for water for all the radionuclides in Table II.3-13. Except the 2.2% of the CG for an unknown mixture of alpha-emitters. Table II.3-14 shows river transport rates for 1972 of five radionuclides at Richland and at Bonneville Dam, approximately 490 km (240 miles) below the N Reactor. This is the farthest downstream location where river water is routinely sampled as part of the Hanford Environmental Surveillance Program; measurements at this location approximate the annual transport of specific nuclides into the Pacific Ocean. More sensitive high volume measurements for several radionuclides were made at McNary Dam, the first dam downstream from the plant, as part of a special study of the changing inventories of radionuclide content and transport in river sediments following the shutdown of the old single-pass, water-cooled reactors. This data is tabulated in Table II.3-15.

An inventory of radionuclides from Hanford reactors present in the Columbia River and Pacific Ocean was estimated for the year 1970, before the last of the direct-cooled plutonium production reactors was shut down and at a period when shorter-lived activation products (^{24}Na, ^{32}P, ^{46}Sc, ^{51}Cr, ^{56}Mn, ^{76}As) were prevalent in the reactor effluents. This estimate[98] was based on extrapolation backward from river transport data at Richland.[40] By the end of 1972, virtually all of the shorter-lived nuclides had disappeared, although a residual of about 1000 Ci of ^{65}Zn (half-life of 8 months) remained. In addition, some 4000 Ci of ^{60}Co and 2000 Ci of ^{152}Eu are estimated to still have been present in the aquatic environment, along with about 30,000 Ci of tritium and 10,000 Ci of ^{99}Tc and less than 1000 Ci of all other nuclides. Of special interest is the estimated inventory of one to two curies of ^{239}Pu from the decay of short-lived ^{239}Np in the reactor effluents. Virtually all of the tritium and most of the other radioactivity were transported via the river and was distributed over thousands of square miles of ocean. Estimates of the environmental inventory from Hanford operations are currently being reviewed and the quantities given here are subject to change; however, these estimates are believed to provide upper limits.

Research studies sponsored by the AEC (ERDA) at the University of Washington and Oregon State University have, among many other objectives, been addressed to the distribution, fate, and significance of radionuclides of Hanford origin in the Columbia River estuary and the Pacific Ocean and its connecting bodies of water. The results of these studies were published in a number of graduate theses and scientific papers[99,100] as well as in a series of annual progress reports. Perhaps the best summary of this work through 1971 is given in a collection of articles in Reference 101. Several contributors to this volume noted the usefulness of the low concentration of radioactivity in the river water as radioactive tracers for their investigations. Documentation is provided for 1) the seasonal changes in distribution of Columbia River water and associated sediments in the ocean, with prevailing northward drift in the winter and southeastward in the summer, 2) the dominance of ^{51}Cr and ^{65}Zn in the measurable radioactivity during the years of direct-cooled reactor operation, and 3) some data on concentration factors for these and other nuclides in shellfish and other marine biota.

9 1 1 3 9 1 0 6 1 5

TABLE II.3-13

CONCENTRATIONS OF RADIONUCLIDES IN COLUMBIA RIVER WATER FOR 1972
(10^{-9} µCi/ml)

	VERNITA						
Radionuclide	Analy. Limit	No. of Samples	Max.	Min.	Avg.	Percent of C.G.	C.G.
Alpha	0.3	12	0.74	0.30	0.54	1.8	30
^{3}H	220	12	1400	*	*	0.003	3,000,000
^{46}Sc	25.	5	*	*	*	<0.01	40,000
^{51}Cr	20.	5	20.	*	*	<0.01	2,000,000
^{60}Co	15.	5	0.30	*	*	<0.01	17,000
^{65}Zn	2.	5	2.0	*	*	<0.01	100,000
^{90}Sr	0.5	12	2.8	*	0.50	0.17	300
^{131}I	1.0	5	5.2	*	1.2	0.4	300
^{137}Cs-^{137m}Ba	3.0	8	*	*	*	<0.01	20,000
^{239}Pu	0.01	4	0.03	*	*	0.0005	1,700

	RICHLAND						
Radionuclide	Analy. Limit	No. of Samples	Max.	Min.	Avg.	Percent of C.G.	C.G.
Alpha	0.3	12	0.92	0.48	0.67	2.2	30
^{3}H	220	12	1300	*	*	0.003	3,000,000
^{32}P	6.	11	*	*	*	<0.02	20,000
^{46}Sc	25.	53	*	*	*	<0.01	40,000
^{51}Cr	300	53	700	*	*	0.005	2,000,000
^{60}Co	15.	53	42.	*	*	<0.02	17,000
^{65}Zn	2.0	4	2.0	*	*	<0.01	100,000
^{90}Sr	0.5	13	0.55	0.12	*	0.12	300
^{131}I	6.0	26	6.4	*	*	<0.03	300
^{137}Cs-^{137m}Ba	3.0	7	*	*	*	<0.01	20,000
^{239}Pu	0.01	4	0.06	*	*	0.001	1,700

* Less than the analytical limit shown.
No entry indicates no specific analysis was made.

TABLE II.3-14

ANNUAL AVERAGE TRANSPORT RATES OF SELECTED RADIONUCLIDES IN THE COLUMBIA RIVER AT RICHLAND AND AT BONNEVILLE DAM, 1972

(Ci/day)

	Richland			Bonneville Dam
	Max.	Min.	Avg.	
^{46}Sc	<15.	0	<1.7	<0.1
^{51}Cr	340	0	<36	--
^{60}Co	42	0	<3.9	--
^{65}Zn	28	0	<3.1	<1
^{131}I	1.7	<0.04	<0.35	--

TABLE II.3-15

ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN COLUMBIA RIVER AT McNARY DAM, 1972

(10^{-12} μCi/mℓ)

	^{60}Co	^{65}Zn	^{137}Cs	^{54}Mn
Filterable	180	190	132	39
Non-Filterable	18	24	16	22
Total	198	214	148	61

As a result of these studies, shellfish from the Willapa Bay location were identified as the critical exposure pathway for Hanford effluents reaching the estuary; sampling of these were incorporated in the Hanford Environmental Surveillance Program. As reported in annual surveillance reports, radioactivity in these shellfish has decreased since 1970 at approximately the rate indicated by the radioactive half-life.

II.3.13.1.1 Columbia River Bed Contamination Studies

The radionuclide discharges in the cooling-water effluent of the original single-pass reactors on the Hanford Reservation were formed by neutron activation of 1) impurities in the Columbia River water used to cool the reactors, 2) corrosion products from reactor components, and 3) chemicals used in the water treatment process. In the river the radionuclides were associated with sediment and biota or remained in solution and subsequently were distributed downstream throughout the river system and the Columbia River estuary to the Pacific Ocean. The most abundant radionuclides found in the sediments are ^{54}Mn, ^{60}Co, ^{65}Zn, ^{137}Cs, and ^{152}Eu and ^{154}Eu, although at one time ^{46}Sc and ^{51}Cr were major components. Studies[32] show that radionuclide concentrations are somewhat related to particle sizes of the sediments.

II.3.13.1.2 Radioactivity in Drinking Water

The city of Richland, about 75 km (45 miles) downstream from N Reactor, is the first community below the Hanford site that uses the Columbia River as a source of drinking water. Pasco and Kennewick, a few miles further downstream, also use the Columbia River as a source of drinking water. The Richland and Pasco water plants use a modern flocculation-filtration treatment method; water for Kennewick is pumped from Raney Well collectors (infiltration pipes) laid in the riverbed.

During 1972, cumulative and grab drinking water samples were collected at the Richland water plant and were analyzed[38] for selected individual radionuclides and gross beta activity (Table II.3-16). Average radionuclide concentrations in Richland drinking water samples, except for total alpha, were much less than 1% of the CG. The estimated annual GI tract dose for the average Richland resident from the consumption of drinking water derived from the Columbia River

7 1 9 0 1 9 6 1 1 1 6

was <0.1 mrem. Radionuclide concentrations in drinking water at 100-H were also measured in 1972 during occupancy by non-AEC contractor personnel; the calculated GI tract dose from this source was estimated as 3.2 mrem.

TABLE II.3-16

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN RICHLAND DRINKING WATER - 1972
(10^{-9} µCi/mℓ)

Radionuclide	Analytical Limit	# of Samples	Concentration Max.	Min.	Avg.	% of Concentration Guide
Alpha	0.67[a]	53	3.9	*	0.71	2.4[a]
Beta[b]	0.220	53	0.360	*	*	<0.01
^{46}Sc	23.	53	37.	*	*	<0.01
^{51}Cr	300.	53	420.	*	*	<0.01
^{60}Co	20.	53	39.	*	*	<0.01
^{65}Zn	35.	53	84.	*	*	<0.01
^{90}Sr	0.4	12	0.38	*	0.22	<0.07
^{137}Cs-^{137m}Ba	0.6	53	49.	*	*	<0.01

(a) Concentration Guide for an unknown mixture not including plutonium.
(b) Concentration Guide 2,000,000.
* Less than the analytical limit.

II.3.13.2 Ditches and Ponds

Radionuclide concentrations in samples collected from open waters on the Hanford Reservation during 1972 were below 5 x 10^{-5} µCi/mℓ. Table II.3-17 shows average 1972 concentrations for open ponds on the Hanford site as determined by routine samples.

TABLE II.3-17

GAMMA ACTIVITY IN WASTE WATER SAMPLES - 1972
(10^{-9} µCi/mℓ)

Location	Date	^{46}Sc	^{51}Cr	^{60}Co	^{65}Zn	$^{95}ZrNb$	$^{106}RuRh$	^{137}Cs	$^{140}BaLa$	$^{144}CePr$
West Lake	6/2	*	*	*	*	*	*	*	*	*
	10/13	*	*	*	*	*	*	*	*	*
Gable Pond	1/14	*	*	*	*	*	*	9.4	*	*
	4/7	*	*	*	*	*	*	37.	*	*
	7/7	*	*	*	*	*	*	90.	*	*
	10/13	*	*	*	*	*	*	32.	*	*
B Pond	1/14	*	*	*	*	59.	*	*	*	*
	4/7	*	*	*	*	*	*	*	*	*
	7/7	*	*	*	*	*	*	*	*	*
	10/13	*	*	*	*	*	*	*	*	*
T Pond	1/14	*	*	*	*	*	*	35.	*	*
	4/7	*	*	*	*	*	*	*	*	*
	7/7	*	*	*	*	*	*	*	*	*
S Pond	1/14	*	*	*	*	*	*	62.	*	*
	4/7	*	*	*	*	*	*	40.	*	*
	7/7	*	*	*	*	*	*	170.	*	*
	10/13	*	*	*	*	*	*	*	*	*
U Pond	1/14	*	*	*	*	*	*	*	*	*
	4/7	*	*	*	*	*	*	*	*	*
	7/7	*	*	*	*	*	*	220.	*	*
	10/13	*	*	*	*	*	*	*	*	*
Redox Pond	1/14	*	*	*	*	*	*	*	*	*
	4/7	*	*	*	*	*	*	*	330.	*
	7/7	*	*	*	*	*	*	*	*	*
216 B 63 Ditch	1/14	*	*	*	*	*	*	*	*	*
	4/7	*	*	*	*	*	*	*	*	*
	7/7	*	*	*	*	*	*	*	*	*
	10/13	*	*	*	*	*	*	*	*	*
331 Pond	1/11	*	*	*	*	*	*	*	*	*
	4/4	*	*	*	*	*	*	*	*	*
	7/11	*	440.	*	*	*	*	*	*	*
	10/10	*	*	*	*	*	*	*	*	*

*Less than analytical limit.

II.3.13.3 Airborne Radioactivity

Tables II.3-18 through 21 give a summary of 1972 data for radioactivity in air at and near the Hanford site. Concentrations of ^{131}I in the atmosphere, measured in charcoal samples, were below 2×10^{-14} µCi/mℓ.

TABLE II.3-18

RADIOACTIVITY IN AIR AT HANFORD ONSITE LOCATIONS - 1972

(10^{-12} µCi/mℓ)

	Beta			^{131}I			Alpha		
Analytical Limit	0.02			0.02			0.001		
Location	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
200 ENC	30.	0.19	4.6	*	*	*	0.060	*	0.004
200 ESE	0.56	0.014	0.294	0.062	*	*	0.012	*	0.002
200 WEC	0.69	0.029	0.228	*	*	*	0.053	*	0.003
Redox	0.58	0.043	0.220	0.043	*	*	0.005	*	0.002
300 Area	0.70	0.016	0.138	0.112	*	*	0.008	*	0.002
ACRMS	1.2	*	0.124	*	*	*			
100-K	0.48	*	0.147						
100-N	0.40	0.023	0.130	0.073	*	*	0.007	*	0.002
100-D	0.46	0.018	0.128						
100-H	0.53	*	0.144				0.008	*	0.002
100-F	0.51	0.022	0.124						
Hanford	1.7	0.015	0.212				0.010	0.001	0.002
Wye Barricade	0.55	0.089	0.243	*	*	*	0.005	*	0.002
Rattlesnake	0.66	0.062	0.187						
ERC	0.41	0.046	0.163						
Yakima Barricade	0.62	0.069	0.189	*	*	*	0.005	0.001	0.002
Vernita	0.36	0.013	0.158						
Wahluke #2	0.43	0.016	0.165						

*Less than the analytical limit.
No entry indicates no analysis was performed.

TABLE II.3-19

ANNUAL AVERAGE CONCENTRATIONS OF SELECTED RADIONUCLIDES IN AIR AT HANFORD ONSITE LOCATIONS - 1972

(10^{-12} µCi/mℓ)

	^{90}Sr	$^{95}ZrNb$	$^{106}RuRh$	^{134}Cs	^{137}Cs-^{137m}Ba	$^{140}BaLa$	$^{144}CePr$	Total Pu
Concentration Guides	200	1000	200	400	500	1000	200	1
Active Areas								
Active Area #1	0.021	0.68	*	0.06	3.1	0.61	*	0.00004
Active Area #2	0.003							0.0002
Active Area #3	0.003	0.044	0.16	*	0.049	0.053	0.035	0.0001
Active Area #4	0.001	0.024	0.20	*	0.004	0.047	0.042	0.000004
Active Area #5		0.027	0.24	0.007	0.01	0.13	0.055	
Inner Ring								
Inner SW Quadrant	0.002	0.032	0.26	*	*	*	0.038	0.00003
Inner NW Quadrant	0.001	0.030	0.22	*	0.005	*	0.032	0.000009
Inner East Quadrant	0.001	0.036	0.27	*	0.012	*	0.042	0.00006
Inner NE Quadrant	*	0.035	0.24	*	*	*	0.037	0.00002
Inner SE Quadrant	0.001	0.027	0.26	*	*	*	0.044	0.00002

*Less than the analytical limit.

TABLE II.3-20

RADIOACTIVITY IN AIR AT HANFORD OFFSITE LOCATIONS - 1972
(10^{-12} μC/mℓ)

	Gross Alpha				Gross Beta				^{131}I			
Analytical Limit		0.001				0.02				0.07		
Concentration Guide		0.03				100				100		
Eastern Quad.	Max.	Min.	Avg.	% CG	Max.	Min.	Avg.	% CG	Max.	Min.	Avg.	% C.G.
Othello	.006	*	.002	6.6	.44	.03	.18	.18	*	*	*	<1
Wahluke W.M.					.50	.01	.14	.14	*	*	*	<1
Connell					.58	.01	.16	.16	*	*	*	<1
New Moon		*			.46	.03	.16	.16	.043	*	*	<1
Eltopia					.40	.04	.15	.15				
Pasco	.005	*	.002	6.6	.35	.03	.17	.17	*	*	*	<1
Kennewick					.44	.03	.16	.16				
Richland	.005	.001	.002	6.6	.43	.04	.17	.17	*	*	*	<1
Berg Ranch	.006	*	.002	6.6	.92	.03	.22	.22	.056	*	*	<1
Ringold	.006	.001	.002	6.6	.57	.03	.18	.18	*	*	*	<1
Byers Landing	.006	.001	.002	6.6	.45	.05	.16	.16	.071	*	*	<1
Perimeter Communities												
Sunnyside					.37	.01	.12	.12				
Ellensburg					.20	.02	.10	.10				
Moses Lake					.35	.03	.14	.14				
Washtucna					.42	.06	.16	.16				
Walla Walla	.004	*	.001	3.3	.45	.02	.15	.15				
McNary Dam	.006	.001	.002	6.6	3.6	.04	.29	.29				
Western Quad.												
Yakima Barr.	.005	.001	.002	6.6	.62	.07	.19	.19	*	*	*	<1
Vernita					.36	.01	.16	.16				
Wahluke #2					.43	.02	.16	.16				
ERC					.41	.05	.16	.16				
Rattlesnake Spr.					.66	.06	.19	.19				
Benton City	.005	*	.002	6.6	.41	.04	.17	.17	*	*	*	<1

* Less than the analytical limit.
No entry indicates no analysis was made.

TABLE II.3-21

AVERAGE CONCENTRATIONS OF SELECTED RADIONUCLIDES IN AIR, QUARTERLY AVERAGES - 1972
(10^{-12} μCi/mℓ)

	Average Gross Beta	^{90}Sr	% C.G.	Average Total Alpha	Pu Alpha	% C.G.
Concentration Guide	100	10		.03	.02	
Eastern Quad.						
Jan-March	.115	.001	.01	.002	.000005	.025
April-June	.281	.001	.01	.001	.000015	.075
July-Sept.	.181	.002	.02	.001	.000045	.225
Oct.-Dec.	.092	.0001	.001	.003	.000006	.03
Perimeter Communities						
Jan-March	.109	.001	.01	.002	.000006	.03
April-June	.309	.001	.01	.002	.00002	.1
July-Sept.	.146	.002	.02	.001	.00003	.15
Oct.-Dec.	.059	.001	.01	.002	.000025	.125

At most locations, both onsite and offsite, the average total beta particulate activity was similar to that of recent years, except that no pronounced summer peaking was observed. The maximum measured beta particulate activity, 3×10^{-11} µCi/mℓ, occurred in October at a 200 East Area fence-line location. Annual average beta particulate activity ranged between 1 and 2×10^{-13} µCi/mℓ and 2 to 3×10^{-13} µCi/mℓ in the 100 and 200 Areas, respectively. Offsite beta activity ranged from 1 to 3×10^{-13} µCi/mℓ and averaged about 2×10^{-13} µCi/mℓ. Total alpha concentrations in air during 1972 averaged about 2×10^{-15} µCi/mℓ at most locations. Analyses of composite samples all showed less than 10^{-16} µCi/mℓ plutonium. Table II.3-21 shows seasonal variations.

II.3.13.4 Soil and Vegetation

Plutonium concentrations in soil and vegetation at perimeter sampling locations in 1972 were typical of current general levels for the arid western states (Tables II.3-22 and 23). Cesium-137 was present in several onsite vegetation samples from near the 200 Areas at higher concentrations than at perimeter sites. Concentrations of gamma-emitting radionuclides and ^{90}Sr at perimeter sites are believed to be the result of regional fallout.

TABLE II.3-22

CONCENTRATIONS OF RADIONUCLIDES IN SOIL SAMPLES - 1972

(10^{-6} µCi/g)

Location	^{40}K		^{58}Co		^{60}Co		^{65}Zn		^{90}Sr		$^{95}ZrNb$		^{106}Ru	
	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.
Onsite														
W. of 100-N	16.	16.	.03	.11	.08	*	*	*	.04	.05	.29	.31	*	.89
331	16.	16.	*	.04	.11	*	*	*	.05	.06	.20	*	*	.84
FFTF	14.	14.	.07	.04	*	.11	.19	*	.05	.02	.29	.21	.51	.43
Wye Barricade	15.	17.	.03	*	*	*	*	*	.28	.18	.21	*	*	.60
Hanford	13.	14.	.06	*	.10	.10	*	*	.33	.26	*	.14	1.4	.49
100-F	11.	14.	.02	.03	*	*	*	*	.28	.10	*	*	1.2	1.2
200 Fire Station	14.	16.	.03	.03	*	*	*	*	.22	.11	.40	.20	.73	1.4
200-E Hill	15.	11.	*	*	*	*	*	*	.71	.30	*	.42	.53	*
Rt. 4x11A	16.	16.	*	*	*	*	*	*	.21	.05	*	*	.98	.59
Army Loop Road	12.	13.	*	*	*	*	*	*	.39	.05	.33	.38	1.4	.43
Average Onsite	14.	15.	.03	.03	.03	.03	.05	*	.26	.12	.22	.21	.73	.72
Perimeter														
Benton City	14.	14.	*	*	*	*	*	*	.38	.27	.27	*	*	1.6
ERC	16.	15.	*	*	.07	*	.18	*	.10	.03	*	*	1.5	.72
Rt. 240 CP54	14.	15.	*	*	.04	*	*	*	.20	.09	*	*	.81	*
Rattlesnake Springs	12.	14.	*	*	.10	*	*	*	.01	.03	*	*	.55	*
Yakima Barricade	13.	12.	*	*	*	*	*	*	.12	.11	.24	.04	*	*
Vernita	16.	16.	*	.041	*	.06	.10	*	.10	.04	.25	*	.57	.91
Wahluke #2	12.	14.	*	*	.04	*	*	*	.30	.13	*	.36	.48	*
Berg Ranch	12.	13.	*	.05	*	*	*	*	.20	.07	.25	.30	*	*
Ringold	16.	14.	.11	*	*	*	*	*	.12	.08	.54	*	1.3	*
Byers P.H.	20.	18.	*	*	*	*	*	*	.08	.09	1.2	.28	*	*
Byers Landing	18.	13.	*	*	*	*	*	*	.13	.18	.34	.13	*	*
Riverview	14.	13.	*	*	.15	*	*	*	.23	.17	*	*	.84	.70
North Richland	16.	14.	*	*	*	*	*	*	.32	.18	.23	*	2.2	*
Average Perimeter	15.	14.	.01	.01	.04	*	.02	*	.18	.11	.28	.12	.64	.36

Location	^{134}Cs		^{137}Cs		$^{144}CePr$		^{224}Ra		^{226}Ra		^{238}Pu		^{239}Pu	
	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.	1 in.	2 in.
Onsite														
W. of 100-N	*	.27	.65	.48	1.2	.76	2.1	1.6	*	.61	*	.006	.015	.022
331	*	*	.15	.25	.41	*	1.7	.88	.59	.62	*	.012	.003	.003
FFTF	.05	*	.13	.06	.39	*	1.0	1.2	*	.47	.004	.006	.005	.011
Wye Barricade	*	*	.76	.42	.79	1.3	1.5	2.4	.50	.79	.003	.005	.014	.016
Hanford	.18	.09	1.2	.31	.53	.89	.54	1.8	*	.56	.005	*	.024	.004
100-F	*	.06	.65	.41	.97	.74	1.6	1.3	*	.44	*	*	.009	.005
200 Fire Station	*	.06	.24	.29	.55	.80	1.2	2.4	.62	.64	*	*	.017	.012
200-E Hill	.08	.04	1.8	.14	.81	.75	.88	1.6	.55	.51	*	*	.023	.008
Rt. 4x11A	*	.07	.49	.30	.40	.51	2.1	2.4	.80	.59	*	*	.009	.009
Army Loop Road	*	*	1.4	.31	*	.84	1.3	3.2	.56	.88	*	.006	.021	.009
Average Onsite	.04	.06	.75	.30	.60	.68	1.4	1.9	.50	.61	.002	.004	.014	.010

*Less than the analytical limit.

TABLE II.3-22 (Continued)

Location	^{134}Cs 1 in.	^{134}Cs 2 in.	^{137}Cs 1 in.	^{137}Cs 2 in.	$^{144}CePr$ 1 in.	$^{144}CePr$ 2 in.	^{224}Ra 1 in.	^{224}Ra 2 in.	^{226}Ra 1 in.	^{226}Ra 2 in.	^{238}Pu 1 in.	^{238}Pu 2 in.	^{239}Pu 1 in.	^{239}Pu 2 in.
							Perimeter							
Benton City	*	.10	1.1	.84	1.3	1.4	1.6	1.8	.61	.55	*	*	.023	.011
ERC	*	.06	.04	*	.68	1.1	2.7	2.2	.69	.47	*	.011	.001	.013
Rt. 240 CP54	.04	.01	.51	.19	1.2	.32	1.9	2.3	.84	.77	.003	.004	.006	.004
Rattlesnake Springs	*	.13	1.5	.35	1.4	*	1.9	1.6	1.3	.86	*	*	.011	.006
Yakima Barricade	*	.07	.26	.36	.52	.93	1.6	1.6	.72	.56	.003	*	.005	.005
Vernita	*	.01	.25	.17	.73	*	.93	2.1	*	*	.008	*	.003	.001
Wahluke #2	*	.14	.72	.16	1.1	1.0	1.3	1.3	*	.81	*	.006	.010	.003
Berg Ranch	*	.12	.23	*	1.1	.65	1.4	1.2	.57	.66	*	.016	.007	.002
Ringold	*	*	.40	.048	.92	.49	1.8	1.8	.48	.94	.005	.016	.008	.022
Byers P.H.	.04	.08	.42	.59	1.8	1.2	1.4	2.6	.78	.88	*	*	.003	.003
Byers Landing	.05	*	.84	.88	1.5	.57	2.6	2.4	.56	.79	*	.003	.006	.013
Riverview	.05	*	.55	.45	.66	.52	1.4	1.6	*	.65	*	*	.008	.009
North Richland	*	*	.75	.36	*	.52	1.3	2.2	.52	.48	.012	.010	.009	.006
Average Perimeter	.01	.06	.58	.34	.99	.67	1.7	1.9	.62	.67	.003	.005	.008	.008

*Less than the analytical limit.

TABLE II.3-23

CONCENTRATIONS OF RADIONUCLIDES IN VEGETATION - 1972
(10^{-6} µCi/g)

Location	^{40}K	^{60}Co	^{65}Zn	^{90}Sr	$^{95}ZrNb$	^{106}Ru	^{137}Cs	$^{144}CePr$	^{238}Pu	^{239}Pu	U (µgm/gm)
					Onsite						
W of 100-N	12.	*	-	.05	.44	3.0	1.2	*	*	.001	.13
331	12.	*	-	.05	.91	3.0	.14	.88	*	*	.22
FFTF	4.7	.16	-	.08	.79	2.5	1.9	*	*	.004	.05
Wye Barricade	6.9	.12	.46	.17	3.2	*	16.	*	*	.004	*
Hanford	6.5	*	-	.04	1.7	5.0	4.2	*	.005	.003	.01
100-F	5.8	.15	-	.13	2.6	7.2	7.0	.88	*	.002	.05
Rt 4 x 11A	11.	*	-	.04	.73	1.7	1.6	*	*	*	.02
Redox P.S.	26.	.13	5.5	.34	18.	*	120.	*	*	.007	.05
200 Fire Station	8.9	.11	.44	.13	2.7	*	12.	*	*	.006	.16
200-E Hill	14.	.11	2.5.	.03	8.7	*	55.	*	*	.008	.03
Average Onsite	11.	.09	.89	.10	4.0	*	22.	*	.001	.004	.07
					Perimeter						
Benton City	5.2	*	*	.08	.36	5.2	.73	1.2	.003	.002	.04
ERC	2.7	*	*	.11	2.1	5.7	1.9	4.4	.003	.007	.02
Rt 240 CP54	3.8	*	*	.12	1.5	5.2	2.7	*	*	.002	.02
Rattlesnake Spring	9.7	*	*	.03	1.0	2.9	.97	1.2	*	.010	.03
Yakima Barricade	10.	*	*	.07	1.1	4.6	1.7	*	*	.001	.12
Vernita	7.1	*	*	.11	2.0	3.8	5.8	*	*	.005	.04
Wahluke #2	9.8	*	*	.06	.66	5.7	.71	*	*	.006	.04
Berg Ranch	11.	.09	*	.10	1.4	1.9	1.2	*	*	.004	.13
Ringold	4.2	*	*	.05	.59	2.4	.56	*	.005	*	.02
Byers P.H.	11.	*	*	.05	.84	2.5	3.8	*	.003	.003	.23
Byers Landing	21.	*	*	.07	.34	2.1	1.0	*	.007	.010	.02
Riverview	15.	*	*	.85	.14	*	.24	*	*	.001	.04
North Richland	7.9	*	*	.04	.70	2.4	.79	.82	*	.001	.10
Average Perimeter	9.1	*	*	.13	1.0	3.5	1.7	.30	.003	.004	.06

*Less than the analytical limit.

II.3.13.5 Biota

Routine sampling of waterfowl and small mammals was attempted at all Hanford waste ponds during 1972, although success of collection was highly variable with the site. Tables II.3-24 and 25 give the results of the radioanalyses of the specimens. The only significant levels of radioactivity were found in mice collected at the 100-N Trench. This trench receives the overflow from the 1301-N Crib; it is screened to prevent access by birds or large mammals, but mice can penetrate the wire mesh.

TABLE II.3-24

CONCENTRATIONS OF SEVERAL RADIONUCLIDES IN SMALL ANIMALS
(10^{-6} μCi/g in muscle)

Date	Location	^{24}Na	^{40}K	^{54}Mn	^{58}Co	^{59}Fe	^{60}Co	^{65}Zn	^{90}Sr	$^{95}ZrNb$
Mice										
2/16	300 Pond	*	*	*	*	*	*	*	0.065	*
2/24	100-N Trench	*	*	*	650.	*	820.	110.	7.9	*
	(Special Diode Count)	*	81.	*	850.	*	*	170.	*	*
2/24	200-E Chem. Ditch	*	*	*	*	*	*	*	0.92	*
4/25	100-N Trench	*	270.	*	640.	*	850.	350.	16.	*
6/14	100-N Trench	*	100.	210.	*	*	210.	55.	30.	*
6/15	U Pond	*	*	*	*	*	*	*	9.9	*
7/20	100-F	*	*	*	*	*	*	*	52.	*
11/29	100-N Trench	*	5.7	5400.	*	7100.	11,000	*	31.	2900.
11/29	300 Pond	*	*	*	*	*	*	*	0.33	*
11/30	200 West	*	*	*	*	*	*	*	0.018	*
Rabbit										
3/15	222 S Pond	*	*	*	*	*	*	*	0.066	*
5/25	300 Pond	*	4.7	*	*	*	*	*	0.010	*
7/31	200-E Area	*	3.2	*	*	*	*	0.14	0.020	*
11/20	100-N Area	*	2.4	*	*	*	*	*	0.004	*

Date	Location	^{103}Ru	^{106}Ru	^{131}I	^{134}Cs	^{137}Cs	$^{140}BaLa$	^{141}Ce	$^{144}CePr$	U	^{239}Pu
Mice											
2/16	300 Pond	*	*	*	*	*	*	*	*	0.099	0.0002
2/24	100-N Trench	*	*	*	*	58.	*	*	*		0.15
	(Special Diode Count)	*	*	*	*	26.	*	*	*		
2/24	200-E Chem. Ditch	*	*	*	*	3.4	*	*	*		0.006
4/25	100-N Trench	*	*	*	*	180.	*	*	*		
6/14	100-N Trench	*	*	*	*	50.	*	*	27.		0.051
6/15	U Pond	*	*	*	*	21.	*	*	*	0.34	0.037
7/20	100-F	*	*	*	*	*	*	*	*		0.002
11/29	100-N Trench	350.	2400.	1500.	140.	120.	140.	510.	3800.		
11/29	300 Pond	*	*	*	*	*	*	*	*	0.006	0.010
11/30	200 West	*	*	*	*	1.0	*	*	*		0.0006
Rabbit											
3/15	222 S Pond	*	*	*	*	9.8	*	*	*		0.004(a)
5/25	300 Pond	*	*	*	*	*	*	*	*	0.021(a)	*
7/31	200-E Area	*	*	*	*	1.3	*	*	*		0.0003(a)
11/20	100-N Area	*	*	*	*	0.13	*	*	*		*

(a) Concentration in liver tissue.
*Less than the analytical limit.
No entry indicates no analysis was performed.

TABLE II.3-25

AVERAGE RADIONUCLIDE CONCENTRATIONS IN MUSCLE OF GAMEBIRDS - 1972
(Units of 10^{-6} µCi/g wet weight)

Location	Species	No. of Samples	^{58}Co	^{60}Co	^{65}Zn	^{90}Sr	^{137}Cs	^{141}Ce
Analytical Limit			0.15	0.15	0.20	0.002	0.1	
U Pond	Ducks	2	*	*	*	0.006	27.	*
Redox Pond	Ducks	2	*	*	*	0.054	3.1	*
Gable Pond	Ducks	4	*	*	*	0.003	26.	*
B Pond	Ducks	4	*	*	0.11	0.003	3.3	*
300 Pond	Ducks	5	*	*	*	*	*	*
100-F Trench	Ducks	3	*	*	0.14	0.11	0.14	*
T Pond	Ducks	1	*	0.20	0.40	0.003	70.	*
West Lake	Ducks	1	*	*	*	*	4.2	*
Columbia River	Ducks	71	*	*	0.096	0.003	0.070	*
Columbia River	Geese	32	*	*	0.079	0.003	0.11	*
100 Areas	Pheasants	24	*	*	.073	0.003	0.084	*

*Less than the analytical limit.

Waterfowl and pheasants are collected along the river during hunting season near public hunting areas. Several deer are also collected. Tables II.3-26 and 27 show the radioanalyses for the 1972 samples. Also shown in Table II.3-27 are radioactivity concentrations in Columbia River fish and shellfish from near the mouth of the Columbia. The coyote was a road kill analyzed for reference data. In all river-associated biota, concentrations of Hanford radionuclides showed a significant decline with shutdown of the single-pass reactors.

TABLE II.3-26

CONCENTRATION OF SEVERAL RADIONUCLIDES
HANFORD DEER AND COYOTE - 1972[a]
(Units of 10^{-6} µCi/g wet weight)

Location	Date	Tissue	^{65}Zn	^{90}Sr	^{137}Cs	^{239}Pu
Deer						
Rt. 11A, Mi. 1.5	1/20	Muscle	*	*	0.048	
Rt. 11A, Mi. 1.5	1/20	Bone	*	0.48	*	0.009
Rt. 11A, Mi. 1.5	1/20	Liver				0.00008
300 Area	9/28	Muscle	0.081	*	0.071	
300 Area	9/28	Liver				0.00005
Rt. 4S, Mi. 13	11/7	Muscle	0.054	*	0.24	
Rt. 4S, Mi. 13	11/7	Liver				*
Coyote						
Rt. 4S, Mi. 20	1/20	Muscle	*	*	0.18	
Rt. 4S, Mi. 20	1/20	Liver	0.28	0.009	0.11	0.0001

*Less than the analytical limit.
No entry indicates no analysis was performed.

(a) Measurements of ^{137}Cs in the muscle tissue of mule deer in the Ft. Collins, Colorado area for the winter of 1972-1973 ranged from 0.04-0.1 x 10^{-6} µCi/g and averaged 0.065 x 10^{-6} µCi/g.[102] Similar measurements for antelope in eastern Idaho during the autumn of 1972 ranged from 0.038-0.060 x 10^{-6} µCi/g and averaged 0.048 x 10^{-6} µCi/g.[103]

The data for ^{137}Cs in the Hanford deer population are about the same as that due to fallout in similar species in the Western United States.

TABLE II.3-27

AVERAGE RADIONUCLIDE CONCENTRATIONS IN MUSCLE
GAMEBIRDS, FISH, AND SHELLFISH - 1972
(10^{-6} μCi/g)

Analytical Limit	^{32}P 1.0				^{60}Co 0.15				^{65}Zn 0.2			
Species	No. Sample	Max.	Min.	Avg.	No. Sample	Max.	Min.	Avg.	No. Samples	Max.	Min.	Avg.
Geese (river)[a]	1	*	*	*	32	0.12	*	*	32	0.37	*	0.079
Duck (river)[a]	1	*	*	*	71	0.24	*	*	71	0.77	*	0.096
Pheasant[b]					24	*	*	*	24	0.29	*	0.073
Whitefish	20	1.8	*	0.62	21	0.18	*	*	21	0.92	*	0.40
Oysters	9				9	*	*	*	9	2.5	1.0	1.7

Analytical Limit	^{90}Sr 0.002				^{131}I	^{137}Cs 0.1			
Species	No. Samples	Max	Min.	Avg.	No. Samples	No. Samples	Max.	Min.	Avg.
Geese (river)[a]	10	0.017	*	0.003	32	32	0.97	*	0.10
Duck (river)[a]	58	0.014	*	0.003	71	71	1.2	*	0.070
Pheasant[b]	20	0.008	*	0.002	24	24	0.24	*	0.084
Whitefish	7	0.003	*	0.002	21	21	0.31	*	0.17
Oysters					9	9	*	*	*

(a) Collected in January 1972 on the Columbia River within the Hanford boundary.
(b) Collected in November and December 1972 within 5 km (3 miles) of the Columbia River and within the Hanford boundary.
* Less than the analytical detection limit.
No entry indicates no analysis was made.

II.3.13.6 Foodstuffs

Milk, meat, eggs, and produce are all purchased in season from nearby farms, including several irrigated with Columbia River water taken downstream from the reactors, as well as commercial sources for comparison. Table II.3-28 gives the results of this sampling for 1972. Although slight indications of Hanford-originating nuclides exist, by far the greatest part of the radioactivity present is from residual world-wide fallout from nuclear weapons testing.

II.3.13.7 Direct Radiation

The maximum annual average exposure rate measured during 1972 with gamma dosimetry was 1.8 mR/day at the fence of the 200 East Chemical Separations and Waste Management Area. The range of exposure rates measured both on and off the Hanford Reservation is given in Table II.3-29.

On the basis of exposure rate measurements offsite and at 100-N, the annual total-body dose of WPPSS personnel from Hanford sources of external radiation at 100-N during 1972 was estimated to be 5 mrem.

Measurements of immersion exposure rates in the Columbia River and of exposure rates above the surface of the river downstream from N Reactor were not statistically different from upstream measurements (Tables II.3-30 and 31). Shoreline dose-rates were slightly higher within the site boundary especially when N Reactor was operating.

TABLE II.3-28

RADIONUCLIDE CONCENTRATIONS IN LOCALLY PURCHASED MILK AND FOOD - 1972

Milk (10^{-6} µCi/ml)

		^{65}Zn			^{90}Sr			^{131}I			^{137}Cs		
Concentration Guide (Water)		100			0.3			0.3			20		
Analytical Limit		.050			0.002			0.002			.030		
Sample	# Samples	Max.	Avg.	% CG	Max.	Avg.	% CG.	Max.	Avg.	% CG.	Max.	Avg.	% CG.
Riverview	21	.092	.016	.02	.004	.003	1.0	*	*	.33	.049	.014	.07
Benton City & West Richland Composite	26	*	*					.004	.001	.33	.029	.009	.05
Col. Basin Composite	52	.067	*		.002	.002	.67	.005	.001	.33	.033	.012	.06
Commercial	37	.062	.016	.02	.007	.004	1.3	*	*	.33	.035	.016	.08

Foodstuffs (10^{-6} µCi/gm)

		^{65}Zn		^{90}Sr		$^{95}ZrNb$		^{106}Ru		^{131}I		^{137}Cs		$^{144}CePr$	
Analytical Limit		.030		.002		.020		.370		.070		.040		.350	
Sample	# Samples	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.
Commercial Meat	12	.064	.016	.006	.001	*	*	*	*	*	*	.084	.034	*	*
Poultry	4	.13	.06	.004	.003	*	*	*	*	*	*	.035	.01	*	*
Eggs	10	.088	.038	.026	.013	*	*	*	*	*	*	.040	.009	*	*
Local Produce	3	*	*	.03	.03	.14	.095	*	*	*	*	.090	.043	*	*
Commercial Produce	5	*	*	.010	.009	.12	.034	1.0	.38	*	*	*	*	*	*

NOTE: Minimum concentrations reported were all below the analytical limit and therefore not listed in this table.

* Less than the analytical limit.

TABLE II.3-29

AVERAGE EXTERNAL GAMMA EXPOSURE RATES
(units of mR/day)

Location	1971 Jan-June	1971 July-Dec	1972 Jan-June	1972 July-Dec
100 Areas				
Vernita	0.22	0.20	0.24	0.26
Midway				
100-B				
100-K	0.21	0.21	0.31	0.28
100-N				
100-N (WPPSS)	0.20	0.20	0.28	0.30
100-D	0.16	0.25	0.22	0.20
100-F	0.22	0.15	0.23	0.23
Hanford	0.16	0.16	0.21	0.21
100-H			0.24	0.23
200 West Area				
Redox	0.31	0.23	0.25	0.27
West-Center	0.22	0.23	0.30	0.31
East-Center	0.16	0.16	0.22	0.21
West-Northwest	0.18	0.19	0.24	0.26
200 East Area				
North-Center	0.36	0.36	0.56	0.78
West-Center	0.45	0.29	0.21	0.21
Southeast	0.22	0.22	0.28	0.27
East-Center	0.80	0.22	0.34	0.24

Location	1971 Jan-June	1971 July-Dec	1972 Jan-June	1972 July-Dec
Wahluke Slope				
C.P. 17	0.20	0.24	0.25	0.25
C.P. 18	0.20	0.20	0.25	0.25
C.P. 19	0.19	0.19	0.24	0.23
C.P. 20	0.20	0.20	0.24	0.25
C.P. 21	0.19	0.18	0.27	0.24
C.P. 22	0.20	0.18	0.24	0.25
C.P. 23	0.19	0.19	0.24	0.24
C.P. 24	0.20	0.20	0.25	0.25
C.P. 46	0.19	0.19	0.24	0.25
Other On-Site				
Yakima Barricade	0.18	0.20	0.28	0.25
Rattlesnake Springs	0.20	0.16	0.20	0.22
Emergency Relocation Center	0.21	0.21	0.24	0.26
FFTF Site	0.20	0.18	0.23	0.23
WYE Barricade	0.16	0.15	0.19	0.20
Rt. 10 Mile 1.6	0.18	0.17	0.26	0.25
300 Area (3705 Bldg)	0.22	0.21	0.25	0.24
300 Area (320 Bldg)	0.20	0.16	0.26	0.25
300 Area (331 Bldg)	0.23	0.17	0.22	0.23
300 Pond	0.26	0.22	0.40	0.25
ACRMS	0.18	0.16	0.24	0.24

No entry indicates no measurement was performed.

TABLE II.3-30

DOSE RATES[a] FROM MONTHLY SHORELINE SURVEYS FOR 1972

(μR/hr)

COLUMBIA RIVER PLANT SHORE

Date	382.5 P[b] Above 181-KW	381.5 P Below 181-KE	379.4 P 100-N Trench	379.0 P Below 100-N	369.7 P White Bluff Ferry	368.3 P 100-F Pond	362.0 P Hanford	350.4 P Power-line Cross.	343.3 P Port of Benton	340.5 P Richland
1/20	12	13	25	18	13	10	15	15		12
2/23	12	12	15	12	11	12	12	13		12
3/16	10	8	15	10	8	9	8	7		10
4/26	8	12	14	12	14	15	17	22		12
5/23	12	12	18	15	14	14	12	13		12
6/21	12	10	20	10	10	11	11	11		12
7/24	13	10	22	10	8		12	13		7
8/18	15	15	15	22	15	15	15	15		15
9/25	10	12	22	11	10	15	15	11	10	12
10/20	12	20	23	14	16	18	15	17	11	12
11/16	9	9	20	12	11	12	11	11	10	10
12/19	10	11	28	11	13	12	14	12	13	12

COLUMBIA RIVER - ISLAND LOCATION

Date	377.4 I D Island	375.8 IF E Island	373.4 IP Locke Island	371.1 IP Locke Island	367.0 IF 100-F Pond	355.7 I[d] Near Ringold
1/20	20	12	9	12	13	
2/23	13	10	10	10	13	10
3/16	10	7	9	7	12	8
4/26	17	11	13	12	17	14
5/23	10	12		11	10	10
6/21	12	10		11	15	10
7/24	13	12	13	12	10	13
8/18	20	12	12	14	18	15
9/25	15	12	13	12	12	12
10/20	15	15	13	13	12	14
11/16	9	10	9	10	11	10
12/19	15	13	17	11	14	13

COLUMBIA RIVER - FAR SHORE

Date	381.0 F 100-K Trench	378.4 F Above 181-D	369.8 F White Bluffs Ferry	362.0 F[d] Hanford	359.1 F Savage Island	354.7 F[c] Ringold	350.4 F Powerline Cross.	345.2 F Byers Landing
1/20	8	10	14	15	10	10	13	25
2/23	9	8	13	15	10	9	12	12
3/16	10	8	7	8	10	8	9	7
4/26	10	10	11	19	10	13	13	21
5/23	11	12	12	10	10	10	12	10
6/21	10	10	10	10	11	10	20	14
7/24	13	10	10	12	11	10	10	13
8/18	15	15	12	15	15	15	15	12
9/25	10	12	10	12	12	12	12	14
10/20	20	13	11	18	13	16	16	17
11/16	8	8	9	12	11	10	11	13
12/19	12	15	12	16	8	13	15	15

(a) Measurements reported in μR/hr are taken 1 meter above the ground and 1 meter back from the water's edge. Measurements reported in () are the maximum c/m found with a GM in the immediate vicinity of the water's edge.
(b) River miles measured from the mouth of the Columbia. Plant shore, far shore, and island are designated by P, F, and I, respectively.
(c) Point open to the general public during the entire year.
(d) Point only open to the general public on Wednesdays, Saturdays, and Sundays, during the hunting season.

No entry indicates no measurement was performed.

9 1 1 1 3 9 1 0 6 2 7

TABLE II.3-31

AVERAGE EXPOSURE RATES BELOW THE SURFACE OF THE COLUMBIA RIVER - 1972

(mR/day)

	Jan-June	June-Dec
100-K Barge	0.14	0.18
Below 100-N	0.16[a]	0.19
Above 100-D	0.15[a]	0.18
D Island	0.20	0.19
100-F Area	0.23[a]	0.17
S. Wooded Island	0.18	0.19[c]
Richland Pumphouse	0.14[b]	0.13

(a) March-June
(b) January-April
(c) September, November, December

II.3.14 Independent Reviews of Waste Management Programs [RPB, X.25]

The ERDA (then AEC) Waste Management Program has been reviewed by special committee of the National Academy of Science (NAS)[121] and the General Accounting Office (GAO)[122,123,124] The Federal Water Pollution Control Administration (now EPA) conducted a review on Waste Treatment and Disposal Operations at the Reactors (100 Areas) and Laboratory (300 Area) Sites in 1969.[125]

II.3.14.1 NAS Review [X.8]

The NAS has reviewed radioactive waste management operations, plans and development work from time-to-time since 1955. A report was issued in 1966 summarizing findings, conclusions and recommendations. Those pertaining to Hanford are:

- The Committee felt that the disposal of low-level waste (above Radiation Concentration Guides) in the vadose water zone (dessicated soil), above the water table, probably involves unacceptable long-term risks. The Committee also stated that 1) acceptable waste management practices would require that isolation from the biosphere be complete during periods of storage in natural containers (soil, etc.), and 2) to the extent radioactive decay of inventory exceeds input (in natural containers) there is no reason for alarm.

  Action Taken: The disposal of low-level waste to the soil has been dramatically reduced since 1966 (by a factor of >1000). Plutonium discharges have been eliminated to less than detectable quantities. Section V describes the alternatives to further reducing radionuclide discharges to the soil and evaluates alternatives which would result in decay of stored radionuclides in cribs to exceed input. Present discharges are so small they do not increase risks greater than already exist. The extensive environmental monitoring program has shown this practice to have resulted in no adverse safety or health effects to the population over the past 30 years. However, ongoing R&D programs are evaluating the need to remove transuranics from natural soil containers (Section V gives more details).

- Future emphasis should be on safe ultimate disposal.

  Action Taken: Research and development for ultimate disposal have been proceeding at Hanford since 1968. The development work is now expanding rapidly since the waste solidification program is nearing completion (Section V gives additional information).

- Continued and intensified field investigation should be arranged to determine amount and rate of precipitation necessary to establish percolation to the water table. The possible extent of upward movement of radionuclides should be determined.

Action Taken: During the past few years an extensive research program has been conducted under ERDA sponsorship to understand fluid migration in the unsaturated zone. Migration of fluids in the zone immediately below the land surface is a very complex process affected by a variety of forces, some of which induce downward migration while others induce upward flow. The actual fluid migration is the net sum of all such forces.

In a dry environment such as Hanford, precipitation does not penetrate more than 15 or 20 feet and in the summer months all the precipitation evaporates before it has a chance to filter into the subsurface. Such a statement is substantiated by data from an experimental facility (a lysimeter) located just south of the 200-E Area. Migration of groundwater upward to within 15 feet of the land surface in the 200 Area cribs is not a credible event.

All research to date shows that fluid migration in the unsaturated zone is negligible. Monitoring programs for the past 30 years have not observed significant upward movement of radionuclides due to any upward moisture flow in the Hanford soils.

- None of the operating sites are geologically suitable for storage of radioactive waste in perpetuity, other than very dilute, very low-level liquids.

  Action Taken: Insufficient information had been developed at the review time to support such a conclusion. Additional research on ultimate disposal of waste on the Hanford site has since been conducted and the information gathered to date has not ruled out the alternative of ultimate disposal onsite (Section V Ultimate Disposal).

- The oil well drilled to 10,655 feet should be reentered for the purpose of obtaining hydrological and geological data.

  Action Taken: The well was reentered, the fluids sampled and geophysical logs taken. Four additional wells (2,500 to 5,600 feet) were drilled to obtain additional data.

- Geological studies are needed in the Rattlesnake Hills before a cavern to store waste is built.

  Action Taken: The recommendation is valid.

II.3.14.2 GAO Review

The GAO reviewed the policies and procedures for the management of radioactive waste at Hanford and other sites in 1968, 1971, and 1974.

- In 1968 the total AEC waste management effort was reviewed. The fiscal and managerial aspects were emphasized. The GAO emphasized the need for: 1) an integrated in-depth review of waste management problems, 2) priority commitment of financial resources, 3) reorganization to vest in a single AEC office the responsibility for waste management policy making and coordination, and 4) development of reserve storage capability for liquid stored in tanks.

  Action Taken: The Manager of the AEC conducted an in-depth review, established a waste management division to make policy decisions and coordinate waste management, and reaffirmed the reserve storage requirement for liquids at each site.

- In 1971 the GAO reviewed progress on recommendations made in 1968 and found progress was made on all recommendations. However, the GAO stated that due to the complex nature of technical aspects of the waste management efforts, certain problems remain unresolved and delays are being experienced. They concluded (Hanford related): 1) more work was required on interim and long-term storage of waste, and 2) further review and consolidation of plans for resolving interim and long-term waste management problems was necessary.

  Action Taken: The interim and long-term waste management effort has since been again reviewed and additional effort has been funded.

- In 1974 the GAO again reviewed radioactive waste management and concluded that considerable progress had been made in safe storage of high-level waste, but problems had been encountered at Hanford with containing liquids and slippage in the solidification program. No recommendations were made.

Action Taken: New double-wall tanks are being built to contain liquids and a new capital project is under construction to accelerate the solidification of liquid waste.

II.3.14.3 EPA Review

The Federal Water Pollution Control Administration (now EPA) reviewed waste discharges in the reactor and laboratory areas in 1969. Recommendations for the 300 Laboratory Areas were: 1) shallow wells should be constructed to pump out the groundwater in the event that radioactive waste is accidentally spilled or leaked to the groundwater, 2) the piping should be pressure tested periodically and, 3) the source and extent of groundwater contamination in the 300 Area should be investigated. For the 100 Reactor Areas, FWPCA recommended that:

- Immediate plans should be initiated for the design and construction of adequate cooling facilities for the waste streams from the KE, KW and N Reactors (an acceptable alternative would be to initiate an immediate program for waste heat utilization).

- Settled sludge and filter backwash from K Reactor water treatment plants should be discharged to a trench.

- The source of ^{122}Sb in the Columbia River should be investigated.

Action Taken: All radioactive liquid effluents from the 300 Areas are now collected in tanks and sent to the 200 Area tanks or the the 100-H Area for solar evaporation. Discharges of nitrate ion also have been essentially eliminated. Collection tank systems for the radioactive liquids are within facilities that have the capability to confine and recollect leaks. The concentration of contaminants in the groundwater below the 300 Area is now dropping and the groundwater meets drinking water standards.

Discharges of radioactivity from the reactors to the Columbia River have been nearly eliminated (<200 Ci/yr tritium and <15 Ci/yr other) by shutdown of those reactors that discharged cooling water directly to the river and by eliminating direct discharge of radioactivity from the N Reactor. Antimony-122 is not detected in the river and only occasionally in N Reactor effluent to the crib. The effect of thermal discharges from N Reactor are discussed in Section III.1.3. The K Reactor water treatment plant operates intermittently now (3 to 4 times per year) and a discharge permit has been requested.

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III ENVIRONMENTAL IMPACT

III.1 ENVIRONMENTAL EFFECTS OF ROUTINE OPERATION OF PLANT FACILITIES

This section considers the effects of existing Hanford facilities and the waste released during routine operation. The waste considered includes radioactive, chemical and thermal wastes that are released to 1) the atmosphere, 2) the Columbia River, and 3) the ground. For impact calculations, routine releases anticipated from normal operation of facilities are considered the same as amounts measured in the environment as a result of 1972 operations. The actual release of waste to the environment will be less than 1972 levels, due to the installation of pollution abatement facilities and progress in solidification of waste. The detailed models and computer codes used for evaluating the environmental radiation doses are given in Appendix III-A and III-B.

III.1.1 Radiological Impact on Man

Radioactive materials are released to the atmosphere, the Columbia River and the ground as a result of operations at Hanford. (The radionuclides released to the environment during CY-1972 are tabulated in Section II of this statement.) Studies have been conducted of the exposure pathways in the Hanford[1] environment. These studies, combined with results of the environmental radiation monitoring and evaluation program, have facilitated the construction of a hypothetical person whose dietary and recreation habits maximize the potential radiation doses he might receive. Such a hypothetical person is called the "maximum individual." The habits and diet of the maximum individual include the maximum reported values for each exposure mode in spite of the fact that the maximum values are not all attributable to the same one person. In addition, these studies permitted delineation of an average member of the population, the "average individual." Similar studies identified the total harvest of such important dietary items as Columbia River fish, game birds, and locally irrigated produce. The potential pathways of exposure to man are summarized in Table III.1-1.

TABLE III.1-1

POTENTIAL PATHWAYS OF RADIATION EXPOSURE TO MAN FROM OPERATION OF THE NUCLEAR FACILITIES AT HANFORD

A. Gaseous Effluents Released to the Atmosphere
- Air submersion
- Inhalation
- Ingestion of foods contaminated via deposition
- Exposure of ground contaminated via deposition

B. Liquid Effluents Released to the Columbia River
- Water immersion (swimming)
- Exposure to water surface (boating)
- Exposure to contaminated shoreline (hunting, fishing, picnicking)
- Ingestion of aquatic foods (fish and waterfowl)
- Ingestion of irrigated foods (produce, milk, eggs, meat)

C. Liquid Effluents Discharged to the Ground
- Ingestion of waterfowl which had access to surface ponds
- Use of well water drawn from contaminated groundwater for drinking or irrigation
- Migration of contaminated groundwater to the Columbia River (pathways under B above)

D. Solid Waste Buried in the Ground
- Leaching of radionuclides from burial sites close to the Columbia River during flood

E. Transportation of Radioactive Materials on Public Highways
- External exposure to persons in the proximity of the shipment

Historically, the principal pathways of exposure involve only the direct releases of effluents to the atmosphere and to the Columbia River. Radioactive effluents released to the atmosphere are diluted and dispersed during their travel to areas of public access and can lead to 1) external exposure of skin and whole body, and 2) internal dose (principally to the thyroid from radioiodine) from inhalation or from ingestion of foods contaminated via deposition of airborne materials. External exposure from ground contamination via deposition is characteristically insignificant (several orders of magnitude less) compared to exposure via the other air pathways.

Release of radioactive materials in liquid effluents that reach the Columbia River can lead to public exposure through several pathways. Direct external exposure can result from swimming in or boating and water skiing upon the Columbia River and from hunting, fishing or picnicking on the shoreline of the river. Ingestion of water or foods derived from the river or from river-irrigated farms can lead to radiation doses to the whole body and internal organs. Such foods include 1) Columbia River fish and waterfowl, 2) irrigated produce, and 3) milk, eggs and meat produced by animals ingesting river water or river-irrigated feeds.

Irrigation of farm land with Columbia River water drawn from immediately downstream of the Hanford Reservation is limited to two areas: Ringold and Riverview. At Ringold, a small number of family farms use Columbia River water for irrigation of orchards, their own gardens and some pasture grass. Riverview, a total of 3300 acres occupied by about 3000 people, is irrigated from the river. About 75% of the acreage used for growing crops is in pasture and hay. Most residents have kitchen gardens, but only a very limited number of gardens are large enough to provide produce for market.

Liquid effluents released to the ground have only a small potential for public exposure through the several different pathways listed. At the present time there is no public access to the groundwater through wells beneath the Hanford Reservation, and the second item under C in Table III.1-1 is listed only as a potential future pathway.

As a result of studies of waterfowl inhabiting open ponds and trenches, measures were taken to prevent waterfowl access to contaminated surface waters in the 100 Areas. Contamination of the waterfowl via the slightly radioactive surface waters in the 200 Areas is a minor contribution to the radiation exposures of the general public.

Radioactive liquid effluents disposed to the ground can reach man via migration to the Columbia River. At the present time, radionuclides in liquid effluents sent to the ground in the 200 Areas (fuels processing areas), with the possible exception of tritium and iodine, are not entering the Columbia River via groundwater migration. Such small amounts of tritium, which could be entering the river from 200 Area sources in 1972, are less than the tritium present in the river as a result of fallout from past weapons testing and natural sources. The quantities of tritium entering the river will increase in the future as a result of the slow migration of groundwater from the 200 Areas disposal sites. From the transport model simulation (Appendix II.3-D), the forecast peak rate of entry of tritium should be reached in the early 1980s, at which time about 2×10^{-7} Ci/day of tritium and 2×10^{-10} Ci/day of gross beta activity would be entering the Columbia River. This discharge rate would probably continue for about 6 years, and then it would decrease. The radiation doses from the entry of tritium and gross beta into the Columbia River during the peak years would be extremely small (less than 10^{-6} mrem/yr to the maximum individual and less than 0.1 man-rem/yr to the local population).

The 100-N Reactor has a disposal trench and crib (1301-N) for liquid effluents which are not directly discharged to the Columbia River. Some of the radionuclides disposed to these facilities reach the river with the groundwater at seepage springs along the riverbank. The radionuclide content of the spring water is reduced below that in the original liquid effluent by soil retention of some radionuclides and by radioactive decay during the travel time between the crib and trench and the river. Similar ground disposal techniques were employed in years past at the older reactors, and seepage springs existed at some of those reactor areas also. By 1973 the major portion of the radionuclides reaching the Columbia River from Hanford operations did so via the groundwater from the 1301-N crib disposal site.

In addition to the radionuclides reaching the Columbia River in 1972, river sediments contain some residual long-lived contamination from past effluent disposal. During the annual spring runoff some of these deposits are scoured by the increased river flow rates and are transported downstream. As a result, occasionally small concentrations of certain radionuclides are measured in river water and biota samples even though no measurable quantities of the nuclides are being released. These small concentrations in turn can lead to radiation doses to local residents from many of the potential pathways outlined above for liquid effluent releases to the river.

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Radioactive solid waste placed in burial grounds has no further impact on the general public. (The potential effects of accidents and floods are discussed in Section III.2.)

III.1.1.1 Impact of Liquid Releases

The radiation doses to the hypothetical maximum individual and to the general population during 1972 were calculated from releases of liquid effluents at Hanford listed in Table III.1-2 and from bio-accumulation factors listed in Table III.1-5.

Several distinct sources of liquid effluents are released to the Columbia River:

- the 102-in. cooling water pipeline and the crib and trench at 100-N
- animal farm waste at 100-F and 300 Areas
- uranium from the 300 Area North Pond
- tritium migrating to the river with the groundwater from the 200 Areas disposal sites.

TABLE III.1-2

RADIONUCLIDES RELEASED TO THE COLUMBIA RIVER WITH LIQUID EFFLUENTS AT 100-N IN 1972[a]

Nuclide	Ci/Yr	Nuclide	Ci/Yr
^{3}H	7000	^{95}Nb	4
^{24}Na	500	^{99}Mo	21.1
^{32}P	160[b]	^{103}Ru	0.4
^{51}Cr	25.3	^{106}Ru	4.
^{54}Mn	40	^{124}Sb	0.8
^{56}Mn	600	^{131}I	41.9
^{59}Fe	10	^{133}Xe	10.
^{58}Co	2	^{134}Cs	0.5
^{60}Co	20	^{137}Cs	5.05
^{65}Zn	440[b]	^{140}Ba	5.25
^{89}Sr	0.05	^{140}La	5.25
^{90}Sr	0.95	^{239}Np	90
^{95}Zr	4.		

(a) Includes both the discharge from the 102-in. pipeline and riverbank seepage from disposal to the 1301-N crib. The annual discharges have been reduced to <200 Ci/yr tritium and <15 Ci/yr of all other radionuclides after CY-1973.

(b) Estimated from concentration measured in whitefish in 1972 and historical data relating water concentrations to fish concentrations.

TABLE III.1-5

BIOACCUMULATION FACTORS FOR RADIONUCLIDES IN FRESH WATER ORGANISMS
(pCi/kg Organism per pCi/liter Water)

Radionuclide	Fish	Invertebrates	Plants
^{3}H	1	1	1
^{24}Na	100[a]	200	500
^{32}P	170[a]	100,000	100,000
^{51}Cr	20	2,000	4,000
^{54}Mn	400	90,000	10,000
^{56}Mn	400	90,000	10,000
^{59}Fe	100	3,200	1,000
^{58}Co	50	200	200
^{60}Co	50	200	200
^{65}Zn	64[a]	10,000	20,000
^{89}Sr	30	100	500
^{90}Sr	30	100	500
^{95}Zr	330	7	1,000
^{95}Nb	30,000	100	800
^{99}Mo	10	10	1,000
^{103}Ru	10	300	2,000
^{106}Ru	10	300	2,000
^{124}Sb	1	10	1,500
^{131}I	15	5	40
^{134}Cs	2,000	100	500
^{137}Cs	2,000	100	500
^{140}Ba	4	200	500
^{140}La	25	1,000	5,000
^{239}Np	10	400	300

(a) Based on actual measurements for panfish in the Columbia River.

A study conducted in 1957 [3] of the behavior of uranium discharged to the 300 Area North Pond indicated that a large fraction of the uranium eventually reached the Columbia River where it was rapidly dispersed in the water and mixed with the much higher concentrations of natural background uranium already present in the river water.

In addition to the radionuclides reported as released to the Columbia River in 1972, certain other radionuclides were detected in water and/or biota samples.[4] Principal among these were ^{32}P in whitefish and ^{65}Zn in river water and fish and in chickens and eggs from local farms adjacent to the river. The ^{65}Zn was undoubtedly scoured from the river sediments during the spring runoff and could also be accumulated to some extent on irrigated farm land and in shoreline insects eaten by the chickens. The ^{32}P was present in low concentrations in the 100-N liquid effluents discharged to the Columbia River through the 102-in. pipeline. Table III.1-2 includes the estimated quantities of ^{32}P and ^{65}Zn released from 100-N.

The population within 50 miles of the Hanford Reservation using Columbia River water for sanitary purposes includes the cities of Pasco (1970 population was 19,500) and Richland (1970 population was 28,500). The city of Kennewick uses groundwater drawn from collectors placed along the Columbia River. Historically, the Kennewick city water has contained significantly lower concentrations of radionuclides than the water in the Pasco municipal system immediately across the river.

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The city of Richland supplements its water supply with well water (recharged with Yakima River water) to a varying degree depending upon seasonal demand. At most, about 20% of the Richland residents receive well water all year around. During the hottest summer days, up to a maximum of another 20% of the residents may receive well water depending upon demand. For purposes of radiation dose calculations, the simplifying and conservative assumption can be made that all Richland residents use Columbia River water and no Kennewick residents use Columbia River water.

Extensive data available on the removal efficiencies for specific radionuclides in the municipal water treatment plants[5] were employed when calculating radiation doses from drinking water. These removal factors are tabulated in Table III.1-6. For nuclides not directly measured at the water treatment plant, factors for chemically similar elements were employed.

TABLE III.1-6[5]

REMOVAL OF RADIONUCLIDES BY WATER TREATMENT SYSTEMS AT RICHLAND AND PASCO, WASHINGTON

Nuclide	Concentration Ratio (Treated Water/Raw Water)
RE + Y[(a)]	0.16
^{64}Cu	0.28 (0.6)[(b)]
^{46}Sc	0.32
^{76}As	0.37 (0.5)[(b)]
^{32}P	0.38
^{65}Zn	0.39
^{24}Na	0.62 (0.9)[(b)]
^{239}Np	0.67
^{122}Sb	0.77
^{131}I	0.83
^{51}Cr	0.87

(a) Rare Earths plus Yttrium.
(b) ( ) indicates ratios estimated for elements by correcting for radioactive decay within the water plant.

The results of these dose calculations are summarized in Tables III.1-7 and III.1-12. Assuming a consumption rate of 2.0 liters/day of water, an average individual living in Richland or Pasco would receive a whole body dose of 0.015 mrem/yr from this source. The total population of consumers (~50,000) drinking an average of 1.2 liters/day would receive an integrated whole body dose of 0.45 man-rem/yr; tritium, ^{32}P and ^{65}Zn contribute about 70% of these doses. The radiation dose to the individual adult thyroid from consumption of 2.0 liter/day of drinking water was estimated to be 0.3 mrem/yr, primarily from ^{131}I with a small contribution from tritium.

Because fish will concentrate radionuclides from the water they inhabit, the potential radiation dose from consumption of Columbia River fish was estimated for both the individual and the population within 50 miles of the plant.

The following assumptions were used:

- For population dose calculations, the fish were assumed caught from water containing radionuclides at concentrations calculated by diluting the radionuclide release rates in the 1972 annual average Columbia River flow (160,000 cfs).
- There was a minimum of 24 hour delay between harvest and consumption.

TABLE III.1-7

ESTIMATED ANNUAL MAXIMUM DOSE TO THE INDIVIDUAL FROM THE EFFLUENTS RELEASED AT THE HANFORD RESERVATION IN 1972(a)

(mrem)

Pathway	Annual Exposure	Skin	Whole Body	GI-LLI	Thyroid	Bone
Gaseous Effluents						
Air Submersion	8766 hr	0.088	0.011	(0.011)(d)	(0.011)	(0.011)
Tritium-Inhalation & Transpiration	8766 hr	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	----
Radioiodine-Inhalation	7300 m^3 air	--	--	--	0.0019	--
Milk	274 liters(b)	--	--	--	0.056	--
Vegetables	30 kg(c)	--	--	--	0.042	--
Total Air Pathways		0.088	0.011	0.011	0.11	0.011
Liquid Effluents(e)						
Drinking Water	730 liters	--	0.015	0.036	0.30	0.066
Fish Consumption	40 kg	--	0.30	1.02	0.31	1.63
Irrigated Foods	710 kg	--	0.16	0.25	0.33	0.33
Shoreline	500 hr	0.10	0.090	(0.090)	(0.090)	(0.090)
Swimming	100 hr	0.0032	0.0026	(0.0026)	(0.0026)	(0.0026)
Boating	100 hr	0.0016	0.0013	(0.0013)	(0.0013)	(0.0013)
Total Water Pathways		0.10	0.57	1.4	1.0	2.1
Total (Adult)		0.19	0.58	1.4	1.1(f)	2.1
Infant Thyroid Dose						
Airborne Tritium	8766 hr				0.0001	
Air Submersion	8766 hr				(0.011)	
Inhalation	2045 m^3				0.002	
Milk	274 liters(b)				0.46	
Drinking Water	292 liters				0.95	
Total (Infant)					1.4(f)	

(a) Using releases tabulated in Tables III.1-2, 3, 4, 8, 9 and 10.
(b) One liter/day for a 9-month grazing season.
(c) 200 g/d for a 5-month produce season.
(d) ( ) indicates internal dose from external exposure.
(e) Essentially all from 100-N effluents.
(f) Does not include contribution from ^{129}I in the environment from previous years' operations estimated to be ~0.4 millirem/yr to both the maximum individual adult and infant.[6]

- There were no losses in preparation of the fish (cooking or long-term freezer storage).
- An individual consumes as much as 40 kg of fish per year.[7]
- The total edible weight of sport fish harvested from the Columbia River between the Ringold area and Boardman, Oregon, is not over 1.5×10^4 kg/yr.[7]

Based on these assumptions, the whole body dose to the individual fisherman would be 0.3 mrem/yr. Integrated dose to the population would be 0.1 man-rem/yr from fish consumption. The doses for an avid waterfowl hunter from consumption of 40 kg/yr of waterfowl from the Hanford environment would be somewhat less than the doses to the avid fisherman reported here, while the integrated dose to the population would be <0.1 man-rem/yr.

Aquatic recreation is a popular pastime in the stretch of the Columbia River below the plant site. Swimming, boating, water skiing and picnicking along the shore or on islands could result in small incremental doses to the local population. Assuming an individual spent 100 hr/yr swimming, 100 hr/yr water skiing or boating, and 500 hr/yr along the shoreline, all near the site his whole body dose from external exposure would total only 0.09 mrem/yr. This dose and others potentially received by such an ardent water sports fan are summarized in Table III.1-7.

The population dose received during water recreation activities can be estimated on the basis of the following assumptions:

- The average number of hours spent in various water sports by the population are:[8]

  10 hr/yr swimming (immersion)
  5 hr/yr boating and water skiing (surface)
  17 hr/yr on rivershore

9 1 1 1 3 9 1 0 5 4 4

- The population within 50 miles of the site in the sectors between the NE and SSW directions, inclusive, are the persons who travel to the Columbia River for their aquatic recreation. This population totaled approximately 120,000 persons in 1972.

- The dilution offered by the Snake River below Pasco and the decay during river travel time to southwest Benton County can be ignored. The majority (over 50%) of the exposed population resides in the vicinity of the Tri-Cities (Pasco, Kennewick and Richland).

Under these conservative* assumptions, the integrated population dose from water sports would be 0.4 man-rem/yr.

Even though a limited amount of fruit, vegetables, eggs and meat are produced on farms irrigated with water drawn from the Columbia River downstream of the Hanford Reservation, the hypothetical maximum individual could possibly eat local irrigated foods during the entire growing season. Certain products such as root vegetables, fruit, eggs, and meat are assumed to be available year-round either because they can be produced any month or because they can be stored for several months after harvest. The uptake and concentration of radionuclides in irrigated produce was calculated using local data on season and irrigation rates and the uptake equation and factors given in the reports on the "Year 2000 Studies."[9,10]

For conservatism, only relatively short decay times were used between harvest and consumption (1 day for most foods, 10 days for potatoes and orchard fruit, and 15 days for beef and pork). The total dose to the maximum individual for all irrigated products was 0.2 mrem/yr to the whole body and 0.3 mrem/yr to the thyroid (Table III.1-7). For the population dose from irrigated products, it was conservatively assumed that 2000 persons each consumed about one-half as much irrigated foods as did the maximum individual. On that basis, the population doses from irrigated products would be 0.2 man-rem/yr to the whole body and 0.3 man-thyroid-rem/yr to thyroids (Table III.1-12).

The radiation dose from all liquid pathways combined listed in Table III.1-7 for the maximum individual adult is 0.6 mrem/yr to the whole body and 1 mrem/yr the thyroid. The infant thyroid dose from the liquid pathways is about 1 mrem/yr, entirely from drinking water, and the total infant thyroid dose is 1.4 mrem/yr. The combined whole body dose to the population from liquid pathways was estimated to be about 1 man-rem/yr, while the combined population thyroid dose from the liquid pathways is ~10 man-thyroid-rem/yr (Table III.1-12).

III.1.1.2 Impact of Gaseous Releases

The radionuclides released to the atmosphere from the several Hanford facilities were discussed in Section II.1.1. The various releases were grouped into five categories for purposes of dose calculation. Table III.1-8 lists the releases from the 200-ft stack at the 100-N Reactor Area. Table III.1-9 summarizes all of the releases to the atmosphere in the 200 East and 200 West Areas into two categories: roof vent releases and stack releases. For purposes of offsite dose calculations, all of these releases were assumed to occur at one location between 200 East and 200 West Areas close to the Hanford Meteorology Station (HMS).

TABLE III.1-8

RADIONUCLIDES RELEASED WITH GASEOUS EFFLUENTS AT 100-N AREA IN 1972[a]

Nuclide	Ci/Yr
^{3}H	27
^{41}Ar	1×10^{5}
^{131}I	0.013
^{133}I	0.5

(a) Released from the 200-ft stack.

* The word "conservative" implies the use of assumptions which would tend to overestimate rather than underestimate the dose to man.

TABLE III.1-9

RADIONUCLIDES RELEASED WITH GASEOUS EFFLUENTS AT THE 200 AREAS IN 1972

Nuclide	Curies/Year Released	
	Roof Vents[a]	Stacks[b]
^{3}H	----	1.0×10^{3}
^{85}Kr	----	4.0×10^{5}
^{90}Sr	2.28×10^{-1}	8.03×10^{-1}
^{131}I	4.71×10^{-3}	2.06×10^{-1}
^{133}Xe	----	2.0×10^{2}
^{239}Pu	1.53×10^{-3}	3.78×10^{-3}

(a) Assumed to be a ground release for purposes of dose calculations.

(b) Released from the 200-ft stacks.

Table III.1-10 summarizes the release data from all of the facilities in 300 Area into two categories: roof vent and 200-ft stack. Many of the stack release measurements in the 300 Area were below detection level in 1972. Nevertheless, the values in Table III.1-10 were assumed to be positive measurements for purposes of dose calculation.

In order to maximize the total dose from all gaseous pathways, the hypothetical maximum individual adult and child were assumed to be located directly across the river from the 300 Area. This is the location of the highest concentrations of radioiodine in the air, on vegetation and in milk, but is not the location of highest dose rate (mrem/hr to a radiation detector) from airborne radionuclides from all sources. Since the major contributors to the air submersion dose rate are the releases from the 100-N stack, the highest external dose rate would be directly across the river from 100-N. However, no permanent residences are located in the near vicinity of the 100-N site, and the annual external doses to nonresident farmers and hunters should not be as great as the combined dose to the permanent residents on farms near the 300 Area. The mathematical model used to calculate air dispersion of the radionuclide releases is given in Reference 11; the computer calculation scheme is given in detail in Reference 12 (excerpts included in Part 1 of Appendix III-A).

TABLE III.1-10

RADIONUCLIDES RELEASED WITH GASEOUS EFFLUENTS AT 300 AREA IN 1972

Nuclide	Curies/Year Released	
	Roof Vents[a]	Stacks[b]
Gross Alpha	$<3.6 \times 10^{-5}$ [c]	$<2.4 \times 10^{-5}$ [d]
Gross Beta[e]	2.9×10^{-3}	$<1.6 \times 10^{-4}$
^{131}I	1.3×10^{-2}	$<1.6 \times 10^{-3}$

(a) For purposes of dose calculations, a ground level release was assumed.

(b) All measurements were below detection limits; however, for purposes of dose calculations, the values were assumed to be positive and a release height of 200 feet was used. The dose contributions of the stack releases so calculated were a small fraction of the total dose from 300 Area releases.

(c) Measured as gross alpha, assumed to be plutonium with a composition like that processed in 327 building during 1972 (viz, 0.035 wt% ^{238}Pu, 86.3 wt% ^{239}Pu, 11.8 wt% ^{240}Pu, 1.7 wt% ^{241}Pu and 0.15 wt% ^{242}Pu).

(d) Assumed to be all ^{239}Pu for purposes of dose calculations.

(e) Reported variously as gross beta, ^{90}Sr and mixed fission products (MFP). Assumed to be all ^{90}Sr for purposes of dose calculations.

The meteorological data bases employed in the calculations were as follows:

- Data collected at the Hanford Meteorological Station (over a 15-year period) were used for the 200 Area releases.
- Data collected (over a 1-year period) at 100-N were used for the 100-N releases.
- A combination of wind velocity data collected (over a 2.5-year period) at the FFTF site and long-term stability data from HMS were used for the 300 Area releases.
- Correction for height of release and plume rise were included.
- Changes in elevation of the receptor location were not included.
- Releases from building vents were treated as though they were at ground level.
- No building wake factors were included. This results in conservative (higher) values for the atmospheric dilution factor ($\overline{\chi}/Q$) and dose to man.

The "maximum individual" across the river from the 300 Area is in a location where the annual average atmospheric dilution is

- 3.2×10^{-7} sec/m^3* from 300 Area vent releases
- 6.0×10^{-8} sec/m^3 from 300 Area stack releases
- 2.3×10^{-9} sec/m^3 from 100-N Area stack releases
- 4.0×10^{-9} sec/m^3 from 200 Area stack releases
- 2.1×10^{-8} sec/m^3 from 200 Area vent releases.

The doses to the maximum individual resulting from these various sources depends also upon the rate of release of the several radionuclides with the gaseous effluent. The external radiation doses to the maximum individual adult and child from air submersion and the internal doses from radioiodine are summarized in Table III.1-7.

Inhalation and transpiration of tritium through the skin contribute a very small increment (2×10^{-4} mrem/yr) to the internal dose received by all organs listed in the table except for the mineral bone which does not accumulate tritium. The release of ^{85}Kr from the 291-A stack contributes 82% of the external dose to the skin but only 8% of the external dose to the whole body of the maximum individual. Approximately 80% of the internal thyroid dose from airborne radionuclides results from the release of ^{131}I from the 300 Area. The total dose to the maximum individual from air pathways is given in Table III.1-7 as 0.088 mrem/yr to the skin, 0.011 mrem/yr to the whole body, GI tract and bone (principally from external exposure) and 0.11 mrem/yr to the thyroid principally from ingestion of radioiodine.

The whole body dose due to air submersion is tabulated versus distance from the HMS in Table III.1-11. The integrated dose from this source is 1.4 man-rem/yr in 1972. The contributions from releases at the 200 Areas (9×10^{-3} man-rem/yr) and the 300 Area (4×10^{-6} man-rem/yr) are a negligibly small fraction of the total air submersion dose.

The population dose from all gaseous pathways is listed in Table III.1-12. A small increment population dose (0.02 man-rem/yr) results from releases of tritium to the atmosphere from the 100-N and the 200 Areas stacks. Table III.1-12a shows the trend of recent years in population doses of Hanford origin, expressed as percentages of annual dose limits as given in ERDAM-0524.

The total population dose to the thyroids of local residents was estimated by two methods. A tabulation of all dairy cows in Benton and Franklin counties was available from the bi-county health department. From these data, it was estimated that 41,200 lb of milk were produced each day for delivery to commercial milk plants in eastern Washington and to a limited extent Portland, Oregon, and Seattle, Washington, In addition, about 10,500 lb/day of milk were produced by non-shippers in Benton and Franklin counties. At an average population consumption of 0.35 liters of milk/day, this quantity of milk would provide for about 74,000 consumers if it were all used as fresh milk.

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* Ci/m^3 divided by Ci/sec.

TABLE III.1-11

ESTIMATED CUMULATIVE POPULATION, CUMULATIVE ANNUAL DOSE AND AVERAGE ANNUAL DOSE IN CIRCULAR AREAS AROUND THE HANFORD METEOROLOGY STATION FROM GASEOUS EFFLUENTS RELEASED FROM ALL FACILITIES IN 1972

Radius (miles)	Cumulative Population (1973)	Cumulative Dose man-rem/year	Average Annual Dose mrem/year per person
10	0	0	0
20	5,885	0.10	0.017
30	71,438	0.78	0.011
40	135,944	1.1	0.0083
50	248,644	1.4 [a]	0.0055

(a) Contributions from 100-N, 200 Area and 300 Area are 1.4, 9×10^{-2}, and 4×10^{-6} man-rem/year, respectively.

TABLE III.1-12

SUMMARY OF ESTIMATED POPULATION DOSES RECEIVED AS A RESULT OF THE HANFORD OPERATIONS

Pathway	Whole Body Dose man-rem/yr 1972	Thyroid Dose man-thyroid rem/yr 1972
Gaseous Effluents		
Air Submersion	1.4	(1.4) [a]
Tritium (Inhalation & Transpiration)	0.02	0.02
Radiodine (Inhalation, Milk, Vegetables)	--	0.6
Liquid Effluents		
Drinking Water	0.45	8.9
Fish Consumption	0.11	0.12
Aquatic Recreation	0.40	(0.40)
Irrigated Foods (Produce, Eggs, Meat)	0.16	0.33
Total	2.5	12 [b]

(a) ( ) indicates internal dose from external exposure.
(b) Not including the contribution from ^{129}I in the Hanford environment presumably as a result of previous years of operation. This contribution can be estimated to be an additional 4 man-thyroid-rem/yr.[6,13]

9 1 1 1 3 9 1 0 6 4 3

TABLE III.1-12a

COMPARABLE DOSE ESTIMATES[a] FOR MAXIMUM AVERAGE INDIVIDUAL AND RICHLAND RESIDENT, 1968-1972[71]

	% of Limit					Limit
	1968	1969	1970	1971	1972	(mrem/yr)
Maximum Individual						
Bone	17	9	6	<1	<1	1500
Whole Body	5	4	2	<1	<1	500
GI Tract	4	3	2	<1	<1	1500
Thyroid (infant)	7	4	2	<1	<1	1500
Average Richland Resident						
Bone	3	3	2	<1	<1	500
Whole Body	2	2	1	<1	<1	170
GI Tract	5	4	2	<1	<1	500
Thyroid (infant)	8	5	2	<1	<1	500

(a) Not including contributions from fallout or natural background radiation.

Concentrations of radioiodine in this milk from all Hanford sources were estimated using the mathematical models previously discussed, and the resultant population thyroid dose to all the milk consumers was calculated to be 0.5 man-thyroid-rem/yr. Inhalation and consumption of fresh leafy vegetables was estimated to add another 0.1 man-thyroid-rem to this total. These results are listed in Table III.1-12.

Another estimate was made of the maximum potential thyroid dose by assuming that sufficient milk and leafy vegetables were produced locally to supply all of the needs of the population within 50 miles. The dairy cows and gardens were distributed the same way that the population was (not necessarily implying each family had their own cow and garden). On this basis, the total integrated thyroid dose was estimated from a modification of the air submersion dose computer code to have an upper limit of 0.9 man-thyroid rem/yr from inhalation, milk and leafy vegetables combined, in reasonable agreement with the value of 0.6 calculated by the first method.

An additional source of thyroid exposure in the Hanford environments is the ^{129}I present from past releases. Measurements of this radionuclide have recently been reported.[6,13,14] From these data,[13] the thyroid doses to individuals in the vicinity of Hanford from all potential pathways were calculated.[6] The dose to the maximum individual adult and infant thyroids were both estimated to be about 0.4 mrem/yr. In a manner similar to that employed for calculating the population doses from ^{131}I and ^{133}I for 1972, the contribution from the total ^{129}I present in the local environment was estimated to be about 4 man-thyroid-rem/yr. These ^{129}I contributions were not included in the thyroid doses tabulated in Tables III.1-7 and III.1-12.

III.1.1.2.1 Inhalation of Plutonium

The estimated dose to the lung and to the bone of individuals in the Hanford environment due to plutonium releases to the atmosphere can be calculated by the methods detailed in Appendix III-8. These calculations have been made for both soluble and insoluble plutonium compounds for 1 year of chronic exposure at the release rates for 1972 as given in Table III.1-9. The first year and the 50 year dose commitments were calculated. The resultant doses depend on the individual's location relative to the 200 Areas. The doses calculated at the distance of closest approach to the Hanford boundary in the prevailing downwind direction (east southeast to southeast) are summarized in Table III.1-13.

An analysis of plutonium air sample data showed no significant difference between nearby areas in the prevailing downwind direction from the chemical processing areas and similar data for more distant perimeter communities in both the upwind and downwind direction. In 1972, the plutonium concentrations averaged 1.9×10^{-5} pCi/m^3 at nearby downwind locations and 1.8×10^{-5} pCi/m^3 at the more distant perimeter communities. Since these are actual air concentration measurements, they include any contribution from resuspension of any previously deposited plutonium. The lung dose due to these concentrations, which are believed to be due to worldwide plutonium fallout, is about 2.2×10^{-4} rem/year. The 50-year lung dose commitment is about 1 mrem. These lung dose

values were calculated from the measured average plutonium air concentrations at perimeter communities using the concentration to dose conversion factor of (12 rem/yr)/(pCi/m^3) as given in EPA report number EPA-520/4-73-003.[15]

TABLE III.1-13

MAXIMUM RADIATION DOSE TO AN INDIVIDUAL FROM INHALATION OF PLUTONIUM RELEASED AT THE 200 AREAS IN 1972[a]

	Soluble		Insoluble	
	1st Year (rem)	50 Year Dose Commitment (rem)	1st Year (rem)	50 Year Dose Commitment (rem)
Lung	2.2×10^{-7}	2.7×10^{-7}	2.2×10^{-6}	1.0×10^{-5}
Bone	1.1×10^{-6}	1.0×10^{-4}	5.9×10^{-8}	3.9×10^{-5}

(a) Results based on ICRP Task Group Lung Model (Appendix III-B).

III.1.1.2.2 Radionuclide Analysis of Human Tissue Samples at Autopsy [X.10]

In 1949 a program of tissue sampling at autopsy was initiated[16] on former Hanford employees, residents of the Hanford regions and persons from distant places who had died locally. The objective of this program is to obtain tissue samples for analysis for plutonium and other radionuclides to form a more direct basis for assessing the radiological impact of the Hanford plutonium facilities on workers and local residents and for evaluation of the long-term effectiveness of safety practices associated with operation of Hanford facilities. This study supplements two other ERDA-sponsored studies relating to the health of Hanford workers and residents: the U.S. Transuranium Registry and the ERDA Health and Mortality Study. Both studies have been documented.

The number of cases analyzed between 1949 and 1970 amounted to about one-third of those coming to autopsy at the local hospital.[17] Samples of lung, liver, bone and the tracheobronchial lymph nodes, when prominent, were taken from noncontagious disease cases as selected by the pathologist. At various times other samples such as blood, pancreas, prostate, seminal vesicles and spleen have been taken. Because of the infrequency of measurable plutonium in these samples, those tissues are no longer sampled on a routine basis. In cases where measurable plutonium was anticipated because of known occupational exposure, the sampling of tissues has been more extensive.

The measurement capability for plutonium in autopsy tissue samples varies with amount and type of sample and with analytical chemistry parameters. For practical purposes, the detectable amount in a sample for the cases reported here may be taken as about 20 fCi Pu (total plutonium alpha) per sample. The detectable concentration then depends on the sample size. For example, using the above, the detectable concentration of plutonium in a one gram tracheobronchial lymph node would be 20 fCi Pu/g whereas if 1000 grams of lung had been processed, the detectable concentration would be 0.02 fCi Pu/g of lung.

Results of sample analyses completed through 1970[17] were published in 1972. At that time, 160 cases had been analyzed for individuals who had worked at Hanford; another 147 cases had been reported for individuals who had lived in the Hanford area for at least three years but who had not worked at Hanford; and another 50 cases had been analyzed for individuals coming to autopsy locally but who had not resided locally.

Of the individuals residing locally, the largest positive measurements were 2.6 fCi Pu/g of lung and 2.3 fCi/g of liver. About one-half of the results for each of these tissues were less than 0.5 fCi Pu/g. Of those individuals not residing locally, the measured concentration of plutonium in lung and liver did not exceed 5 fCi Pu/g except for one liver specimen in which a measured concentration of 6.5 fCi/g was obtained in 1950. Again, about one-half of these results were less than 0.5 fCi Pu/g. The largest positive measurements obtained since 1950 were 1.8 fCi Pu/g of lung and 1.1 fCi Pu/g of liver.

Measurement of plutonium in tracheobronchial lymph nodes was initiated in late 1959, and results have been obtained on 76 cases of local residents and 31 cases of nonlocal residents. Among local residents, the highest concentration found was 140 fCi Pu/g. Ninety-seven percent of the results were less than 20 fCi Pu/g and over one-half of the results were less than 5 fCi Pu/g.

9 1 1 1 3 9 1 0 6 5 0

Among nonlocal cases, the highest concentration measured was 68 fCi Pu/g and again about 97% of the results were less than 20 fCi Pu/g and over one-half of the concentrations were less than 5 fCi Pu/g.

Except for one individual residing locally, the concentration of plutonium in bone was less than 20 fCi Pu/g for all individuals of either environmental category. A plutonium concentration of 49 fCi/g of bone was determined for one individual in 1967. More than three-fourths of the results of measurements of plutonium in bone indicated concentrations of less than 5 fCi Pu/g.

The amount of fallout plutonium that might be expected in local lung tissue samples is estimated to be approximately 0.5 fCi Pu/g.[16,17] This result as well as the Hanford measurement results for both categories of environmental residents are in substantial agreement with analytical results obtained elsewhere for the general population in New Mexico, Colorado, Georgia, South Carolina, Tennessee and New York.[18] As a consequence, the Hanford data are considered to suggest preclusion of past Hanford operations as an important contribution to the presence of plutonium in local residents.

Maximum values were reported for the various groups. The minimum was uncertain because so many results were very near background and could be reported only as less than some value, which varies with the size of the sample as well as statistical parameters associated with the radiochemical measurements. The best that can be done is to state the number of samples which are less than some prescribed value. However, the problem with such reporting is that how much less than the value shown the true activity may be is not known. Standard deviation of such data is meaningless.

No reports on ^{90}Sr in human teeth of Hanford personnel have been made because even during times of weapons fallout such measurements were not thought to yield significant results. In 1961,[74] measurements of ^{90}Sr in sanitary water at Pasco indicated an annual average of about 0.3 pCi ^{90}Sr/liter, with a maximum of 1 pCi ^{90}Sr/liter. Also during that year, the average concentration of ^{90}Sr in milk was about 3 pCi/liter, which was among the lowest in the nation. In 1972 an average of about 0.2 pCi ^{90}Sr/liter was measured in Richland sanitary water while the average in local milk was about 3×10^{-3} pCi ^{90}Sr/liter.

A number of autopsy tissue samples were analyzed for fission products prior to 1963; none of these gave positive results so the measurement program was abandoned.

With such small amounts of ^{90}Sr in the environs, bones of animals were only infrequently analyzed for ^{90}Sr. Analyses of deer bone for ^{90}Sr in 1972 detected 0.48 pCi ^{90}Sr/g. ^{90}Sr concentrations[75] in Hanford deer are similar to the concentrations in deer from other parts of the country and are attributed to fallout.[76]

A 1960 study[77] of mortality from congenital malformation concluded that the incidence of congenital malformation deaths in Benton County was normal. A 1965 paper[78] asserted that malignancy indices for counties bordering along the Columbia River correlated significantly with a mathematical expression of exposure to the river and closeness to Hanford. However, another study[79] pointed out that omissions were made in the earlier analysis and concluded that no evidence existed that persons living downstream from the Hanford complex have had an excessive risk of death from cancer in general or from leukemia in particular. Also noted was that both Oregon and Washington have had a consistent excess in leukemia mortality but that the excess was present before Hanford began operation.

The occurrence of "thyroid nodules" was not investigated. Symptoms appeared 10 years after Rongelap islanders had been exposed to about 1200 rads of ^{131}I radiation.[80] Upper limits on exposed persons, as measured in the Hanford environs, suggest doses of less than one rad over a 10-year period. The likelihood of thyroid nodules appearing as a result of such low exposures is judged to be very remote.

For the most part, ^{131}I found in human thyroids has been primarily associated with weapons fallout or as a result of occasional unusual releases. In 1962, 37 children in the Hanford environs were examined[81] for the presence of ^{131}I in their thyroids. The values ranged from less than 20 pCi ^{131}I to 100 pCi ^{131}I in the thyroid. In a study[82] of radionuclides in people just downstream from the Hanford reactors in late 1962, ^{131}I found in thyroids ranged from less than 30 pCi to 300 pCi among 12 individuals. As a result of an unusual release of ^{131}I from the Hanford site in September 1963, a measured value of 73 pCi ^{131}I was reported[83] based on food consumption. A child and his sister were residents of the farm where the maximum concentration of ^{131}I (less than 30 pCi) was found following this incident. Iodine-131 in bovine thyroids is also documented.[84] The emission of ^{131}I from the Hanford facilities has been so reduced over the years that such sampling, collection and measurement are no longer warranted.

III.1.1.3 Direct Radiation

Because of the isolation of the major nuclear facilities within the Hanford Reservation, no direct radiation exposure of the public occurs from these sources. Potential direct radiation exposure from a severe accident will be discussed later.

III.1.1.4 Transportation of Radioactive Materials [X.26]

Close coordination between ERDA, and the U.S. Department of Transportation (DOT) is maintained, assuring compliance with all pertinent regulations prior to the shipment of any radioactive or other hazardous materials. Special shipping containers are used when specified by the DOT.

During 1972 the radioactive materials transported to or from the Hanford site did not result in any measurable population exposure. The quantities shipped were either small or consisted of alpha emitting radionuclides (uranium and plutonium), which had extremely low external radiation potential.

Prior to 1972, approximately 40 shipments of 100-N irradiated fuel were made to West Valley, New York, for processing. The population dose potential received from such shipments was estimated using the shipping data and the calculation methods published by the USAEC in WASH-1238.[19] The population density along the shipping route was taken to be 110 persons per square mile in the western half of the route and 330 persons per square mile in the eastern half. Thus, for 12 shipments made per year at 3000 miles each, the general population dose would be ~0.01 man-rem. However, a few individuals would receive additional radiation exposure from closer approach to the vehicles. If a person were to spend about 3 minutes at 3 feet from the shipment, where the dose rate was 3 mR/hr, he would receive a whole body dose of 0.15 mrem. Assuming 10 such persons/shipment and 12 shipments/yr, the whole body dose to all such persons would be 0.018 man-rem/yr. The dose to the transportation workers can also be estimated to be about 0.15 mrem/person/shipment; with the same total of 10 workers/shipment and 12 shipments/yr, the total dose to the workers becomes 0.018 man-rem/yr.

Thus, the total whole body population dose for all three categories combined is estimated to be ~0.04 man-rem/yr. Since this dose was not incurred in 1972, it was not included in Tables III.1-7 and III.1-12. But it is a potential dose if the alternative of offsite shipment instead of local processing were selected for the 100-N irradiated fuels.

III.1.1.5 Dose to Population from all Sources

The total doses to the whole body and the thyroids of the population living within 50 miles of the Hanford Reservation from the several pathways are summarized in Table III.1-12. The whole body population dose rate from all sources is 2.5 man-rem/yr. The average per-capita annual dose rate is 1.0×10^{-2} mrem/yr. When N Reactor is shut down, the current release of ^{41}Ar and some tritium and ^{131}I as well as other activation and fission products from N Reactor effluents will cease. At that time, the air submersion dose to the population will be reduced to about 0.09 man-rem/yr and the dose attributable to the liquid effluents will be reduced as the radioactive materials already in the river sediments decay. The radionuclides reaching the Columbia River from the groundwater system, (mostly tritium and ^{106}Ru-Rh) will, at their maximum rate of discharge, contribute less than 0.1 man-rem/yr to the local population dose. The population whole body dose in the first year after N Reactor is shut down is not expected to exceed 0.5 man-rem/yr and will then continue to decrease as the river inventory decays.

The 50-year population lung dose commitment due to the 1972 Hanford Waste Management Operations release of ^{239}Pu (all assumed to be insoluble) was 0.03 man-rem. The corresponding 50-year population lung dose commitment due to worldwide fallout plutonium (all assumed to be insoluble ^{239}Pu) was about 250 man-rem. The 50-year lung dose commitment from fallout plutonium was nearly 9,000 times the calculated 50-year lung dose commitment from Hanford 1972 emissions.

Both the whole body population dose and the average per-capita dose are insignificant compared with the doses received by the same residents from natural background radiation and other man-made sources. The external penetrating whole-body dose from natural cosmic and terrestrial radiation sources in the Hanford vicinity has been measured at 75 to 92 mrem/yr.

In addition to this background, natural radioactive materials within the body, acquired from ingestion and inhalation, add another 25 mrem/yr to the whole body dose.[4] Therefore, the natural background per capita dose from external and internal sources is about 100 mrem/yr and the total population dose is about 27,000 man-rem/yr. Thus, the total exposure from Hanford sources (2.5 man-rem/yr) is 9×10^{-5} of that from natural background and would be imperceptible when compared to the normal 10 to 15% fluctuation which occurs annually in the natural background radiation levels.

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Medical and dental radiation from diagnostic and therapeutic procedures received in the U.S. in 1970 totaled about 70 mrem/yr/capita.[20] Other miscellaneous sources listed by the EPA totaled 2.6 mrem/yr per capita in 1970. These included 0.1 from television receivers, 1.0 from high altitude air flights, and 1.5 from miscellaneous consumer products containing radioactive materials (such as luminescent dials on watches). The dose from high altitude jet aircraft travel includes an average of 670 mrem/yr per crew member and a total of about 200,000 man-rem/yr for passengers at a rate of 0.7 mrem/hr while flying at an altitude of 30,000 feet. The dose received during a single high altitude cross-country flight (~6 hours) would then be about 4 mrem.

Assuming the people within 50 miles of the Hanford Reservation are typical of the national average, they probably received total population doses of 17,400 man-rem/yr from medical sources of radiation, 250 man-rem/yr from jet air travel, 25 man-rem/yr from television receivers, and 370 man-rem/yr from miscellaneous consumer products for a total of 18,000 man-rem/yr in addition to the natural background radiation. The population dose of 2.5 man-rem calculated to be received as a result of Hanford operations is within normal fluctuations of doses received from natural background radiation.* Therefore, relation of a dose of this magnitude to any environmental effect would be unrealistic to postulate and impossible to demonstrate.

III.1.1.6 Maximum Health Effects [X.6]

The reports, "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation" (The BEIR Report)[20] and "Ionizing Radiation: Levels and Effects,"[21] have attempted to relate radiation dose to the population to a quantity called "health effects." The health effects generally considered are cancer deaths, cancer cases, general ill health and genetic damage.

Both reports discuss the difficulties in arriving at dose to health effect relationships because of the very low number of health effects that might occur at the low doses of radiation being considered. Because of the lack of data at the very low actual dose rates (usually 10^{-3} or less rem/hr), health effect assumptions are extrapolated from data from radiation exposures at very high dose rates (many rem/hr). An additional assumption is then made that when the population doses (sum of the dose received by each member of a population group) for population groups of various sizes are equal, the number of health effects are the same for each group. It does not matter whether the doses are small and the populations are large or vice versa. The calculations make the conservative (yielding higher effects) assumption that the population dose health effects relationship is linear and passes through the origin of a plot, i.e., zero dose equal zero effect.

For the analysis of the maximum potential number of health effects that might occur as a result of the 1972 environmental radiation doses due to the Hanford Waste Management Operations, the dose to maximum number of health effect conversion factors from the BEIR Report as summarized by EPA[15] were used. These values are given in Table III.1-14.

For the population doses due to 1972 Hanford Waste Management Operations, the maximum potential health effects are summarized in Table III.1-15. For this calculation, the lung and genetic organ doses were conservatively estimated to be the same as the whole body dose.

Since the number of health effects are all far less than one, it may be concluded that there are no health effects due to Hanford operations for 1972. The naturally-occurring radiation background whole body dose is 11,000 times larger than the dose contribution from the Hanford operations for 1972 (27,400 man-rem background to 2.5 man-rem Hanford). The maximum numbers of health effects (cancer deaths, cancer cases and genetic effects) arising from this natural background is about 11,000 times the number of health effects calculated for Hanford operations.

The question of whether low doses of radiation received at low dose rates results in any carcinogenic or genetic injury at all has not been resolved. Thus far animal experimentation has given no evidence that such injury results. In some experiments, the exposed animals have outsurvived the controls. Low exposures at low rates could some day be demonstrated to be truly insignificant. In the meantime, until this question can be resolved one way or other, it is prudent to employ conservative dose expected-effect assumptions. The Hanford Waste Management Operations have never considered adopting practices that would lead to exposures approaching recommended limits or standards. The National Council on Radiation Protection and Measurements has stated in their report:[73]

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* The U.S. Public Health Service recently reduced estimates of population dose due to errors found in earlier calculations. From the new estimates the population dose due to medical source would be reduced from 17,400 man-rem/yr to about 5000 man-rem/yr and the population dose from miscellaneous consumer products would be reduced from 18,000 man-rem/yr to about 6,000 man-rem/yr.

"Before considering any further restriction of radiation protection standards, it is important to attain realistic values for risks and benefits, for weighing risks and benefits in decision-making, and for the most effective application of the principle of "lowest practicable level." This approach is important in order to avoid the expenditure of large amounts of the limited resources of society to reduce very small risks still further with possible concomitant increase in risks of other hazards or consequent lack of attention to existing greater risks."

TABLE III.1-14

CONVERSION FACTORS

Population Dose to Maximum Number of Health Effects

Organ	Conversion Factors
Mortality	
Whole Body	200 cancer deaths/10^6 man-rem
Lung	50 cancer deaths/10^6 man-rem
Thyroid	5 cancer deaths/10^6 man-rem
(Weighted Average)[a]	
Morbidity	
Whole Body	400 cancer cases/10^6 man-rem
Thyroid <1 year old	150 cancer cases/10^6 man-rem
1-19 years old	35 cancer cases/10^6 man-rem
>20 years old	5 cancer cases/10^6 man-rem
(Weighted Average)[a]	20 cancer cases/10^6 man-rem
Genetic Damage	300 effects/10^6 man-rem

(a) Weighted for an assumed population age distribution given by EPA in Reference 15.

TABLE III.1-15

MAXIMUM NUMBER OF HEALTH EFFECTS FOR 1972 ENVIRONMENTAL DOSE LEVELS

Organ	Population Dose	Maximum Number of Health Effects[a]
Mortality		
Whole Body	2.5 man-rem	5.0×10^{-4} cancer deaths
Lung	2.5 man-rem	1.2×10^{-4} cancer deaths
Thyroid	12 man-rem	6.0×10^{-5} cancer deaths
Morbidity		
Whole Body	2.5 man-rem	1.0×10^{-3} cancer cases
Thyroid	12 man-rem	2.4×10^{-4} cancer cases
Genetic Damage	2.5 man-rem	7.5×10^{-4} genetic effects

(a) This column gives the total number of health effects through all future years for the doses received in 1972 from Hanford Operations.

The data on lung doses referenced in the previous section and the Appendix III-B have assumed uniform distribution,[70] the method adopted by the International Commission on Radiological Protection. However, it has been proposed that summing the energy released from radioactive material in the lung over the entire lung may not be a proper assessment of consequences.[22,23] Particulate radioactive materials (hot particles) may be considered to produce a much larger health effect than would be expected from the total organ dose because of the very high dose delivered to the tissue by alpha particles from the deposited material.

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The Radiation Alert Network of the Division of Atmospheric Surveillance, EPA, routinely collects airborne particulates from eleven stations across the U.S. for plutonium analysis.[24] The high, low and Seattle values are:

Anchorage, Alaska	14×10^{-18} Ci/m^3
Austin, Texas	44×10^{-18} Ci/m^3
Seattle, Washington	20×10^{-18} Ci/m^3

The measurements for 1972 at Richland, Washington and other locations in the vicinity of the Hanford Operations averaged 19×10^{-18} Ci/m^3. At this background level, it is not possible to measure the Hanford contribution to the general fallout plutonium. However, a calculation of the maximum plutonium concentrations at an offsite location can be made from the measured stack and vent emission rates and the measured dilution factors. The calculated maximum concentrations at the nearest occupied location is 1.5×10^{-18} Ci/m^3, about one-tenth of the concentration of fallout background. The average concentration is considerably less.

In summary, the Hanford measurement of 19×10^{-18} Ci/m^3 includes the calculated maximum addition from Hanford of 1.5×10^{-18} Ci/m^3 and any resuspension that would result from previous Hanford or fallout depositions. Thus, the Hanford contribution does not measurably contribute to the plutonium fallout background. It is concluded from Tables III.1-14 and III.1-15, and from the plutonium measurements, that the Hanford Waste Management Operations for 1972 did not impact harmfully to any significant degree on the health and well being of the population in the Hanford environment.

The question of whether or not there is such a thing as a "harmless" or "safe" dose of radiation has not been conclusively answered to date. At very low doses of radiation the existence or non-existence of any effect has not been proven. However, acceptable risk dose levels have been established by competent medical and scientific authorities. As indicated in the BEIR Report,[20] there is insufficient information and scientific data on which to base estimates of the actual risk of health effects attributable to a particular increase in the level of exposure of the general population to ionizing radiation. This report also recognizes that the assumptions and models used in making an analysis of health effects are fraught with uncertainty. There are responsible views to the effect that assumptions used in calculating so-called health effects are simply not correct. The President of the National Council on Radiation Protection and Measurements has stated:[25]

> "If this is true it becomes purely a matter of judgment as to where to set permissible standards, and that is precisely the dilemma into which we have worked ourselves during the past decade.
>
> "In the development of this concept, there were many reservations and explanations but if the linear dose-effect relationship is taken at its face, and you literally accept the relationship as fact rather than as assumption or model, you can presumably calculate the number of people that will be killed by any level of radiation exposure that you wish to use. This is precisely what has happened during the past three or four years. A couple of authors predicted a 'kill' up to 100,000 people a year--in the minds of the average reader and the public--due to the use of current standards applied to the generation of electric power by nuclear means. Another author predicted that the medical profession would 'kill' a third of that number because radiologists are not sufficiently careful about diaphraming their x-ray beams. Still another author predicts a 'kill' of countless babies by exposure to radiation from power reactors at radiation levels far less than the natural background radiation. What has happened is that each of these people have taken the assumptions or models and used them as though they were facts."

There has been a history of disagreement with the established radiation protection standards on the part of some members of the scientific community. In some instances, the absence of sufficient data concerning biological effects from radiation at low levels has resulted in disagreement with the value judgment that use of radiation producing materials and processes should proceed even though all risks may not be known. The BEIR report does not propose new numerical standards for radiation exposure but rather concludes that such decisions require technical, economic and sociological considerations of a complex nature.

III.1.1.7 Occupational Doses to Hanford Workers* [RPB, X.6, X.25]

The average number of Hanford employees during the years 1965 to 1973 was 8,951. The annual average dose ranged from 0.30 to 0.68 rem and for the period averaged 0.41 rem. The maximum received during the same period ranged from 4.4 to 8.4 rem. The average accumulated for this period was 4.1 rem with a maximum accumulated of 38.1 rem.

Whole body occupational doses to Hanford workers for the past ten years are shown in Table III.1-15a. The whole body occupational dose is included for all persons employed during each year, not just for those on the rolls at year-end. The averages are the total dose, either for a particular year or that accumulated since 1965 divided by the number of employees on roll at year-end.

TABLE III.1-15a

WHOLE BODY OCCUPATIONAL DOSE

(rem)

Year	Total No. Employees	Annual Total	Annual Average	Annual Maximum
1965	9,697	6,640	0.68	5.0
1966	9,379	4,430	0.47	5.1
1967	9,405	4,150	0.44	4.6
1968	9,050	4,040	0.45	5.4
1969	8,796	3,290	0.37	8.4
1970	8,934	2,700	0.30	5.0
1971	8,563	3,090	0.36	4.9
1972	8,338	3,090	0.37	4.4
1973	8,240	2,550	0.31	4.8
1974	9,111	2,940	0.32	4.7

III.1.8 Environmental Dose Commitment [RPB, X.24, X.25]

The EPA has developed a concept called the "environmental dose commitment" to assess the total impact of a nuclear facility on the environment. EPA claims that "The concept encompasses the total projected radiation dose to populations committed by the irreversible release of long-lived radionuclides to the environment, and forms a basis for estimating the total potential consequences on public health of such environmental release."[15] As stated by EPA, "Because of the difficulty of making projections of radionuclide transport on the basis of present knowledge, these potential consequences have been calculated only for the first one hundred-year period following release." The particular radionuclides considered by EPA were tritium, ^{85}Kr, ^{129}I, and the actinides.

The environmental dose commitment from Hanford Waste Management Operations is small because of the small quantities of radionuclides released to the environment. An estimate of the Hanford environmental dose commitment can be calculated by comparing the releases used by EPA[15] and the Hanford releases. For comparison, all assumptions stated by EPA were adopted and the resulting health effects for Hanford Waste Management Operations for several postulated time periods were calculated. Operating periods and emission rates assumed were:

* The Health and Mortality Study of employees of ERDA contractors provides a comparison of radiation worker groups and their siblings with respect to longevity and cause of death. The study concludes that to date the gross analysis of relative longevity of employees exposed to external radiation has given no indication of any general adverse effect within the time span currently available. However, the data do not warrant concluding that in the future some adverse effects may not become evident. Additional studies aimed at detecting any biological effects of radiation doses occupationally received at selected ERDA facilities were started in FY-1976. The emphasis of these new studies is to search for deleterious effects in the definitive class of occupationally exposed workers who have received the higher exposures. Recently, an advisory committee recommended procedures for incorporating exposure data from internally deposited radionuclides into the individual worker's exposure estimate. Programs of certification of radiation exposure values for all Oak Ridge employees and of ascertainment of date and cause of death on that population are now in progress. Personnel and radiation data collection are scheduled for early completion at Mound Laboratories.

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- N Reactor and Purex operate through 1978 with emission rates equal to those observed in 1972.
- N Reactor and Purex operate through 1983 with emission rates equal to those observed in 1972.
- N Reactor and Purex operate through 1990 (the full design life of N Reactor) with emission rates equal to those observed in 1972.

The emission rates assumed for all three cases are believed high because process improvements and effluent reduction programs are continually being developed and adopted. The environmental dose commitment was calculated for the four radionuclides considered in the EPA study. Exposures were calculated for a U.S. population increasing from 200 million in 1970 to a constant 400 million in the year 2030 and beyond. The earth's population was taken as 3.5 billion in 1970 with a growth rate of 1.9% per year.

The quantities of radionuclides potentially released by the nuclear power industry through 2020 were calculated by summing the 5-year inventory quantities and multiplying by the EPA assumed release fraction as shown in Table III.1-15b.

TABLE III.1-15b

POTENTIAL RADIONUCLIDE RELEASES FROM NUCLEAR POWER INDUSTRY

Radionuclide	Total Quantity Produced to 2020 (Ci)	Assumed Release Fraction	Calculated Quantity Released (Ci)
Tritium	1.1×10^{9}	1	1.1×10^{9}
^{85}Kr	1.4×10^{10}	1	1.4×10^{10}
^{129}I	5.5×10^{4}	0.1	5.5×10^{3}
^{239}Pu	1.0×10^{9}	10^{-6}	1.0×10^{3}

The health effects calculated to result from this release from the nuclear power industry for the period 1970 to 2020 and for the following 100 years as given by EPA are shown in Table III.1-15c.

TABLE III.1-15c

POTENTIAL HEALTH EFFECTS ON THE EARTH'S POPULATION FROM NUCLEAR POWER INDUSTRY AS STATED BY EPA

Radionuclide	Calculated Curies Released	Total Health Effect	Severity
Tritium	1.1×10^{9}	2,800	2/3 Fatal
^{85}Kr	1.4×10^{10}	6,900	2/3 Fatal
^{129}I	5.5×10^{3}	250	1/4 Fatal
^{239}Pu	1.0×10^{3}	24,000	All Fatal

The quantities of these radionuclides released by Hanford Waste Management Operations under the three postulated operating periods are given in Table III.1-15d.

TABLE III.1-15d

ESTIMATED RADIONUCLIDE RELEASE FROM HANFORD WASTE MANAGEMENT OPERATION

	Curies Released for Postulated Operating Periods		
Radionuclide	1972→1978	1972→1983	1972→1990
Tritium	4.8×10^{4}	8.8×10^{4}	1.4×10^{5}
^{85}Kr	2.4×10^{6}	4.4×10^{6}	7.2×10^{6}
^{129}I	1.8×10^{1}	3.3×10^{1}	5.4×10^{1}
^{239}Pu	3.1×10^{-2}	5.7×10^{-2}	9.3×10^{-2}

For the releases of radionuclides given in Table III.1-15d, the environmental dose commitments in maximum number of health effects are given in Table III.1-15e for each postulated operating period. The calculation is made by taking the ratio of the releases used by EPA and the estimated releases from the Hanford Waste Management Operations and applying the resulting ratio to the health effects as calculated by EPA. This approach accepts all assumptions and calculatory methods used by EPA.[15]

TABLE III.1-15e

MAXIMUM POTENTIAL HEALTH EFFECTS ON THE EARTH'S POPULATIONS FROM HANFORD WASTE MANAGEMENT OPERATIONS

Radionuclide	Health Effects for Postulated Operating Periods		
	1972-1978	1972-1983	1972-1990
Tritium (2/3 Fatal)	0.3	0.5	1
^{85}Kr (2/3 Fatal)	2	4	7
^{129}I (1/4 Fatal)	2	3	5
^{239}Pu (All Fatal)	2	3	5

The significance of these values is not known. Although the dose rate is extremely low, the population exposed is taken to be very large. The uncertainties involved in using health effects data from high dose and high dose rate exposures to estimate the effects for extremely low doses and extremely low dose rates were reviewed earlier. The whole body dose to an average earth resident from one years total release of ^{85}Kr from Hanford is about 2×10^{-9} rem/yr. Naturally-occurring radiation background is about 100 million times greater for each individual on the earth.

III.1.1.9 1974 Update-Radiological Impact on Man[72]

The preparation of this impact statement began in August, 1973, thereby necessitating the use of 1972 data. Throughout its preparation, some data updating has been provided. This section summarizes the radiological impact on man for CY-1974. The improvements in effluent controls put into service since 1972, the change in N Reactor product requirements, and the fact that the Purex Plant did not operate in 1974 all tend to reduce the quantities of effluents released. The low population dose of 2.5 man-rem calculated for 1972 operations was further reduced. The environmental measurement program results of 1974 and a bibliography of earlier reports are included as Appendix III-G of Volume 2.

III.1.1.9.1 Maximum "Fence-Post" Exposure Rate

The maximum "fence-post" exposure rate during 1974 was calculated to be 2×10^{-5} mR/hr along the northwest boundary of the Hanford Reservation. Although no one lives in this particular area, the dose potentially received by an individual continuously present on the boundary was estimated to be 0.17 mrem. The majority of the dose received would be from ^{41}Ar (half-life 1.8 hours) released at N Reactor.

III.1.1.9.2 Maximum Individual Dose

The maximum dose to an individual member of the public during 1974 and the 50-year dose commitment from 1974 effluent were calculated for all of the radionuclides listed in Table III.1-15f.

All significant environmental exposure pathways were evaluated including submersion in the plume, drinking water, foodstuffs irrigated with Columbia River water, atmospheric iodine-pasture-cow-milk pathway, etc. The methods employed are expected to provide a best estimate of the doses due to the different exposure pathways. The calculated doses are conservative since less-than numbers in Table III.1-15f were assumed to be positive measurements for purposes of dose calculation.

TABLE III.1-15f

RADIONUCLIDE COMPOSITION OF EFFLUENT - 1974[a]

	Half Life	Effluent (Curies) Liquid to River	Gaseous 100 Areas	Gaseous 200 Areas	Gaseous 300 Areas
^{3}H (HTO)	12.3 yr	190.	4.2		
^{24}Na	15 hr	1.0			
^{32}P	14.3 d	0.004			
^{41}Ar	1.8 hr		50,000		
^{46}Sc	84 d	0.02			
^{51}Cr	28 d	0.22			
^{54}Mn	303 d	0.5			
^{56}Mn	2.6 hr	5.0			
^{58}Co	71 d	0.02			
^{59}Fe	46 d	0.18			
^{60}Co	5.3 yr	1.2			$<5 \times 10^{-5}$[b]
^{65}Zn	245 d	0.2			
^{76}As	26.4 hr	0.03			
^{90}Sr	28 yr	0.3	5×10^{-6}	<0.2[c]	$<4 \times 10^{-4}$[c]
^{95}Nb	35 d	0.1			
^{95}Zr	66 d	0.11			
^{99}Mo	67 hr	<0.6			
^{99}Tc	2.1×10^{5} yr	<0.1			
^{103}Ru	40 d	0.12			
^{106}Ru	368 d	0.5			
^{122}Sb	2.8 d	<0.01			
^{124}Sb	60 d	<0.07			
^{125}Sb	2.7 yr	0.02			
^{131}I	8 d	2.33	0.5		$<3 \times 10^{-3}$
^{132}I	2.3 hr		0.1		
^{133}I	20.3 hr		2.2		
^{133}Xe	5.3 d	0.003	0.15		
^{134}Cs	2.0 yr	0.02			
^{135}I	6.7 hr		3.1		
^{135}Xe	9.1 hr		1.8		
^{137}Cs	30.0 yr	0.12			
$^{140}BaLa$	12.8 d	0.8			
^{141}Ce	32.5 d	0.05			
^{144}Ce	284 d	0.103			
^{187}W	23.9 hr	<0.01			
^{239}Np	2.3 d	0.02			
^{241}Am	458 yr				$<3 \times 10^{-7}$
Pu-Alpha[d]	24,390 yr		$<4 \times 10^{-7}$	$<2 \times 10^{-3}$	$<4 \times 10^{-5}$
U-Alpha[d]	4.5×10^{9} yr				$<4.3 \times 10^{-4}$
Particulates[e]	---		0.23		

(a) Table includes all reported releases.
(b) Actually reported as mixed activation products. Cobalt-60 assumed for simplification and was used in dose calculations.
(c) Actually reported as mixed fission products. Strontium-90 assumed for simplification and was used in dose calculations. For 300 Area, 2×10^{-4} curies of ^{90}Sr was reported. The additional, $<2 \times 10^{-4}$, was reported as mixed fission products.
(d) Gross alpha counts for different facilities interpreted as either reflecting ^{239}Pu or uranium activity depending on the nature of the operations inside the facilities.
(e) Gross activity collected on particle filter. Subsequent analyses have shown the majority of the particulate activity to be ^{99}Mo. This radionuclide was used in the dose calculations.

Past studies, combined with results of the environmental surveillance program, have facilitated the construction of a hypothetical person whose dietary and recreational habits maximize the dose he might receive from Hanford operations. Such a hypothetical person is called the maximum individual. The habits and diet of the maximum individual include the maximum reported for each exposure mode in spite of the fact that the maximum values are not, in actuality, attributable to the same person. The maximum individual is a person assumed to have the following characteristics:

- Resides continuously directly across the river from the Hanford 300 Area.
- Obtains drinking water from the Columbia River.
- Drinks 275 liters of milk during a nine-month period from a cow eating pasture grass near his residence.
- Eats 710 kg of produce grown near his residence and irrigated with Columbia River water.
- Eats 40 kg of fish per year caught from the Columbia River.
- Spends as much as 500 hours per year on the shoreline of the Columbia River, 100 hours per year swimming in the river, and 100 hours per year boating.

The estimated whole body dose received during 1974 for such an individual from effluent released during 1974 is 0.03 mrem as shown in Table III.1-15g. The dose received was primarily the result of external radiation from ^{41}Ar releases from N Reactor (0.02 mrem) and radionuclides ingested with fish from the Columbia River and foodstuffs irrigated with Columbia River water (0.01 mrem).

TABLE III.1-15g

ESTIMATED DOSE TO THE MAXIMUM INDIVIDUAL DURING 1974 FROM EFFLUENTS RELEASED FROM HANFORD FACILITIES DURING 1974

Pathway	Annual Exposure	Annual Dose (mrem)[a] Skin	Body	GI-LLI	Bone	Thyroid
Gaseous Effluents						
Air Submersion	8766 hr	3.0×10^{-2}	2.0×10^{-2}	(2.0×10^{-2})[b]	(2.0×10^{-2})	(2.0×10^{-2})
Tritium-Inhalation & Transpiration	8766 hr	7.0×10^{-10}	7.0×10^{-10}	7.0×10^{-10}	-	7.0×10^{-10}
Radioiodine-Inhalation	7300 m^3	-	-	-	-	2.0×10^{-3}
Milk	274 liters[c]	-	-	-	-	6.0×10^{-2}
Vegetables (leafy)	30 kg[d]	-	-	-	-	1.0×10^{-2}
Total Air Pathways		3.0×10^{-2}	2.0×10^{-2}	2.0×10^{-2}	2.0×10^{-2}	9.0×10^{-2}
Liquid Effluents						
Drinking Water	730 liters	-	2.4×10^{-4}	4.9×10^{-4}	2.0×10^{-4}	1.7×10^{-2}
Fish Consumption	40 kg	-	5.7×10^{-3}	2.1×10^{-2}	6.2×10^{-3}	1.8×10^{-2}
Irrigated Foods	710 kg	-	4.8×10^{-3}	7.5×10^{-2}	2.5×10^{-3}	6.3×10^{-2}
Shoreline	500 hr	4.0×10^{-3}	3.0×10^{-3}	(3.0×10^{-3})	(3.0×10^{-3})	(3.0×10^{-3})
Swimming	100 hr	2.0×10^{-5}	2.0×10^{-6}	(2.0×10^{-6})	(2.0×10^{-6})	(2.0×10^{-6})
Boating	100 hr	1.0×10^{-5}	8.0×10^{-6}	(8.0×10^{-6})	(8.0×10^{-6})	(8.0×10^{-6})
Total Water Pathways		4.0×10^{-3}	1.4×10^{-2}	3.2×10^{-2}	1.2×10^{-2}	1.0×10^{-1}
Total (Adult)		3.4×10^{-2}	0.03	0.05	0.03	0.19
Infant Thyroid Dose						
Airborne Tritium	8766 hr					4.0×10^{-10}
Air Submersion	8766 hr					(2.0×10^{-2})
Inhalation	2045 m^3					6.0×10^{-3}
Milk	274 liters[c]					0.4
Drinking Water	292 liters					5.0×10^{-2}
Total (Infant)						0.5

(a) Dose received during 1974 due to effluent released during 1974.
(b) Internal Dose from external exposure indicated by parenthesis ( ).
(c) One liter per day for a 9-month grazing season.
(d) 200 g/d for a 5-month growing season.
(e) Only the potentially irrigated produce is included.

9 1 1 1 8 9 1 0 6 6 0

The dose potentially received by the thyroid of an infant (one year old) was estimated to be 0.5 mrem from effluent released during 1974, as shown in Table III.1-15g. The dose was primarily due to ^{131}I in milk and drinking water. The iodine in milk results from irrigation of the pasture with Columbia River water and deposition on the pasture grass of airborne iodine. Essentially all of the dose would be received during 1974 since ^{131}I has an eight-day half-life. The previously estimated thyroid dose contribution from ^{129}I is not included.

The 50-year whole body dose commitment to the maximum individual from 1974 effluents is 0.05 mrem as shown in Table III.1-15h. The additional 0.02 mrem received after 1974 is due primarily to the consumption during 1974 of ^{90}Sr in drinking water, fish, and irrigated foods. The bone dose received during 1974 was estimated to be 0.03 mrem due primarily to external exposure. The 50-year dose commitment to the bone was estimated to be 0.1 mrem, as shown in Table III.1-15h. The dose received after 1974 is due primarily to ^{90}Sr.

TABLE III.1-15h

ESTIMATED 50-YEAR DOSE COMMITMENT TO THE MAXIMUM INDIVIDUAL FROM EFFLUENTS RELEASED FROM HANFORD FACILITIES DURING 1974

Pathway	Annual Exposure	Dose Commitment (mrem)[a] Skin	Body	GI-LLI	Bone	Thyroid
Gaseous Effluents						
Air Submersion	8766 hr	3.0×10^{-2}	2.0×10^{-2}	(2.0×10^{-2})[b]	(2.0×10^{-2})	(2.0×10^{-2})
Tritium-Inhalation & Transpiration	8766 hr	7.0×10^{-10}	7.0×10^{-10}	7.0×10^{-10}	-	7.0×10^{-10}
Radioiodine-Inhalation	7300 m^3	-	-	-	-	2.0×10^{-3}
Milk	274 liters[c]	-	-	-	-	6.0×10^{-3}
Vegetables (leafy)	30 kg[d]	-	-	-	-	1.0×10^{-2}
Total Air Pathways		3.0×10^{-2}	2.0×10^{-2}	2.0×10^{-2}	2.0×10^{-2}	9.0×10^{-2}
Liquid Effluents						
Drinking Water	730 liters	-	8.3×10^{-4}	4.9×10^{-4}	2.6×10^{-3}	1.7×10^{-2}
Fish Consumption	40 kg	-	1.1×10^{-2}	2.1×10^{-2}	2.6×10^{-2}	1.8×10^{-2}
Irrigated Foods	710 kg[e]	-	1.5×10^{-2}	7.5×10^{-2}	4.6×10^{-2}	6.3×10^{-2}
Shoreline	500 hr	4.0×10^{-3}	3.0×10^{-3}	(3.0×10^{-3})	(3.0×10^{-3})	(3.0×10^{-3})
Swimming	100 hr	2.0×10^{-5}	2.0×10^{-6}	(2.0×10^{-6})	(2.0×10^{-6})	(2.0×10^{-6})
Boating	100 hr	1.0×10^{-5}	8.0×10^{-6}	(8.0×10^{-6})	(8.0×10^{-6})	(8.0×10^{-6})
Total Water Pathways		4.0×10^{-3}	3.0×10^{-2}	3.2×10^{-2}	7.8×10^{-2}	1.0×10^{-1}
Total (Adult)		3.4×10^{-2}	0.05	0.05	0.10	0.19
Infant Thyroid Dose						
Airborne Tritium	8766 hr					4.0×10^{-10}
Air Submersion	8766 hr					(2.0×10^{-2})
Inhalation	2045 m^3					6.0×10^{-3}
Milk	274 liters[c]					0.4
Drinking Water	292 liters					5.0×10^{-2}
Total (Infant)						0.5

(a) Dose commitment for 50 years (1974-2023, inclusive) due to effluents released during 1974.
(b) Internal dose from external exposure indicated by parenthesis ( ).
(c) One liter per day for a 9-month grazing season.
(d) 200 g/d for 5-month growing season.
(e) Only the potentially irrigated produce is included.

III.1.1.9.3 50-Mile Radius Population Dose

The whole body population dose received during 1974 by the population within an 50-mile (80-kilometer) radius of the Hanford Reservation and the 50-year dose commitment from effluent released during 1974 were estimated for all of the radionuclides listed in Table III.1-15f. Table III.1-15i lists the population dose received during 1974 by the whole body, bone, GI-LLI (Gastro-Intestinal tract - Lower Large Intestine), lung, and thyroid. The estimated whole body population dose received by the approximate 250,000 people living within the 50-mile (80-kilometer) radius during 1974 was 1.1 man-rem or an average annual dose per capita of 0.004 mrem.

TABLE III.1-15i

ESTIMATED POPULATION DOSE DURING 1974 FROM EFFLUENTS RELEASED FROM HANFORD FACILITIES DURING 1974

Exposure Mode	Radionuclide	Annual Dose (man-rem)[a] Whole Body	Bone	GI-LLI	Lung	Thyroid
Gaseous Effluent						
Air (Inhalation and Submersion)	^{3}H	2.5×10^{-4}		2.5×10^{-4}	2.5×10^{-4}	2.5×10^{-4}
	^{41}Ar	1.1	(1.1)[b]	(1.1)	(1.1)	(1.1)
	^{60}Co	3.8×10^{-7}			3.2×10^{-7}	
	$^{90}Sr+D$	7.8×10^{-3}	2.9×10^{-2}		1.3×10^{-1}	
	$^{99}Mo+D$	2.5×10^{-5}			7.1×10^{-4}	
	^{241}Am	2.3×10^{-7}	2.8×10^{-6}		3.5×10^{-5}	
	^{239}Pu	7.2×10^{-4}	1.7×10^{-2}		1.1×10^{-1}	
	U-nat	1.4×10^{-4}	1.1×10^{-3}		4.1×10^{-2}	
Radioiodine (Inhalation, Milk, Vegetables)	$\{^{131}I, ^{133}I\}$					2.5
Total Gaseous Pathways		1.1	1.1	1.1	1.4	3.6
Liquid Effluent						
Drinking Water	(c)	7.3×10^{-3}	6.0×10^{-3}	1.5×10^{-2}		0.5
Fish Consumption	(c)	2.1×10^{-3}	2.3×10^{-3}	8.0×10^{-3}		6.7×10^{-3}
Aquatic Recreation	(c)	1.3×10^{-2}	(1.3×10^{-2})	(1.3×10^{-2})		(1.3×10^{-2})
Irrigated Foodstuffs	(c)	4.8×10^{-3}	2.5×10^{-3}	7.5×10^{-3}		6.3×10^{-2}
Total Liquid Pathways		2.7×10^{-2}	2.4×10^{-2}	4.4×10^{-2}		5.8×10^{-1}
Total		1.1	1.1	1.1	1.4	4.2

(a) Dose received during 1974 from effluent released during 1974.
(b) Internal dose from external exposure indicated by parenthesis ( ).
(c) Radionuclides released to the river listed in Table III.1-15f.

This dose is primarily due to external irradiation from ^{41}Ar. The dose received by the bone, GI-LLI, and lung is due primarily to external irradiation. The dose to the thyroid is primarily due to isotopes of iodine released to the atmosphere and Columbia River. The population thyroid dose was estimated to be 4.2 man-thyroid-rem during 1974.

Table III.1-15j lists the 50-year dose commitment (1974 to 2023, inclusive) potentially received by the 250,000 people from effluents released during 1974. The whole-body population dose commitment was estimated to be 1.6 man-rem; the 0.5 man-rem received by the population after 1974 is due primarily to ^{90}Sr; ^{239}Pu also contributes. The 50-year dose commitment to the thyroid is all received during 1974 since the iodine nuclides which contribute the majority of the thyroid dose have short half-lives and the external exposure sources are no longer present after 1974. The 50-year dose commitment for the G.I. tract is also all received in 1974 since there is no accumulation of material within the tract. The estimated 50-year dose commitments to the bone and lung are 4.4 (man-bone-rem) and 2.4 (man-lung-rem), respectively. The doses received by these two organs after 1974 are due primarily to ^{90}Sr and ^{239}Pu.

In summary, the maximum "fence-post" exposure rate was calculated to be 2×10^{-5} mR/hr along the northwest boundary of the Hanford Reservation. The whole-body dose received by the maximum individual during 1974 and the 50-year dose commitment from effluent released during 1974 are 0.03 mrem and 0.05 mrem, respectively. The whole-body dose potentially received by the assumed 250,000 people living within a 50-mile radius of the Hanford Reservation during 1974 and the 50-year dose commitment from effluents released during 1974 are 1.1 man-rem and 1.6 man-rem, respectively.

TABLE III.1-15j

ESTIMATED 50-YEAR POPULATION DOSE COMMITMENT FROM EFFLUENTS RELEASED FROM HANFORD FACILITIES DURING 1974

Exposure Mode	Radionuclide	Dose Commitment (man-rem)[a] Whole Body	Bone	GI-LLI	Lung	Thyroid
Gaseous Effluent						
Air (Inhalation and Submersion)	^{3}H	2.5×10^{-4}		2.5×10^{-4}	2.5×10^{-4}	2.5×10^{-4}
	^{41}Ar	1.1	(1.1)[b]	(1.1)	(1.1)	(1.1)
	^{60}Co	3.8×10^{-7}			3.2×10^{-7}	
	$^{90}Sr+D$	0.3	1.3		0.6	
	$^{99}Mo+D$	2.5×10^{-5}			7.1×10^{-4}	
	^{241}Am	2.0×10^{-5}	2.7×10^{-4}		1.6×10^{-4}	
	^{239}Pu	8.3×10^{-2}	1.8		0.5	
	U-nat	2.5×10^{-4}	4.1×10^{-3}		1.9×10^{-1}	
Radioiodine (Inhalation, Milk, Vegetables)	$\{^{131}I, ^{133}I\}$					2.5
Total Gaseous Pathways		1.5	4.2	1.1	2.4	3.6
Liquid Effluent						
Drinking Water	(c)	2.9×10^{-2}	7.9×10^{-2}	1.5×10^{-2}		0.5
Fish Consumption	(c)	3.9×10^{-3}	9.8×10^{-3}	8.0×10^{-3}		6.7×10^{-3}
Aquatic Recreation	(c)	1.3×10^{-2}	(1.3×10^{-2})	(1.3×10^{-2})		(1.3×10^{-2})
Irrigated Foodstuffs	(c)	1.5×10^{-2}	4.6×10^{-2}	7.5×10^{-3}		6.3×10^{-2}
Total Liquid Pathways		5.7×10^{-2}	1.5×10^{-1}	4.3×10^{-2}		5.8×10^{-1}
Total		1.6	4.4	1.1	2.4	4.2

(a) Dose commitment for 50 years (1974-2023, inclusive) from effluents released during 1974.
(b) Internal dose from external exposure indicated by parenthesis ( ).
(c) Radionuclides released to the river listed in Table III.1-15f.

III.1.2 Radiological Impact on Biota Other than Man

III.1.2.1 Terrestrial [X.10]

Research and surveillance programs indicate that the release of radioactivity to the terrestrial environment from Hanford operations since startup in 1944 has not affected the local biota. No change in community types is recognized except following major perturbation from construction activity. No significant amounts (in most cases no detectable amounts) of long-lived radionuclides have escaped the Hanford site boundary and accumulated in soils or biota.[4,26] Similarly, the effects of routine operation, manufacturing and waste management programs on terrestrial ecosystems are not expected to be significant from a radiological standpoint.

Some biological uptake and dispersion of radionuclides from waste management zones can be expected at least at a low level.[27] Most uptake of waste radionuclides from current routine Hanford operations is from a soil substrate into plants. Burial grounds of one type or another represent the largest source of radionuclides accessible to local biota.

Tumbleweed (Russian thistle), a noxious weed because of its opportunistic growth habit, has an affinity for radionuclides such as ^{90}Sr. The first tumbleweeds found growing into soil contaminated from a waste-pipe leak contained about 3 μCi ^{90}Sr-^{90}Y/g.[28] Soil at a depth of 4 feet contained about 6.6 μCi ^{90}Sr-^{90}Y/g, suggesting a concentration factor (CF) of about 0.5. Cytological examination of the growing tips failed to show differences between plants containing these radionuclides and those without. Tumbleweed populations are now controlled at radioactive as well as nonradioactive sites by several methods. Herbicides (almost exclusively "Krovar," 50% Bromacil, 50% Diuron, i.e., substituted ureas, or "trysben," 2,3,6-Trichlorobenzoic acid) are applied periodically when necessary to limited waste management areas under strict control procedures to eliminate mature tumbleweeds and other growth.

Over the years, deeper placement of buried materials and containment of transuranics in retrievable containers has reduced the likelihood of biological uptake problems. Another method used to discourage tumbleweed growth is the layering of a plastic sheet below the soil surface over the buried material. This reduces the need for herbicide treatment. Tank farm ground surfaces are covered with rock and gravel layers; herbicides are used to control weed growth.

Animal interaction with waste storage sites occurs when waterfowl find areas of open water (ditches and ponds). Vegetation control reduces the availability of food, cover and nesting sites. Potential problem areas, such as the 1301-N trench, are covered with wire mesh to prevent access by large mammals or waterfowl. Surveillance data for 1972 for various radionuclides in tissues of waterfowl are given in Table III.1-16. Data for other animals are given in the most recent Hanford Environmental Status Report.[29]

TABLE III.1-16

AVERAGE RADIONUCLIDE CONCENTRATIONS IN MUSCLES OF WATERFOWL (1972)

Units of 10^{-6} µCi/g (wet weight)

Location	Species	Number of Samples	^{58}Co	^{60}Co	^{65}Zn	^{90}Sr	^{137}Cs	^{141}Ce
Analytical Limit			0.15	0.15	0.20	0.002	0.1	0.16
U Pond	Ducks	2	--	--	--	0.006	27.	--
Redox Pond	Ducks	2	--	--	--	0.054	3.1	--
Gable Pond	Ducks	4	--	--	--	0.003	26.	--
B Pond	Ducks	4	--	--	0.11	0.003	3.3	--
300 Pond	Ducks	5	--	--	--	--	--	--
100-F Trench	Ducks	3	--	--	0.14	0.11	0.14	--
T Pond	Ducks	1	--	0.20	0.40	0.003	70.	--
West Lake	Ducks	1	--	--	--	--	4.2	--
Columbia River	Ducks	71	--	--	0.096[a]	0.003	0.070[a]	--
Columbia River	Geese	32	--	--	0.079[a]	0.003	0.11	--

(a) Result smaller than analytical limit due to larger sample size.

The most significant interaction of terrestrial biota with waste management is related to the B/C Controlled Area which lies south of 200-E Area.[68] The B/C Controlled Area covers an area of about 4 square miles and was contaminated with radioactive animal feces and urine in 1960. A process liquid containing ^{90}Sr and ^{137}Cs had been disposed of to the 216-B trenches which were burrowed into by animals (presumably a badger) exposing a salt layer. Rabbits subsequently used the sites as a "salt lick" and soon spread the radionuclides over a large area. The stability of this source of radioactivity under current environmental conditions is being studied. Air monitoring studies[30] indicate that concentrations of airborne ^{137}Cs (e.g., 0.19 to 3.0 x 10^{-14} µCi/cm^3 air) are roughly one 1 millionth of guide values for radiation workers and are not far different than general onsite environmental surveillance data for 1972.[29]

Changes in animal populations and vegetation abundance ascribable to the deposition of radionuclides are not evident. Studies of the uptake of radioactive materials by plants and animals have evaluated such uptake as a potential pathway of radionuclides to man. Comprehensive stud of the effects of the depositions of radionuclides in plants and animals have not been made.

III.1.2.2 Aquatic

III.1.2.2.1 Columbia River

The main sources of radioactivity presently entering the Columbia River are from the spring seages along the banks below N Reactor. The aquatic biota in the Hanford reach of the Columbia River are exposed to significantly lower levels of radionuclides in the water now than prior to December 1971 when the once-through cooling, plutonium production reactors were operating. Concentrations of the various radionuclides in the Columbia River are orders of magnitude less than during the period when several reactors were in operation.

Much data have accumulated on the concentrations of various radionuclides in the biota of the Columbia River from the start of reactor operation in 1944 until December 1972. Since then, studies were made of the declining concentrations of radionuclides in the biota of the Columbia River-McNary Reservoir ecosystem. Much of the evaluation presented here relies heavily on the results of studies made during periods when greater amounts of radionuclides were present, with inferences made to the present lower levels of radioactivity.

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The most recent ecological study of a variety of Columbia River biota while several reactors were operating took place from February 1966 to September 1967 (six reactors were operating at this time).[31] A comparison of radionuclide concentrations in biota from this and earlier studies is given along with information on concentration factors (CF). Table III.1-17 presents a comparison of gamma-emitting radionuclides in several organisms from 1957 to 1967. No consistent changes could be attributed to the number of operating reactors; the same was true for total beta measurements (not included in the table). Evidently highest concentrations of most radionuclides are found in the lower trophic levels, such as plankton, algae, and sponges. These organisms have a large surface to volume ratio and present a relatively large surface for adsorption of radionuclides. In general, CFs were highest for the biologically important radionuclides ^{32}P and ^{65}Zn and were highest in the net plankton (9,000 to 68,000 for ^{32}P and 3,500 to 40,000 for ^{65}Zn) and periphyton (5,000 to 24,000 for ^{65}Zn) and decreased in higher trophic levels.

TABLE III.1-17

COMPARISON OF CONCENTRATIONS OF ^{32}P AND GAMMA EMITTING RADIONUCLIDES IN COLUMBIA RIVER ORGANISMS 1957-67[31]

		pCi/g wet weight						
		Plankton	Sessile Green Algae	Sponge	Caddisfly Larvae	Limpet Soft Parts	Limpet Shell	Minnows
^{32}P	1957	-	66,000	4,460	24,300	-	-	24,000
	1966	-		3,270	6,560	3,790	988	7,110
	1967	-	12,800	15,100	28,200	19,000	2,310	
^{46}Sc	1957[a]	-	1,730	94.7	70.6	-	-	0.702
	1967[b]	5,690	3,020	2,130	968	87	475	0[b]
^{51}Cr	1957	-	7,900	4,580	6,000	-	-	372
	1964[c]	59,500	43,400	10,200	3,590	1,940	1,080	-
	1965[c]	28,400	32,900	16,000	4,890	2,260	1,350	-
	1967	12,600	10,200	5,060	3,030	696	1,060	17.6[b]
^{54}Mn	1957	-	1,030	-	79.1			
	1967	791	1,080	603	447	136	359	0[b]
^{59}Fe	1957	-	1,640	-	-	-	-	-
	1967	1,250	1,360	860	537	260	274	28.4[b]
^{60}Co	1957	-	155	11.6	1.72	-	-	-
	1967	41	456	0	7	80	31	0
^{65}Zn	1957	-	12,300	1,460	1,980	-	-	762
	1964	14,000	8,870	3,070	1,970	2,820	658	-
	1965	1,910	3,250	2,500	1,770	1,360	346	-
	1967	4,580	2,050	1,910	1,790	1,560	435	237[b]
^{95}Zr-Nb	1957	-	1,790	-	66.3	-	-	-
	1967	953	380	553	156	109	13	0
^{140}Ba	1957	-	901	-	42.2	-	-	-
	1967	1,910	459	510	367	96	117	0[b]
^{140}La	1957	-	3,270	1,230	347	-	-	-
	1964	5,900	1,610	950	223	73	113	-
	1965	2,010	1,760	1,330	322	107	107	-
	1967	4,630	2,400	2,400	656	333	379	0[b]
^{239}Np	1957	-	2,690	401	311	-	-	-
	1967	3,010	1,750	1,080	384	79	173	0[b]

(a) Reference 85
(b) Reference 31
(c) Reference 33

Considerable data have been collected on the movement of radionuclides from Columbia River water to biota and from one organism to another.[34] An early paper[35] on some of the principles involved with the transfer of radionuclides from water to higher organisms in the food web reported CFs of 150,000 for ^{32}P in shiners and 350,000 in caddis fly larvae. The relative concentration of beta emitters in Columbia River biota varies for three reasons: 1) the several radionuclides involved have different relative proportions in the various organisms, 2) variation in moisture content exists between organisms, and 3) the relative position in the food pyramid is influential.[32] A study[36] in 1957 provided data on CFs in various organisms from the Columbia River and considered the basic concepts governing the uptake and retention of radionuclides by aquatic biota.

The factors governing the amounts and kinds of radionuclides accumulated by Columbia River fish have been investigated.[37] Radionuclide concentrations in fish are mediated by a host of factors including metabolic rates. Relative radionuclide concentrations in fish do not reflect the relative concentration of that nuclide in the water; this is an example of selective uptake of essential elements. Concentrations of ^{32}P in whitefish varied over two orders of magnitude in one year; ^{65}Zn varied over one order of magnitude. Dilution of radionuclides in the water by runoff is a major contributing factor to these seasonal variations.

The pathways of accumulation of Columbia River radionuclides through food chains and the ultimate dose estimates to man have been considered in detail.[38] These pathways may be entirely aquatic, in which the food chain terminates in fish eaten by fishermen, or partially terrestrial, in which Columbia River water is used to irrigate crops. In each case, ^{32}P and ^{65}Zn were of greatest importance.

Columbia River plankton have been studied since the late 1940s. In 1953[39] plankton averaged about 3.7×10^{-3} μCi total beta/g wet wt, and no harmful influence from the Hanford Operations could be detected. Seasonal variation in radionuclide burden in the river biota has a wide range. In plankton, lowest radionuclide concentrations of ^{32}P and ^{65}Zn were found in the spring-summer runoff period; the increased biomass at this time resulted in a greater transport of ^{32}P and ^{65}Zn.[40] Concentration factors for ^{32}P ranged from 5,000 to 118,000 and for ^{65}Zn from 300 to 19,000; highest values were in the fall.

The uptake of ^{32}P and ^{65}Zn by periphyton in the Columbia River was closely related to dry and ash weight of the periphyton and to chlorophyll a content.[41] Net production rate was highly related to solar energy and chlorophyll a. The data suggest that adsorption was the dominant mode of uptake.

In laboratory tests, ^{65}Zn uptake by periphyton was proportional to ambient levels of ^{65}Zn in the water and adsorption was the dominant mode of uptake.[42] The ^{65}Zn uptake could be decreased by addition of stable divalent cations, either zirconium or magnesium, demonstrating that uptake involves a competition for binding sites. Uptake of ^{65}Zn in this system was essentially complete after about 80 hours. While ^{65}Zn is strongly bound to periphyton in the pH range around 8.0, ^{65}Zn is not absorbed at a pH below about 4.0, which could be significant in transfer of ^{65}Zn from ingested particles in the intestines of higher animals like the sucker. Studies of the cycling of ^{65}Zn from water to periphyton to juvenile carp in laboratory streams showed that equilibrium concentrations for the periphyton were reached in about 28 days.[43] The effective half-life was about 15 days; approximate equilibrium in the fish was attained after about 43 days.

In situ radiation dose measurements made in periphyton communities near a reactor effluent outfall in 1969 ranged from 350 mR/day near the surface of the river to 230 mR/day near the bottom.[44] Twenty-four km below the reactors, dose rates were 20 mR/day and less. Twenty-two km below a reactor outfall, dose in the periphyton ranged from about 30 mR/day in March to September 1969, to about 34 mR/day from September to December.[45] Dose rates beneath stones were from 10 to 20% less than on the upper side. Doses to adult fish 23 km downstream of reactor outfalls ranged from 11 mR/day on the dorsal surface to 17 mR/day near the intestinal tract. ^{32}P has been shown to be the dominant beta emitting nuclide in crayfish and Cladocera.[46] Approximate retention times[47] for various radionuclides in limpet snails, with both a slow and fast component, have been observed. The slow component for ^{65}Zn in the body resulted in an effective half-life of about eight days in November to thirty days in March. Data[48] on the accumulation of various radionuclides by aquatic insects in the Columbia River showed that CFs for caddis fly larvae ranged from 30 for ^{239}Np to 100,000 for ^{32}P.

Concentrations of ^{65}Zn in the tissues of freshwater mussels[49] have been shown to decrease in the following order: gills, mantle and palps, body mass (including the digestive gland, digestive tract, and gonad), adductor muscles, and foot. The whole body burden was directly related to the ambient concentration of ^{65}Zn.

Studies of uptake, cycling, etc., of radionuclides by fish far outnumber studies of other organisms in the Columbia River at Hanford. The most recent data on radionuclide concentrations in various species were published in 1970.[31] A bibliography[50] with abstracts of all aquatic bioenvironmental studies in the Columbia River at Hanford from 1945-1971 provides a guide to the extensive data available on fish and other aquatic organisms.

The above discussion attempted to put the radiological status of Columbia River organisms into some perspective as it related to water conditions while several reactors were in operation. Three studies provide data related to concentration and cycling of radionuclides by Columbia River biota when reactors were shut down. The first[33] presents information from a limited sampling program to document the effects of the closure of three reactors in 1965. A significant decrease of biologically important radionuclides was evident with some indication of a trophic level response. Also documented[51] is the response of several organisms to a complete shutdown of all reactors for several weeks and subsequent reactions after the reactors were restarted.

A significant study of the cycling and retention of radionuclides in the Columbia River - McNary Reservoir ecosystems presently in progress was initiated the summer of 1971 following closure of all reactors except N Reactor. (Data from this study are still being processed, but cursory information has been published.[52]) In general, the biota at White Bluffs and McNary Reservoir exhibited concentrations of various radionuclides of at least an order of magnitude lower by the winter of 1972. This was especially true of the organisms in the lower trophic levels while concentrations declined more slowly in fish due to their slower biological turnover. By 1974, levels of ^{65}Zn and ^{60}Co were just above detection limits in most biota in McNary Reservoir, while levels of ^{46}Sc, ^{54}Mn, and ^{137}Cs have essentially become unmeasurable.

The following comparisons may be useful in evaluating the impact of present operation upon portions of the food-web. In water, 15 to 35% of the ^{65}Zn was ionic when the reactors were operating, but less than 2% was present in ionic form in 1971 and 1972. Ratios of ^{65}Zn can be compared in various organisms and in their principal food for that period. Suckers graze on periphyton communities and when the reactors were operating, approximately 10 times as much ^{65}Zn was in the periphyton as in the suckers. In 1971 and 1972, only about 2 times as much was in the periphyton. The same ratios, essentially, were found for the squawfish which prey on smaller forage fish. Manganese-54 was undetectable in the plankton in McNary Reservoir for several months, yet it had the highest concentration of any radionuclide in the flesh of the freshwater mussels. Mussels utilize plankton for food and are known concentraters of ^{54}Mn; the measured levels of ^{54}Mn ($\sim$10 pCi/g dry weight) are probably related to the long biological half-life of ^{54}Mn in Anodonta, about 1300 days.[53] Zinc-65 is also present in higher concentrations in mussels than in other organisms. Catfish have similar concentrations of ^{65}Zn as their food items, crayfish and forage fish.

In summary, extensive studies have investigated the relationship between the concentrations of radionuclides in water and in a wide range of lower and higher aquatic life forms. The concentration factors for various chemical forms of radionuclides and various aquatic life forms have been studied also. Studies of the radionuclide concentrations in aquatic organisms between times of widely varying radionuclide concentrations in the Columbia River show how these changes affect deposition in aquatic organisms. Comparisons of the quantity and species of aquatic organisms during the periods of substantially different radionuclide concentrations in the river indicates no gross effects from these conditions. Comprehensive studies of the effects on individual organisms are limited. Most studies have investigated the deposition in aquatic organisms as a pathway to exposure of man.

III.1.2.2.2 <u>200 Areas Ponds and Ditches</u>

Measurement of the radionuclide burden in the biota in the chemical processing areas of Hanford Reservation has been mainly concerned with the life forms that are potential vectors for the offsite transfer of radioactive materials to nearby uncontrolled regions. These aquatic life forms have not been as thoroughly studied as some of the other natural systems of the area.

An intercomparison of the concentrations of radioactivity in several of the surface waters receiving low-level radioactive waste is shown in Table III.1-18. These data indicate that the concentration of radionuclides is highly variable with no consistent pattern evident in the burdens in algae and bottom muds. A more extensive study of aquatic organisms within one of these ponds (Gable Mountain Pond) suggests a number of points concerning the distribution of radioactivity in a waste pond ecosystem (Table III.1-19). The concentration of radionuclides in the bottom muds is usually an order of magnitude greater than that of the biota and is nonuniformly distributed. Burdens in plants, periphyton and rooted submergents, usually exceed that of the animal forms. Goldfish, which are a potential food source for aquatic birds, contain higher levels of radioactivity than some of the invertebrates. The adults of two of the major emergent insects in the ponds, damsel flies and dragonflies, have very low radionuclide concentrations and appear to be of minor importance in the translocation of radioactivity from the pond.

TABLE III.1-18

COMPARATIVE RADIONUCLIDE CONCENTRATIONS - 200 AREAS SURFACE WATERS
(MARCH 1970)

	pCi/g wet wt					
	^{137}Cs		Total Alpha		Total Beta	
Location	Mud	Algae	Mud	Algae	Mud	Algae
Laundry Ditch	10	74	3	6	140	630
U Pond - N.E. Shore	420	25	6	900	440	130
- S.E. Shore	500	2	14	2	320	5
Gable Mtn Pond Inlet	38	360	1	0.5	810	540
B Plant Ditch Inlet	44	-	1	-	290	-
B Plant Pond Inlet	59	32	0.7	2	320	320
Purex Chemical Sewer	58	3	240	2700	430	1900

TABLE III.1-19

CONCENTRATION OF RADIONUCLIDESIN GABLE MOUNTAIN POND BIOTA - 1972

	pCi/g wet wt										
	^{137}Cs			^{95}Zn			^{60}Co			Total Alpha	^{239}Pu
Sample Type	June	July	Sept	June	July	Sept	June	July	Sept	June	June
Mud-lower end	11,300	16,400	6,900	910	382	218	56.0	40.8	26.0	-	1.99
Mud-near inlet	-	80.8	76.8	-	5.60	8.56	-	2.61	1.76	-	
Periphyton	74.5	7,480	516	8.30	398	37.4	1.10	25.1	4.00	-	
Rooted Plants											
Potamogeton sp.	174.5	1,460	161	9.36	29.5	16.2	0.70	4.55	0.250	-	
Snails	91.8	3.72	-	5.78	9.68	-	-	0.472	-	-	
Waterboatmen	13.2	3.36	12.0	2.30	0.330	1.69	-	0.400	-	-	
Dragonfly-adults	10.3	9.34	-	1.95	1.65	-	-	-	-	-	
Damselfly-adults	7.84	14.3	-	0.942	1.38	-	-	0.525	-	-	
Goldfish	130	75.7	67.5	7.28	3.20	3.11	1.79	0.42		1.06	

Several studies involving the cycling of specific radionuclides by biota have been published.[54] When ^{137}Cs, at a concentration of 6×10^{-3} µCi/ml was added to a pond, the rapid uptake of ^{137}Cs by algae occurred (100 times the water concentration in 2 hours). Concentration factors for ^{137}Cs by various aquatic biota ranged from 50 for bullrush culms to over 10,000 in scuds.

Studies are currently in progress in Gable Mountain Pond (an effluent discharge pond) to explore the relationship between the rate of radionuclide accumulation in goldfish and sediment radioactivity. Uncontaminated goldfish confined in a pen over sediments of relatively low radioactivity and permitted to feed naturally, approached equilibrium concentrations of about 300 pCi ^{137}Cs/g net weight in approximately 15 weeks. A similar group of fish penned over higher level sediments attained body burdens nearly twice this high over a period of about 19 weeks. Levels of ^{137}Cs in the free-ranging native goldfish population were similar to those in experimental fish over the low-level sediments. The food base of the goldfish appears to be largely organic plant debris, presumably obtained from the pond bottom. Goldfish in U Pond have a similar food base.

Radiation doses at the sediment-water interface of Gable Mountain Pond, as measured with thermoluminescent dosimeters, ranged up to 230 mR/day during the first quarter of 1973. Large location-dependent differences were in the measured dose, again indicating the heterogeneous distribution of radionuclides in the pond bottom.

III.1.2.2.3 Radiation Doses to Aquatic Organisms

Radiation doses to waterfowl and aquatic organisms were estimated from the radionuclide analyses previously listed in Tables III.1-16 through III.1-19. In addition, external radiation doses for Columbia River organisms were also estimated from the release rates of radionuclides to the Columbia River in 1972. In the latter instance, external doses from both water immersion and shoreline exposure were included. The results of these calculations are summarized in Table III.1-20. All of the doses listed in this table are well below the levels where any observable radiological effects should occur. Indeed, no such effects have ever been seen in the Hanford environment.

TABLE III.1-20

ESTIMATED RADIATION DOSES TO AQUATIC ORGANISMS AND WATERFOWL FROM LIQUID RELEASES AT THE HANFORD RESERVATION - 1972 (rad/yr)

Organism	Location	Internal Dose(a)	External Dose(b)
Waterfowl			
Duck	T Pond	0.41	-
Duck	U Pond	0.16	-
Duck	Redox Pond	0.02	-
Duck	Gable Mtn Pond	0.15	-
Duck	B Pond	0.20	-
Duck	West Lake	0.025	-
Duck	100-F Trench	0.003	-
Duck	Columbia River	6×10^{-4}	8×10^{-3}
Goose	Columbia River	8×10^{-4}	8×10^{-6}
Heron	Columbia River	-	8×10^{-6}
Fish			
Goldfish	Gable Mtn Pond	0.55	-
Salmon	Columbia River	-	4×10^{-4}
Plants			
Rooted Plants	Gable Mtn Pond	2.9	-
Miscellaneous Biota			
Muskrat	Columbia River	-	3×10^{-4}
Invertebrates	Columbia River	-	6×10^{-4}

(a) From radionuclide concentrations listed in Tables III.1-16 through III.1-19.
(b) Calculated from liquid effluent releases to the Columbia River.

III.1.3 Nonradiological Effects on Ecological Systems

III.1.3.1 Effects on Terrestrial Ecological Systems

Other than loss of habitat, the significant nonradiological impacts on terrestrial ecosystems that might result from routine waste management operations programs would be associated with 1) the use of herbicides for weed control, 2) waste oils used on unpaved roads for dust control, 3) fires arising from plant activity, and 4) vehicular traffic. In general, no serious threat is posed to higher biota and only localized interference occurs with lower life forms. In fact, observations of a variety of wildlife, even within the confines of exclusion area fences, suggest that several species are making use of the works of man to their advantage.

The total commitment of land to Hanford operations (as described in Section II.1) has always been a small fraction of the 570 square miles of the Hanford Reservation and in recent years has actually decreased with the retirement of older facilities. Positive actions taken by the AEC to

preserve existing ecosystems for the future include the dedication of the Arid Lands Ecology Reserve and the release of much of the Reservation north of the Columbia River for wildlife management. Although construction activities at Hanford have been locally disruptive to vegetation, much of the affected land not in actual use has shown a succession of other local flora which may be more productive than the original.

Herbicides are selected from a list approved for use by federal agencies and are used under prescribed conditions. Such usage is necessary for weed control along roadsides and railroad rights-of-way, and especially around both liquid and solid waste disposal sites to prevent the uptake of radioactive materials in the soil by vegetation. About 17,000 pounds of a soil sterilant (Krovar) and 104 gallons of oil-basic herbicides were used during CY-1972.

About 23,000 gallons of nonradiological waste oil are generated annually at Hanford and used to stabilize roads, parking lots and "blow" areas throughout the Reservation. This material also acts as a temporary soil sterilant in the immediate area of application, but has the compensating benefit of limiting the smothering of nearby vegetation by excessive dust.

Only minor amounts of insecticides are used on the Hanford site and then directly around and inside of buildings, especially for black widow spider control.

III.1.3.2 Effects on Aquatic Ecological Systems

The principal potential effects of the routine operation of Hanford Waste Management Operations Program on the aquatic environment include the following:

- the impingement of some fish on the traveling screens of water intake structures in the Columbia River
- the entrapment or entrainment of some fish in such intake structures
- destruction of drift organisms passing into the water withdrawal systems
- thermal and chemical stress on organisms residing in or passing through zones of elevated thermal or chemical concentrations, either at points of direct discharge in the Columbia River or as a result of waste streams reaching the Columbia River via groundwater movement and riverbank seepage
- thermal and chemical stress on organisms residing in or using other surface waters affected by plant discharges of cooling water
- effects on Columbia River water quality for other uses, including public water supply.

III.1.3.2.1 Effects of Intake Structures on Aquatic Ecological Systems

At present, intake structures are operating and withdrawing water from the Columbia River at 100-B, 100-K, 100-N and 300 Areas (listed in Table III.1-21). Only at 100-N Area is there a major withdrawal of water amounting to as much as 490 cubic feet per second (cfs) for the ERDA N Reactor facility and up to 1260 cfs for the WPPSS power generation facility.* The maximum withdrawal rate at the other structures is 30 cfs or less.

TABLE III.1-21

HANFORD INTAKE STRUCTURES DRAWING FROM THE COLUMBIA RIVER

Location	Maximum Rate of Withdrawal	Maximum Velocity at Intake Screen	Type of Protection for Biota
100-B Area	29 cfs	1.0 fps	Traveling Screens
100-K Area	22 cfs	0.5 fps	↓
100-N Area	490 cfs	1.0 fps	↓
WPPSS*	1260 cfs	0.89 fps	↓
300 Area	5 cfs	1.0 fps	No Screens

* Although the WPPSS electrical generating station and associated water intake and discharge facilities are not part of ERDA's Hanford operations, they are included here and in Table III.1-22 to provide full coverage.

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With the exception of the 300 Area, all intakes were designed in accordance with U.S. Fish and Wild Life recommendations and include traveling screens with continuous backwash capability and appropriate piping to return the dislodged biota back to the river. These screens are of approximately 1/4-in. mesh, typical for such facilities. The pump wells and traveling screens are protected by steel bars to prevent entry of any large river debris, but at such a spacing as to be no hindrance to the free passage of fish in either direction. Although velocities at the intakes and at the screens (the potential point of impingement) vary somewhat with facility and with river elevation, the range of screen velocities is generally 0.1 to 1.0 feet per second. Although no studies have been completed which would quantify impingement of biota upon the traveling screens protecting each of these intakes, most juvenile fish should be able to escape impingement at average river flow rates. A study evaluating impingement and screen passage is in progress at the WPPSS intake structure.*

The small fraction of the total Columbia River flow being withdrawn for plant use (less than 2%) implies a negligible effect on available food supplies to higher trophic levels from drift organisms entrained at the water intakes.

III.1.3.2.2 Effects on Aquatic Ecosystems of Dredging or Shoreline Disturbance

No dredging or other river bottom or shoreline disturbances are in progress or are planned by the ERDA.

III.1.3.2.3 Thermal and Chemical Effects on Aquatic Ecosystems [X.15, X.17, X.18, X.24, X.25]

III.1.3.2.3.1 Effects of Direct Thermal and Chemical Discharges to the Columbia River [X.15, X.18]

Fourteen liquid effluent lines from Hanford facilities discharge their contents directly to the Columbia River. An EPA permit application made in 1970 is pending for these discharges. Pertinent data for these streams are summarized in Tables III.1-22 and III.1-23; a description of the discharges is given in Appendix II.1-D.

The lack of significant impact due to nonradiological contamination or heating of the Hanford stretch of the Columbia River is probably best illustrated by the various ecological studies discussed in Section II.1. In general, the heated effluents from up to nine plutonium-production reactors have had no detectable harmful influence on the number of salmon spawning in the Hanford reach of the river nor caused demonstrable biotic downgrading of the aquatic ecosystem in the almost 30 years of operation and concurrent scientific observation. The annual aerial survey of chinook salmon nesting in the free flowing Hanford reach of the river shows a fairly constant increase in the number of chinook salmon redds from the late 1940's up through the fall of 1973.[55]

Salmonids are singled out for mention frequently in evaluations not because they are more important ecologically than the other species nor because they are popular and economically important, but rather because: 1) scientific literature concerning them is extensive, 2) they are generally considered to be among the most sensitive of fishes to temperature alterations and chemical toxicants, and 3) they are seasonally abundant in the Hanford reach of the Columbia River.

When the chemical and thermal tolerance of fish are considered, a reasonable assumption is that if there is not a significant impact on salmonids, a significant impact on other species is not occurring. Salmonids, especially in the early life stages, are quite susceptible to mortality from various causes. However, to conclude that if salmonids are not adversely affected, other components of the trophic food web are also not affected, is not entirely correct. An organism(s) in the food web could be adversely affected or eliminated by a perturbation but be replaced by another organism to fill this niche without disrupting other components, i.e., salmonids.

Synergistic effects can occur when two or more potentially harmful perturbations occur together. A large literature exists on both the effects of single and multiple parameters on various aquatic organisms. An active research program on combined effects on aquatic organisms is ongoing at Battelle-Northwest. Parameters being studied include temperature (cold and hot), nitrogen supersaturation, chlorine, and degree of parasitism. These and many such studies reported in the literature have been performed in the laboratory but caution must be used when extrapolating to field conditions. Relatively small areas of the Columbia River are subject to potential detrimental effects from Hanford operations effluents. Even in the immediate vicinity of effluent discharges concentrations or levels of potentially harmful parameters are rapidly diluted by the large flow of the river. Mobile organisms encountering deleterious conditions are

* Although the WPPSS electrical generating station and associated water intake and discharge facilities are not part of ERDA's Hanford operations, they are included here and in Table III.1-22 to provide full coverage.

TABLE III.1-22

DISCHARGE LINES TO COLUMBIA RIVER

Area	Discharge Lines	Discharge Rates, cfs or Quantities	Use	Temperature	Other Potential Water Quality Effects
100-B/C	12-in. steel pipe	6000 gallons twice a week	Backflush pump inlet screens	Ambient	None - untreated raw river water
100-B/C	42-in. steel pipe	2.2	Drains and filter backwash	2.8°C, Above ambient	Total Solids Turbidity Aluminum Sulfate Chloride
100-KE and KW	12-in. steel pipe	5000 gallons 3 times a year	Backflush pump inlet screens	Ambient	None - untreated river water
100-KE and KW	two 84-in. steel pipes	1.1	Drains, overflow and cooling water for compressors and pumps	2.8°C Above ambient	Total Solids Turbidity Aluminum Sulfate Chloride Chlorine (0.25 mg/ℓ)
100-N	16 in. steel pipe	75,000 gallons 3 times a day	Backflush pump inlet screens	Ambient	None - untreated river water
100-N	3 by 4-ft concrete chute	1.1	Overflow from filtered water and raw water storage tanks, condensate from medium pressure steam system, filter backwash	11 to 20°C Above ambient	Total Solids Ammonia (as well as radioactive waste) Chlorine (0.05 mg/ℓ) Turbidity
100-N	42-in. steel pipe	0.01	Filtered water overflow, and waste from floor drains	6 to 8°C Above ambient	Sulfate Chloride Chlorine (0.05 mg/ℓ)
100-N	66-in. pipe to 12-ft concrete flume on riverbank	140	Turbine condenser cooling water and graphite heat exchanger cooling water	16°C Above ambient	Aluminum Turbidity
100-N	102-in. steel pipe	300 (extremes 140 and 410 cfs)	Steam condenser cooling water	5.5°C Above ambient	Turbidity Ammonia Sulfate, Iron Sodium (occasionally 0.3 mg/ℓ ortho-phosphate) Chlorine - 2 to 40 ppb
WPPSS[a]	132-in steel pipe	940 when river <25°C 1260 when river >25°C	Steam condenser cooling water	15 to 20°C Above ambient	(same as above)
100-D/DR	12-in. steel pipe	6000-gallons once a month	Backflush pump inlet screens	Ambient	None - untreated river water
100-D/DR	two 42-in. steel pipes	4.4 (2.2 to 22)	Filter backwash and process (coolant and wash) water, hydraulic test loop water	2.8°C Above ambient	Total Solids Turbidity Aluminum Sulfate Chloride chlorine (0.74 mg/ℓ) (max. 2.2 mg/ℓ)
300	24-in. concrete pipe terminating as a 30-in. half-round corregated metal pipe	6 to 12 batches/day of 12,000 gal	Filter backwash (from water treatment plant)	Ambient	Total Solids Turbidity Aluminum Sulfate "Separon" (a proprietary poly-acrylamide filter aid) chlorine (0.5 mg/ℓ)
300	36-in steel pipe	0.01	Air conditioner cooling water and floor drains	25°C Above ambient	Aluminum Sulfate chlorine (~0.5 mg/ℓ)
300	12-in. steel pipe	1.1 (0.04 to 2.3)	Drainage from roof and parking lot, tanks for aquatic organisms	2 to 3°C Above ambient	Total Solids Turbidity Organic nitrogen

(a) Not an ERDA facility. Heated discharge occurs only when N Reactor is supplying steam to the WPPSS generating plant.

TABLE III.1-23

TOTAL DIRECT CHEMICAL DISCHARGE TO COLUMBIA RIVER PER YEAR

Materials	Quantity from All Facilities (tons)
Aluminum sulfate	260
Chlorine	20
Polyacrylamide	0.8
Salt (rock)	22
Sodium Dichromate	2
Sulfuric Acid	650
Ammonium Hydroxide	60
Hydrazine	8
Morpholine	1.5
Sodium Hydroxide	230

capable of moving to favorable locations. If adverse conditions existed over significant areas of the Columbia River, population or community changes would be apparent; none have been noted in these studies. The only organisms likely to experience potentially harmful conditions would be sessile (fixed) organisms living in the immediate vicinity of a discharge. Changes have been noticed in the community structure of sessile algae populations growing in heated water; blue-green algae dominate these communities, whereas diatoms and green algae are the normal constituents. Areas of such changes comprise a negligible portion of the Columbia River ecosystem within the Hanford reach.

Major effluent discharges, including river water warmed from use as a coolant, to the Columbia River are limited to those from the 100-N Reactor and associated electrical steam generating plant. Water containing low levels of radioactivity also reach the river via seepage springs from a disposal trench. The heated water discharged into the river results in a plume of water extending from the midstream outfall downstream until it is completely mixed and diluted to ambient temperatures by the river water. The feasibility of adult salmonids being adversely affected by these heated waters is remote because of their capability to avoid unsuitable areas. The downstream migration of juvenile salmonids could result in small fish being carried by the currents into this thermal plume. If this were possible, the amount of time the fish were exposed to lethal temperatures would be small because of 1) the rapid reduction in temperature by dilution and mixing, and 2) the location of the outfall away from the region where most of the migrants move.

Studies to determine mortality such as this were performed in 1969 by allowing caged juvenile salmonids to drift through thermal plumes and through areas away from discharges. Delayed mortality due to nitrogen supersaturation prevented analysis of some experiments in spring, but those done in summer showed that the fish passing through midriver plumes did not remain in thermally hot waters long enough to cause mortalities. Even if those fish which could possibly enter the area of the plume with lethal water temperatures stayed there long enough to suffer mortality, the numbers involved would be quite small compared to the total migrating population. The studies further showed that significant mortality could occur to the juveniles if they migrated through shoreline thermal discharge areas where insufficient mixing results in larger areas of lethal water temperatures. No such discharges exist at Hanford now.

Thermal Effects on the Columbia River Ecosystems

At present, the only thermal discharges of sufficient magnitude to affect Columbia River temperatures occur either from 100-N Area or from the associated WPPSS power generating stations when the N Reactor is operating. Other discharges entering the river have sufficiently small flow rates and temperature increments as to affect at most a few square feet of river bottom or to impinge on drifting organisms for a few seconds.

The largest heated stream arising from N Reactor operation is the cooling water from the WPPSS Station (Table III.1-22) which has a flow-rate of 940 to 1260 cfs depending on incoming river temperature. Surveys[56] of the thermal plume created by this discharge showed a maximum measured temperature increment in the plume of 4.5°C with a river flow rate of 44,000 cfs and a maximum increment of 2.5°C at 100 yards downstream at which point the width of the plume was less than

300 feet, 20% of the river width. Directly below an island some 4000 yards downstream, turbulent mixing occurs and the plume becomes well mixed across the river width. The calculated temperature increment for complete mixing at the minimum river flow rate of 36,000 cfs would be 0.6°C.

Outside a limited mixing zone, river temperatures would be in compliance with the Washington State Water Quality criteria[57] (excerpted in Appendix II.1-G) for incoming river water temperatures up to about 19°C. The temperature criteria were aimed especially at preservation of cold-water fish such as salmonids.

During N Reactor operation, a cooling water stream of about 140 cfs, with a temperature up to 16°C above ambient river temperature, discharges at the river shoreline via a concrete flume. The construction of this flume is such that the lower the river level, the more gradual the slope of the flume where the effluent enters the river.[58] This tends to spread the discharge across the river surface where the heat will dissipate to the atmosphere more rapidly and will not be as likely to interact with the benthic biota. Although partial mixing with surface river water begins immediately, a potential exists for interaction between certain fishes and this heated water.

The principal migration routes of juvenile salmonids in the Columbia River are nearshore.[59] In a study, about 30% of the total migrating population was found near each shore, with the remaining 40% distributed across the expanse of the river. Therefore, a significant number of these salmonids could encounter this heated water while still only partially diluted. A recent review of laboratory studies conducted at Hanford on juvenile salmonids suggests that these fish would have to remain in the undiluted effluent of this line for 1/2 minute or longer before noticeable sublethal effects would occur. As long as no entrapping structures or circumstances are present, most fish are able to detect and avoid heated areas which are uncomfortable for them. Because of the turbulent flow, the consequent rapid decrease in the temperature increment, and the river velocity, juvenile fish will be carried rapidly through the elevated temperature zone, if they encounter it. Exposure to the elevated temperatures is limited, and the thermal impact would be of minimal significance to the survival of downstream migrants.

In a limited area immediately downstream from the point of entrance of the heated water benthic aquatic life may be affected. The extent of this area will depend on the flow rate of the river but does not appear to represent a significant effect when compared to the entire free-flowing stretch of the Columbia River within the Hanford Reservation.

Effects of Other Water Quality Parameters on Columbia River Ecosystems

Other than direct thermal effects, potential effects of effluent releases on the river ecosystem would be associated with toxic chemicals in effluent mixing zones and solids deposits on the river bed from water plant filter backwash streams. Routine river monitoring data[29] have shown the lack of effect of Hanford operations on river water quality after mixing.

Several of the smaller effluent streams, consisting largely of treated water, may contain free chlorine at concentrations up to a maximum of 1 mg/ℓ. In limited mixing zones for these discharges, concentrations in the river may exceed at times the 0.002 mg/ℓ guideline[61] suggested for salmonids in water receiving a continuous discharge. The rapid disappearance of free chlorine from natural waters, coupled with the rapid mixing of the effluents in the river and natural avoidance mechanisms of most species, indicate any effects would be limited in extent and negligible in the overall impact on the river ecosystem.

Other chemical concentrations in treated water are mostly the result of the use of alum (aluminum sulfate) and small quantities of proprietary materials in the water filtration plant. None of these are present in the treated water in toxic concentrations, and the usual small change in pH leaves the treated water well within the State water quality standards for aquatic life.

Filter backwash contains suspended solids, principally an aluminum hydroxide floc plus an accumulation of suspended solids removed from the raw river water during the filtration process. Although the effluent may be visibly of higher turbidity during the intermittent backwash operation, the daily fluctuation of several feet in river elevation along with the high river velocity and rapid mixing prevent any appreciable buildup of these solids at the discharge points.

III.1.3.2.3.2 Effects of Columbia River Bank Seepage

The degree of environmental impact caused by waste discharged to the groundwater is determined by the flow rates and concentrations of the various contaminants entering the Columbia River as well as by the effects of the contamination on groundwater quality under the Hanford Reservation. 100-N Area and the 300 Area are the two principal locations along the Hanford reach of the

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Columbia River where liquid effluents discharged to the ground form groundwater mounds which cause seepage "springs" to form at the riverbank. Nitrate ion is present in the groundwater along much of the shoreline, particularly at the 300 Area.

Much of the available information on the springs in the 100-N Area pertain to radionuclides. However, the concentraton of chemicals found in the seepage springs were measured in August of 1972 and compared to the ambient river concentrations. That comparison revealed that sulfate, calcium, chromium, nitrate and total solids were higher in the seepage water than in the river (Table III.1-24).

Chromium appears to be the only nonradiological component of the spring water which, due to higher levels than the ambient river water, had any potential toxicity for aquatic life. Chromium discharge at N Reactor has now been eliminated. Nitrate, which is relatively low in toxicity,[62] is an important plant nutrient and would be expected to support a fairly luxuriant growth of attached algae at the point of emergence of the springs. Other than an increase in algae biomass supplying more food for shoreline benthic fauna, no impact to the ecosystem is predicted from the nitrate. Since the flow from these springs is relatively low (estimated observable flow at less than 0.1 cfs), the more than 300,000:1 dilution by the passing river water keeps the impacted area very localized.

The riverbank seepage springs in the 300 Area were sampled routinely from May 1971 through March 1972. The components of the principal spring (which is about 100 yards upstream from the 300 Area water intake) were identified and their range of values over this sampling period is given in Table III.1-25.

TABLE III.1-24

CHEMICAL CONCENTRATIONS AT 100-N AREA, AUGUST 1972

	Riverbank Springs (mg/ℓ)	Ambient River Concentration (mg/ℓ)
Sulfate	5.5	4.5
Calcium	24.5	17.
Chromium	20.	0.1
Nitrate	2.7	0.1
Total Solids	123.	81.
Aluminum	0.050	0.080
Iron	0.025	0.075
Magnesium	3.	3.
Ammonia	<0.1	<0.1
Nitrate	<0.002	<0.002
Strontium	0.080	0.120

TABLE III.1-25

300 AREA SPRING DISCHARGE

Material	Concentrations mg/ℓ
Iron	0.002 to 0.150
Copper	0.006 to 0.080
Sulfate	13 to 40
Chloride	1.1 to 16.0
Fluoride	0.8 to 1.8
Nitrate	1.2 to 212.0
Chromium	0.001 to 0.023
Uranium	0.016 to 0.20

The pH of this spring discharge ranged from 7.4 to 8.2. When the data given in the table above were collected, 300 Area process waste was being routed to the South Pond of the 300 Area waste treatment complex. The South Pond is not now used for waste disposal and is presently dry (it will be used in the future only on a temporary basis). The North Pond, which is now receiving the waste, has a much slower pond-to-river flow time. The waste ponds are now kept at neutral or basic pH which keeps the copper fairly well retained as copper hydroxide. The waste component which contains most of the metals (copper, chromium+6, and uranium) will be disposed of in evaporation basins in 100-H Area. A new pond location, more remote from the river, also has been selected and will be brought into use in the future. These actions should greatly reduce the metal input to the ponds and to the river.

Copper analyses made on the riverbank springs effluent since use of the South Pond was discontinued have contained 1 μg/ℓ or less of copper. Chromium concentrations can be toxic (reduced growth in chronic exposures) to juvenile salmonids at levels as low as 0.013 mg/ℓ. The few studies on the nonradiological toxicity of uranium compounds to aquatic life have observed effects on bacteria, algae, zooplankton and fathead minnows only at concentrations greater than 1.0 mg/ℓ.[64] With metals, the accumulation in lower trophic levels and the biomagnification as nutrients pass through food chains are always potential problems. Copper, chromium and uranium concentrate in these lower trophic levels.[63] Numerous studies have reported toxic effects due to fluoride; however, the lowest value found to produce toxic effects was 1.5 mg/ℓ.[64] Fluoride also accumulates in fish tissues, especially bone.[65]

Nitrate generally does not pose a toxicity problem for aquatic life, but is a plant nutrient and may be used as a tracer. River samples taken upstream from Hanford in early 1972 showed nitrate concentrations up to 0.96 mg/ℓ, while during the same period, the 300 Area spring sample contained up to 195.0 mg/ℓ, and the 300 Area water intake, about 100 yards downstream from this seepage spring, contained a maximum of 6.0 mg/ℓ nitrate. A comparison with river concentrations indicates a 90% reduction may reasonably be used to predict dilution effects for the other spring effluent components for a 100 yard travel path. Thus, the metals and fluoride from the 300 Area springs will be restricted to a very localized area which should not have significant effects on the aquatic ecosystem of the Hanford reach of the Columbia River or the area immediately downstream, even after considering the potential for food chain interactions.

III.1.3.2.3.3 Effects on Aquatic Ecosystems of Discharges to Other Surface Waters

Numerous surface water ponds, trenches and ditches at the 100, 200 and 300 Areas on the Hanford Reservation are used primarily for the disposal of cooling waters; several also receive nonradiological waste, as discussed in Section II.1.

The 100-N Area contains the only active reactor and has a 1600-ft long dispersal trench which receives some overflow from the waste crib. However, this trench has been screened to exclude game birds and the larger mammals.

The 200 Areas have by far the majority of the onsite surface ponding, including about 30 previously or presently used sites covering 360 acres of land. Data on the chemical composition of these ponds are not taken regularly, although ecological studies have been made on Gable Mountain Pond and U Pond. Some potential may exist for mammals and migratory waterfowl to accumulate nonradiological pollutants, such as heavy metals, although there is no evidence of any effects.

In the 300 Area, about 17 acres of pond surface serve as lagoons for waste generated in the various research and industrial locations. Since only one of the two ponds is used at a time, there are generally only 7 acres (North Pond) or 10 acres (South Pond) of standing water. The inlet to the North Pond was analyzed routinely in early 1972 and found to contain potential pollutants in the ranges of concentrations as shown in Table III.1-26.

TABLE III.1-26

NORTH POND - INPUT CHEMICAL CONCENTRATION

Material	Concentration Range mg/ℓ	Material	Concentration Range mg/ℓ
Chloride	8.1 - 17.9	Nitrate	43 - 93
Copper	0.55 - 5.85	Sulfate	14 - 37
Iron	0.02 - 0.64	Chromium (+6)	0.001 - 0.008
Fluoride	0.3 - 6.6	Uranium	0.029 - 0.130

9 1 1 1 8 9 1 0 6 7 6

The pH ranged generally from 6.1 to 9.4.[29] In addition to these, the North Pond was found to contain an average of 0.58 μg/ℓ mercury (detection limit 0.5 μg/ℓ) during the last quarter of 1972. Although the ponds are not suitable for most aquatic life and have not been studied ecologically, they are visited frequently by waterfowl. The close proximity of this area to the Columbia River suggests that the potential for transfer of certain chemicals, in particular the metals and fluoride, through algal or detrital food chains into the filter feeding waterfowl (and perhaps on to local hunters) exists to a degree. The planned actions described in the preceding section to reduce the metallic waste input to the 300 Area waste ponds will largely eliminate this potential.

III.1.4 Effects on Land Use

The Hanford Reservation is now, as it was in the early 1940's, a reasonable choice for the location of facilities both for experimental and industrial application of nuclear processes. This land commitment does not substantially interfere with other offsite pursuits. Further nuclear industry development on the Hanford Reservation is viewed as increasing the importance of this commitment, rather than resulting in any conflict.

One potential constraint on future land usage onsite exists as a result of the nitrate and radioactivity in the groundwater beneath part of the Reservation. Major withdrawal of water from or discharge to the aquifer could affect existing local groundwater elevations and travel times. Such a constraint does not prevent further land use, although it may cause an economic penalty.

III.1.5 Effects on the Atmosphere

Although chemicals released to the atmosphere from Hanford power houses and other facilities were detailed in Section II, the more significant releases, SO_2 and NO_2, are presented in Table III.1-27.

TABLE III.1-27

POLLUTANT RELEASES TO THE ATMOSPHERE FROM POWER HOUSE STACKS (tons/yr - 1972)

	100 Areas	200 Areas	300 Areas	Total
SO_2	1000	1050	380	2430
NO_2	170	690	210	1070

Four atmospheric monitoring stations are located at farms east of the river in the vicinity of the 300 Area where the power house and other facilities nearest the Hanford site boundary are located. The nearest monitoring station is about 1 mile east of the 300 Area where measurements made during 1972 indicated levels of NO_2 <0.006 ppm (Table III.1-28). The standard for NO_2 concentrations at such sites is 0.05 ppm.[66] Similarly, the concentrations of SO_2 were measured as <0.01 ppm during the first quarter of 1972 and <0.005 during the remainder of the year. The accepted standard for SO_2 concentrations at such sites is 0.02 ppm[66] on an annual basis. Since emissions from the 300 Area stacks are occasionally noticeable for some distance, these stack releases may be a visual nuisance.

TABLE III.1-28

AIR QUALITY MEASUREMENTS ANNUAL AVERAGES - 1972

Location	No. of Samples	NO_2 (ppm) Max.	Min.	Avg.
Opposite Richland (Hobkirk Ranch)	109	0.034	<0.0008	0.006
Opposite N. Richland (Gillum Ranch)	109	0.014	<0.0008	0.004
Opposite 300 Area (Sullivan Ranch)	109	0.019	<0.0008	0.004
Ringold (Keys Ranch)	103	0.010	<0.0008	0.004

III.1.6 Effects on Water Use

III.1.6.1 Effects of Surface Water and Groundwater Withdrawals

The withdrawal rate of Columbia River water needed for conduct of the manufacturing and waste management program is expected to average approximately 11 cfs to 45 cfs through FY-1985. This does not include the cooling water used and returned to the river at 100-N Area. Based on historical flow data presented in Section II, these withdrawals would range from about 0.03 to 0.13% of the expected minimum river flow (on the order of 36,000 cfs). Since upstream dams extensively control the Columbia River flow, record low flows are not expected to be repeated in the future. Thus, these withdrawals would only range from about 0.01 to 0.04% of the annual Columbia River flow (55-year average flow of 120,800 cfs) in the vicinity of Hanford and have no significant effect on water availability for other uses.

Most of this withdrawal is discharged to the ground as industrial waste or sanitary sewage while a small portion is returned to the river essentially unchanged (e.g., back flushing at pump inlets). This leaves a minor portion that is actually "consumed" through evaporation or storage in high-level radioactive waste tanks.

Groundwater withdrawn from various wells on the Hanford Reservation amounts to an average of about 0.32 cfs (28,000 ft^3/d), including a present withdrawal of 0.05 cfs (4200 ft^3/d) for WPPSS construction purposes. About 80% is obtained from the unconfined aquifer and the rest from lower, confined aquifers. Uses of this water include sanitary, construction and emergency cooling systems supplies. However, this groundwater withdrawal from the unconfined aquifer is completely overshadowed by a factor of about 100 by the disposal of process water to the ground. The groundwater withdrawal is about 0.7% of the largest withdrawal rate from the Columbia River for manufacturing and waste management programs. The groundwater withdrawal is inconsequential relative to alteration of the site-wide groundwater elevations, flowpaths and flowrates caused by groundwater inputs, although localized changes in flowpaths must be considered.

III.1.6.2 Effects on Water Quality for Other Uses

In addition to the process waste discharges already discussed, sanitary waste is generated in all operating areas, as well as animal waste in 100-F and 300 Area. Most of the sanitary waste is discharged through septic tanks and tile fields. The animal waste and 300 Area sanitary waste are discharged to leach trenches instead of tile fields, and some sanitary waste goes to the Richland sewer system. Water quality monitoring in the river is designed to measure the overall effect on river water quality of all plant discharges.

Washington State Standards[57] for biological and chemical quality applicable to the local river reaches have been excerpted in Appendix II.1-G. In accordance with these standards, routine measurements were made both upriver at Priest Rapids or Vernita and downriver either at Richland or the 300 Area upriver from the Richland water plant, for the parameters for which quantitative criteria are given. These parameters are pH, turbidity, dissolved oxygen, coliform organisms, BOD, and temperature (Tables III.1-29 through III.1-31).

Enterococci measurements are made to clarify the types of coliforms present.

Columbia River water analysis for biological quality indicates an increase in coliform organisms and a slight increase in BOD between the Vernita and Richland measurement points. These additions are related to drainage from farming and animal husbandry activities not associated with Hanford facilities. Additionally, this stretch of the river is heavily populated by waterfowl which contribute to the biological load. However, essentially identical values for enterococci at both upstream and downstream locations indicated that coliform increases were not of fecal origin and demonstrated compliance with the water quality standards. On the average, nitrate was the same at upstream and downstream measurement points. Turbidity, pH and dissolved oxygen measurements were made only at 300 Area during 1972. The range associated with these

TABLE III.1-29

TEMPERATURE OF COLUMBIA RIVER WATER IN 1972
(°F)

Priest Rapids Daily			Richland Daily		
Maximum	Minimum	Average	Maximum	Minimum	Average
66.7	33.8	51.8	66.2	31.5	50.2

9 1 1 1 8 9 1 0 6 7 8

TABLE III.1-30

COLUMBIA RIVER CHEMICAL ANALYSES FOR 1972

	NO_3 (ppm)		pH		Turbidity (Jackson Turbidity Unit)		Dissolved O_2 (ppm)	
Standard[67]	45		6.5 to 8.5		5 + Background		8.0 min.	
	Vernita	Richland	Vernita	300 Area	Vernita	300 Area	Vernita	300 Area
# Samples	51	52	47	224	48	219	34	181
Maximum	1.3	1.0	9.2	9.4	28.	30.	13.6	14.7
Minimum	(a)	0.14	7.4	7.2	0.6	0.05	4.0	8.1
Average	0.36	0.37	8.1	8.0	5.0	4.6	11.0	10.

(a) Less than the analytical limit.

TABLE III.1-31

COLUMBIA RIVER BIOLOGICAL ANALYSES FOR 1972

	Coliform (N/100 ml)		Enterococci (N/100 ml)		BOD (ppm)	
Standard[67]	240 (median value)		No Standard		No Standard	
	Vernita	Richland	Vernita	Richland	Vernita	Richland
# Samples	14	11	14	11	14	11
Maximum	210.	460.	280.	88.	4.1	4.2
Minimum	1.0	2.0	1.0	2.0	1.0	1.2
Average	49.	88.	37.	34.	2.6	2.9

measurements is believed to be of natural origin and not associated with the Hanford facilities. In addition there was a net decrease in average Columbia River temperature between Priest Rapids and Richland for 1972, as indicated in Table III.1-29.

The results of this program indicate no effects from Hanford operations which would affect the use of the Columbia River for other purposes assigned by the Washington State Water Quality Standards, including domestic use, recreation, and fish and shellfish rearing.

Water quality measurements of the unconfined and confined aquifers are obtained routinely by utilizing test wells on the Hanford Reservation. Maps of the nitrate ion concentration near the surface of the unconfined aquifer are published semiannually. (The map for the last 6 months of 1972 appears in Figure II.1-68.) Since the nitrate ion is not absorbed on the soil, the map indicates the extent of wastewater movement. In Figure II.1-68, the major plume is from the 200 Areas disposal operations. Plumes are also beneath the 300 Area and emanating from the 100-N Area. The plume at the 100-F Area is presumably from continued disposal of BNW Animal Lab waste. The isolated plume south of 100-N and east of 100-K Area is probably due to previous reactor operations. A residual nitrate background of up to 6 mg/ℓ in the groundwater north of Gable Mountain and Gable Butte is due to pre-Hanford operations agricultural activities. Similarly, occasionally detectable nitrate ion is in the groundwater between the Yakima River and the Columbia River.

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III.2 WASTE MANAGEMENT ACCIDENTS

III.2.1 Introduction [RPB, X.4, X.6, X.25]

This section discusses the range of accidents which might occur from waste management operations. These accidents were selected on the basis of present facility design and operations. Previous accidents and other possible accidents, more severe than have been experienced at Hanford, were also considered. In both the selection of accidents and methods and assumptions made for analysis (Appendix III-C contains a discussion of methods), a consistent attempt was made to be conservative (to analyze the worst conditions credible). The possible effects of credible natural forces (earthquakes, tornadoes, high winds and flooding) were also considered even though the site has not experienced the maximum credible natural forces and the probability of their occurrence is extremely small. Factors involved in accidents were examined analytically where data were available and subjectively where data were not available. The final judgments as to accident credibility were subjective and represent a concensus of many knowledgeable individuals.

Each of the selected accidents is described and estimates are made of 1) the probability of its occurrence, 2) the resulting release of radioactivity (source term), and 3) possible impacts. The accidents considered are:

- Tank Leaks
- Tank Gaseous Release
- Tank Dome Failure
- Line Leaks
- Filter Failure (B Plant)
- Onsite Liquid Waste Shipping Accident
- Solid Waste Accidents
- Range Fire
- Criticality at Ground Disposal Sites
- Accidents Due to Natural Forces.

III.2.1.1 Sabotage

The accidents analyzed may represent potential consequences of sophisticated sabotage directed at waste management operations. However, sabotage scenarios are almost unlimited and may represent unwarranted speculation. In addition to set forth specific methods to perform such sabotage would be unreasonable. For example, tanks leaks, pipe leaks, or surface spills might be the result of sabotage. Explosives added to a waste tank might lead to consequences such as the tank dome failure. Onsite transportation accidents might result from less sophisticated sabotage.

III.2.1.2 Site Security

The Hanford site has a formally developed program to provide physical and special nuclear material (SNM) security for all operating facilities. This program includes limited and controlled personnel access to operating facilities as well as detection and recovery of waste and SNM relocated in or out of the operating facilities or site without prior approval by ERDA or its responsible contractors. Some of the measures used to provide these assurances are:

- Multiple physical barriers between the operating facilities and the uncontrolled access area.
- Personnel access/mobility controls through carefully developed and implemented administrative control.
- Fixed and mobile guard positions with redundant communications and a limited outside law enforcement response backup capability.
- Alarm systems and SNM personnel monitors.
- Personnel security program for employees having SNM access.
- An elaborate SNM accountability system involving the "two-man-rule," documentation, electronic detection systems, and redundant internal checks and audits.

A special access barrier is provided by maintaining the air space over the Hanford site as a restricted air space; flights within this air space under 10,000 feet of elevation require prior approval by ERDA.

Procedures are in place to provide adequate control of unauthorized access to the waste storage facilities at Hanford. These measures and procedures are continually under review and evaluation; at this time, upgrading of facilities and associated barrier requirements are in progress.

III.2.2 Leakage of High-Level Liquid Waste from Storage Tanks

A total of 152 large underground storage tanks exist at Hanford for high-level waste (described in Section II.1) and an additional one is complete except for piping interties into the system. The older tanks are single-wall, carbon steel, concrete design. Currently, all high-heat liquid waste is only stored in the new double-wall tanks and low-heat waste and salt cake is stored in the older single-wall tanks.

Since 1958, 18 confirmed tank leaks have occurred (described in Section II.1 and Appendix II.1-C). All leaks have been from the single-wall tanks. The causes of leaks have been either corrosion of the carbon steel tank liner (general corrosion, pitting corrosion or stress corrosion cracking) or mechanical failure of the steel liner (thermal expansion due to local overheating or buckling due to other causes). These tank leaks have varied in size from very small to 115,000 gallons for the 106-T tank leak in 1973 (described later).

During the time that liquid waste is being converted to salt cake, additional tank leaks are expected to occur. Extrapolation of past data would indicate that future leaks may occur at a rate of 2 to 3 per year. As the amount of liquid stored in tanks is reduced, this expected number of leaks will decrease. In the future, an increasing fraction of the liquid waste will be stored in double-wall tanks. Here, a leak in the inner tank can be detected and corrective action taken without escape of liquid from the outer tank to the ground.

III.2.2.1 Leak Detection Capability [RPB, X.4, X.5, X.8]

The capability to detect tank leakage varies with tank design, type of stored waste and tank service. These variations include:

- Radiation and conductivity monitors on the double-wall tanks (AY and AZ tanks) will allow detection of leakage at less than 100 gallons.
- Special leak collection sumps under the newer single-wall tanks (AX tanks) will allow detection of leakage at less than 100 gallons.
- For those single-wall tanks which have radiation monitoring lateral wells directly under the tank, detection of leakage at less than about 5,000 gallons is expected.
- For older single-wall tanks, the leak detection depends on liquid level measurement and vertical radiation monitoring wells. The expected leak detection capability is from about 2,000 gallons up to 30,000 gallons. This variation depends on several factors including the degree of evaporation which makes liquid level interpretation difficult, the degree of floating salt crust in the tank, and the proximity of the leak to one of the dry wells, etc.

With the improved leak detection systems, procedures and increased frequency of monitoring and management attention, future leakage is expected to be detected at less than 30,000 gallons. A leak as large as the 106-T quantity of 115,000 gallons is not expected to occur again under normal operations.

After the 106-T leak the following actions were taken:

Immediate Actions

- All operations were shut down except surveillance, which was immediately increased, until all operating procedures (approximately 85) were reviewed and rewritten where appropriate.

Organization Changes

- Contractor management of the tank farms was separated from the other production operations at the department level to concentrate attention in this area, and some 52 additional personnel were assigned to the tank farm operations and surveillance organization. Further, responsibility for all tank farm surveillance, performance and analysis was consolidated into the Tank Farm Surveillance Section under the direction of a senior manager.
- Internal audits in the Production and Waste Management organization were reinforced and clarified in the organization structure and procedures.
- A new division, Quality Assurance and Safety, reporting to the president of the company, was established to maintain appropriate audits and assure that proper Quality Assurance procedures are in place and are being followed in all operations in the company.

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- A number of new personnel, two at the division level, were recruited to bring new and more aggressive management into place.

Operational Changes

- Manual liquid level readings are taken a minimum of once per shift on all liquid waste storage tanks available for and/or in active service. Readings are taken once every 2 hours with automatic computerized liquid level measuring instrumentation.

- The computerized liquid-level measuring instrumentation alarms on out-of-limit readings and prints out the actual liquid level.

- Radiation wells and laterals are read weekly for prompt detection of change, versus a previous monthly schedule. Wells showing increases or readings above a pre-established limit are read on an increasing frequency.

- Material-balance calculations during transfer-type operations are made every 2 hours to monitor the location of the liquid and promptly detect losses. The calculations are checked by responsible supervision and also by process control engineers at least once per day.

- All direct buried lines used for the transfer of radioactive waste solutions are pressure-tested on a routine schedule to reduce potential for liquid losses during transfers.

- A rigorous policy of operating equipment according to the procedures has been implemented to assure compliance with approved procedures.

Program Impacts

- Accelerated evaporation of water from radioactive solutions has reduced the volume of liquids that needs to be stored.

- Concentration of operating, technical, and management personnel in promptly detecting small leaks prevents these small leaks from becoming large-magnitude leaks.

- Use of double-wall underground waste storage tanks permits detection and containment of leakage should the primary wall fail.

- Future conversion of terminal evaporator solutions to solids will further reduce the potential for radioactive solution leakage.

III.2.2.2 Description of the 106-T Leak

The 106-T tank leak is the largest leak that has occurred from Hanford high-level waste storage tanks. A detailed report on the reasons for and results of this leak has been prepared.[1]

On June 8, 1973, the 241-T-106 underground liquid waste storage tank, located in the 200 West Area, was confirmed as leaking. Subsequent investigation of this tank revealed that 115,000 gallons of radioactive liquid waste had leaked into the adjacent sediments. Soon after the leak volume and the radiochemical constituents of the waste liquid were determined, it was predicted that the waste liquid would be sorbed in the dry sediments near the 241-T-106 tank and would not percolate to the underlying water table. This prediction was based on knowledge of the geology and hydrology underlying the 241-T tank farm and on more than 20 years of experience with liquid waste effluents in 200 West Area sediments.

To confirm this prediction, a study was conducted to define the boundary of the contaminated zone and the depth to which this liquid waste had percolated toward the water table.[1] Sixteen wells were drilled to delineate the contaminated zone. The deepest penetration of contamination observed in the wells drilled was 89 feet below ground surface (115 feet above the water table). The 1 μCi/liter ruthenium isopleth was used to delineate the contaminated zone. The volume of contaminated sediments was calculated to be about 880,000 ft^3.

Based on results of the study described above and the basic knowledge of liquid movement in Hanford sediments, further movement of the radioactivity from its present location is expected to be negligible.

III.2.2.3 Postulated 800,000 Gallon Tank Leak

Although no such release is considered credible, the following tank leak is described for the purpose of analyzing the impact from a so-called "worst case." The tank has a volume of

1,000,000 gallons and is assumed to contain 80% liquid and 20% sludge which does not leak. Such a leak is more than five times greater than any leak previously experienced at Hanford.

III.2.2.3.1 Calculated Source Term for the 800,000 Gallon Leak

The waste composition in the tanks was taken from radionuclide data presented in Appendix III-D. The supernate composition is:

Na^+	4.0 M	^3H	$4.21 \times 10^{+4}$ µCi/gal
Ca^{++}	0.002 M	^{90}Sr	$3.72 \times 10^{+2}$ µCi/gal
$SO_4^=$	0.25 M	^{99}Tc	$1.40 \times 10^{+3}$ µCi/gal
OH^-	0.24 M	^{106}Ru-^{106}Rh	$7.42 \times 10^{+5}$ µCi/gal
AlO_2^-	0.06 M	^{125}Sb	$1.38 \times 10^{+2}$ µCi/gal
K^+	0.016 M	^{129}I	6.15×10^{-1} µCi/gal
pH	11.9	^{134}Cs	$1.12 \times 10^{+4}$ µCi/gal
$NO_3^- + NO_2^-$	3.22 M	^{137}Cs	$4.34 \times 10^{+5}$ µCi/gal
$CO_3^=$	0.75 M	^{239}Pu	1.43×10^{-1} µCi/gal

The PERCOL Model[2] was used to simulate the sorption phenomena between soil and waste following the leak of the contents of a full tank. Input parameters for the analysis were those laboratory-measured values determined on soil samples from wells in the 200 West T tank farm. Only those soils below the backfill were used. The thin silt and caliche layers known to exist under some of the tank farms were omitted. This does not imply that soil profiles are the same everywhere but illustrates the effect of a "worst case" leak.

The following assumptions were made:

- the tank leaks 800,000 gallons
- the tank is 170 feet above water table
- average porosity of the soil is 0.35
- a silt layer typical of 200-W Area controls the waste percolation rate
- measured distribution coefficients for high salt waste on 200-West T tank farm soils are applicable
- the spreading of the waste laterally wets a circular area 126 feet in diameter
- a conservative specific retention for the soils is 6% of the pore volume or 2% of the total column volume
- seepage velocity is slow enough for sorption and chemical equilibrium to be attained.

The soil pore volume in the soil column 126 feet in diameter and 170 feet high is 7.42×10^5 ft^3. Six percent of this volume is 4.45×10^4 ft^3. The tank leakage volume is 1.07×10^5 ft^3 of which only 6.25×10^4 ft^3 (or 4.7×10^5 gallon) drains into the groundwater, within the time scale that allows for a measureable impact on groundwater quality.

The empirical concept of specific retention (Appendix II.3-D) was used to remove from the analysis that portion of liquid that takes thousands of years to drain to the water table. The assumed specific retention value of 2% of the column volume was selected to cause some liquid to pass through the column and show the capacity of the soil to sorb radionuclides. If 6% of the total column volume were assumed as the specific retention volume, no liquid would reach the water table within a reasonable time and the PERCOL model would not be applied to the analysis.

The soils beneath the 200 Area plateau consist mainly of layers of sand and silt mixed with gravels. In 200-W Area, a layer of caliche up to several feet thick was identified in many of the wells. The soils beneath this caliche are generally classed as the Ringold Formation. This caliche does not exist in 200-E Area. The assumed soil layers for this analysis are schematically shown in Figure III.2-1. The sorption results of the leak solution flowing down to the water table are illustrated in Figures III.2-2, III.2-3 and III.2-4.

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Figure III.2-1 shows the regions within the soil profile where the ^{90}Sr, ^{137}Cs, and ^{125}Sb are sorbed. Figures III.2-2, III.2-3 and III.2-4 show the concentration-distributions of ^{90}Sr, ^{137}Cs, and ^{125}Sb on the soil as a function of depth:

- ^{90}Sr is removed by ion exchange and by precipitation as $SrCO_3$ close to the source
- ^{137}Cs is sorbed within the first 15 feet
- ^{125}Sb sorbs only on the fine silt and in the Ringold sediments where higher clay contents exist
- ^{106}Ru generally is not sorbed on the soil and travels with the water.

In order to treat the nonsorbed nuclides, ruthenium, technetium, iodine, and tritium, it was assumed that the only reduction in concentration was due to the decay during transport to the Columbia River. Therefore, the convective groundwater flow transport rates in both the partially saturated zones down to the water table and in the saturated zone to the Columbia River became the governing factor in determining efflux rates to the environment.

The rate of flow through the one-dimensional partially saturated column is difficult to calculate because of the changing hydraulic conductivity, moisture content and potential gradient. In the layered soil system, the soil with the lowest hydraulic conductivity will control the flow. Using the flow rate of the 106-T tank leak as typical for leaking tanks and restricting the flow to the 126-ft diameter column, the first arrival of liquid at the water table occurs in approximately 2 to 11 years. Subsequent to the first arrival, 1 year is assumed to be required for the bulk of the water to enter the water table. This is conservative since the rate of entry will decrease as the moisture content of the column decreases. The shortest travel time to the Columbia River from the 200 Areas is estimated as 20 years. Therefore, the 2-yr travel time for the liquid down to the water table, with the 1-yr duration of flow into the water table, followed by a 20-yr travel time down the fastest flowpath to the river bank were assumed. These assumed travel time values mean that the tritium, technetium, iodine and ruthenium reach the river in about 22 years. The bulk of the leaked liquid is assumed to merge within about a year after first arrival since dispersion effects were neglected.

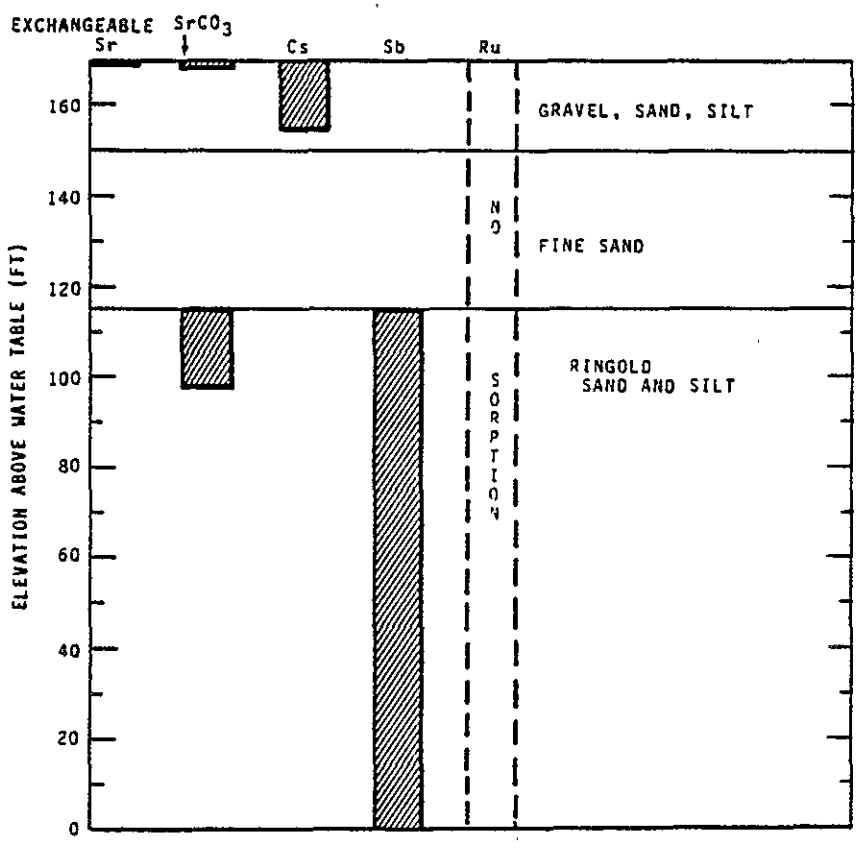

FIGURE III.2-1 SORPTION OF RADIONUCLIDES IN SOIL BENEATH WASTE TANK

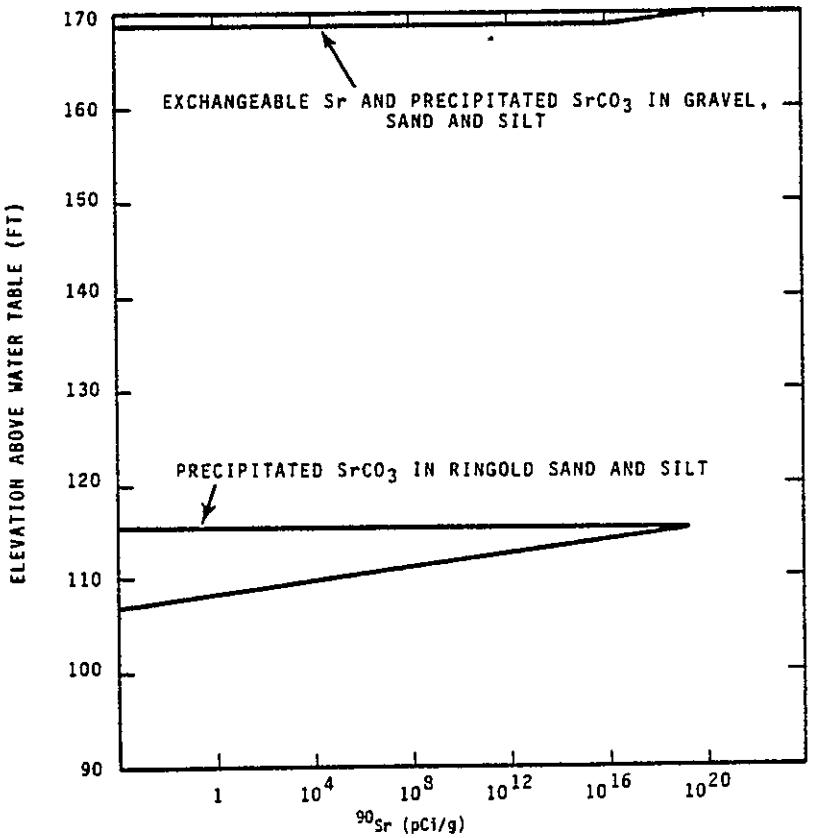

FIGURE III.2-2 SORPTION OF ^{90}Sr BENEATH WASTE TANK

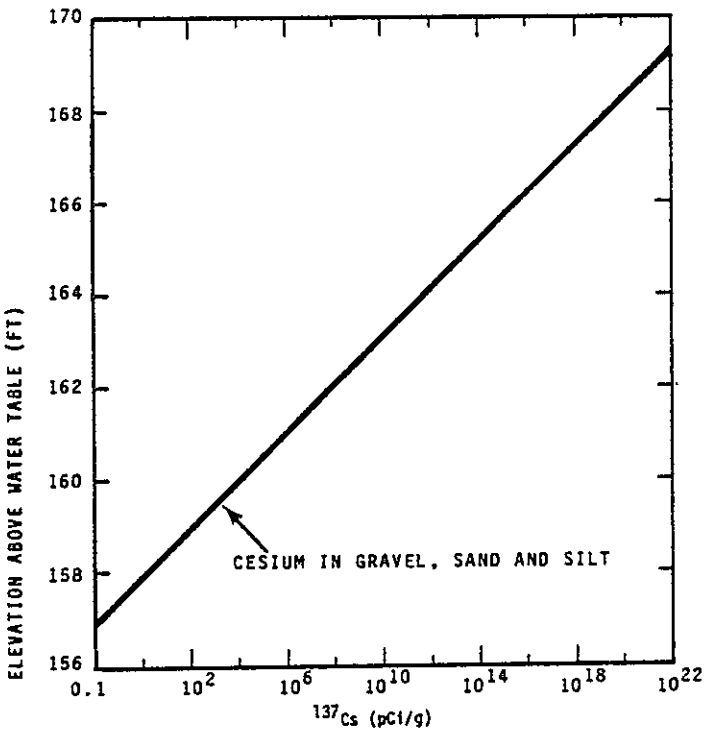

FIGURE III.2-3 SORPTION OF ^{137}Cs BENEATH WASTE TANK

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The total amounts of these nuclides reaching the river are given in Table III.2-1 with radioactive decay taken into account where significant. Analysis of this tank leak case with "worst case" assumptions demonstrates that the cesium and strontium never reach the river. For the nonsorbed or slightly sorbed radionuclides, only ^{99}Tc reaches the river undiminished. The remaining nuclides, ruthenium, tritium, antimony and iodine, are discharged to the river at negligible levels due to the small quantities initially present (tritium, iodine), radioactivity decay (ruthenium, antimony) or due to sorption in the soil (antimony).

III.2.2.3.2 Calculated Radiological Impact on Man from 800,000 Gallon Leak

The calculated radiation dose to the maximum individual and to the population within 50 miles of the postulated accident is given in Table III.2-2. The effective half-lives in the body of all of the nuclides involved are short enough so that essentially all of the listed dose is received in the first year. The total potential dose was calculated by summing the contributions from eating foods irrigated with the potentially contaminated water, eating fish in equilibrium with the water, drinking the water, and participating in aquatic recreation such as boating, water skiing, swimming, etc.

III.2.3 Tank Gaseous Releases

III.2.3.1 High-Heat Waste Tanks

The high-heat waste resulting from Purex Fuel Processing operations is stored in the A-AX-AY-AZ tank farm complex located in 200 East Area. In the past, this waste has contained sufficient fission product decay heat to cause boiling and self-concentration. Currently only one tank contains sufficient decay heat to sustain boiling.

Each of the tanks in A, AX, AY and AZ tank farms vents through a baffled carbon steel header which is common to the tanks in each tank farm and then through either a primary or secondary ventilation system. The tank vent systems from the A, AX and AY farms join together near the filtration building in a common line which conducts the gas and vapors through a series of decontamination equipment and then through filtration. Motive force is provided by one of two exhaust fans located downstream of the filters. One of these fans is maintained in standby for automatic activation if the operating fan fails. Both fans are supplied with emergency power by diesel generators. The gas exhausted by the stack is continuously sampled and monitored for radioactive material. The maximum daily radioactive releases given in Appendix II.1-C, Part 7, are well within the release guide limits. A standby ventilation system backs up the primary ventilation system in the event of an emergency.

III.2.3.1.1 Filter Failure

The manifold piping arrangement with shut-off valves for each of the six filters operating in parallel permits manual isolation of each filter as required when filter failure occurs due to overloading or breakthrough. Should a breakthrough occur in all filters simultaneously, the release (and its consequences) would be expected to be less than the seal failure case discussed below.

III.2.3.1.2 Seal Failure in Exhaust Piping

Emergency venting of the waste storage tanks is provided by a 24-in. line from the vapor header directly to the standby stack. This line contains a water-filled seal pot that relieves at a pressure of 60 inches of water positive or 6 inches of water negative. Instruments indicate the seal pot water level.

A tornado hitting a high-level waste farm (discussed later under capability of facilities to resist natural forces) would significantly damage above ground facilities, which includes the ventilation system. The release of radioactivity in the unfiltered noncondensed vapor resulting from the total severence of the system has been estimated to be less than 5 Ci/hr. For the single tank involved, emergency control should be established in less than 24 hours, (total calculated maximum release, 120 Ci). Since this source term is on the same order of magnitude but is less than that estimated for the tank dome failure case presented later in this section, the consequences of seal failure are not analyzed here.

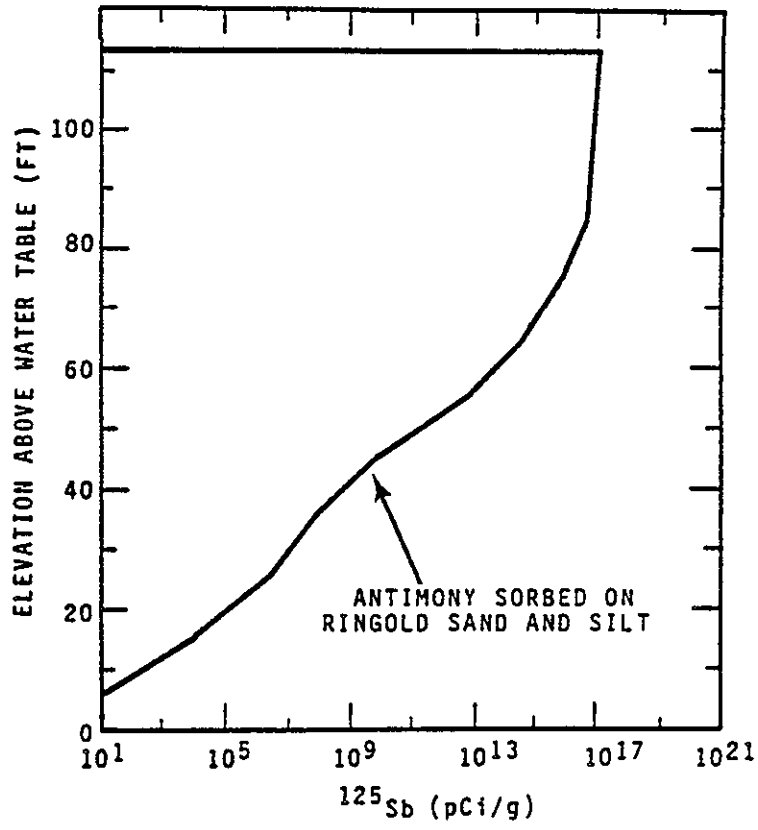

FIGURE III.2-4 SORPTION OF ^{125}Sb BENEATH WASTE TANK

III.2.3.1.3 Solution Rollover (Bumping)

In the past, emergency venting of a waste tank has resulted from solution rollover. Venting is not likely to occur again since an elaborate air circulation system has been incorporated. However, should venting happen, the result would be similar to that described under seal failure in exhaust piping except that recovery could be effected within a few hours.

TABLE III.2-1

SOURCE TERM FOR THE POSTULATED WASTE TANK LEAK TO GROUND

Radionuclides	Quantity[a] Released to River (Ci)
^{3}H	5600
^{125}Sb	2.4×10^{-16}
^{106}Ru	8.2×10^{-2}
^{99}Tc	650
^{129}I	0.29

(a) Assumed to be released in 1-yr period following a 22-yr travel time from the tank site.

TABLE III.2-2

RADIATION DOSE FROM POSTULATED 800,000 GALLON TANK LEAK

	Dose	
	Maximum Individual (rem)	Population (man-rem)
Whole Body	1.4×10^{-4}	2.9×10^{-1}
G.I. Tract	4.0×10^{-4}	1.2×10^{0}
Bone	5.3×10^{-6}	2.0×10^{-2}
Thyroid	3.8×10^{-4}	7.9×10^{-1}

III.2.3.2 Low-Heat Waste Tanks [X.4]

Presently a number of tanks containing low-heat waste are vented to an aboveground air cooled condenser. This venting is being replaced with a filtered exhaust system similar to that used on tanks containing high-heat waste. Low-heat waste tanks are in a static state except for transfers in and out of the tank. These tanks are normally isolated from the atmosphere except for a small vent to accommodate the transfers. No significant spread of contamination has been detected from these vents.

These tanks contain less strontium and cesium than the high-heat tanks. The probability of failure of any given tank is higher than the probability of failure of high-heat tanks, but the lower radionuclide inventory and the lesser quantities of strontium and cesium make the degree to which soil may become contaminated in event of a failure far less than for high-heat tanks.

Some low-heat waste tanks, used to store evaporator bottoms solutions at elevated temperatures, are equipped with exhauster systems. Each of the systems is equipped with high-efficiency particulate air (HEPA) filters and facilities for collecting a 24-hr filter sample of the gaseous effluents. Standard operating procedures state requirements for routine audit of filter integrity and define the limits. The filter samples are collected on a 24-hr schedule and delivered to the laboratory for total beta and total alpha analyses. The resultant data are the input for computer processing and the issuance of two reports. The first report is a routine listing of all data and the second is a special out-of-limits report that lists only those emissions that have exceeded stated limits for radionuclide content. Beta samples that exceed such a limit are reanalyzed by gamma energy analysis to identify specific fission products present. These safeguards are considered adequate for the prevention of releases that exceed maximum permissible concentrations, and the probability of failure is believed to be remote.

III.2.4 Salt Cake Storage Dome Failure [X.4, X.5, X.6]

No dome failure of the high-level waste tanks has occurred at Hanford or at any other site. Modeling tests have indicated a margin of safety of 4 to 5 times the earth load (~1500 tons) over the tanks. A life of 100 years and probably longer could be reasonably expected based on life of other reinforced concrete structures (bridges, dams, etc.). High-heat waste is to be contained in the newest double-wall tanks (<3 years old). Temperature effect from salt cake will have greater impact than radiation. Available evidence indicates that radiation has little effect on the strength of reinforced concrete.[25]

The oldest tanks containing low-heat liquid waste are about 30 years old. Liquid waste will be removed from these tanks within the next few years. Thereafter, the salt cake will remain until a final disposal method is developed, a determination that is expected to be made long before 100 years pass. Once a tank has been filled with salt cake and has been isolated from other tanks, a surveillance program will be initiated to detect any creep (sagging) in the dome. During this interim period, the tank volume between the salt cake and the dome will not be filled in order to avoid increasing the volume of contaminated material to be handled should removal of salt cake be required for ultimate disposal. This void volume could be filled (with sand, clay, etc.) should serious weakening of the dome be detected.

An analytical approach involving relationships of time, elevated operating temperatures, and the earth cover loads is underway and has been carried out for several years to develop predictive capability on creep and cracking of underground waste tanks, effects which could result in some sagging of the dome. These waste tanks with reinforced concrete dome tops are unique structures for which failure probabilities have not been definitely established. Hanford experience appears to be the only basis for estimating failure probabilities and has accumulated 2,500 tank years without a failure.

III.2.4.1 Source Term of Dome Failure

If the dome on a waste tank were to collapse onto salt cake, particulate salt cake could be released to the atmosphere.

Based on evaluations of aerosol behavior,[3] a cubic meter of air could be expected to contain 5 grams of solids with particle diameters less than 10 μm. Particles in this size range could be easily carried away from the accident site by air currents. Since the free volume above the salt cake prior to the dome failure is approximately 2800 m^3, 14 kg of solids with particulate diameters less than 10 μm could be expected to be entrained in the air following the accident. At least half the entrained solid is expected to be particles of soil and debris from the collapsed dome. This leaves 7 kg of solidified waste made airborne from the dome failure which is equivalent to the fission products associated with 60 liters of liquid solution.

The above analysis assumes the salt cake is a dry solid. If the salt cake is moist so that liquid surface tension and viscous effects must be overcome prior to entrainment, then the air concentration of fission products is at least two orders of magnitude lower.[3] Therefore, the 60 liter estimate is at present conservative because at this time the salt cake is not completely dry. The quantity of radionuclides estimated to be released under these conditions is given in Table II.2-3.

TABLE III.2-3

SOURCE TERM FOR POSTULATED DOME FAILURE

Radionuclide	Quantity Released from Dome Failure, Ci	Radionuclide	Quantity Released from Dome Failure, Ci
^{3}H	6.7×10^{-4}	^{144}Ce	1.9×10^{1}
^{89}Sr	1.6×10^{-10}	^{147}Pm	1.2×10^{2}
^{90}Sr	6.0	^{238}Pu	1.0×10^{-3}
^{95}Nb	2.4×10^{-6}	^{239}Pu	2.3×10^{-3}
^{95}Zr	1.2×10^{-6}	^{240}Pu	7.9×10^{-4}
^{103}Ru	5.0×10^{-13}	^{241}Pu	4.3×10^{-2}
^{106}Ru	1.2×10^{1}	^{242}Pu	1.2×10^{-7}
^{129}I	9.8×10^{-6}	^{241}Am	5.8×10^{-2}
^{134}Cs	1.8×10^{-1}	^{242}Cm	2.0×10^{-4}
^{137}Cs	7.0×10^{0}		

III.2.4.2 Calculated Radiation Doses for Postulated Dome Failure Accident [X.6]

The calculated radiation doses to the maximum individual and to the population within 50 miles of the postulated accident are given in Table III.2-4. The table presents the inhalation dose from all radionuclides released, including the transuranic elements. That portion of the dose due to the inhalation of only transuranic elements is given in Table III.2-4a.

TABLE III.2-4

RADIATION DOSES FOR POSTULATED DOME FAILURE

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External Whole Body	6.2×10^{-6}	1.5×10^{-3}	6.2×10^{-6}	1.5×10^{-3}
Inhalation (All Radionuclides Released)				
Whole Body	1.4×10^{-2}	2.3	1.3×10^{-1}	$2.1 \times 10^{+1}$
Lung	3.6×10^{-1}	$6.0 \times 10^{+1}$	6.5×10^{-1}	$1.1 \times 10^{+2}$
Bone	1.9×10^{-1}	$3.1 \times 10^{+1}$	1.4	$2.4 \times 10^{+2}$
Thyroid	1.9×10^{-7}	3.1×10^{-5}	2.2×10^{-7}	3.6×10^{-5}

III.2.5 Postulated Liquid Waste Transfer Accidents [X.4]

Two general types of high-level liquid waste are transferred in underground pipes; high-heat waste and low-heat waste. The high-heat waste is produced from fuel dissolution in the Purex

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TABLE III.2-4a

RADIATION DOSES FOR POSTULATED DOME FAILURE (INHALATION OF TRANSURANICS ONLY)

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
Whole Body	1.5×10^{-3}	2.6×10^{-1}	5.5×10^{-2}	9.1
Lung	2.5×10^{-2}	4.2	6.7×10^{-2}	$1.1 \times 10^{+1}$
Bone	2.4×10^{-2}	3.9	8.7×10^{-1}	$1.5 \times 10^{+2}$

Plant and is sent to the B Plant for removal of ^{90}Sr and ^{137}Cs (long-lived heat emitters). The waste is then sent to the boiling waste tanks for a period of about 5 years to permit decay of the shorter lived heat emitting fission products. Thereafter, the liquid waste becomes low-heat waste. Low-heat waste is also generated in the dissolution of fuel cladding, by organic wash water, from reactor and equipment decontamination, from laboratory operations which handle radionuclides, etc.

High-heat waste is transferred in encased lines which provide drainage to sumps where leaks can be detected. Low-heat waste, for the most part is also transported in encased lines, but some unencased lines are still in use within the older tank farms. A number of unencased lines for liquid waste transfer have been replaced within the last 5 years. All new transfer lines which will be constructed under new projects in the future will be encased.

Appendix II.1-C lists the liquid waste transfer line leaks (nine to date) which have resulted in soil contamination. Leaks in lines with encasements do not result in release of radioactive material to the environment and can be readily detected. Usually such a leak will be limited to less than 100 gallons. Line leaks in unencased lines are more difficult to detect and leaks up to 36,000 gallons have occurred. Procedures have been modified to detect this type of leak earlier. Material balances are made with each transfer and the transfer line is patrolled with a vehicle-mounted radiation monitor.

Based on past experience, three types of leaks are considered:

- Leakage of high-heat waste from the inner encasement of a doubly encased line to the outer encasement and drainage to a sump. Less than 100 gallons would probably be involved. Since no release to the environment occurs, this event does not result in an environmental impact.

- Leakage of a few thousand to a few tens of thousands of gallons of low-heat waste to the soil surrounding an unencased line. If the line is near the surface and the leakage rate is high, most of the leaked material may form a surface pool before seepage into the soil.

- Leakage of an upper limit of 100,000 gallons of low-heat waste of which a fraction forms a surface pool. Such large leaks have not been experienced to date and are not expected.

For analysis, a so-called "worst case" transfer line leak of 100,000 gallons was selected. It is assumed that 1/4 (or 25,000 gallons) of the waste would reach the surface and form a pool and that the remainder of the waste would be released to the soil beneath the spill. An inventory of 5 year old waste with 95% of the strontium and cesium removed by B Plant processing was selected for consideration.

The selection of this inventory for transfer line accident analysis is a conservative approach, since this composition represents the highest concentration of radioactivity transferred in unencased lines. Most solutions transferred in unencased lines contain less radioactivity. Liquid waste transfers involving high-heat waste, or waste in which the strontium and cesium have not been removed, are transferred in encased lines (double containment).

The probability of the 100,000 gallon leak occurring is difficult to assess. At Hanford, during the last 30 years, approximately 40 unplanned releases of this general type occurred, most of them remaining underground. A total of 16 of these leaks were associated with fission product transfer operations.[4] Of these 16, six resulted in no surface contamination, while in six others the surface became wet. In three cases, liquid flowed onto the surface and in one case an airborne spray was produced. The postulated accident assumes that the liquid, including solids,

flows onto the surface. Similar events occurred three times in 30 years. Based solely on this past record, similar events may have a mean recurrence interval of approximately 10 years, assuming a constant level of transfer operations and taking no credit for any newly installed double-wall transfer lines or deterioration of other existing lines.

The accident being evaluated assumes the existence of unfavorable high winds at the same time. Winds greater than 10 m/sec (22 mph) can be expected to occur at the Hanford site about 5.8% of the time.[5] Therefore, the probability that both the spill and the high winds will be coincident is once in 170 years.

III.2.5.1 Source Term for Liquid Waste Transfer Accident

Assuming a transfer leak does occur, the radioactive material that reaches the surface will be exposed and available for atmospheric dispersal until corrective action is taken (corrective action is assumed to occur within 12 hours). The important variables are 1) the fraction of the radionuclides in the top few centimeters of soil and 2) the fraction that is entrained in the air and travels offsite.

Past experience involving spills of approximately one third this size indicates that the liquid would be expected to percolate into the ground and the solid fraction of the waste would be expected to be filtered out and remain in the top few centimeters of the soil column. Thus, the top few centimeters would contain all the solid fraction and, if the liquid penetrated the soil to a depth of 10 cm, perhaps as much as 1/10 of the liquid fraction. Usually the depth of liquid penetration would be more than 10 cm and, consequently, the liquid contributions would be much lower, perhaps only 1/100 or 1/1000 of that leaked.

In addition to the distribution of radionuclides in the soil, the fraction of the nuclides which are available for entrainment and actually get entrained in the air currents is a fundamental factor in determining the release to the environment. Based on experimental studies, carried out at Hanford (discussed in detail in Appendix III-D), no more than 0.1% of the waste exposed to surface erosion would be expected to be effectively entrained in the air. In the 12-hr release period envisioned, the top centimeter of soil, which contains all the solids and 1/10 of the liquids, would be expected to be exposed to surface erosion. Since the spill was postulated to form a 25,000-gal surface pool, this last statement is equivalent to stating that all the solids and 1/10 of the liquids associated with the 25,000 gallons of waste would be made airborne and dispersed offsite. The calculated source term for a surface pool of 25,000 gallons of liquid waste is given in Table III.2.5.

TABLE III.2-5

SOURCE TERM FOR POSTULATED SURFACE SPILL
OF NEUTRALIZED 5 YEAR OLD WASTE

Radionuclide	Quantity Released to Air, Ci	Release Rate Ci/sec (12-hr duration)	Radionuclide	Quantity Released to Air, Ci	Release Rate Ci/sec (12-hr duration)
^{3}H	3.4×10^{-3}	7.9×10^{-8}	^{144}Ce	1.6	3.8×10^{-5}
^{89}Sr	4.8×10^{-11}	1.1×10^{-15}	^{147}Pm	7.4	1.7×10^{-4}
^{90}Sr	3.1×10^{-1}	7.2×10^{-6}	^{238}Pu	5.4×10^{-6}	1.3×10^{-10}
^{95}Zr	3.0×10^{-7}	6.9×10^{-12}	^{239}Pu	1.2×10^{-4}	2.7×10^{-9}
^{95}Nb	5.6×10^{-7}	1.3×10^{-11}	^{240}Pu	4.1×10^{-5}	9.5×10^{-10}
^{103}Ru	1.9×10^{-13}	4.4×10^{-18}	^{241}Pu	2.4×10^{-3}	5.5×10^{-8}
^{106}Ru	1.2	2.8×10^{-5}	^{242}Pu	5.9×10^{-9}	1.4×10^{-13}
^{129}I	5.4×10^{-8}	1.3×10^{-12}	^{241}Am	3.0×10^{-3}	6.9×10^{-8}
^{134}Cs	1.4×10^{-3}	3.2×10^{-8}	^{242}Cm	1.6×10^{-5}	3.7×10^{-10}
^{137}Cs	3.9×10^{-2}	8.9×10^{-7}			

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III.2.5.2 Calculated Radiological Impact on Man

The calculated radiation dose to the maximum individual and to the population within 50 miles from the postulated accident is given in Table III.2-6. The values for the first year dose and the 50 year dose commitment are given.

TABLE III.2-6

DOSES IN REM FROM POSTULATED TRANSFER LINE LEAKAGE OF 100,000 GALLONS OF WASTE

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	3.5×10^{-6}	3.3×10^{-3}	3.5×10^{-6}	3.3×10^{-3}
Inhalation				
Whole Body	5.4×10^{-3}	1.9	5.9×10^{-2}	3.7×10^{1}
Lung	1.3×10^{-1}	4.6×10^{1}	2.6×10^{-1}	9.0×10^{1}
Bone	7.0×10^{-2}	2.6×10^{1}	5.6×10^{-1}	2.0×10^{2}
Thyroid	4.6×10^{-9}	1.7×10^{-6}	5.5×10^{-9}	2.0×10^{-6}

III.2.6 Accidents in B Plant [RPB]

In B Plant, strontium and cesium are removed from the high-level waste to reduce greatly the length of boiling time for high-level liquid waste. For the tank inventory given in Appendix III-D, the time can be reduced by a factor of 14, from 85 years to about 6 years.

III.2.6.1 Postulated Accidents Considered for B Plant [X.4]

Postulated accidents considered in the B Plant safety analysis,[6] and a summary of preventive measures, include:

- Accumulation of hydrogen by radiolytic decomposition of water followed by an explosion. The tank is purged with air to prevent the accumulation of hydrogen. Emergency air compressors are available.
- Accumulation of ammonia followed by an explosion. Temperatures of aqueous solutions containing concentrated ammonia are maintained below 39°C to prevent accumulation of explosive mixtures of ammonia and air.
- Explosion of "red oil" [a complex mixture of nitrated organic decomposition products of tributylphosphate (TBP) and heavy metal nitrates]. Concentrators are operated at temperatures less than 140°C to prevent the explosion should "red oil" accumulate.
- Chemical oxidation of ruthenium to volatile ruthenium tetroxide. A series of five independent operating errors is required to inadvertently add persulfate (a strong oxident) to the tank in which ruthenium could be oxidized.
- Loss of cooling water allowing solutions containing fission products to evaporate to dryness. Backup supply systems are provided.
- Loss of electrical power. Emergency backup systems are provided.
- Loss of instrument or process compressed air. Preventative features include an emergency portable air compressor and operating procedures and design features to assure safety.
- Temperature excursion in solids settling out from feed streams. Administrative controls and temperature instrumentation are used to maintain liquids on the solids.

- Cell drain line failure causing solutions of high concentrations of fission products to leak to soil. Leak checks of transfer lines, leak-detectors in the openings of cell floor drains, control of solution transfer volumes, and visual inspection are employed to prevent this occurrence.

- Concentrator pressurization. Concentrator pressure and seal-pot liquid levels are measured, operating procedures are carefully conducted, and a gas eductor (jet) is used to maintain proper pressures in the system.

- Vessel coil failure. Monitors detect any contaminants of cooling water and activate diversion to a lined retention trench.

- Condensates. Since the safety analysis was made, catch tanks to hold up and monitor process and steam condensates have been added. Condensates contaminated with radioactivity can be returned to the process for rework. Additional sampling tanks and a diversion system to an enclosed catch trench (from which the stream may be recycled) are now being installed to further prevent accidental discharge of contaminated condensates.

- A fire in the B Plant ventilation filter. Preventative measures include use of fire resistant absolute filters, a heat detection system, minimization of quantity of combustible materials and sources of ignition in the canyon, an automatic foam system for cells containing organic solvents, separate process vent system for off-gases which could contain ammonia, and good housekeeping practices. In the event of a fire, alarms are sounded, water sprays can be activated, and exhaust air is diverted from HEPA filters to a sand filter.

Postulated accidents considered in the safety analysis of the encapsulation and storage facility,[7] and a summary of preventive measures, are:

- Hydrogen accumulation and explosion. Process vessels, the storage basins and process cells are purged with air to prevent accumulation of explosive mixtures. Emergency air compressors are available.

- Vessel coil failure. Cooling coils are maintained under positive pressure to prevent any leakage of the process solutions. Careful design, quality assurance, operating safeguards, monitoring and diversion of any contaminated streams are used to avoid environmental dispersal of contaminated cooling water or stream condensates.

- Loss of cooling water. Emergency diesel driven pumps, parallel supply lines, and a water reservoir are employed to minimize this potential and to provide cooling water if the primary source should be lost.

- Loss of process or instrument air. Parallel-operated compressors and a portable diesel-driven compressor are available.

- Loss of electrical power. A diesel-driven generator automatically assumes the load.

- Encapsulation problems. Highest standards in manipulator design, construction, operation and maintenance are employed. Engineered safeguards and operating procedures are carefully considered.

- Capsule failure during storage. Material selection and welding procedures are carefully controlled to prevent corrosion. Safety features in operating equipment are provided to avoid inadvertent mechanical damage. Process solution back-flow. Redundancy in air compressors (previously discussed) and "fail-safe" diaphragm-operated valves minimize the potential of this event.

- Fire. Accumulation of combustible materials and sources of ignition are limited. Fire detection, alarms, and cell spray systems for extinguishing are provided. Filters are fire resistant.

Based on these evaluations, the accident with the largest potential impact would be a fire in the B Plant ventilation filter. Other postulated accidents within B Plant or the encapsulation and storage facility have less potential consequences.

The B Plant exhaust ventilation system provides for 1) the removal of process-generated heat and 2) control of the release of contaminated air from the canyon. The system comprises a canyon supply air system and a filtered exhaust system discharging to atmosphere. The 45,000 cfm

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capacity system is operated to maintain a negative pressure in the canyon with respect to atmosphere of 0.2-in. water gauge pressure to ensure directional flow of contaminated air. The filtered and washed supply air enters near the top of the canyon, flows downward around process cell cover blocks, into the cells and through openings into the canyon exhaust air tunnel.

Exhaust air is filtered through three (A, B, and C) underground, reinforced concrete filter bays operated in parallel. Each filter bay consists of a roughing prefilter followed by two banks of HEPA filters in series. Metal screens are provided following the prefilter and the first bank of HEPA filters to prevent mechanical damage to the following filters. Each filter bay is connected to a common underground exhaust plenum through a structural baffle which, when filled with water, will isolate from service any one or all of the filters. Above grade stainless steel duct work connects the plenum to two electrically driven exhaust blowers and one standby steam turbine driven exhaust blower which discharge through a 200-ft tall concrete acid brick lined stack.

The exhaust ventilation system is equipped with an air sampler, monitors and alarms to measure radioactive discharges and to detect off-standard conditions. An isokinetic sampling probe located in the exhaust stack provides for continuous sampling of air exhausted to the atmosphere. An existing exhaust air sandfilter (25,000 cfm) paralleling the HEPA filter system remains in serviceable standby, although isolated from the system by water seals. The sandfilter can be activated automatically by removal of its seal water and by adding water to the HEPA filter seals. The diversion of the exhaust air system is designed to be accomplished within 5 minutes. The 221-B process cells and the filter system incorporate several fire detection and control systems for protection of the filters.

For this postulated accident, one of three roughing/prefilter banks in C cell is assumed to burn and release its entire inventory to the first bank of HEPA filters. Thus, the inventory on the first HEPA filter in that bank becomes 1/3 of the entire inventory in C cell, shown in Table III.2-7. Following the destruction of the prefilter, 5 of the 25 HEPA filters are assumed to burn through releasing their inventory to the final HEPA filter bank in that section. At elevated temperatures, the transmission through the last filter bank could be as high as 1.0% at the expected condition.[8]

TABLE III.2-7

ESTIMATED INVENTORY OF RADIONUCLIDES ON B PLANT FILTERS

	Quantity on Prefilters and First HEPA Filter Bank, Ci	
	^{137}Cs	^{90}Sr
A Cell	3.6×10^3	4.0×10^4
B Cell	2.3×10^3	2.5×10^4
C Cell	3.5×10^3	9.9×10^3

The probability of a fire occurring in the B Plant filter system was estimated based on Hanford experience. Three fires in the ventilation and filter system of processing facilities at Hanford have been recorded over the past 30 years. The fires involved the burning of lint or other residue on hood filters or prefilters. In all cases, no filter failures or resulting environmental impacts resulted from these fires. Conservatively estimating that an annual average of 100 process ventilation systems were operative during the 30-yr period, the probability of a fire occurring in a filter system is 10^{-3} per plant year. Since none of these fires were of the magnitude postulated in B Plant, and since fire preventative controls have increased during this 30-yr period, the probability of a postulated fire is expected to be at least one or two orders of magnitude less than that estimated by Hanford experience. Therefore, a probability of less than 10^{-4} per year has been assigned to the postulated B Plant filter fire.

III.2.6.2.1 Calculated Source Term for Filter Failure in B Plant

Recent radiation measurements provided estimates of the radionuclide inventory on the B Plant exhaust filter system. From these radiation measurements taken at specific locations, with relation to the filter banks in each of the three filter cells (designated A, B, and C cells), estimates were made of the probable radionuclide loading on the prefilters and the first bank of HEPA filters in each cell. The prefilter system was assumed to remove between 90% and 75% of the particulate material with the remaining amount deposited on the first bank of HEPA

filters. The loading of radionuclides on the second bank of HEPA filters was assumed to be insignificant and was not considered as a contributor to the radiation dose measurements used to estimate the exhaust system inventory.

The ^{137}Cs inventory was inferred directly from the radiation measurements. Since ^{90}Sr is primarily a beta radiation emitter, direct determination by the techniques used was not possible. The ^{90}Sr inventory within each filter cell was estimated, using ^{137}Cs:^{90}Sr ratios developed assuming attenuation of beta radiation by varying depths of dirt deposited on the filter. The estimated maximum inventories of ^{137}Cs and ^{90}Sr contained in each filter cell are shown in Table III.2-7.

The calculated source term for the filter fire described earlier in this section is shown in Table III.2-8. The release occurs as an elevated release from the 200-ft 291-B ventilation stack.

TABLE III.2-8

SOURCE TERM FOR POSTULATED B PLANT FILTER FIRE

Radionuclides	Quantity Released to Air, Ci	Release Rate Ci/sec (10-min. duration)
^{137}Cs	2.3	3.8×10^{-3}
^{90}Sr	6.6	1.1×10^{-2}

III.2.6.2.2 Calculated Radiological Impact on Man

The calculated radiation doses to the maximum individual and to the population within 50 miles of the postulated accident are given in Table III.2-9.

TABLE III.2-9

RADIATION DOSE FOR CESIUM AND STRONTIUM PROCESSING POSTULATED FILTER FAILURE

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	1.0×10^{-6}	2.3×10^{-4}	1.0×10^{-6}	2.3×10^{-4}
Inhalation				
Whole Body	2.5×10^{-3}	2.8×10^{-1}	4.9×10^{-2}	5.4
Lung	4.3×10^{-2}	4.8	1.0×10^{-1}	1.2×10^{1}
Bone	9.1×10^{-3}	1.0	4.8×10^{-2}	2.2×10^{1}

III.2.7 Liquid Waste Shipments Accidents

III.2.7.1 Leakage from an Overfilled Rail Tank Car

During the diverse research and development activities which utilize large quantities of radionuclides, liquid waste streams of intermediate-level are frequently generated in the 300 Area. This waste is collected and transferred to 200-W using specially designed 20,000-gal rail tank cars. These same cars are also used to transfer intermediate-level waste from N Reactor to 200-W. The liquid waste received from these shipments is incorporated into the high-level liquid waste processing operations in the 200-W Area. The car is loaded and unloaded from the top ports arranged on a top flange closure plate. Valves and disconnect-fittings which mate with the piping in the loadout facilities are mounted on the fill and vent line nozzles. During transport, caps are installed on each line. Liquid level and temperature gauges are installed on their respective nozzles and remain in place during transport.

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During shipment, the tank car normally contains a 7-in. air space between the surface of the liquid and the top of the car. A pressure buildup of 0.70 psig is enough to discharge liquid through the fill/discharge line if all the flanges in the air space are leak tight and the valve and cap in the fill/discharge line are not leak tight. A temperature rise of 5°F could cause liquid to be discharged onto the external surfaces of the car. Also, if one of the vent flanges leaks, permitting the tank to be filled up so there is no air space, then the tank will leak with any temperature increase. Since this last case is considered the most likely to result in a release, it was selected for evaluation.

In the case evaluated, the tank car, due to equipment failure or improper use, would be completely filled with waste at 60°F, leaving no expansion air space, and then transported to 200-W from the 300 Area. The trip would take two hours, with an average speed of 20 mph. On that particular day, the sun was assumed bright and the air temperature was 110°F. The rate of expansion of the liquid under these conditions would determine the amount of liquid released during transfer.

III.2.7.1.1 Probability of Event

The absolute failure or leakage probability was not estimated because improper loading or sealing and plugging of the line can lead directly to some leakage. The mean time to failure for valves, seals and gaskets is probably less than 20 years. Failure of these components might occur once every 10 to 20 years.

III.2.7.1.2 Calculated Source Term for Leakage from an Overfilled Rail Tank Car

In 1972, an estimated 47,000 Ci of radioactivity contained in 340,000 gallons of liquid was shipped to 200-W from laboratory operations (300 Area). Analytical data indicated that two cars contained the major fraction of this radioactivity. One car contained an estimated 21,000 Ci and another contained 10,000 Ci. The estimated amount of radioactivity shipped in each of the remaining 15 shipments ranged from 50 to 4,000 Ci. The radionuclide content of a typical shipment is shown in Table III.2-10.

TABLE III.2-10

RADIONUCLIDE CONTENTS OF A TYPICAL TANK CAR SHIPMENT FROM 300 AREA

	Activity Contained in Liquids and Solids, Ci	
Radioisotope	Filtrate	Solids
Total Beta (a)	572	3220
Total Alpha (b)	0.84	2.50
^{60}Co	<0.45 (c)	<3.5 (c)
^{90}Sr	23.0	27.6
^{106}Ru - ^{106}Rh	3.18	30.2
^{137}Cs	24.3	2.88

(a) Total beta is calculated as a hypothetical, nonvolatile nuclide emitting a beta particle of energy 0.3 MeV.

(b) Total alpha is calculated as ^{239}Pu.

(c) "Less than" is used when the results were below detection level concentrations in the shipments.

For the postulated accident, the heatup rate was calculated to be 3.75°F/hr. Based on the volume expansion of water with temperature, this rate of heating corresponds to a resulting liquid discharge rate of about 10 gal/hr. The total amount which would be spilled in the 2 hour trip is estimated not to exceed 20 gallons.

The radioactive materials dissolved in the liquid could become airborne in two ways: 1) formation of small droplets by film break-up and 2) small particles formed by the evaporation of solution. An estimate of 10% was used for the airborne release of the radioactive material from a tank car leak. The potential quantity of radioactive materials released is shown in Table III.2-11.

TABLE III.2-11

SOURCE TERM FOR POSTULATED RELEASE FROM LEAKING TANK CAR

Radionuclide	Quantity Released to Air, Ci	Release Rate Ci/sec (2-hr duration)
Total Beta[a]	0.379	5.26×10^{-5}
Total Alpha[b]	3.33×10^{-4}	4.63×10^{-8}
^{60}Co	$<3.93 \times 10^{-4}$[c]	$<5.46 \times 10^{-8}$
^{90}Sr	5.06×10^{-3}	7.03×10^{-7}
^{106}Ru-^{106}Rh	3.34×10^{-3}	4.64×10^{-7}
^{137}Cs	2.72×10^{-3}	3.78×10^{-7}

(a) Total beta is calculated as a hypothetical, non-volatile nuclide emitting a beta particle of energy 0.3 MeV.
(b) Total alpha is calculated as ^{239}Pu.
(c) "Less than" is used when the results were below detection level concentrations in the shipments.

III.2.7.1.3 Calculated Radiological Impact on Man

The calculated radiation dose to the maximum individual and to the population within 50 miles of the postulated accident is given in Table III.2-12. The values for the first year dose and the 50 year dose commitment are given. The leakage is assumed to take place near the 300 Area, the nearest area to the City of Richland.

TABLE III.2-12

RADIATION DOSE FROM A POSTULATED LEAKING RAIL TANK CAR SHIPMENT

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	9.4×10^{-9}	9.2×10^{-7}	9.4×10^{-9}	9.2×10^{-7}
Inhalation				
Whole Body	8.5×10^{-4}	2.9×10^{-2}	3.8×10^{-2}	1.3
Lung	1.5×10^{-2}	7.1×10^{-1}	3.7×10^{-2}	1.4
Bone	3.3×10^{-2}	1.1	1.4	4.7×10^{1}

III.2.7.2 Rail Tank Car Transport Accident [X.4]

Three rail tank car events were identified that could result in a major release from the tank: 1) car derailment, 2) collision with another train, and 3) a grade crossing accident. The credible accidents would be similar to any other train accident.

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The Hanford railroad is maintained to the standards of the Association of American Railroads through the full-time use of two track maintenance crews. The entire working portion of the railroad is inspected monthly, and repair work is normally performed as items needing attention are disclosed during the inspections. The safety of roadbed, ballasting, and condition of ties is routinely surveyed. In addition, the Sperry-Rand Rail Survey Car is used to perform ultrasonic checks of all mainline trackage on a regularly scheduled basis. Defective rail revealed during the ultrasonic checks is replaced on a priority basis. Management frequently seeks advice and counsel of representatives of the local Class 1 railroads on technical matters relating to maintenance of the Hanford railroad.

The Hanford railroad is operated very conservatively with dispatcher control (via radio) of the trains at all times. Standard train orders govern all train movements, and the conductor and dispatcher can be in radio contact with each other at all times. Operating speeds are governed by the nature of the material being moved. For example, movement of rail tank cars of radioactive material are made at conservative lower speeds, as contrasted to movements of commercial cars. Operating speeds are also governed by weather conditions whether or not radioactive materials are being hauled.

The probability of rail accidents occurring was examined and the recurrence rate for an accident at Hanford involving mixed trains (more than just a tank car, which is normal practice for such shipments) was estimated to be once in 240 years. Grade crossing accidents which could result in tank failure were estimated to occur once every 1000 years, assuming the same train usage. Derailments would be expected to be caused by defective equipment such as trucks, wheels, and axles on non-Hanford maintained cars in a mixed car shipment. These would be expected to occur at high speed, outside the yard.[9] Although experience suggests that only one out of 100 derailments will cause a tank car to rupture, some cars ahead of a tank car may provide corners which could rupture a tank car. It is assumed that 10% of the derailments would result in a rupture of the tank car. Based on current Hanford practice and experiences, a derailment and a rupture of a tank car may occur at a rate of once every 2400 years. This frequency would be reduced to once every 10,000 years if only the waste tank car is transported during a shipment.

III.2.7.2.1 Calculated Source Term for Rail Tank Car Transport Accident

The consequences of the tank car rupture with the entire contents of the tank spilling onto the ground was evaluated. It was assumed that the material was not covered over for a 12-hr period and that during this time some of the spill would dry up and blow away. The solids would stay in the top layer of soil and the liquid would soak into the ground. The depth of penetration would depend on the type of soil, the land contour and the volume of the spill. It appears likely that a 20,000-gal spill would soak into a depth of about 10 cm over 2 acres of land. As discussed in Appendix III-E, for liquid spills on soil, it is assumed that no more than 0.1% of the content of the tank would become airborne under the most adverse circumstances. Table III.2-13 give the source term for the postulated release using the 0.1% airborne release fraction.

TABLE III.2-13

SOURCE TERM FOR POSTULATED TANK CAR DERAILMENT AND RUPTURE

Radionuclide	Quantity Released to Air, Ci	Release Rate Ci/sec (12-hr duration)
Total Beta[(a)]	3.3	7.6×10^{-5}
Total Alpha[(b)]	2.6×10^{-3}	6.0×10^{-8}
^{60}Co	$<3.5 \times 10^{-3}$[(c)]	$<8.2 \times 10^{-8}$[(c)]
^{90}Sr	3.0×10^{-2}	6.9×10^{-7}
^{106}Ru-^{106}Rh	3.1×10^{-2}	7.1×10^{-7}
^{137}Cs	5.3×10^{-3}	1.2×10^{-7}

(a) Total beta is calculated as a hypothetical, non-volatile nuclide emitting a beta particle of energy 0.3 MeV.
(b) Total alpha is calculated as ^{239}Pu.
(c) "Less than" is used when the results were below detection level concentrations in the shipments.

III.2.7.2.2 Calculated Radiological Impact on Man

The calculated radiation dose to the maximum individual and to the population within 50 miles of the postulated accident is given in Table III.2-14.

TABLE III.2-14

RADIATION DOSE FROM A POSTULATED RAIL TANK CAR TRANSPORT ACCIDENT

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	7.8×10^{-9}	3.0×10^{-6}	7.8×10^{-9}	3.0×10^{-6}
Inhalation				
Whole Body	5.6×10^{-4}	5.2×10^{-2}	2.2×10^{-2}	2.1
Lung	1.2×10^{-2}	1.1	2.7×10^{-2}	2.5
Bone	1.8×10^{-2}	1.7	7.7×10^{-1}	7.1×10^{1}

III.2.8 Solid Waste Transfer and Storage Operation Accidents

III.2.8.1 Fire from Vehicle Accident

Contaminated solid waste is generated in all Hanford facilities handling radioactive materials. The contamination varies with each building depending upon the nature of the development programs and waste generating operation. The solid contaminated waste from each of the facilities is sorted and packaged by standardized waste disposal procedures. In accordance with these procedures, contaminated solids integrally possessing less than 0.05 Ci of beta and gamma emitters are packaged in 4.5 ft^3 cardboard boxes. Additionally, the total amount of plutonium in one of these boxes should not exceed 10 nCi/g of waste in the box. Waste with greater than these limits are shipped in 30 or 50-gal steel drums or treated on an individual basis, depending upon the dose rate on the surface of the container. Containers with a surface dose rate in excess of 100 mR/hr cannot be routinely handled without undue radiation exposure to transport workers. Solid waste with greater radioactivity than stated above is shipped in special containers with some form of shielding, such as concrete.

The cardboard waste boxes are disposed of in burial trenches in the 200-W Area. Drums with surface dose rates less than 100 mR/hr are stored in the same trench. The special containers with higher dose rates are placed in burial caissons. Drums containing plutonium activity are taken to the 20-yr retrievable transuranic storage trenches.

For this postulated event, a solid waste carrying truck bound for a burial ground is assumed to be involved in an accident with a resultant fire. A defective vehicle or spontaneous combustion in one of the packages while being transported could also lead to a fire. The probability of a truck accident occurring is 2.45×10^{-6} per mile.[10] Of those accidents, 1.26% would result in fire.[11] Thus, the probability of an accident which results in a 30-minute fire is less than 1×10^{-7} per mile. On an annual basis, the loaded truck makes no more than 4 trips/week of 35 miles; the total annual mileage for the loaded truck on the Hanford site is approximately 7200 miles. The probability of an accident and ensuing fire is less than 10^{-3}/year. Thus, the mean recurrence interval between probable dispersals of solid waste during transport from a vehicle accident accompanied by fire is greater than 1000 years.

III.2.8.1.1 Calculated Source Term for Fire from Vehicle Accident

The truck is assumed to carry a maximum load of 100 cartons of waste averaging 20 pounds each and is involved in an accident just outside the 300 Area. Fifty cartons contain potentially contaminated plutonium waste in an amount equal to the allowable limit of plutonium (i.e., 10 nCi/g) and the other 50 boxes contain a total of 5 Ci of mixed fission products, a factor of two greater than the allowed packaging limit. A fire lasting 30 minutes is assumed to ensue following the accident and 50% of the radioactivity is dispersed to the air. The value of 30 minutes for the fire duration is based on the probable response time of the Fire Department and an analysis of transport accidents being carried out at Sandia Laboratories. This study indicates that less than one in four of this type of fire will last longer than 30 minutes.

Experiments carried out at Hanford[12 13] indicate that from 10 to 50% of the material present in combustible waste can be expected to be airborne. In the consequence calculation, it is conservatively assumed that the radioactive material followed the airborne ash and that there was no short distance fallout. The source term for this postulated accident is given in Table III.2-15.

TABLE III.2-15

SOURCE TERMS FOR POSTULATED SOLID WASTE FIRE DURING TRANSPORTATION

Radionuclide	Total Inventory (Ci)	Fraction Released (%)	Amount Released (Ci)	Release Rate (Ci/sec)
F.P.[(a)]	5	50	2.5	1.4×10^{-3}
^{239}Pu	4.5×10^{-3}	50	2.3×10^{-3}	1.3×10^{-6}

(a) Assumed to be ^{90}Sr

III.2.8.1.2 Calculated Radiological Impact on Man

The calculated radiation dose to the maximum individual and to the population within 50 miles of the postulated accident is given in Table III.2-16.

TABLE III.2-16

RADIATION DOSE FROM POSTULATED FIRE ACCOMPANYING A WASTE VEHICLE ACCIDENT

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	6.8×10^{-12}	3.7×10^{-9}	6.8×10^{-12}	3.7×10^{-9}
Inhalation				
Whole Body	1.9×10^{-2}	9.1×10^{-1}	4.2×10^{-1}	2.0×10^{1}
Lung	3.1×10^{-1}	1.5×10^{1}	7.6×10^{-1}	3.6×10^{1}
Bone	1.0×10^{-1}	4.8	2.9	1.4×10^{2}

III.2.8.2 Fire in Solid Waste Burial Trench

Solid waste is routinely accepted and buried twice a week on the 200 Area plateau. The activity and volume of waste associated with an average and maximum burial day are shown in Tables III.2-17 and III.2-18, respectively. After the day's inventory of waste is placed into the burial trenches, a heavy equipment operator, using one of two bulldozers, covers the waste with clean dirt. Any waste which arrives after the operator began to cover the waste is refused burial and the truck must return the waste to its point of origin. Normally, high winds are no deterrent to burial unless rigging equipment is being used, in which case high winds would result in unsafe operation for riggers.

Since the dry waste is combustible and can potentially contain reactive chemicals, fire by spontaneous combustion is possible. In addition, sparks from vehicles, a carelessly thrown cigarette, or lightning could cause ignition. One significant fire in a burial ground has occurred in the 30 years of Hanford operation. Based on this experience, the probability of a significant fire in a burial trench could be estimated at 0.03/year. However, this accident occurred when there was no requirement to cover the waste accumulated during each day. This requirement reduces the probability of a similar accident by the fraction of the time the burial ground is left uncovered at the end of the day and, of course, reduces the amount of

TABLE III.2-17

CHARACTERISTICS OF DRY WASTE BURIED ON AN AVERAGE DAY

Source	No.	Container	Volume (ft^3)	Activity, Ci
222-S Bldg. (Hot cell)	4	30-gal	30	20.0 F.P.[a]
	9	Cardboard boxes	40	0.6 F.P.
221-T	14	Cardboard boxes	60	0.1 F.P.
Laundry	9	Cardboard boxes	40	
Misc.	5	Cardboard boxes	20	
BNW	70	Cardboard boxes	300	<5 F.P.
HEDL	45	Cardboard boxes	200	

(a) Fission Products

TABLE III.2-18

CHARACTERISTICS OF THE MAXIMUM VOLUME OF DRY WASTE BURIED ON ANY DAY

Source	No.	Container	Volume (ft^3)	Activity, Ci
222-S Bldg. (Hot cell)	5	30-gal	38	70 F.P.[a]
	22	Cardboard boxes	100	3 F.P.
221-T	22	Cardboard boxes	100	2 F.P.
Laundry	22	Cardboard boxes	100	
Misc. (Tank Farms, etc.)	22	Cardboard boxes	100	
BNW	150	Cardboard boxes	~700	<10 F.P.
HEDL	75	Cardboard boxes	~350	

(a) Fission Products

combustible and radioactive material available for involvement in a fire. A recurrence interval of once in 300 years is estimated for this postulated event.

III.2.8.2.1 Calculated Source Term for Fire in Solid Waste Burial Trench

It is assumed that the fire in the burial ground burns for 4 hours and that:

- a total of 10 Ci of activity is accessible to the fire in the trench in cardboard boxes
- the waste in the 30-gal steel drums is unaffected by the fire
- waste is left uncovered due to trouble with the bulldozers.

The source term for this postulated accident is given in Table III.2-19.

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TABLE III.2-19

SOURCE TERM FOR POSTULATED SOLID WASTE FIRE IN BURIAL GROUND

Radionuclide	Total Inventory (Ci)	Fraction Released (%)	Amount Released (Ci)	Release Rate (Ci/sec)
F.P.[a]	10.0	50	5.0	3.5×10^{-4}
^{239}Pu	6.8×10^{-3}	50	3.4×10^{-3}	2.4×10^{-7}

(a) Assumed to be ^{90}Sr

III.2.8.2.2 Postulated Radiological Impact on Man

The calculated radiation dose to the maximum individual and to the population within 50 miles of the postulated accident is given in Table III.2-20.

TABLE III.2-20

RADIATION DOSE FROM POSTULATED FIRE IN SOLID WASTE BURIAL TRENCH

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	1.1×10^{-11}	9.4×10^{-9}	1.1×10^{-11}	9.4×10^{-9}
Inhalation				
Whole Body	1.3×10^{-3}	4.3×10^{-1}	2.8×10^{-2}	9.2
Lung	2.1×10^{-2}	6.9	5.0×10^{-2}	1.7×10^{1}
Bone	6.3×10^{-3}	2.1	1.7×10^{-1}	5.7×10^{1}

III.2.9 Range Fire on Contaminated Land

As a result of Hanford Waste Management Operations, some isolated land areas have been contaminated with varying amounts of radioactivity. A range fire on this land can serve as a release and transport mechanism for some of the surface contamination. The contamination associated with the plant foliage can be volatilized, while the contamination held by the top soil can be re-entrained by the wind erosion following a fire. Thus, a fire on contaminated land can be a potential release mechanism for presently stable surface or near surface contamination.

Most of the contaminated land on the Hanford site is within controlled zones and was stabilized by covering the zone by clean overburden and/or by selective herbicide treatment. Since these areas are within operational areas, any fires would be quickly detected, controlled and the area restabilized. However, the B-C controlled area, including the B-C Crib near 200-E area, is a region of land contamination which is not inside an operational area. The B-C Crib Controlled Area is approximately 2,100 acres of typical desert terrain situated due south of the 200 East Area. A fire in this region could release some of the contained radioactivity.

At present, the radionuclides in the area are associated with various contaminated materials on the surface and in the sandy soil to the depth of 8 inches or more. Transfer of the radionuclides is believed to be from urine, decay of rabbit fecal pellets, and possibly leaching of soluble materials from fecal pellets.

The probability of a range fire burning the B-C Crib Controlled Area was estimated based on a 10 year summary of such a fire at Hanford. (This summary is included as Appendix III-F.) An average of 12 fires per year have occurred, ranging from less than 1 acre to less than 32,000 acres. The median fire burns about 6 acres and occurs at the end of June. In the last 10 years

a total of three fires have burned an area at least as great as the B-C Crib Controlled Area. Based on these statistics, a probability of 2×10^{-3} per year was estimated for a fire burning the entire B-C Crib Controlled Area at about a 500 year recurrence rate.

III.2.9.1 Calculated Source Term for Range Fire on Contaminated Land

The radionuclide inventory in and above the top cm of soil in the B-C Crib Controlled Area was estimated to total 32 Ci of ^{90}Sr and 8 Ci of ^{137}Cs held in the vegetation, organic debris, animal droppage, sagebrush, and soil. For ^{137}Cs the distribution is as shown in Table III.2-21.

TABLE III.2-21

POSTULATED DISTRIBUTION OF ^{137}Cs IN AVERAGE SQUARE METER PLOT
(depth of 1 cm)

	Vegetation	Organic Debris	Animal Droppings	Sagebrush	Soil
Mass (Grams)	166.7	522.2	45.1	733.7	20862.4
Percent of Mass	0.74	2.33	0.20	3.28	93.44
Activity (μCi)	9.10×10^{-3}	1.90×10^{-1}	1.11	4.59×10^{-2}	1.19×10^{1}
Percent of Activity	0.1	1.4	8.3	0.4	89.8
Specific Activity (μCi/g)	5.46×10^{-5}	3.64×10^{-4}	2.46×10^{-2}	6.26×10^{-5}	5.70×10^{-4}

The fire was assumed to have burned the entire area and released 10% of the radioactive material. (The source term for this postulated event is shown in Table III.2-22.) The Hanford site experienced within recent years several large range fires in which the burning rate ranged from 200 to 350 acres per hour. Based on this rate, the release was assumed to occur over a 6-hr period. This 10% release has been demonstrated as conservative by an experiment conducted where flammable materials collected from the B-C Crib Controlled Area were burned. In this experiment, only 0.04% of the ^{137}Cs was made airborne at a windspeed of 2.5 mph at 1 foot above the surface.[12,13]

TABLE III.2-22

SOURCE TERM FOR POSTULATED RANGE FIRE ON B-C CRIB CONTROLLED AREA

Radionuclides	Quantity Released to Air, Ci	Release Rate Ci/sec (6-hr duration)
^{137}Cs	0.8	3.7×10^{-5}
^{90}Sr	3.2	1.5×10^{-4}

Following such a fire, the area would probably take some time to stabilize. The flammables would be burned to some extent. Thus, some release of the remaining activity in the flammable material would follow the fire. About 50% of this remaining activity would be released over a 24 hour period. The source term for this postulated event is shown in Table III.2-23.

TABLE III.2-23

SOURCE TERM FOR POSTULATED WIND DISPERSAL OF REMAINING ACTIVITY
FOLLOWING A FIRE IN THE B-C CRIB CONTROLLED AREA

Radionuclides	Quantity Released to Air, Ci	Release Rate Ci/sec (24-hr duration)
^{137}Cs	3.2	3.7×10^{-5}
^{90}Sr	12	1.4×10^{-4}

9 1 1 1 9 6 0 7 0 9

III.2.9.2 Calculated Radiological Impact on Man

The calculated radiation dose to individuals and to the population within 50 miles of the postulated accident is given in Table III.2-24 for the direct effect of a range fire and in Table III.2-25 for the effects of wind dispersal of radioactive materials following a range fire.

TABLE III.2-24

RADIATION DOSE DUE TO POSTULATED FIRE ON CONTROLLED AREA

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	2.7×10^{-7}	1.0×10^{-4}	2.7×10^{-7}	1.0×10^{-4}
Inhalation				
Whole Body	1.0×10^{-3}	2.8×10^{-1}	2.0×10^{-2}	5.5
Lung	1.7×10^{-2}	4.7	4.2×10^{-2}	1.1×10^{1}
Bone	3.8×10^{-3}	1.0	8.3×10^{-2}	2.3×10^{1}

TABLE III.2-25

RADIATION DOSE DUE TO POSTULATED WIND DISPERSAL AFTER FIRE ON CONTROLLED AREA

	First Year Dose		50 Year Dose Commitment	
	Maximum Individual, rem	Population, man-rem	Maximum Individual, rem	Population, man-rem
External				
Whole Body	4.4×10^{-7}	4.2×10^{-4}	4.4×10^{-7}	4.2×10^{-4}
Inhalation				
Whole Body	2.9×10^{-3}	1.1	5.8×10^{-2}	2.1×10^{1}
Lung	5.0×10^{-2}	1.8×10^{1}	1.2×10^{-1}	4.3×10^{1}
Bone	1.1×10^{-2}	3.9	2.4×10^{-1}	8.5×10^{1}

III.2.10 Criticality at Ground Disposal Sites [X.10, X.25]

Several ground disposal sites in the 200 Area which, in the past, were used for the disposal of low and intermediate-level waste have accumulated kilogram quantities of plutonium (Table III.2-26). With the exception of U Pond, these sites are referred to as covered trenches. The designs vary considerably. The Z-9 Crib is a large enclosed area, 20 feet deep with a 60 by 120-ft concrete roof and a dirt floor of 60 by 30 feet. Some others consist of underground caverns with wooden cribbing to prevent cave-in and are covered with earth, whereas some are like underground tile fields. These cribs are no longer used for disposal of plutonium.

The water in the low-level waste streams drains into the ground, and the plutonium remains within the top soil layers. This occurs either because the plutonium is in the form of solids and is filtered out or because it is in a soluble form and is adsorbed by the soil. In either case, the plutonium concentrates in the top few feet of soil. Once the site is deactivated, it will begin to dry out as it reverts back toward its original state. The presence of water has three effects: 1) water acts as a neutron absorber, which reduces reactivity, 2) water moderates (slows down) the neutrons, which increases reactivity, and 3) water located around or adjacent to plutonium reflects neutrons back into the system, which increases reactivity.

TABLE III.2-26

ESTIMATED INVENTORIES OF PLUTONIUM IN DISPOSAL SITES[14]

Disposal Site	Plutonium (kg)	Disposal Site	Plutonium (kg)
216-U-10 U Pond and Ditches	8.3	216-Z-3	5.7
		216-Z-4	0.002
216-B-7 224-B, 221-B 5-6 Cell and Construction Waste	4.3	216-Z-5	0.34
		216-Z-6	0.005
216-S-1 and 2 Redox Process Condensate	1.2	216-Z-7	2.0
216-T-32 224-T Waste	3.2	216-Z-8	0.05
		216-Z-9[a]	38.[b]
216-Z-1AA	30.	216-Z-10	0.05
216-Z-1AB	17.	216-Z-12	25.
216-Z-1AC	11.	216-Z-16	0.07
216-Z-1 and 2	7.0	216-Z-17	0.05
		216-Z-18	22.

(a) "Z-9" Crib.
(b) Reference 15 estimates the system to contain between 25 and 70 kilograms of plutonium.

NOTE: The accuracy of these estimates is ±30%. The numerical values were re-examined throughout the text and corrected where indicated.

As the site dries out, neutron absorption and reflection decrease and the average energy of the neutrons increase. The net effect in the Z-9 crib was a possible slight increase in reactivity, but far from the amount of increase necessary for criticality to occur. A most probable neutron multiplication factor (k_{eff}) for the Z-9 crib was identified as 0.5, well below that required for criticality.[16] It is believed that other trenches, as they dry out, will have a lesser reactivity increase than Z-9 or even a decrease in reactivity.

The addition of water to a crib or trench at the optimum water concentration would then make the system more reactive by the addition of a reflector. Too much water would once again poison the system. For the system to reach criticality, sufficient plutonium must be available and the soil and water must be physically rearranged.

For the above postulated event to occur, there must not only be a total lack of monitoring, but there must also be a total lack of administrative control, to the extent that man must actually take positive action to make the crib or trench critical, i.e., rearrangement of the plutonium and soil in the trench which became flooded. For this reason, criticality in these trenches is not considered credible under the present mode of operation and no accident analysis was performed. Also, it is currently planned to mine the 216-Z-9 crib for recovery of the plutonium, thereby greatly reducing the contamination of the facility. Information obtained from this mining operation will provide input for any decision concerning the other trenches.

III.2.11 Effects of Natural Forces [RPB]

Consideration of the environmental impact of potential accidents must also include possible initiation by natural forces such as flooding, seismic activity, tornadoes, etc. The following is a discussion of Hanford waste management facilities with regard to the potential effect of natural forces.

9 1 1 1 8 9 1 0 7 1 1

III.2.11.1 Effect of Natural Forces on Radioactivity Stored in the Ground

No credible natural forces event other than major flooding by the Columbia River (described later) can be postulated that will release a significant amount of radioactivity from the groundwater or ground storage sites.[17] Natural forces evaluated include those resulting from seismic activity, heavy rains, heavy snow melt, flooding, tornadoes, and high winds. Increased rate of movement in ground or in groundwater can only arise from the addition of inordinate amounts of water which is far in excess of what can be credibly considered to arise from rains, snow melt and flooding.[18]

The selection of ground storage sites was based on extensive geological data and considerable soil measurements of cation exchange capacity. Essentially all sites are below the ground surface in which at least 4 feet of ground cover have been applied. These sites are not subject to disturbance by winds and tornadoes for the foreseeable future.

III.2.11.2 Capability of Facilities to Resist Natural Forces

Natural force resistance has been included in the designs of Hanford's waste management facilities over the past 30 years using state-of-the-art knowledge and applicable criteria at the time of the design. Natural force resistance criteria (seismic and wind) for various waste management facilities are summarized in Table III.2-27 and beneficial use dates are listed.

III.2.11.2.1 Designs for Seismic Activity [RPB]

Different structural design practices have been used on Hanford waste management facilities in the time periods 1943 to 1949, 1949 to 1968, and 1968 to the present.

1943-1949: In the period 1943 to 1949, preceding the inclusion of seismic provisions in the Uniform Building Code, Hanford's above ground waste management structures were designed for static, vertical live and dead loads. Design calculations were performed manually and approximation techniques were used for indeterminate structures. Lateral wind forces, based on projected area, were included in the designs. During this period, Hanford was designated as a low intensity, minimum occurrence earthquake zone. Thus, only small lateral earthquake design forces related to the mass of the structures were considered.

In this same period, below ground waste tank structures were designed for: 1) static loads from soil backfill, 2) live loads on the ground above, and 3) internal hydrostatic pressures. Empirical design data for concrete cylinders and dome shell structures were used. Design and operating considerations were included for the elevated temperatures to be encountered. Wind forces were not considered for the buried structures. Buried structures have considerable inherent earthquake resistance because they are stiff and strong as required to support the backfill, and a properly placed backfill will restrict relative motions between the structure and ground during an earthquake.

1949-1968: In the period 1949 to 1968, Hanford's above ground waste management structures were designed for static, vertical live and dead loads in accordance with the Uniform Building Code which included seismic provisions. Design calculations were performed manually. State-of-the-art improvements in designs, construction practices and construction materials were incorporated. Lateral wind forces related to areas and lateral earthquake forces related to the mass of structures were specified according to the Uniform Building Code seismic provisions which designated Hanford as Zone 2. Designs of below ground structures were similar to designs of the time period 1943-1949 but included provisions for some increases in waste tank temperatures.

1968 to date: Since 1968, Hanford's above ground waste management structures, facilities, and equipment have been designed for the most severe possible combination of dead, live, and operating loads plus seismic forces from a maximum credible earthquake. Rigorous state-of-the-art analyses, including dynamic elastic analyses for 0.25 g* ground motions are performed using digital computers. The structures must have the capacity to resist the above conditions and maintain radiological safety during and after experiencing the 0.25 g ground accelerations.[26]

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* A unit of acceleration equal to 9.807 m/sec.^{2}

TABLE III.2-27

NATURAL FORCE DESIGN PARAMETERS FOR WASTE MANAGEMENT FACILITIES

Waste Management Facility (year)	Dynamic Seismic Design Earthquake Magnitude 6.8 0.25 g	Static Structural Design Uniform Building Code(a)	Winds	
			Circular (Tornado)	Straight
Double-Wall Underground Waste Tanks (1971-1974) (Boiling Waste)	X		(c)	X
Single-Wall Underground Waste Tanks (1944-1974)	(c)	X(b)		X
Fractionization (B) Plant (1944)	(c)	X		X
Waste Encapsulation Plant (1974)	X		(c)	X
242-S Evaporator (1973)	X		(c)	X
242-A Evaporator (1976)	X		(c)	X
AR Vault (1968)		X		X
CR Vault (1952)		X		X
242-T Evaporator (1951)		X		X
ITS-1 Evaporator (1965)		X		X
ITS-2 Evaporator (1967)		X		X
Sluicing Facilities (1968)		X		X
Decontamination (T) Plant (1944)	(c)	X		X
222-S Laboratory (1952)		X		X
Boiling Tank Vent System (1971)	X			X

(a) Early site structures were designed for static, vertical live and dead loads and have limited seismic resistance, since the Hanford site was classified as a low intensity, low frequency earthquake zone. Later a classification was made as Zone 2 on the Uniform Building Code Seismic Risk Map and currently as an area of moderate to low seismicity. Some seismic resistance is inherent in structures because of design for winds (lateral forces), nonstructural elements (reserve strengths), stability requirements, limits on deflections, plus safety factors included in design and working stress values for materials.
(b) Buried structures have considerable inherent earthquake resistance because they are stiff and strong as required to support the backfill, and the backfill will restrict relative motions between the structures and ground during an earthquake.
(c) Discussed in text.

The maximum credible earthquake for the Hanford site is postulated to be a Richter Magnitude 6.8 earthquake (with an epicentral distance approximately 10 miles from the Hanford waste management facilities) which produces a maximum horizontal ground acceleration at the waste management facilities of 0.25 g and a simultaneous vertical ground acceleration two-thirds of the horizontal acceleration.[19] The 0.25 g earthquake has an occurrence associated with an unlimited time span per occurrence whereas the probability of 0.20 g would be once in 16,700 years, 0.15 g once every 4,000 years, 0.10 g once every 1,850 years, and 0.05 g once every 840 years.[20] Since 1968, structural designs for below ground concrete waste tanks have included elastic and nonlinear time dependent analyses, which account for creep and cracking in the structure, for dead, live, thermal, pressure, and hydrostatic loads. Rigorous dynamic, finite element analyses of the tank structure for the 0.25 g ground motions are performed. The overall adequacy of the tanks are assessed under the combined service loads and the 0.25 g ground motions.[21]

III.2.11.2.1.1 Previous Seismic Activity

The largest local earthquake of historical record occurred at Corfu, a few miles north of the site, in 1918. Various damage estimates have been reported resulting in a classification of Modified Mercalli IV or V. Estimates of the peak ground acceleration made for this Corfu event range from 0.01 to 0.03 g.

III.2.11.2.1.2 New Facilities

Table III.2-27 shows that the newer facilities, the Double-Wall Underground Waste Tanks (1971-1974), the Waste Encapsulation Plant (1974), the 242-S Evaporator (1973), the 242-A Evaporator (1976), and the Boiling Tank Vent System (1971) include 0.25 g seismic forces in their designs.

III.2.11.2.1.3 Single-Wall Underground Waste Tanks

In 1969 to 1971, Illinois Institute of Technology performed a "Strength and Stress Analysis for Waste Tank Structures at Hanford, Washington." Results of analyses of the A Farm single-wall underground waste tanks for 0.25 g seismic forces "indicate no additional risk of containment loss beyond the risk associated with static loading."[22]

III.2.11.2.1.4 Fractionization B Plant

A preliminary assessment has been made of the capability of the Fractionization B Plant Canyon Building to withstand strong earthquake ground motions with a 0.25 g peak horizontal acceleration (Richter Magnitude 6.8, epicentral distance approximately 10 miles). Results of a first phase elastic analysis indicate that the canyon walls would be substantially overstressed near the roof (above the crane rails) and at the canyon wall-gallery slab intersections. The overstressing would be due to high bending moments. Primary load bearing, reinforced concrete walls in the B Plant canyon would be damaged in the event of 0.25 g ground motions. Technical judgment is that these walls will be able to experience this overstressing, to have the capacity to satisfy the 0.25 g earthquake ductility demands and lateral loads, and to avoid collapse, such that process cell integrity can be maintained. A second phase inelastic analysis will be performed to finally establish if this is the case.

Seismic analyses and evaluations of the B Plant cooling water piping (outside the building, in the pipe gallery, through the cells) plus the emergency power and pumping systems have not been made. Problem areas requiring at least the need for minor modifications would be revealed by such analyses.

The three HEPA filter cells for the B Plant exhaust ventilation air do not have potential seismic problems like those found during the review of the sandfilter; these filter cells are the units normally in use. A review of design drawing for the B Plant exhaust ventilation air sandfilter (backup) revealed potential structural deficiencies such that additional seismic resistance studies will be performed.

Detailed seismic analyses of the B Plant reinforced concrete ventilation exhaust stack have not been made, but little or no damage was noted in stacks of this type after the 1971 San Fernando earthquake.

The B Plant has not been affected by the low seismic forces experienced during its 30-yr active life. No structural damage nor radiological impact is expected from the low seismic forces expected in its projected remaining operating life (approximately 10 years).

III.2.11.2.1.5 Other Structures

Seismic effects on the Decontamination T Plant (1944) would be similar to those for the Fractionization B Plant (1944) since these structures are virtually identical.

Other waste management structures such as the AR Vault (1968), the CR Vault (1952), the 242-T Evaporator (1951), the ITS-1 Evaporator (1965), the ITS-2 Evaporator (1967), Sluicing Facilities (1968), and the 222-S Laboratory (1952) have not been analyzed for the effects of 0.25 g seismic forces.

III.2.11.2.2 Designs for Winds

Hanford's waste management facilities have been designed to withstand straight winds according to the Uniform Building Code. At Hanford, a peak gust wind (straight) of 80 miles per hour was measured on January 11, 1972 at the 50-ft level of the HMS Tower. Hanford's waste management facilities have not been designed to withstand tornado (circular) winds. Tornadoes are rare in

the Hanford region and tend to be small; their occurrence is associated with little damage. On June 16, 1948, a tornado was observed near the east end of Rattlesnake Mountain approximately 10 miles south of Hanford's waste management facilities, and no damage resulted.

Current policy and practice impose a criterion[23] that those facilities which contain fissile radioactive materials such as reactors and structures for the storage[23] of plutonium shall be able to withstand:

Wind force - horizontal wind of 175 mph, over the full height of the structures

Pressure transient - 0.75 psi atmospheric pressure drop in 3 seconds, and return at the same rate

Missiles -

- 2" x 12" plank, 12-ft long, traveling end-on at 100 mph, at any height
- 4' x 8' plywood sheet, 3/4" thick, traveling end-on at 150 mph, at any height
- 26" x 20' sheet of No. 20 corrugated steel siding traveling end-on at 150 mph, at any height

All facilities covered by the Hanford Plant Standard SDC-4.1 category have been modified to withstand the specified loading. Most of the waste management facilities are massive concrete structures inherently resistant to tornado forces. Utility lines to these facilities and ventilation exhaust systems from these facilities do not possess this inherent tornado resistance.

The exhaust ventilation filters for the Waste Encapsulation Plant (1974) have been located below grade which would provide protection from tornado forces. The heavily shielded interior cells of the Waste Encapsulation Plant (1974) would receive little damage from a tornado.

The reinforced concrete walls of the 242-S Evaporator (1973) and the projected 242-A Evaporator (1976) are thick, providing resistance to tornado forces. Ventilation exhaust capability from these facilities could be damaged by a tornado. Both facilities possess an inventory dumping capability to return the radionuclide inventory to underground storage tanks in a few minutes. The relatively low (3 Ci/gal) radionuclide concentration of the liquid in the evaporator system would not create a severe radiological impact during and following a tornado.

The most vulnerable Waste Management Operations facility to tornado forces is a boiling waste tank farm system, because the above ground facilities are not protected or shielded and the radionuclide concentration is sufficiently high to continue boiling for long periods of time. An evaluation of the effects of a tornado on a boiling waste tank farm system is included below.

Hanford's boiling waste tank farm systems above ground support facilities were not designed to withstand tornado winds. They would withstand straight winds according to the Uniform Building Code. The probability of a tornado hitting a boiling waste tank farm system at Hanford is approximately six in a million per year. For a large tornado, the probability would be much less because of the specific meteorological conditions present in the Pacific Northwest east of the Cascade Mountains. Significant damage to the above ground facilities and utilities could be experienced.

These "surface" utilities and facilities consist of steam, normal electrical power, emergency electrical power, instruments and controls, cooling water, "make-up water" systems (to replace that boiled off), condensers, instrument air, circulator process air, de-entrainer vessels, liquid seals in vapor system, buildings housing instruments and equipment, and ventilation heaters, filters, exhausters, and stack. Depending on the specifics of the tornado and the area hit, part or most of these utilities and facilities could be damaged.

If the air lift circulators are not reactivated within 12 to 24 hours, temperature gradients could develop in the sludge and cause "bumps" (or "burps"), as experienced in the past. These bumps are the result of steam bubbles which build up at localized points within the liquid. The calculated vacuum transient within a boiling waste tank is expected to be less than 1 psi dampened by increased boil-off from the liquid surface. From past experience the tank contents are not expected to burp or bump.

A preliminary assessment of the impact of the tornado concludes that no structural damage would be experienced by the underground tanks and their envelope structures. Credible tornado damage has not been postulated which would seal the tank farm vapor system. Calculated effects were negligible for pressure transients for the boiling waste vapor system if the tank farm were hit

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by a tornado. Two factors dampen the pressure transient: 1) resistance to flow in the vapor system and 2) vapor boil-off from the thermally hot liquor as the pressure is reduced.

Should a Hanford boiling waste tank farm be hit by a tornado and the "surface" utilities and facilities be damaged, the activity release from the vapor system during the tornado has been estimated in the range of a fraction of a curie to a few curies. No significant adverse effects should be experienced offsite by such a release, and activity at the Hanford site boundary should be less than the maximum permissible air concentration for uncontrolled areas set by ERDAM-0524. Following destruction of the surface utilities and facilities, radioactive material could be released in the unfiltered noncondensed vapor at a rate estimated at less than 10 Ci/hr; this release rate should not create an offsite problem but could create a local site problem which would require recovery operations. Re-establishment of control could be effected within 48 hours.

III.2.11.3 Columbia River Flood [RPB, X.8]

Disposal of radioactive and chemical waste at sites adjacent to the processing area was previously a common waste management operations practice at Hanford. Solid waste burial grounds, cribs for low-level liquid waste, and waste retention basins are located in the 100 Areas and the 300 Area. The only sites remaining active in these areas are for 100-N Area. Because of their proximity to the Columbia River, the impact of involvement and release of some of the contents of these waste disposal sites during flooding is evaluated.

Material which may be vulnerable for dispersal during a flood include: 1) the buried sludge in the retention and storage basins in some of the 100 Areas, 2) the content of the 1301-N Crib, and 3) the 100 and 300 Area burial grounds. The radioactive materials in the deactivated reactor buildings are assumed not to be affected significantly by a flooding condition and are ignored in this analysis.

Radioactivity in the 100 Area burial grounds is found in a diversity of carriers including paper, rags, wood, structural concrete and steel, and a variety of metal objects of aluminum, steel and Zircaloy. At the time of burial, more than 99% of the radioactivity was contained in a solid metal matrix. The remainder was surface contamination accumulated over a period of time from the coolant stream. This "crud" contains both activation and fission products.

The radioactivity contained in the metal is primarily in the form of activation products, with the major contributor being ^{60}Co. The source of this activity is irradiated aluminum process tubes and dummy fuel elements. Other metallically-contained activity includes:

- ^{95}Zr-^{95}Nb in Zircaloy process tubes
- ^{65}Zn in aluminum tubes
- ^{59}Fe and ^{60}Co in steel reactor components.

The primary radioactivity found in the sludge and soil surrounding the 100 Area retention basins is ^{152}Eu and ^{239}Pu. Most predominant in the irradiated fuel basin sludge are ^{90}Sr and ^{137}Cs.

The 300 Area burial grounds and retention basins are estimated to contain significant amounts of uranium and copper from past and present operations. The amount of uranium has been estimated to be about 30 metric ton (MT) ($\sim$10 Ci). The inventory of copper in the retention basin has been estimated to be 200 MT (the range on this number is from 150 to 220 MT). An estimated 300 Ci of ^{147}Pm and 10 Ci each of ^{90}Sr and ^{137}Cs are buried near the 307 Building as a result of a spill in 1970.

III.2.11.3.1 Postulated Probable Maximum Flood

The flooding condition used in the following analysis is the dam regulated "Probable Maximum Flood" (PMF) previously predicted[24] by the U.S. Army Corps of Engineers. This prediction was derived using extensive data and computer modeling techniques and incorporating assumptions of a combination of conditions which were the most severe considered "reasonably possible" for the Columbia River Basin.[a] Contributing factors of winter snow accumulation, spring melting and runoff-season rainstorms were maximized.

(a) The Basin's 260,000 square miles include major parts of the States of Washington, Idaho and Oregon, small segments of Montana, Wyoming, Utah and Nevada, and most of the Southeastern portion of the Canadian Province of British Columbia.

The basic cause of the PMF would be spring snowmelt runoff following exceptionally cold and wet weather during the October to April snow accumulation season. It was assumed that, over the Columbia River Basin as a whole, the October to April precipitation equaled 1.3 times the normal annual precipitation. Unusually rapid melting due to meteorological conditions was predicted as a result of the assumption of extreme seasonal values for air temperatures, dew point, solar radiation albedo, and wind speed.

In addition, two hydrologically significant (the most severe considered "reasonably possible") basin-wide rainstorms were assumed. It was assumed that rain contributions to the PMF fell entirely during two 5-day periods during the snowmelt season. The first was arbitrarily chosen in mid-May, the second was timed to maximize the natural peak discharge of the lower Columbia River.

In Table III.2-28, the discharge rate of the dam regulated PMF flood was compared[24] along with others to the calculated natural discharge rate of the PMF at The Dalles, Oregon. The comparison was made at The Dalles because it is a key gauging station with daily records back to 1878 and maximum discharge records back to 1858. Also shown in Table III.2-28 for comparison is a flood calculated to be the most severe, using assumptions "reasonably characteristic" of the Columbia Basin. This flood is called the "Standard Project Flood" (SPF).[(a)] For the dam regulated PMF, the discharge rate remains greater than 80% of the peak rate for almost a month. Consequently, inundated regions would be subjected to erosion for an extended period.

Flow rates along the Hanford Reservation are considerably less than that indicated in Table III.2-28 because the Snake and other smaller rivers empty into the Columbia River downstream from Hanford. Upstream from Richland, the Corps of Engineers applied a regional adjustment to the peak discharges predicted in Reference 24. This increases the peak discharge predicted for the regulated PMF from 1.36 million cfs to 1.44 million cfs. Therefore, this latter value represents the flow rate at the Hanford site that is reasonably possible as a result of natural phenomena during the present era of river management.

TABLE III.2-28

PREDICTED AND MEASURED PEAK DISCHARGES OF THE COLUMBIA RIVER AT THE DALLES, OREGON

Flood	Peak Discharge 1,000 cfs	Ratio of Each Peak to Natural PMF
Natural Probable Maximum Flood (PMF)	2,660	1.0
Regulated PMF	2,060 (a)	0.77
Natural Standard Project Flood (SPF)	1,550	0.58
Regulated SPF	840	0.32
Greatest Peak of Record (1894)	1,240	0.47
2nd Greatest Peak of Record (1948)	1,010	0.38
3rd Greatest Peak of Record (1876)	958	0.36
100 yr. Frequency Natural Peak	1,200	0.45
100 yr. Freq. Reg. Peak as of 1975	690	0.26
Mean of Obs. Annual Peaks	583	0.22
Greatest Median Daily Discharge	495	0.19

(a) The Columbia River flow rate in the Hanford area used in this analysis for this flood condition is 1.44×10^6 cfs.

Portions of the Hanford site that would be inundated during the PMF are shown on the map of Figure III.2-5. The reactor areas inundated are 100-N, -D, -H, and -F. Virtually all of the populated area of Richland is inundated while most of the 300 Area becomes an island.

With the 100-yr flood as the basis, an estimate was made of the probability of the PMF occurring. The discharge rates for the PMF are more than double the corresponding peak discharges for the 100-yr frequency flood. Since the 100-yr discharge rate is similar to the SPF (Table III.2-28), the difference in the frequency can be credited with the October to April precipitation accumulation. (The SPF October to April precipitation is assumed equal to the normal annual precipitation. For the PMF, the October to April precipitation is assumed to be 1.3 times the normal annual precipitation.)

(a) The "Standard Project Flood" is related to a general Columbia River condition and not meant to be inferred as the condition of the Columbia River at the Hanford Reservation.

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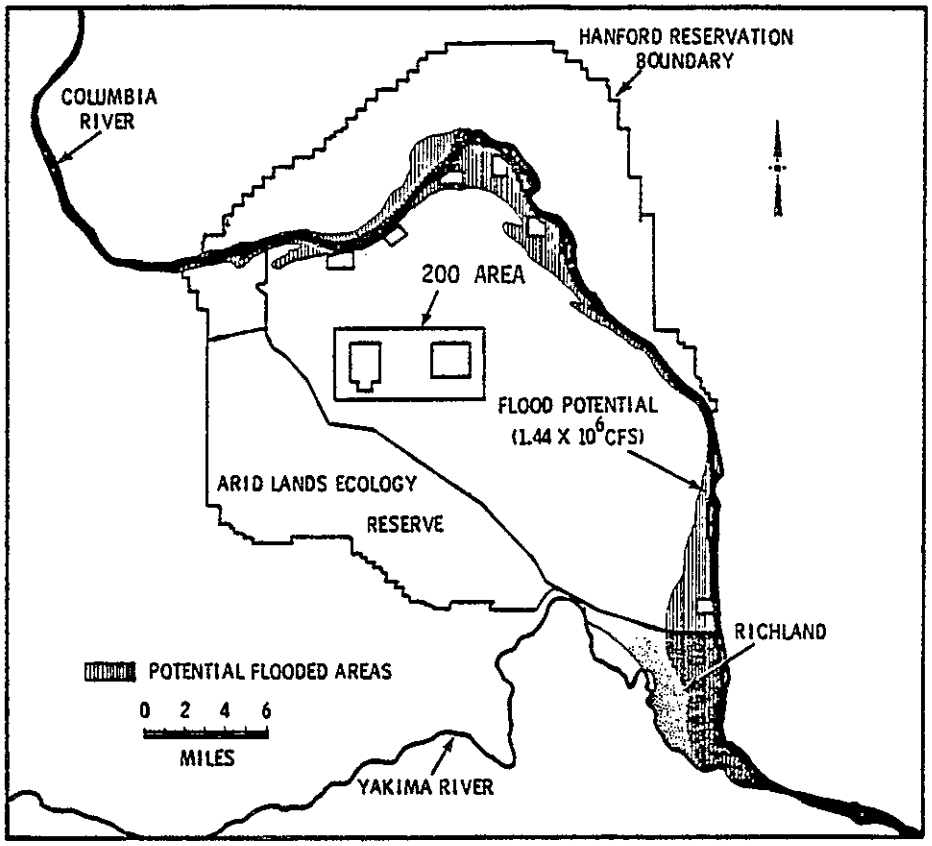

FIGURE III.2-5 MAP OF FLOOD POTENTIAL

In addition to unusually great winter snow accumulation, both the SPF and the PMF require unusually hot sunny spring weather and two unusually heavy, basin-wide spring storms (with the PMF assumptions more extreme than the SPF ones). Clearly, the compounding of probabilities for these additional assumptions requires for the PMF an average recurrence frequency of many thousand years. Since climatic changes invalidate extrapolations for thousands of years based upon data accumulated in the last century, a more precise estimate of this quantity is not feasible.

III.2.11.3.2 Calculated Source Term for Probable Maximum Flood

In the postulated flood, erosion of protective cover over buried radioactivity was assumed and thus, some fraction of the radionuclides could be picked up by the river. The movement of activated metallic pieces, such as dummy fuel elements, down the river is considered a possibility under this degree of flooding. Entrainment might be possible of major portions of the sludge and uranium and copper contaminated soil but not for metal objects in which ^{60}Co was produced by activation. Nevertheless, buried metal objects do corrode and at widely varying rates. But before much of a metal object was corroded away, radioactive decay would reduce its ^{60}Co activity to insignificant levels. Since corrosion rates in the soil cannot be well defined due to the variation of storage environments, all uncontained radionuclides with half lives exceeding 1 year (including the ^{60}Co in the metal) and all other chemicals, in all inundated areas shown in Figure III.2-5, are assumed entrained during a 24-hr period at the peak of the PMF of the Columbia River. These materials are assumed to be soluble and uniformly mixed into the quantity of water equal to 24 hours flow at 1.44×10^6 cfs (3.53×10^{12} liters).

Table III.2-29 presents the quantities of copper and radionuclides assumed released (the contents of the 1301-N Crib and of the 100-D, -H, and -F burial ground, the radioactivity in the retention and storage basin sludges and surrounding soils in these 100 Areas, and radioactivity buried in the 300 Area). Also tabulated are the resulting concentrations of individual radionuclides or mixtures of individual radionuclides in the flood waters.

TABLE III.2-29

STORED RADIONUCLIDE QUANTITIES ($T_{1/2}$ > 1 YR) AND TOXIC CHEMICALS INUNDATED BY THE PEAK FLOW OF THE PROBABLE MAXIMUM FLOOD OF THE COLUMBIA RIVER AND THEIR CONCENTRATIONS IF MIXED WITH 1 DAY'S RIVER FLOW AT THE PMF PEAK

Radionuclides	Quantity Released (curies)	Estimated Concentration in River,[b] (μCi/mℓ)
^{60}Co	11,400	3.2×10^{-6}
^{90}Sr	60	1.7×10^{-8}
^{90}Sr, ^{137}Cs, ^{239}Pu[a]	40	1.1×10^{-8}
^{137}Cs, ^{134}Cs	450	1.3×10^{-7}
^{152}Eu, ^{239}Pu[a]	200	5.7×10^{-8}
^{106}Ru	80	2.3×10^{-8}
U	10	2.8×10^{-9}
^{147}Pm	300	8.5×10^{-8}
Toxic Chemicals	**grams**	**(ppb)**
Copper	2×10^{8}	52

(a) For purposes of dose evaluation, the activity will be assumed to be equally divided among the components of these mixtures.

(b) The material was assumed to be all released to the river in one day and diluted by the volume of the PMF (144×10^{6} cfs or 3.53×10^{12} liter/day).

III.2.11.3.3 Calculated Radiological Impact on Man

Possible consequences of the postulated flood were evaluated independent of the fact that in actual practice, the residents of Richland, Kennewick, Pasco and other towns along the Columbia would probably be evacuated. The radiation doses from ingestion of Columbia River water and fish and exposure to the contaminated shoreline were estimated, assuming that the listed mixtures of radionuclides (Table III.2-29) were made up of equal proportions of each component radionuclide. The calculated radiation doses for Whole Body, GI Tract and Bone in the first year following the consumption of 2 liters of water and 200 grams of fish harvested from the contaminated flood waters and assumed to be in equilibrium with the radioactivity in the river are listed in Table III.2-30.

TABLE III.2-30

RADIATION DOSE FROM POSTULATED COLUMBIA RIVER FLOOD

	Maximum Individual, rem	50 Year Dose Commitment
Whole Body	6.1×10^{-3}	1.2×10^{-2}
GI-Tract	3.5×10^{-3}	4.8×10^{-3}
Bone	5.0×10^{-3}	6.3×10^{-3}

The external exposure to the shoreline during the first year following the flood, assuming an avid fisherman would spend 500 hours on the contaminated shoreline, is included in the whole body dose given in the Table III.2-30.

The highest total calculated dose listed in Table III.2-30 is about 6×10^{-3} rem to the whole body in the first year. About 70% of this dose would come from ^{134}Cs and ^{137}Cs in the fish, presumably harvested from the contaminated flood water. Only about 1% of the dose is from drinking water. About 40% of the GI tract dose would result from consumption of fish, with most of this dose resulting from ^{60}Co. Most of the bone dose, from both the drinking water and fish consumption would be due to ^{90}Sr.

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IV UNAVOIDABLE ADVERSE EFFECTS

Unavoidable adverse effects from the Hanford Waste Management Operations program may arise from radioactive, chemical, or thermal components in waste effluents being released to the atmosphere, Columbia River, or the ground. The adverse effects may be both onsite, such as limiting use of actual waste disposal areas for other purposes, and offsite, such as the populations radiation dose incurred as a result of Hanford programs.

Reduction of adverse environmental impacts from Hanford Waste Management Operations are initiated by 1) cleanup of gaseous waste prior to release, 2) concentration and storage in tanks of high-level radioactive waste and 3) controlled burial of solid radioactive waste. Transuranic waste is segregated and buried to permit retrieval in 20 years without loss of packaged containment integrity. An environmental surveillance and evaluation program is maintained independent of waste handling operations to detect and permit corrective action if abnormal conditions are found. Several installations have been completed to avoid accidental releases of radioactive materials into ditches and ponds due to cooling coil failures by monitoring such streams and switching their flow to contained systems for reprocessing where adverse quantities of radioactive materials are found.

Facilities to solidify high-level radioactive waste (evaporators) are in operation and additional units are being built to speed the solidification effort. New double-wall waste tanks are being built and improved equipment and procedures are now in place to monitor for liquid waste tank leaks.

Onsite, about 3% of the 365,000-acre Hanford Reservation is used for structures and waste disposal sites. The areas directly associated with the major waste disposal sites are committed to long-term control (thousands of years). The small total area committed for such control and use does not constitute a significant adverse effect to the Hanford ecological community.

The waste management practices utilizing cribs and trenches probably prohibit major irrigation projects for much of the onsite land because of the changes in water table levels that would result. Similarly, the use of large reactor cooling channels or lakes would require study to determine their possible influence on the groundwater system. Also, the groundwater onsite contains some radionuclides, principally tritium, ^{106}Ru-^{106}Rh, ^{129}I, ^{99}Tc and nitrate ion.

The offsite effect for 1972 due to Hanford Waste Management Operations was the small individual and the small population doses that resulted from releases of radioactive materials to the atmosphere and the Columbia River. The average per capita dose rate in 1972 was 9.6×10^{-3} mrem/yr while the maximum individual whole body dose was 0.58 mrem/yr. Table IV-1 summarizes the maximum annual doses to an individual and relates the resulting dose to its exposure pathways. The whole body dose for the 249,000 people living within 50 miles of the Hanford Waste Management Operations facilities was 2.5 man-rem/yr for 1972. Table IV-2 summarizes the population annual dose and relates the dose to its exposure pathways. The whole body dose contributions of 2.5 man-rem/yr compares to a whole body dose due to natural background radiation for the same population of 27,400 man-rem/yr. The Hanford contribution is only 0.01% of the dose received from the natural background radiation. The Hanford-contributed doses result principally from gaseous releases of ^{41}Ar from N Reactor (1.3 man-rem/yr) with lesser contributions of tritium in drinking water (0.5 man-rem/yr) and from consumption of irrigated crops (0.2 man-rem/yr).

When N Reactor is shut down, the current release of ^{41}Ar and some tritium and ^{131}I, as well as other activation and fission products in the N Reactor effluents, will cease. At that time, the air submersion dose to the population will be reduced to about 1.3×10^{-3} man-rem/yr and the dose attributable to the liquid effluents will be reduced as the radioactive materials already in the river sediments decay. The radionuclides reaching the Columbia River from the groundwater system (mostly tritium and ^{106}Ru-^{106}Rh) will, at their maximum rate of discharge, contribute less than 0.1 man-rem/yr to the local population dose. The population whole body dose in the first year after N Reactor is shut down is not expected to exceed 0.5 man-rem/yr and will then continue to decrease as the river inventory decays.

For the population doses due to 1972 Hanford Waste Management Operations, the maximum potential health effects are summarized in Table IV-3. For this calculation, the lung and genetic organ doses were conservatively estimated to be the same as the whole body dose. Since the number of health effects are all far less than one, it may be concluded that there will be no health effects due to Hanford operations for 1972.

TABLE IV-1

ESTIMATED MAXIMUM DOSE TO AN INDIVIDUAL FROM THE EFFLUENTS RELEASED AT THE HANFORD RESERVATION IN 1972[a]
(mrem/yr)

Pathway	Annual Exposure	Skin	Whole Body	GI-LLI	Thyroid	Bone
Gaseous Effluents						
Air Submersion	8766 hr	0.088	0.011	(0.011)[d]	(0.011)	(0.011)
Tritium-Inhalation & Transpiration	8766 hr	2×10^{-4}	2×10^{-4}	2×10^{-4}	2×10^{-4}	----
Radioiodine-Inhalation	7300 m^3 air	--	--	--	0.0019	--
Milk	274 liters[b]	--	--	--	0.056	--
Vegetables	30 kg[c]	--	--	--	0.042	--
Total Air Pathways		0.088	0.011	0.011	0.11	0.011
Liquid Effluents[e]						
Drinking Water	730 liters	--	0.015	0.036	0.30	0.066
Fish Consumption	40 kg	--	0.30	1.02	0.31	1.63
Irrigated Foods	710 kg	--	0.16	0.25	0.33	0.33
Shoreline	500 hr	0.10	0.090	(0.090)	(0.090)	(0.090)
Swimming	100 hr	0.0032	0.0026	(0.0026)	(0.0026)	(0.0026)
Boating	100 hr	0.0016	0.0013	(0.0013)	(0.0013)	(0.0013)
Total Water Pathways		0.10	0.57	1.4	1.0	2.1
Total (Adult)		0.19	0.58	1.4	1.1[f]	2.1
Infant Thyroid Dose						
Airborne Tritium	8766 hr				0.0001	
Air Submersion	8766 hr				(0.011)	
Inhalation	2045 m^3				0.002	
Milk	274 liters[b]				0.46	
Drinking Water	292 liters				0.95	
Total (Infant)					1.4[f]	

(a) Using releases tabulated in Tables III.1-2, 3, 4, 8, 9 and 10.
(b) One liter/day for a 9-month grazing season
(c) 200 g/d for a 5-month produce season
(d) ( ) indicates internal dose from external exposure
(e) Essentially all from 100-N effluents
(f) Does not include contribution from ^{129}I in the environment from previous years' operations estimated to be ~0.4 millirem/yr to both the maximum individual adult and infant.[1]

TABLE IV-2

SUMMARY OF ESTIMATED POPULATION DOSES RECEIVED AS A RESULT OF THE OPERATION OF THE HANFORD RESERVATION IN 1972

Pathway	Whole Body Dose man-rem/yr	Thyroid Dose man-thyroid rem/yr
Gaseous Effluents		
Air Submersion	1.4	(1.4)[a]
Tritium (Inhalation and Transpiration)	0.02	0.02
Radioiodine (Inhalation, Milk, Vegetables)	--	0.5
Liquid Effluents		
Drinking Water	0.45	8.9
Fish Consumption	0.11	0.12
Aquatic Recreation	0.40	(0.40)
Irrigated Foods (Produce, Eggs, Milk)	0.16	0.33
Total	2.5	12[a,b]

(a) ( ) indicates internal dose from external exposure
(b) Not including the contribution from ^{129}I in the Hanford environs presumably as a result of previous years of operation. This contribution can be estimated to be an additional 4 man-thyroid rem.[1,2]

TABLE IV-3

MAXIMUM NUMBER OF HEALTH EFFECTS FOR
1972 ENVIRONMENTAL DOSE LEVELS

Organ	Population Dose	Maximum Number of Health Effects
Mortality		
Whole Body	2.5 man-rem	5.0×10^{-4} cancer deaths
Lung	2.5 man-rem	1.2×10^{-4} cancer deaths
Thyroid	12 man-rem	6.0×10^{-5} cancer deaths
Morbidity		
Whole Body	2.5 man-rem	1.0×10^{-3} cancer cases
Thyroid	12 man-rem	2.4×10^{-4} cancer cases
Genetic Damage	2.5 man-rem	7.5×10^{-4} genetic effects

About 550 cfs of Columbia River water is withdrawn at the Hanford Reservation, including 440 cfs for cooling purposes. From this withdrawal, 140 cfs and 300 cfs are heated to 16°C and 10°C, respectively, above ambient river temperatures and returned to the river. This cooling water is withdrawn at a rate of about 0.4% of the average river flow rate and about 1% of the low river flow rate. Upon return to the river, rapid mixing of this warm water with the main body of the river occurs. Minimum local effects due to the warm water return may take place. For 1972, the Richland daily average river temperature was 10.1°C, compared to an upstream (Priest Rapids) daily average of 10.9°C. Hence, on the average there was a slight cooling trend in the Hanford Reservation stretch of the Columbia River. Any possible adverse effects due to heat have not been detected but would be limited to local areas, probably not reaching more than a few hundred yards from the point of discharge.

Water withdrawal from the Columbia River for Hanford use is generally at intake velocities sufficiently low to avoid fish entrapment. Studies during the previous years of Hanford operation have demonstrated no significant effect on the river ecosystems due to entrainments, even when substantially larger quantities of water were removed for plant use. Also, no changes were obvious in the numbers of phytoplankters or their species composition over the past years. Such studies indicate that any adverse effects due to water pumping and removal of lower level aquatic life are insignificant to the overall food chain of the larger species and have not led to observable adverse effects.

Chemical releases to the atmosphere and the Columbia River produce only limited impacts on nearby biota. Chemical disposals to the ground do not give rise to adverse effects other than the very local effects where cribs and ponds located on the Columbia River bank discharge into the river in seepage areas. Chromium, nitrate ion, and total solids are added to the river in concentrations above ambient river concentrations. These small additions are quickly diluted and any adverse effects (none were observed) would be limited to the immediate area of the discharge. Approximately 2,300 tons of SO_2 and nearly 1,200 tons of NO_x were released from the power plant stacks in 1972, but the accepted standard limits of SO_2 and NO_x were not exceeded at offsite locations. No adverse environmental effects have been demonstrated over approximately 30 years of plant operation. No chemical disposal activities or waste emissions led to any known adverse effects on humans.

IV REFERENCES

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2. J. K. Soldat, et al., Radioecology of ^{129}I: An Interim Report, BNWL-1783, Battelle, Pacific Northwest Laboratories, Richland, WA, 1973.

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V ALTERNATIVES

V.1 INTRODUCTION [RPB, X.4, X.18, X.24, X.25]

This section discusses the range of reasonable alternatives to the current Waste Management Operations Program at Hanford, particularly those that might enhance environmental quality and avoid or reduce adverse environmental effects. The alternatives considered deal with high-level liquid radioactive waste, other radioactive liquid waste, radioactive gaseous waste, radioactive solid waste, nonradioactive waste, and other environmental pollutants. For comparison purposes, the discussion of each alternative is preceded by a short statement of the current waste management plan.

The present existence of approximately 72 million gallons of radioactive waste (38 million gallons as of March 1975) (liquids, salt cake, and interstitial liquids) requires some type of waste management program. Therefore, the analysis of an alternative that does not require a waste management program is not considered reasonable. The exact consequences of terminating all waste management operations depend on the time such a termination takes place. If all waste management operations were terminated in the next few years, the resulting environmental conditions could become locally undesirable. At the conclusion of the solidification program, retrieval of the salt cake and sludges in the tanks will be accomplished by varying techniques depending on the design details, the current condition and the particular contents of the tank. Instead of using conventional sluicing or redissolving techniques, adaptations and modifications to mining and other standard techniques for excavation and movement of solid materials will be used. When solidification of waste and strontium and cesium encapsulation are completed in the early 1980's, the ability to withstand an interruption of waste management will be greatly improved. Nevertheless, waste management operations at Hanford should not cease at this time or for some time to come.

Alternatives currently under consideration for ultimate storage of Hanford's high-level waste are briefly discussed but additional research and development is required before the best waste form and storage location can be determined. Ultimate disposal of Hanford waste will be considered in another impact statement prior to decisions on various ultimate disposal options.

This section also includes an analysis of the environmental impact which would occur if the primary production facilities at Hanford (N Reactor and Purex) were to cease to operate. The current program plan does involve the generation of new waste primarily from the processing of N Reactor fuel in the Purex processing facility and from research and development activities. This waste is expected to amount to an addition of a few percent per year to the existing waste inventory. N Reactor operating periods through 1978, 1983 and 1990 are considered.

An analysis of reasonable alternatives to the current operations solely on the basis of changes in radiation dose to the general population clearly indicates that comparatively little change in the radiation dose would occur. The radiation dose resulting from the current practices is small (about 2.5 man-rem/yr) and the resulting health effects (based on the assumptions discussed in Section III) also pose a small comparative risk. However, consideration of the long-term requirements for control and isolation of radioactive waste materials from man's environment requires that reasonable alternatives be evaluated in terms beyond the projected radiation dose to the population. Therefore, the analysis of alternatives also includes such concepts as improved controls, retrievability, and reduction of discharges to the environment to as low as economically and technically practicable. The changes in amount of land used, the total curies of radioactive waste discharged to soil and curies of tritium to the groundwater are considered in examining the alternatives.

A range of alternatives for each level and each type of waste generated at Hanford is examined. For the high-level liquid waste, four major alternatives (summarized in Table V-1), most with several suboptions, are examined. For other radioactive liquid waste, the alternatives are summarized in Table V-2. The current plans and reasonable alternatives for handling of solid and gaseous radioactive waste as well as all other forms of waste generated at Hanford are then discussed.

In most cases, the alternatives are not mutually exclusive and several could be simultaneously adopted. For example, the number of new double-wall tanks (4 to 12) which could be beneficially used would depend on the operating period of the N Reactor and Purex as well as when a solidification method for the final residual liquids is developed. Purex could be shutdown with or without continuing N Reactor operation. New facilities for solidifying the final residual liquid will be needed whether or not waste generating facilities (N Reactor and Purex) are operated in the future.

TABLE V-1

HIGH-LEVEL WASTE ALTERNATIVES

- Continue Present Program
  1) Replace all single-wall tanks
  2) Replace older single-wall tanks
  3) Final Solidification
- Shutdown N Reactor
- Shutdown Purex
- Discontinue Solidification to Salt Cake
  1) New double-wall tanks
  2) Calcine
  3) High temperature melt formations
  4) Insoluble formation

TABLE V-2

LIQUID EFFLUENT WASTE ALTERNATIVES

- 200 Areas Effluent Treatments
  1) Continue Present Program
  2) Evaporate B Plant Streams
  3) Evaporate Purex Ammonia Scrubber Streams
  4) Evaporate All Discharge Streams
- N Reactor Effluent Treatments
  1) Continue Present Program
  2) Reinject Rupture Monitor Bleed Stream
  3) Closed Loop Cooling for N Fuel Storage Water
  4) Provide both Reinject Rupture Loop and Closed Loop Cooling
  5) Total Treatment of All Effluent Streams

V.2 ALTERNATIVES TO HIGH-LEVEL WASTE TREATMENT

V.2.1 Continue Present Program [X.25]

Approximately 47 million gallons of liquid waste and 25 million gallons of solidified waste (38 and 28 respectively as of March 1975) are currently stored in underground tanks at Hanford. This waste was generated during the period 1944 to 1974 and represents more than 95% of the total high-level waste expected to be generated through the operation period of the Hanford plutonium production facilities through 1978. Based on current production plans, the operation of N Reactor[1] and the Purex Processing Plant results in the generation of approximately 1 million gallons of high-level waste each year. Operation of these facilities through 1983 or 1990 will generate about 5 or 12 million gallons of additional high-level liquid waste, respectively. This liquid would be converted to 1 to 3 million gallons of solidified waste.

The thrust of the current waste management program for high-level waste is to convert stored and currently generated high-level waste from a liquid to a salt cake form. The existing evaporators, along with one evaporator currently under construction (1972), will solidify most of the stored and currently generated liquid waste to salt cake. A residuum of highly caustic liquid will remain which cannot be further evaporated with these evaporators. The residuum will be treated to produce a solid either by chemical addition or a special type evaporator, alternatives which are now under development. If a satisfactory solidified waste (immobile but removable) cannot be developed for interim storage at a reasonable cost, then the residuum could continue to be stored in double-wall tanks until an ultimate disposal method is in place. Replacement tanks could be built from time-to-time as needed to continue storage of this liquid and since any leakage from the primary tank can be collected, detected and removed by pumping from the secondary tank, leakage of liquid ~~waste to~~ the soil would be effectively eliminated.

The solidification of the liquid waste, along with the construction of additional double-wall tanks to contain the liquids in interim periods, is considered to be the current program for management of the high-level waste. The objective of this program is to continue to maximize the isolation of the high-level waste from man's environment.

Within the current program, which has continued to advance during the preparation and review of this statement, a number of facilities and activities were planned for the budget cycle, FY-1973 through FY-1975. All of these programs were designed to further improve total containment of radioactive materials and to maintain their release to the environment to the lowest level technically and economically feasible. Just under 33 million dollars worth of improvement was budgeted. The programs are summarized in Table V-3.

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The FY-1976 and FY-1977 programs (summarized in Table V-4), involving about 77 million dollars of improvements and additional facilities, are designed to further improve total containment of radioactive materials.

TABLE V-3

WASTE MANAGEMENT FACILITIES AND ACTIVITIES
PLANNED OR UNDER CONSTRUCTION, FY-1973 THROUGH FY-1975

In-Tank Solidification Systems, Auxiliaries — $2,500,000

The project provides additional concentrate routing facilities to permit transfer of slurries from the 242-S Evaporator to existing tanks in the 241-U Farm.

Additional Waste Concentration and Salt Cake Storage Facilities — $30,000,000

This project provides a waste evaporator system, additional underground storage tanks for cumulative capacity of at least 3 million gallons of highly radioactive waste, routings for new tanks and existing underground storage tanks, underground lines, encasements, pumps and auxiliaries, which are needed for the waste concentration program and for minimizing the potential for leakage of radioactive liquids to the ground.

Provision of the proposed facilities will allow acceleration of the waste solidification program. The liquid waste in 30 of the older waste tanks, some of which are associated with the existing waste concentration systems, can be emptied at least 1 year sooner for solidification by evaporation-crystallization. Also, most of the liquid waste can be stored in single-wall 200 East Area waste tanks of later improved design or the new double-wall waste tanks provided by this project instead of the older tanks which otherwise would be utilized. This will reduce the potential for future leaks.

Groundwater Monitoring Wells — $100,000

Additional wells will be drilled at selected strategic locations to enhance the existing routine groundwater monitoring capability.

Encase Waste Lines 232-Z to 241-Z — $115,000

A short run of existing piping which transports incinerator scrubber waste from the plutonium incinerator building to a sump will be replaced with an encased pipeline, thus affording double containment provisions.

Total Dollars — $32,700,000

TABLE V-4

WASTE MANAGEMENT FACILITIES AND ACTIVITIES PLANNED, FY-1976 AND FY-1977

Additional Waste Storage Tanks — $75,000,000

Each of two proposed projects, one in FY-1976 and one in FY-1977, will provide six new double-wall tanks for storage of liquid waste. These projects will provide up to 12 million gallons additional capacity for residual liquids, interstitial and concentrated liquids and combined dilute and aging wastes, and will include piping interties and necessary auxiliaries. The new tanks are needed to minimize the potential for leakage of radioactive liquids to the ground.

Groundwater Monitoring Wells — $200,000

Additional wells are being drilled at selected strategic locations to enhance the existing routine groundwater monitoring capability.

Waste Unloading Facility — $1,500,000

The existing, outdoors facility for unloading liquid waste, shipped via rail tankers, from other areas at Hanford will be replaced by a new enclosed facility thus eliminating a potential for unplanned releases and for personnel exposure during unloading.

Total Dollars — $77,000,000

The current program also includes research and development to determine the best ultimate disposal method for the salt cake. The focus is on alternate solid forms and storage methods which would have minimum dispersability characteristics. Research and development efforts directed toward final disposal of high-level waste from the commercial power industry will be studied for possible applicability to Hanford waste.

Alternatives within the present high-level waste management program are:

- replace all single-wall tanks with new double-wall tanks
- replace all of the older single-wall tanks with new double-wall tanks
- add materials to salt cake tanks to solidify all residual liquids
- build a special evaporator to solidify all remaining residual liquids associated with salt cake formation and storage.

At the present time, dilute and interstitial liquid waste awaiting processing by the evaporators is stored in single-wall tanks. After this waste is processed through the evaporators, approximately 10 to 17 million gallons of liquid waste will remain for underground storage. Two to three million gallons will be from combined dilute and aging waste, 2 to 5 million gallons from combined interstitial and concentrate liquids in the evaporator loops, and 7 to 10 million gallons of residual liquids. The dilute liquids are liquids which have not been processed through the evaporators; combined liquids are those processed through the evaporator at least once; and residual liquids are liquids which cannot be further solidified in the evaporator or crystallizer.

Two storage alternatives to the present program are currently under consideration: 1) store all liquid waste in new double-wall tanks or 2) store the highest level liquid waste in new double-wall tanks and continue to use the newer of the single-wall tanks for selected liquid waste.

V.2.1.1 Replace All Single-Wall Tanks [RPB]

To replace all single-wall tanks (the current program in mid-CY-1975) requires the construction of up to 12 double-wall tanks of 1 million gallon capacity each to permit storage of all liquid waste in double-wall tanks, including the residuum liquids in the evaporator bottoms loops. After processing the current liquid waste inventory through the evaporators, a minimum of 10 million gallons of liquid waste would remain for tank storage or other treatment. The present Hanford evaporators would not be able to further concentrate this 10 million gallons because of the chemical content. The 12 double-wall tanks would provide the needed liquid waste containment capacity plus some spare capacity to meet emergency needs.

Building 12 new double-wall tanks would provide improved containment of high-level liquid waste. Leakage of these liquids to the soil would be eliminated by the second tank wall. Monitoring for leaked liquids between the inner and outer tank walls would provide leak detection. Leaking tanks could be taken out of service before material leaked from the second wall to the soil.

The adoption of this alternative would result in a major construction effort. After funding is obtained, an estimated 4 years minimum would be required before these tanks could be procured and placed into operation. The cost would be about $75,000,000. About 10 acres of land would be required for the new tanks.

Based upon the extrapolation of past leak data, some leakage from the existing tanks would be expected during the time these tanks were being constructed and the liquid waste was being processed by the evaporators. The population dose resulting from the current waste tank storage program including any contributions from leaking tanks is essentially zero ($<1 \times 10^{-6}$ man-rem/yr). Adoptions of this alternative would not change this population dose significantly, but would prevent leakage of waste placed in double-wall tanks for storage.

V.2.1.2 Replace Some Single-Wall Tanks

To replace some, but not all, single-wall tanks requires storing the highest level liquid waste in new double-wall tanks and continuing use of newer single-wall tanks for selected liquid waste. For example, construction of six additional double-wall tanks of 1 million gallon capacity each to replace some of the older single-wall tanks would provide a combination dilute waste receiver and feed tank for each evaporator, and would permit storing approximately 70% of the residual liquid inventory in double-wall tanks. The other 30% of the residual liquid inventory would be stored in the newer single-wall tanks that have improved leak detection capabilities. Rapid leak detection and tank pump-out would keep the loss of liquid waste to the soils to a few thousand gallons or less per leak.

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Process development of partial neutralization and reconcentration of residual liquids is continuing and its application, should the process prove successful, might reduce the stored inventory to 70% of the original volume. If the process is developed, then the single-wall tanks with the improved leak detection equipment would hold the solids formed by this process. The remaining residual liquids would then be stored in the new double-wall tanks. The unused single-wall tanks would remain available as emergency spares.

New tanks could be available 3 to 4 years after funding. The cost is approximately $5 million per tank. About 5 acres of land would be required for the new tanks. Adoption of this alternative would result in the continued storage of all but 1 to 6 million gallons of liquid waste in double-wall tanks. This remaining liquid waste would be stored in the best single-wall tanks. No change in population dose would result from adoption of this alternative.*

V.2.1.3 Final Solidification [RPB]

As part of the current waste management program, development work is proceeding now to solidify the residual liquids which the existing evaporators cannot further evaporate. Nearly 10 million gallons are expected to require such treatment at the end of the solidification program. Development work is proceeding to reduce the quantity of residual liquids at the end of the program by nitric acid addition. Acid addition should precipitate some additional salts which should permit further evaporation of residuum in the existing evaporators.

Two basic processes are under consideration for the final solidification: 1) addition of materials such as clay which would react with the residual liquids to form a solid product, and 2) evaporation of the highly caustic residual liquids by a different type evaporator, such as wiped film evaporator.

V.2.1.3.1 Material Addition for Residual Liquids

The residual liquid and new liquid waste after completion of the current solidification program could be immobilized by the addition of chemicals or materials which would either react with the water or absorb it. Typical examples are phosphate compounds which form hydrates and clays which absorb the water. These possibilities have not been studied in sufficient detail for decision making. Several additional years of effort are necessary before decisions can be made on the best method and its costs. Final solidification of all liquids would, of course, make liquid leaks impossible. There would be no change in the essentially zero population dose ($<1 \times 10^{-6}$ man-rem/yr) now received from the liquid waste management program. Further contamination of soil from tank leaks would not occur.

V.2.1.3.2 Further Evaporation for Residual Liquids

After completion of solidification of most of the liquids by use of the evaporator-crystallizers, about 10 million gallons of saturated bottoms liquid will remain. A continuous supply of new liquid waste of from 1 to 2 million gallons per year will be generated by research and development activities plus operation of Purex. Because of the chemical composition of these residual liquids, the current evaporator-crystallizers may not be able to make the final solidification.

Several process alternatives or equipment changes are being studied to reduce the volume of this liquid, all of which appear to be technically feasible. The liquid can be partially neutralized, converting a portion of the caustic to a sodium salt; soluble aluminum can be precipitated as alumina or removed as alumino-silicates; or the solution can be further concentrated either by using a special concentrator such as a wiped-film evaporator or the existing evaporator-crystallizers. The latter product would be a wet salt cake (mush) which would be stored in the new double-wall underground tanks. The design and costs for these processes or equipment changes are not yet established, and laboratory and pilot plant studies are still being conducted. For example, present corrosion data indicate that tank life of the new double-wall tanks would be reduced for the storage of "mush." Before utilizing the tanks for this type of waste storage, a detailed safety analysis and cost-benefit analysis will be made. Cathodic protection devices are also under development and can be utilized if such technology would improve tank life time. Final solidification of the residual liquids by these approaches minimizes the volume of any final liquids, and the leakage potential to soils from liquid waste storage tanks is virtually eliminated by storage in new double-wall tanks. There would be no change in the essentially zero population dose resulting from the liquid waste management program.

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* The current program (mid-CY-1975) is to build 12 double-wall tanks. The alternative of building 6 tanks is not being considered now but is included here since it was one of the alternatives considered in 1972 at the time of preparation of this statement.

V.2.2 Shutdown of N Reactor, 1978, 1983 or 1990 [X.10, X.25]

An alternative to generating and processing most new radioactive waste is to shut down N Reactor and Purex. As stated earlier, the primary role of these facilities is production and recovery of plutonium and other materials for national defense and research and development activities. The need for this material is beyond the scope of this statement. This section and the one following include an analysis of the environmental impact if these production facilities cease to operate to provide a basis for comparing the impact of managing the waste to be generated in the future with managing the waste that has been generated over the last 30 years.

The shutdown of N Reactor would result in the following changes:

- 625 ton/yr of uranium fuel would not be irradiated
- 750 kg/yr of plutonium would not be produced
- 4.5 billion kW hr/yr of electricity would not be produced
- 110 Ci/yr of ^{90}Sr plus ^{137}Cs would not be added to the N Crib soil column
- 300 Ci/yr of ^{60}Co would not be added to the N Crib soil column
- 5200 Ci/yr total would not be added to the N Crib soil column
- <15 Ci/yr would not be released to the Columbia River (excluding tritium)
- ~200 Ci/yr tritium would not be sent to groundwater
- 5000 ft^3/yr of solid waste would not be generated
- 50,000 Ci/yr of ^{41}Ar would not be released to the atmosphere
- 2.4 man-rem/yr of population radiation dose would not be received
- Purex would be shutdown when N Reactor fuel was processed
- One to two fewer new double-wall tanks would be required.

The shutdown of N Reactor would not substantially change the inventory of radionuclides to be added to the presently stored waste. The 410 Ci/yr of long half-life nuclides not added to the N Crib is ~12% of the current crib inventory of 3300 Ci (1974). Most of these radionuclides are near the floor of the crib and trench. The longer lived constituents are 1200 Ci of ^{60}Co, 430 Ci of ^{137}Cs, and 160 Ci of ^{90}Sr. The 200 Ci/yr of tritium not added to the groundwater is only a few thousands of 1% of the current groundwater tritium inventory. The 5000 ft^3/yr of waste not generated is about 0.02% of the solid waste already stored. The 2.4 man-rem/yr of radiation dose not received is about 0.01% of the radiation dose received from natural background each year.

V.2.3 Shutdown of Purex, 1978, 1983 or 1990 [RPB]

The alternative of shutting down Purex presents two options: 1) shutdown after processing all N Reactor fuel currently on hand and 2) shutdown now with the existing inventory of irradiated N Reactor fuel either shipped offsite for processing or stored onsite without processing.

V.2.3.1 Shutdown of Purex After Processing Current Inventory

The shutdown of Purex after processing the current inventory of irradiated N Reactor fuel would result in the following changes compared to planned operations:

- 625 ton/yr of uranium fuel would not be processed
- 225,000 gal/yr of boiling waste would not be generated which is equivalent to 30,000 gal/yr of salt cake not produced
- 2 wk/yr of evaporator operating time would not be needed
- 80 Ci/yr of fission products would not be sent to cribs
- 12,000 Ci/yr of tritium would not reach the groundwater

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- 1.2 billion gal/yr of cooling water would not be used
- Small reductions in solid waste volumes would occur
- Power plant fuel consumption and waste emissions would be reduced
- The population radiation dose would be reduced by <0.1 man-rem/yr
- One to two fewer new double-wall tanks would be required.

The shutdown of Purex would change the inventory of radionuclides to be added to the presently stored waste. The reduction of 225,000 gal/yr of waste would require one less waste storage tank every 4 years. The 80 Ci/yr of fission products not absorbed on soil columns would be a reduction of about 1% of the current crib soil column inventory. All cribs except those serving B Plant discharges are in a net decay mode. The 12,000 Ci/yr of tritium not reaching the groundwater would be a reduction of less than 0.02% of the tritium now in the groundwater. The 1.2 billion gal/yr of cooling water not used represents less than 1 hour of average flow of the Columbia River.

V.2.3.2 Shutdown of Purex Immediately

For immediate shutdown of Purex, two alternative methods for irradiated fuel handling may be considered: 1) ship fuel offsite in the near term for processing, and 2) store the fuel for an indefinite period (in reactor or in storage basin). The total amount of irradiated fuel available for processing through FY-1978 is about 3700 tons, of which 1200 tons are now in inventory.

V.2.3.2.1 Ship Fuel Offsite [RPB]

This alternative would require the irradiated fuel produced by N Reactor to be processed either at a commercial plant or at the ERDA Savannah River Plant (SR). No commercial processing capability is available at the present time. Approximately 400 tons of N Reactor fuel were sent to Nuclear Fuel Service near Buffalo, New York in the mid 1960's. Difficulty was encountered in processing the fuel utilizing a chop-leach method of fuel dissolution. Also, the metallic N Reactor fuel is brittle, and massive fracture with fuel element disintegration in the fuel shipment cask was encountered. As a result of these problems, commercial plants have been unwilling to process this type fuel, particularly since the projected commercial power reactor oxide fuel will probably fully utilize existing plants and those under construction.

Savannah River could process the fuel. Significant plant and capital investments would be required. Total capability to process the fuel would be available about 5 years after funding was obtained. The plutonium and uranium would be in an unusable form requiring carefully controlled storage for 3 to 5 years. No significant change in the quantity of high-level liquid waste would result with processing at SR. Since SR also produces salt cake, there would be no change in total salt cake quantity. The following changes would result.

- The waste products would be disposed of at SR.
- Shipping costs are estimated at 2.5 million dollars per year.
- Shipping casks would be required at a cost of approximately 20 million dollars.
- 80 Ci/yr less fission products would be released to the cribs at Hanford.
- Capital costs for modifications to the SR plant would be an estimated 30 million dollars.
- Processing cost would be about equal for either plant.
- Radiation dose to the population would be increased due to some low exposures along the shipping route.
- Three to four fewer new double-wall tanks would be required.

Since the radioactive material would require more handling and cross-country shipment, some increased potential for worker radiation exposure and for accidents would result. Shipment costs and capital modification costs would increase total processing cost. If this alternative were used, close coordination between the ERDA and the Department of Transportation would be maintained regarding the transportation and handling of hazardous materials.

The reduction of 80 Ci/yr released to the cribs at Hanford would result in management of this same activity at Savannah River.

V.2.3.2.2 Store Irradiated Fuel

Irradiated N Reactor fuel could be stored for the long-term without processing. Results of adoption of this alternative would be:

- Modifications would be made to old reactor fuel storage areas to accept long-term irradiated fuel storage.
- 80 Ci/yr of fission products would not be sent to cribs.
- Fuel cladding corrosion could result in the release of an unknown amount of radioactivity to the air and to the ion-exchange cleanup systems at the fuel storage areas.
- The quantity of strontium and cesium requiring separation from high-level waste would be decreased by a few percent.
- Long-term storage would probably preclude processing due to lack of suitable facilities.
- Uranium and plutonium values in the fuel would not be realized.
- The population radiation dose would be reduced by <0.1 man-rem/yr.
- Three to four fewer new double-wall tanks would be required.

The technology for long-term storage of irradiated fuel would need to be developed. Extensive control systems to detect fuel element failure, to cleanup storage areas, and to re-package or otherwise repair corroding fuel elements would need to be developed. The total quantity of radioactive material to be handled would remain the same, but irradiated fuel storage would add another and a new type of waste management system to be monitored and controlled. The presence of plutonium in the fuel elements would require perpetual control and surveillance of the fuel elements as transuranic waste. Storage of unprocessed but irradiated fuel for N Reactor operating periods to 1983 or 1990 would add significantly to the storage problems stated above.

V.2.4 Discontinue Solidification to Salt Cake [RPB]

The present fractionization and solidification program could be discontinued with the goal of 1) converting the high-level liquid waste to a better solid form for interim storage, (extensive R&D and conceptual design work would be required and take years to implement,) or 2) holding the remaining liquid waste until an ultimate disposal method is developed and implemented. Implicit in these options is the need to construct new double-wall tanks.

Converting to an acid waste storage system is not an attractive alternative to continuing solidification to salt cake because of the large volume of basic waste already on hand (47 million gallons) and the relatively small volume of liquid waste yet to be generated by Purex under current planning (4 million gallons). For 1983 or 1990 operating periods this volume would be increased to 9 million and to 16 million gallons, respectively. None of the waste storage tanks now at Hanford are suitable for acid waste storage. At least 4 new double-wall acid waste storage tanks would need to be constructed at a total cost in excess of 20 million dollars. To extend N Reactor operations would require at least 9 or 16 new tanks for this waste at an estimated cost of 45 to 80 million dollars, respectively. There would be no flexibility in handling the acid waste since it would always be limited to the special tanks and systems designed for it.

The generation of two different waste characteristics would lead to a possible need for two processes for conversion for long-term or ultimate storage. Maintaining a single waste type would seem to be the wisest course of current action.

V.2.4.1 Construct New Double-Wall Tanks

This alternative would discontinue the current waste solidication program and would provide new double-wall tanks of 1 million gallon capacity each for high-level liquid waste storage. New double-wall tanks would avoid tank leakage to soil. To discontinue the solidification program and hold the current liquid inventory in presently available tanks would, over the years, lead to additional leaks.

The waste would be stored in the double-wall tanks until a better form of interim storage is developed (5 years to develop plus 5 years to implement) or until an ultimate storage mode is developed (selection by 1985, implementation at least 5 years later) and implemented. Based on the status in 1972, double-wall tanks would be required for: 47 million gallons of current liquid, 4 million gallons of additional Purex waste, and 5 million gallons of research and

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development generated waste, for a total of 56 million gallons through FY-1978. Fifty-six double-wall tanks of 1 million gallon capacity each would be required. Current construction cost estimates are 5 million dollars per tank for a total cost of 280 million dollars. Hanford operations through 1983 would require 61 tanks, while operation through 1990 would require 78 tanks at an estimated cost of 310 and 390 million dollars, respectively.

New waste resulting from continued operation of Hanford facilities would initially be put in existing double-wall tanks. Simultaneously, the construction of new double-wall tanks in 200 East and 200 West Areas would be started, and as these new tanks with their associated piping and ancillaries were made available, the liquid waste now stored in the single-wall tanks would be transferred into them. Approximately 80 tanks contain liquid that would be transferred under this alternative. The old tanks, whether empty, partially filled, or totally filled with solids, would be isolated and held pending ultimate disposition of their contents. Twenty-five million gallons of solids are being held at this time (1972).

The ability of industry to respond to such a massive tank building program would be severely taxed. A large increase in capital expenditures would be required. The construction program would result in the irretrievable commitment of additional resources such as steel (360 tons per tank) and concrete. The new tanks would require a total of about 50 acres of additional land that would be committed to the radioactive waste management program for the indefinite, but very long term, future.

The amount of liquid waste leaking from old tanks into the ground would be proportional to the length of time required to complete the solidification of the current waste. Leakage during this period could be thousands of gallons and a few thousands of curies annually. Adoption of this alternative would not reduce the essentially zero population dose resulting from the liquid waste management program, but would terminate contamination of underground soil from leaking tanks once the liquids were stored in double-wall tanks.

V.2.4.2 Calcine Waste

An alternative to salt cake formation is calcining of the Hanford high-level liquid waste. Several different techniques have been studied including pot, spray, and fluidized bed calcination for acid waste:

- Pot calcination has the advantage of being a relatively simple process that can handle a broad range of waste feed compositions. However, stainless steel pots are required for both product formation and storage, the batch wise process capacity is inherently low, heat conductivity through the calcine is low and the calcine can be dissolved in water as readily as salt cake.

- The spray calcination is a continuous process with good capacity and low hold-up volume. It produces a wide range of good quality solids, but is relatively complicated and difficult to operate, and may require use of expensive materials. When combined with a continuous melter for the calcine, it produces a monolithic, microcrystalline solid with approximately one order of magnitude less leachability than the pot calcine.

- The fluidized bed calcination is a high-capacity continuous process extensively developed and currently in use at the National Reactor Testing Station in Idaho. The process is moderately complicated to operate. The product is a dry, granular solid easily transportable by pneumatic means.

Little development work has been done on the application of a calcination process to the Hanford-type of waste, but what has been done indicates that spray calciner would probably be the most successful of the calcination techniques for Purex-type waste.

All three of the above calcining processes would convert the high sodium content of the current liquid waste to sodium oxide. This compound is hygroscopic and will absorb sufficient moisture to create an unstable condition. In this sodium oxide form, the calcine product is quite similar to salt cake in stability and leachability. The chemical addition required to convert to a more stable form, e.g., sodium sulfate, significantly increases the final volume of the waste to be stored.

An estimated 10 years would be required for the research, designing, building, and placing a calciner into operation for processing Hanford waste. A calciner for Hanford waste should have a capacity of 15 million gallons of high-level liquid waste per year. It would have to operate for 5 years to reach current (equilibrium) status with the liquid inventory. Operating costs of the calciner would be 6 to 8 million dollars per year. Capital investments of approximately 200 million dollars would be required to construct the calciner, its auxiliaries and calcine

storage facilities. At least, 30 acres of additional land would be required for these facilities. Underground calcine storage bins would require extensive procurement lead time. Not included in the above cost are the 5 million dollars per double-wall tank needed for storage of the millions of gallons of waste being generated during the 10 years before the calciner would have processed the high-level liquid waste.

Also, adoption of this alternative would probably need to be coupled with the building of some new double-wall tanks to provide improved liquid waste containment for the existing inventory prior to calcination. Holding the existing liquid inventory for some 10 years beyond when it might have been converted to salt cake would lead to leaks from the single-wall tanks and consequently more soil contamination than expected by pursuing the salt cake formation program. Adoption of this alternative would not reduce the essentially zero population dose resulting from the liquid waste management program.

V.2.4.3 High Temperature Melt Formations [X.6]

Another alternative to salt cake formation is converting the high-level liquid waste to a stable insoluble solid by a high temperature melt treatment.[2,3,4]

Numerous chemical formulations plus related process equipment and operations are being studied relating to the conversion of liquid waste to various types of glasses, glass-ceramics, devitrified phosphate glasses and others. Such formations could provide long-term storage stability and leach resistance. Silicate melt technology is the most advanced waste fixation technology on a world-wide basis. It is a leading near-term contender for producing an acceptable waste form.

This alternative would propose the use of an aluminosilicate formulation (basalt rock). The process would include an evaporative operation to concentrate the dilute liquors. The product material is a dense silicate glass resembling obsidian. This particular process should work well with the existing highly basic waste. Although radiation stability of the specific glass (resembling obsidian) is not known, it would be anticipated to be more stable than similar glass formations from high-level waste since the contained radioactivity would be less (lower dose). Possible devitrification would need to be studied in detail as part of the development program investigating the acceptability of glass formations. About 10 years would be required to design and build the facility. The costs for the "glass plant" would be about 100 million dollars, exclusive of storage facilities for the containers of "product." At least, 30 acres of additional land would be required for these facilities. The final volume of glass would be approximately equal to the volume of calcine for an equivalent amount of liquid waste.

The adoption of this alternative would probably need to be coupled with the building of some new double-wall tanks to provide improved liquid waste containment for the existing inventory prior to processing. Holding the existing liquid inventory for some 10 to 15 years beyond when it might have been converted to salt cake would lead to leaks from the single-wall tanks and consequently more soil contamination than expected by pursuing the salt cake formation program. Adoption of this alternative would not reduce the essentially zero population dose resulting from the liquid waste management program. It would produce a product of good stability and low leachability.

V.2.4.4 Insoluble Formation

Concentrated liquid waste would be mixed[5,6] with clays at low temperatures (less than 100°C) form reaction products--solid brick-like, insoluble minerals such as cancrinite suitable for long-term storage. Liquid waste would be drawn up out of the storage tanks, mixed with the reagents in an in-line type of operation, extruded and cured in a selected geometric form, then returned to storage bins. Future retrievability would be accomplished by pneumatic or mechanical means.

Although considerable definitive work has been done on the technology of this process, operating plans and costs are viewed as tentative. The research, development, design, and implementation would require a minimum of 10 years. Costs are estimated at approximately 30 million dollars for the plant and 100 million dollars for the storage bin facility.

Liquid waste would be converted to solid, more rapidly and starting earlier (within 5 years) than would be the case with either the fluid-bed calciner or the glass plant, thus reducing the potential risk and amount of waste leakage into the soil. Some construction of new double-wall tanks would be needed. This alternative requires storing the waste in liquid form until implemented. The process essentially doubles the volume of the waste material so larger areas are required for waste storage, perhaps 75 acres. Adoption of this alternative would not reduce the essentially zero population dose resulting from the liquid waste management program.

V.2.5 Ultimate Disposal [RPB, X.6, X.7, X.8, X.10, X.18, X.23, X.25]

This section provides a summary description of the current research and development programs relating to ultimate disposal. The R&D plan is updated annually to reflect the impact of results of the R&D activities. Earlier versions of the plan have been documented.[9]

Current activities in the Hanford high-level waste management program result in two general categories of waste materials that require consideration for ultimate disposal:

- Salt cake, sludge, and terminal (nonevaporable) liquid stored in underground tanks.
- Cesium-137 and ^{90}Sr encapsulated in metallic canisters.

All radioactive waste resulting from Hanford operations must be stored and ultimately disposed of in a manner that provides protection for the public and the environment during the hazardous life of the radionuclides.

The R&D plan is based upon the assumption that salt cake and sludge will continue to be stored in existing tanks and new double-wall tanks until the decision is made to remove the waste and place it in either another form of interim storage or ultimate disposal. This R&D plan focuses on the storage/ultimate disposal of high-level waste. Subsequent subsections 1) address ultimate disposal research and development for salt cake, sludge, and terminal liquor, 2) describe the R&D support for in-tank storage, and 3) address the long-term management of encapsulated ^{137}Cs and ^{90}Sr. Ultimate disposition of plutonium and fission product contaminated soil, solid waste, and failed equipment must also be considered as both a decommissioning and a waste management activity.

V.2.5.1 Ultimate Disposal Research and Development

The state of knowledge and the progress of research and development programs relating to ultimate disposal will be periodically reevaluated so that an appropriate impact statement relating to ultimate disposal can be prepared as soon as sufficient information is available.

As in the case for long-term management of commercial high-level waste, ultimate disposal of ERDA waste implies termination of controlled management of the waste. The waste would be placed in a form and location where isolation from man does not depend upon a controlled management program and the waste has an acceptably low probability of release to man's environment for the toxic lifetime of the waste material. Many or all of the optional commercial waste disposal modes described in BNWL-1900[1] may be equally suitable for the Hanford waste. Commercial waste disposal alternatives range from disposal in stable geologies (salt, granite, shale, deep sea bed) to transmutation and deep space disposal. Much of the technology developed for commercial waste disposal should be transferable to the ERDA waste program.

In the event that the decision is made to remove the waste from the tanks, the removal step would possibly be followed by processing to remove radionuclides for volume reduction, immobilization of the salt cake, sludge, and terminal liquor, and emplacement in the ultimate disposal facility either onsite or offsite. The major difference between onsite and offsite disposal would be in the number of disposal systems available and the requirement for packaging suitable for offsite transportation.

The current solidification program may change the waste recovery and treatment methods for ultimate disposal compared to treatment of liquid waste, but solidification to salt cake does not foreclose options for ultimate disposal. In the first place, any ultimate disposal option will have to start with salt cake in semisolid form, since the equivalent 30,000,000 gallons of it already exists, and planned new waste generation will add only a small increment to this amount. In addition, as more fully described in the section immediately following, there are two processes under development suitable for salt cake, liquid or sludges, which may be used as the waste form for ultimate disposal. Neither the continuation of the solidification program nor the discontinuance of that program would affect the availability of these improved waste forms if a decision is made to remove the waste (liquid or salt) from the tanks.

As indicated in Section II.1.1.2.5.5, recovery of plutonium from Hanford soil storage is necessary to avoid the need for ultra-long-term surveillance. A research and development program is underway to demonstrate the ability to recover plutonium. Since May 1972, essentially zero amounts of plutonium have been released to soil columns. Therefore, the current program does not affect ultimate disposal of such plutonium. Although the ultimate disposal plan must consider the possible recovery of fission products from soil columns, current plans are based on leaving fission product materials (not associated with plutonium) in the soil columns for decay. See Section II.1.1.2.5.6. The alternatives to the current program of discharging some fission products to soil columns are discussed in Section V.3.

A development program is underway which will ensure availability of the technology required to immobilize and dispose of Hanford waste which involves concentrated R&D in the following areas:

- Salt Cake and Sludge Retrieval

  The objective of this task is to develop equipment and procedures for production-scale removal of solidified waste from the tanks. Conceptual designs have been prepared for alternate systems using vendor-supplied components developed for the mining and material handling industries. Vacuum, hydraulic, and mechanical systems are under evaluation relative to cost, maintainability, lifetime, etc. One or more systems will be fabricated for testing with nonradioactive materials followed by demonstration on radioactive material in an actual retrieval operation. Salt cake could be recovered at any time. To do so in the next few decades would result in some radiation dose that could be avoided by waiting several hundred years for radioactive decay of most of the fission products.

- Waste Fractionization

  Economic incentive may exist for the development of processes and equipment for the separation of the waste into a high-level waste and a chemical waste fraction to reduce the volume of high-level waste requiring treatment and ultimate disposal. ERDA has recently initiated a program to develop waste fractionization processes to facilitate separation of the waste into a high-level waste fraction and a fraction which could be treated as a slightly contaminated substance. Laboratory scoping studies have confirmed that technology exists for various elements of a process, and the task will be to develop these elements and others into a definitive process which could be demonstrated in a pilot plant facility.

- Waste Immobilization

  Improved waste forms have been developed which are more suitable than salt cake for long-term storage and disposal. Desirable product characteristics include low dispersibility, low solubility, and low leach rates. Currently, two immobilization processes are under active development. One process, which appears particularly suitable for salt cake and terminal liquor, is referred to as the aqueous silicate process. The other process, called the silicate melt process, is applicable to sludges as well as salt cake and terminal liquor.

  1) Aqueous Silicate Process - The waste, in an aqueous form, is mixed with a Bentonite, Kaolinite, or other suitable clay, and undergoes a low-temperature consolidation reaction yielding a relatively insoluble, monolithic product similar to unfired ceramic. The process has been successfully demonstrated, on the laboratory scale, using both simulated and actual waste. Engineering studies are underway to develop a flowsheet and equipment which would permit pilot scale demonstration and ultimate production-scale operation of the process.

  2) Silicate Melt Process - The waste is mixed with ground basalt or Hanford sand and melted in a crucible to yield a glass product similar to that produced with commercial waste. Trade-off studies are being conducted between the lower leach rate and lower solubility of the silicate melt product and the advantages of low temperature operation of the aqueous silicate process. Batch quantities of this product have been produced on a routine basis in laboratory experiments.

- Waste Packaging

  Various packaging modes ranging from high integrity canisters to bulk storage are being considered in the effort to develop a container suitable for onsite storage of the waste. The packaging mode will be highly dependent on whether the waste is stored in an engineered facility for an extended period or committed directly to ultimate geologic disposal.

- Waste Processing Facility

  The present program is limited to consideration of scale-up of processes for production-scale operations. Once the flowsheets are developed, functional design criteria will be established and conceptual designs for facilities will be prepared.

V.2.5.2 R&D Support for In-Tank Storage [RPB]

A comprehensive R&D program is underway to determine the period of time during which salt cake, sludge, and terminal liquor can continue to be safely stored in underground tanks and to deter-

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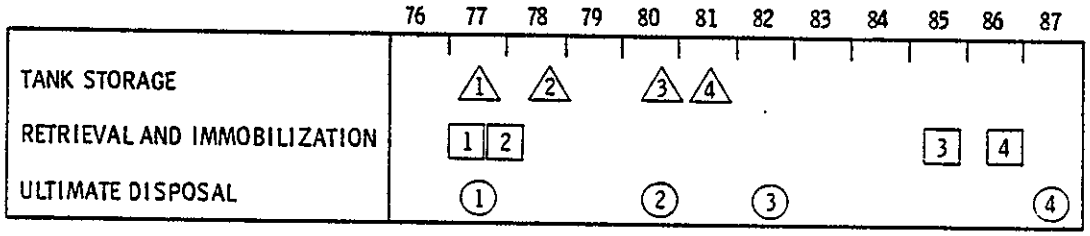

△1 CONTAINMENT INTEGRITY FORECAST ISSUED
△2 EVALUATION OF IN-PLACE IMMOBILIZATION COMPLETE
△3 COMPLETE DEMONSTRATION OF IMPROVEMENTS TO STORAGE SYSTEM
△4 Sr AND Cs CAPSULE SAFETY EVALUATED
[1] PUBLICATION OF OBJECTIVES AND PROGRAM REQUIREMENTS
[2] NONRADIOACTIVE EVALUATIONS OF RETRIEVAL METHODS COMPLETE
[3] DEMONSTRATION COMPLETE FOR HOT RETRIEVAL
[4] DEMONSTRATION COMPLETE FOR PROCESSING RETRIEVED WASTE
(1) SELECTION OF OPTIONS FOR ULTIMATE DISPOSAL
(2) SELECTION OF ULTIMATE DISPOSAL MODE FOR DEMONSTRATION
(3) START DEMONSTRATION OF ULTIMATE DISPOSAL
(4) ULTIMATE DISPOSAL CONCEPT DEMONSTRATED

FIGURE V-1 R&D MILESTONES FOR STUDYING DISPOSAL OF HANFORD HIGH-LEVEL SALT CAKE WASTE

mine the engineered improvements that might be used to extend the safe storage period. Continued storage of a stable waste form in tanks allows in-place radioactive decay of fission products prior to implementation of programs to relocate or modify the salt waste for ultimate disposal of the very long half-life materials in the salt waste. The decay of fission products should significantly simplify any subsequent excavation of the waste materials, minimize the potential radiation exposure to the work force, and may reduce the cost of an excavation operation. Figure V-1 shows a milestone chart for the basic R&D.

ERDA's in-tank waste management R&D program has been segmented into two phases for planning purposes: 1) near-term use of in-tank storage and 2) extended use of in-tank storage. Research and development activity supporting in-tank storage is concentrated in the following key task areas:

- Failure Mode Analysis

  Fault tree analysis techniques developed for the NASA programs are being applied to identify events which could result in a release of radioactivity to the environment. Consideration is being given to both natural and man-caused events; failure modes are being identified and ranked using existing engineering experience. An understanding of these events will both provide direction to R&D programs and identify possible beneficial modifications in waste physical and/or chemical form, the waste tank structure, or the environment around the waste storage area which could increase the confidence level in continued tank storage. Results of these analyses will provide a technical basis for the decision to either establish a date to begin removal of the waste or to proceed with engineered modifications to the waste tank system. Criteria for acceptability limits are being developed using results of the failure mode analyses, radionuclide migration studies, etc. Although the evaluation of potential engineered improvements has recently been initiated, several improvements have already promise for extending the usable life of the tanks for storage of solidified waste. Development for engineered improvements should be completed by the early 1980's.

- Storage Structure Degradation

  The primary high-level waste storage container for salt cake is the concrete tank. Lack of sufficient quality control documentation on the majority of the steel tank liners prevents credit being taken for the steel liner as a containment barrier. Consequently, major emphasis will continue to be placed on thermal, chemical, and radiation effects on concrete

deterioration. Studies have been initiated on the corrosive effects of salt cake, sludge, and terminal liquor on concrete tank materials. Preliminary engineering examination of representative concrete samples taken from the tanks show no evidence of degradation. Testing of concrete samples will continue throughout the next decade to permit observation of any long-term changes which might occur in the concrete.

- Salt Cake Stability

Chemical stability of the salt cake is necessary for storage of high-level waste in tanks. Studies have been initiated to assess the presence of chemical reactions which could occur either between the existing tank contents and structural materials or as a result of planned or unplanned addition of material to the tanks. Initial studies have focused on nitrate-organic instabilities. Preliminary shock sensitivity tests on $NaNO_3$-organic resin (ion exchange) mixtures in July 1974 showed no evidence of shock-initiated instability. Salt cake characterization studies will include determination of the potential for radionuclide release due to radiation effects, release of chemically bound water, leaching, and moisture movement.

- In-Place Immobilization Methods

The objective of this task is to assess the feasibility of in-place conversion of the high-level waste into a highly insoluble and nondispersible form, with a resultant increased confidence level for extended storage in tanks.

A preliminary engineering analysis of in-place immobilization of high-level waste reveals many significant problems. For example, consideration has been given to in-place immobilization of the waste using low temperature consolidation such as the aqueous silicate process. In this process, powdered bentonite or kaolinite clay is mixed with the liquids in the tank and allowed to consolidate at a low temperature (100°C) to form a relatively insoluble, nondispersible product similar to unfired ceramic. The product is an aluminosilicate mineral called cancrinite, containing salt and radionuclides in a crystalline matrix. Although the material has been successfully produced routinely in laboratory and batch scale runs, the requirement for near complete mixing of the materials may reduce the feasibility of application of the process to in-tank waste. Process tests are being planned. Alternate processes will continue to be examined and evaluated relative to their engineering feasibility.

- Surveillance and Monitoring and Groundwater Management

A comprehensive air and water surveillance and monitoring program is being maintained to evaluate any radioactive waste material movement into pathways that could lead to human exposure. Soil monitoring by dry wells and sampling is being used to detect movement of radioactive materials from storage locations. These surveillance and monitoring programs are described in earlier sections of this statement. The activities can be briefly summarized as follows:

1) Radionuclide Transport - Programs are in progress to provide additional data on the transport of surface waters through the sediments to identify potential interactions of waste and groundwater. Transport models are under development for use in analyzing the dose to man resulting from a hypothetical release. The models will be sufficiently detailed to permit sensitivity studies on the effects of moisture, soil retention, etc. These studies will continue.

2) Analysis of Seismic Stability - Seismic data have been collected in a continuing program at Hanford. Studies will be continued to assess the probability of occurrence, probable magnitude, and postulated consequences of a seismic event relative to changes in tank integrity.

3) Groundwater Monitoring and Management - The groundwater monitoring program is an ongoing program which supports total operations at the Hanford site. Future activities will be focused on the tank farm areas to develop a more specific hydrologic data base to ensure the absence of significant changes in hydrologic patterns which could result in redissolution and transport of the waste from the tank envelope. For example, attention will be focused on possible impacts of increased offsite irrigation or the future construction of onsite ponds or condensate discharge areas on the hydrology of the tank farm area. Such changes would be detected through the monitoring program, and termination or relocation of recharge sources could be effected to permit continued safe storage of the waste in tanks.

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V.2.5.3 Management of Encapsulated ^{137}Cs and ^{90}Sr

A large fraction of the radioactive strontium and cesium is removed from the bulk mixed fission product waste and doubly encapsulated as strontium fluoride and cesium chloride. The capsules are stored in a controlled water temperature and water chemistry basin which is monitored routinely. The design life of these capsules is 600 years (which is equivalent to approximately 20 half-lives of strontium and cesium). During the next decade a decision will be made whether to continue basin storage or to engineer an improved storage facility.

V.3 OTHER RADIOACTIVE LIQUID WASTE

V.3.1 Current Program

In addition to the high-level liquid waste from fuel processing plants, large volumes of wastewater both with and without low concentrations of radioactive materials are produced during operations. For some of this waste, it is practical to reduce the radioactivity to levels within established standards for release to uncontrolled areas by treatment methods such as ion exchange, evaporation, or retention to allow for the decay of radionuclides.

The effluents discharged to the ground contain levels of radioactivity which, while unacceptable for release to uncontrolled areas, are at a level where they may be safely released to controlled areas with suitable natural characteristics.* Present practice is to use soil columns, seepage basins, evaporative ponds or retention ponds to retain radionuclides. Wherever such practices are followed, a continuing program of extensive monitoring maintains knowledge of the locations of the radionuclides.

The practice of using the favorable ion exchange properties of some soils to remove radioactivity from liquid waste and confine it in soil columns is a well established procedure. However, an implicit assumption is that favorable environmental conditions will exist until the radioactivity in the soil columns decays to innocuous levels. Because of the long-term burden of control and surveillance inherent in the use of a technique that results in local accumulations of radioactivity in soil columns, the ERDA program at Hanford is based on the goal of reducing the concentration of radionuclides in effluent streams to the lowest technically and economically practical levels. Even so, plutonium discharged to the soils requires recovery at a later date.

The largest current environmental impact from liquid waste is from the release of liquid waste to 100-N Crib and subsequently to the Columbia River. The EPA and others maintain that discharge of N Reactor effluents to the N Reactor crib and trench is environmentally unacceptable in the hydrologically active regime that exists at Hanford. (The alternatives to continued use of the N Reactor crib and trench are discussed in this section.) The seepage from this disposal site is monitored to estimate the quantity of Hanford generated waste that may reach the river. Also, the river itself is monitored to determine and record the quantities actually present. The radionuclides that enter the Columbia River from the N Reactor operations result in a population dose of about 1.0 man-rem/yr. The normal background dose is about 27,400 man-rems/yr. The dose to the public from the radionuclides released to the ground in the 200 and 300 Areas is less than 0.1 man-rem/yr.

Table V-5 summarizes the programs planned and budgeted through FY-1975 for liquid effluent waste cleanup. All of these programs are designed to reduce radionuclide discharges or to provide increased control over radionuclides during both normal operations and potential accident conditions. A summary description of each of these programs is provided in Table V-6.

V.3.2 Liquid Waste Treatment Alternatives [X.14]

V.3.2.1 100 Areas [X.18]

The facilities and programs planned and/or under construction for FY-1973 through FY-1975 are given in Table V-6. Five alternatives to treatment of water discharge streams containing radionuclides from the N Reactor are listed in Table V-7, along with curies discharged, the cost estimate and the installation time required for each.

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* The EPA, the Natural Resources Defense Council and others believe that no liquid effluent with radionuclide concentrations greater than those permitted for discharge in uncontrolled areas should be discharged to the soil within the controlled areas of the Hanford Reservation. The ERDA also believes that such discharges should be discontinued as soon as it is technically and economically feasible to do so. This statement examines the consequences of the current discharge practices; the costs for treatment and cleanup of the liquid waste streams are discussed in this section.

TABLE V-5

LIQUID WASTE MANAGEMENT FACILITIES AND ACTIVITIES PLANNED AND UNDER CONSTRUCTION FY-1973 THROUGH FY-1975

	Cost
100 AREAS	
N Reactor Control Rod Coolant Dump System	$ 75,000
N Reactor Gravity Drain and Disposal Basin	445,000
200 AREAS	
Waste Management Effluent Control (B Plant)	1,000,000
Contaminated Soil Removal Facility	1,000,000
Purex Ammonia Scrubber Waste Conc.	405,000
Purex Condensate Recycle	450,000
Waste Management Effluent Control	410,000
300 AREA	
300 Area Liquid Waste Disposal	190,000
Replace and Upgrade 300 Area Contaminated Waste Line	400,000
Total	~$4,400,000

TABLE V-6

DESCRIPTION OF RADIOACTIVE LIQUID WASTE MANAGEMENT FACILITIES AND ACTIVITIES PLANNED AND UNDER CONSTRUCTION FY-1973 THROUGH FY-1975

100 AREAS

N Reactor Control Rod Coolant Dump System — $75,000

Valves and piping will be provided in the N Reactor control rod coolant system to provide a positive way to discharge this stream to the 1301-N crib, thus further reducing the potential for discharging small amounts of radioactivity to the river.

N Reactor Gravity Drain and Disposal Basin — $445,000

An emergency disposal basin will be installed east of the existing 1301-N Crib. The purpose is to provide an adequate emergency cooling water disposal capacity in case of 1) an emergency dump of the N Reactor primary loop to the dump tank followed by once-through cooling, and/or 2) a cooling system break inside the 105-N or 109-N Buildings and a concurrent drain pump failure. Emergency drainage sufficient to prevent direct overflow of contaminated water to the Columbia River and to prevent possible water damage to the 105-N and 109-N Buildings will be provided. The basin will provide a soil column 25 to 30 feet deep between the bottom of the basin and the average groundwater level for absorption of radioactivity.

200 AREAS

Waste Management Effluent Control (B Plant) — $1,000,000

Four waste effluent streams, 1) 244-AR cooling water, 2) B Plant cooling water, 3) B Plant steam condensate and 4) B Plant process condensate will be provided with lined trenches, monitoring, and automatic diversion facilities such that in event of accidental contamination of these streams, the waste will be contained and recycled rather than released.

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TABLE V-6 (Continued)

200 AREAS (Continued)

Contaminated Soil Removal Facility $1,000,000

Plutonium containing soil will be removed from the underground disposal crib 216 Z-9 for packaging and restorage in facilities affording retrievability provisions.

Purex Ammonia Scrubber Waste Concentration Facilities $405,000

The amount of radioactivity in the Purex Ammonia Scrubber waste discharged to a covered trench will be reduced significantly by providing for routing of all of this stream to an existing concentrator system. The decontaminated condensate will be routed to a crib and the concentrated radioactivity will be routed to underground tanks.

Purex Condensate Recycle $450,000

This project provides for recycling condensates from the 1) backcycle concentrator as extractant for the first uranium cycle and as the scrub solution for the first decontamination cycle, and 2) first uranium cycle concentrator as the final uranium cycle extractant. With the proposed facilities, all process condensates except the final uranium concentrator condensate, which is well within release limits established by the ERDA, would be recycled within the Purex Plant. This provides for a significant reduction in the amount of radioactive material discharged to the ground. The total population dose from all 200 Area pond and crib discharges is about 1×10^{-6} man-rem/yr. This project prevents some discharge of radioactive material to the soil but makes no change in the essentially zero population dose resulting from past pond and crib disposal practices.

Waste Management Effluent Control $410,000

Diversion facilities will be provided to detect contamination which may accidentally enter normally nonradioactive cooling water streams and stream condensate from the Purex plant and to divert such an affected stream to either a lined and covered reservoir or to existing waste tanks for decontamination.

300 AREA

300 Area Liquid Waste Disposal $190,000

The existing process waste system will be provided with new leaching trenches, a sampling station and two monitoring wells. The new leaching trenches will replace the existing process ponds, thus eliminating the possibility of leaching the minerals which have accumulated over the years to the river. The total population dose estimated from use of present process ponds is about 0.04 man-rem/yr. This dose will be reduced by construction and use of the new leaching trenches.

Replace and Upgrade 300 Area Contaminated Waste Line $400,000

The existing entire radioactive contaminated sewer system consisting of a 6-in. trunk line fed by smaller 3- and 4-in. lines will be replaced and upgraded to eliminate the possibility of line deterioration resulting in the release of radioactivity to the ground.

V.3.2.1.1 Alternative 1

Alternative 1 is the continuation of present operations with improvements as shown in Table V-6.

The radioactive liquid waste streams from the reactor are currently discharged to the ground at the rock-filled N Crib and the screened overflow treach extending about 1500 feet beyond the crib. About 5400 Ci/yr of radionuclides with half lives greater than 66 hours are expected to be discharged with these streams. At the discharge to the crib the concentrations of these radionuclides would generally exceed Table II, Annex A, ERDAM-0524 concentration guides. The longer-lived radioactive constituents of the 5400 Ci/yr discharged would be: $^{137}Cs + ^{90}Sr$ about 110 Ci/yr, ^{60}Co about 300 Ci/yr and tritium about 200 Ci/yr.

Essentially all the water discharged to the crib eventually seeps into the Columbia River along a several mile stretch of the river below N Reactor. A few small springs appear at the river bank directly below the crib. The spring area represents the shortest time path for the discharge water flow to the river. The remaining water seeps into the river below its water level.

TABLE V-7

N REACTOR EFFLUENT TREATMENT ALTERNATIVES

Alternatives	Radionuclides Discharged, Ci/yr >66 hr half-life: To Crib (Soil) Total[a]	To Crib (Soil) $^{60}Co + ^{90}Sr + ^{137}Cs$	To River Total[a]	To River $^{60}Co + ^{90}Sr + ^{137}Cs$	Costs, FY-77 $: Capital	Annual Incremental Operating	Installation Time, Months After Funding
1. Continue Present Operations	5,400	410	206	<1	-	-	--
2. Reinject Rupture Monitor Bleed Loop	4,300	330	205	<1	600,000	-	12
3. N Fuel Basin Closed Loop Cooling	3,900	240	204	<1	2,200,000[b]	40,000	24
4. Provide both Reinject Rupture Loop and Closed Loop Cooling	2,800	150	203	<1	2,800,000[c]	40,000	24
5. Total Effluent Treatment plus N Basin Closed Loop Cooling	300	<1	200	<1	22,000,000	600,000	36

(a) Includes 200 Ci/yr tritium which moves directly with the bulk water effluent.
(b) The July 1975 cost estimate is 4 million dollars.
(c) The July 1975 cost estimate is 4.6 million dollars.

Based on the measurement of the radionuclide concentrations at the springs below the crib, about 206 Ci/yr of radionuclides will be reaching the river.

Of this 206 Ci/yr, 200 are tritium which moves directly with the bulk water discharged into the river. The river in CY-1974 moved about 40,000 Ci/yr of tritium from other sources (bomb-test fallout and natural). The tritium from N Reactor cannot be detected in the river above the tritium from other sources. The other 6 Ci/yr entering the river consist of less than 1 Ci/yr of combined ^{60}Co, ^{90}Sr and ^{137}Cs; 2.5 Ci/yr of ^{131}I and the remainder other short-lived radionuclides (<2 yr > 66 hr half-lives).

There are approximately 3300 Ci total radionuclides held in the soil. Most of these radionuclides are near the floor of the crib and trench. The longer lived constituents are 1150 Ci of ^{60}Co, 430 Ci of ^{137}Cs and 160 Ci of ^{90}Sr and are slowly increasing with time. In addition, a small quantity of plutonium (below 1 nCi/g of soil) is just within the surface of the soil of the N Crib and trench.

The maximum predicted flood (1.44 million ft^3/sec) would raise the river elevation to 423 feet MSL, still about 30 feet below the floor of the crib. The normal fluctuation of the river is between 410 feet and 380 feet MSL elevations.

V.3.2.1.2 Alternative 2

Alternative 2 is to provide reinjection of the rupture monitoring bleed stream.

The fuel rupture sample water drain system presently discharging about 250 gpm to the crib will be modified by intercepting the drain before depressurization and reinjecting the water back into the reactor primary recirculation system. Two reinjection systems are required for the left and right monitoring systems. A reinjection system will consist of redundant pumps, rated at 125 gpm at 200 psig, mechanical filters, and instrumentation. The piping tie-in to the primary system will be made at the base of the reactor inlet pipe risers.

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V.3.2.1.3 Alternative 3

Alternative 3 provides closed loop cooling of the N fuel storage water with ion-exchange cleanup of the basin water.

The fuel storage basin will be modified from an existing once-through cooling system, discharging 500 to 1000 gpm of water, to a recirculation cooling system, discharging 50 to 100 gpm of water. The recirculation cooling system will be sized for a heat removal load of 4 MW. The system will circulate 2000 gpm of water through heat exchangers, cooled on the secondary side with river water. A side stream of the circulating water will be passed through sand filters to maintain clarity of the water for fuel handling. Backwash of the filters will be discharged to a settling tank. The sludge from the settling tank will be periodically transferred to a tank truck and transported to the 200 Areas for final disposal. A mobile ion exchange system, consisting of cation and anion columns of 350 gpm capacity, will be used to limit radioactivity in the storage basin water to acceptable radiation levels. Regeneration of the ion exchange columns will be performed at the treatment building. The pumps, heat exchangers, filters, and settling tank will be housed in a shielded concrete building of approximately 2500 ft^2.

V.3.2.1.4 Alternative 4

Alternative 4 is to provide both Alternative 2 and 3.

V.3.2.1.5 Alternative 5

Alternative 5 provides total treatment of all effluent streams by ion-exchange along with closed loop cooling of the fuel storage basin and reinjection of the rupture monitor bleed stream. This alternative requires construction of a radioactive effluent treatment facility which would treat all radioactive liquid effluents generated in N Reactor prior to discharge in the existing 1301-N Crib.

The treatment process would consist of filtration followed by three ion exchange columns in series (cation, anion, and mixed bed). Two parallel process lines would be provided for the high and low purity effluent streams. The treatment would be continuous with routine effluent discharges of 800 gpm of ~~which 400~~ gpm would be high purity and 400 gpm, low purity water. The treated water would be collected in 100,000-gal tanks and recycled back for N Reactor use or discharged into the 1301-N Crib. An upstream surge tank system of 1,000,000-gal capacity would be provided to collect effluents resulting from reactor upsets; fuel ruptures, graphite cooling, system dumps, etc. The ion exchange regeneration waste would be collected and concentrated with a 10 gpm evaporator. The concentrated waste would be transferred to railcars for final disposal in the Hanford 200 Area waste management facilities.

The treatment process would be housed in a new concrete building with about 24,000 ft^2 of floor space, first floor and basement. The concrete walls and floors would be utilized for shielding. A control room, laboratory, change rooms for men and women, lunchroom, and toilet facilities would be provided in the building. Automatic sprinklers, fire, radiation, and evacuation alarm systems would be installed in the new facility to comply with current ERDA standards.

N Crib could be moved further inland, thus moving the soil column containing the radionuclides further from the river. This could be done along with any of the effluent treatment alternatives listed above. Since this action would not reduce the quantity of radionuclides released to the ground, it was not included as an alternative.

V.3.2.1.6 Bases for Evaluation of Alternatives

The requirements to be met in releasing liquid waste to the environment are identified in the ERDA Manual Chapter ERDAM-0511, paragraph 044 - Operating Criteria. The specific sections involved in evaluating low-level liquid radioactive waste disposal practices are:

- Radioactive waste disposal practices shall assure that radiation exposures to individuals and population groups will be at the lowest levels technically and economically practical (ALATEP) not exceeding the exposure standards in ERDAM-0524.
- Radioactive waste disposal practices shall strive to reduce radioactivity releases to the ALATEP level.
- The extent and/or degree of land contamination shall be minimized.

- As soon as technically and economically practical, the use of natural soil-columns as disposal sites for streams that exceed established standards for release of radioactivity to uncontrolled areas (Table II, Annex A, ERDAM-0524) shall be replaced with other treatment.

- Diversion systems shall be provided for streams that normally meet Table II, Annex A, ERDAM-0524 Concentration Guides but have the potential for exceeding these values.

Also considered in the evaluation of the alternatives is the buildup of ^{90}Sr and ^{137}Cs in the soil column as recommended by the National Academy of Science in its 1966 report to the AEC.

In the cost-benefit analyses N Reactor is assumed to continue operations through 1990 (the design life of the reactor). The costs for an alternative case with N Reactor operating through 1983 are also provided.

V.3.2.1.7 Evaluation of Alternatives

Calculated impacts of the proposed alternatives are compared graphically in Figure V-2 dose to the public Figure V-3 radionuclide releases to the river, Figure V-4 radionuclide releases to the soil, and Figure V-5 soil inventory of radionuclides >66-hr half-life. Table V-8 compares the alternatives in respect to ERDAM-0511 criteria while Table V-9 summarizes the impact/merit of the proposed alternatives in respect to ERDAM-0511 and cost.

Continuing present operations would result in about a 55% increase through 1983 in the inventory of radionuclides held in the soil below the N Crib and Trench. Thereafter, the inventory would decay out and in about 300 years, the concentration of radioactivity in the soil below the crib would approach that for the average natural background, with the exception of the small amount of plutonium which now exists close to the soil surface. The estimated dose to the public from future operations of 0.023 man-rem/yr is expected to continue through 1990 at which time it would decrease. Erosion of the bank by flood waters should not release significant quantities of radionuclides since the maximum predicted flood for the next 300 years results in a flow of 1.44 million ft^3 with the transient water level 30 feet below the crib floor. Most of the radionuclides are held relatively close to the crib floor and only minor scouring of the river bank, approximately 800 feet from the crib is expected with the maximum predicted flood. The transient change in groundwater level below the crib during the maximum flood will not move sorbed radionuclides from the soil.

The second alternative, reinjection of rupture monitor bleed water, would result in about a 40% increase through 1983 in the soil inventory of radionuclides (reduction from Alternative 1 is primarily short-lived radioactivity and ^{60}Co). The whole body dose to the population is reduced 5% as a result primarily of a slight reduction in the radionuclides reaching the river. The cost of providing this capability is about $500,000.

The third alternative, closed loop cooling of the N fuel storage basin water, results in about a 40% reduction of an already low population dose rate (0.023 to 0.014 man-rem/yr). Also, the discharge of long-lived fission products (^{137}Cs, ^{90}Sr) to the soil would be reduced more than 90%. The inventory of radionuclides in the soil below the crib would be in a "net decay mode." Assuming the basin cooling facility can be installed in mid-CY-1978, the inventory of radionuclides would drop nearly 25% from that time to the end of the operating period in 1990. This results in about a 10-year reduction in the decay of the inventory in the soil (over the 300-yr period to approach background radioactivity). The cost of this alternative is $2,200,000 capital and $40,000 annual operating, for a total cost of about $2,700,000. On a dose reduction basis, this cost is equivalent to about $270,000,000 per man-rem. The alternative cannot be justified on a dose reduction basis (in WASH-1538 the recommended cost/benefit ratio is substantially less than $10,000 per man-rem reduction). However, the National Academy of Science recommended in 1966 that the AEC adopt a "net decay mode" for crib operations. In view of this recommendation and a 90% reduction in the discharge of long-lived fission products to the soil, this alternative is marginally justifiable.

The fourth alternative, which provides both rupture monitor bleed reinjection and N fuel storage basin closed loop cooling, results in about a 45% reduction of an already low population dose rate (0.023 to 0.013 man-rem per year). The discharge of long-lived fission products (^{90}Sr, ^{137}Cs) to the soil would be reduced more than 90% and ^{60}Co would be reduced more than 50%. The inventory of radionuclides in the soil below the crib would be in a net decay mode, decreasing nearly 40% from mid-CY-1978 to 1990. This results in more than a 15-yr reduction in the decay period (300 years) to background radioactivity in the soil (except plutonium); after the year 2010, the residual curies of radioactivity are essentially the same as for total cleanup of effluents attainable by ion-exchange (Alternative 5). The total cost of this alternative is $2,600,000 capital and $40,000 annual operating, for a total cost of about $3,000,000. This

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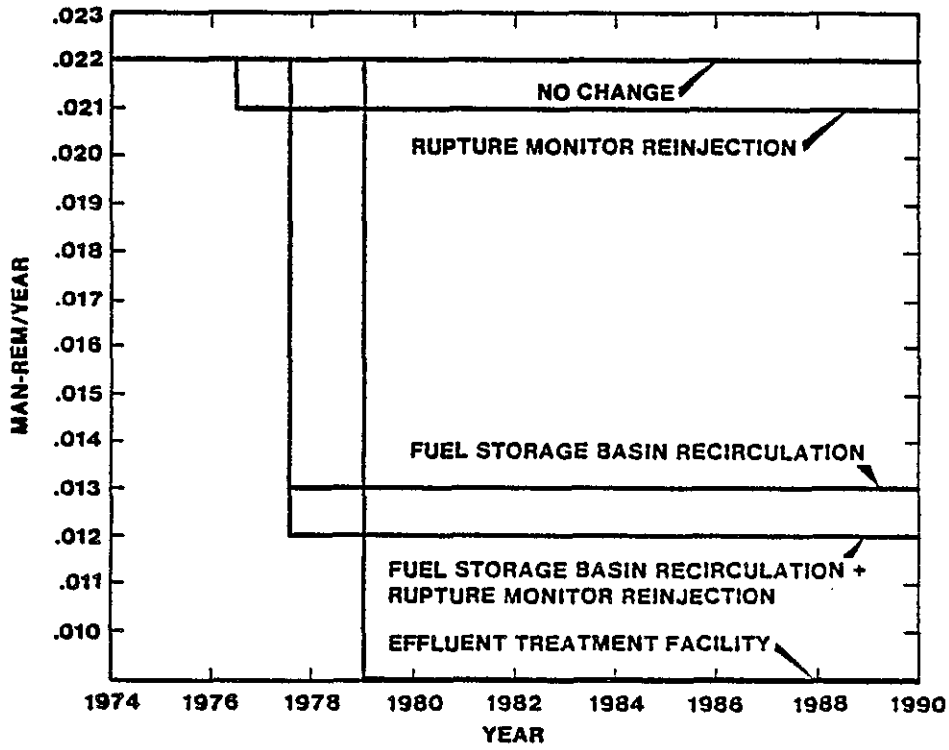

FIGURE V-2 ANNUAL WHOLE BODY DOSE TO PUBLIC FROM N REACTOR EFFLUENTS

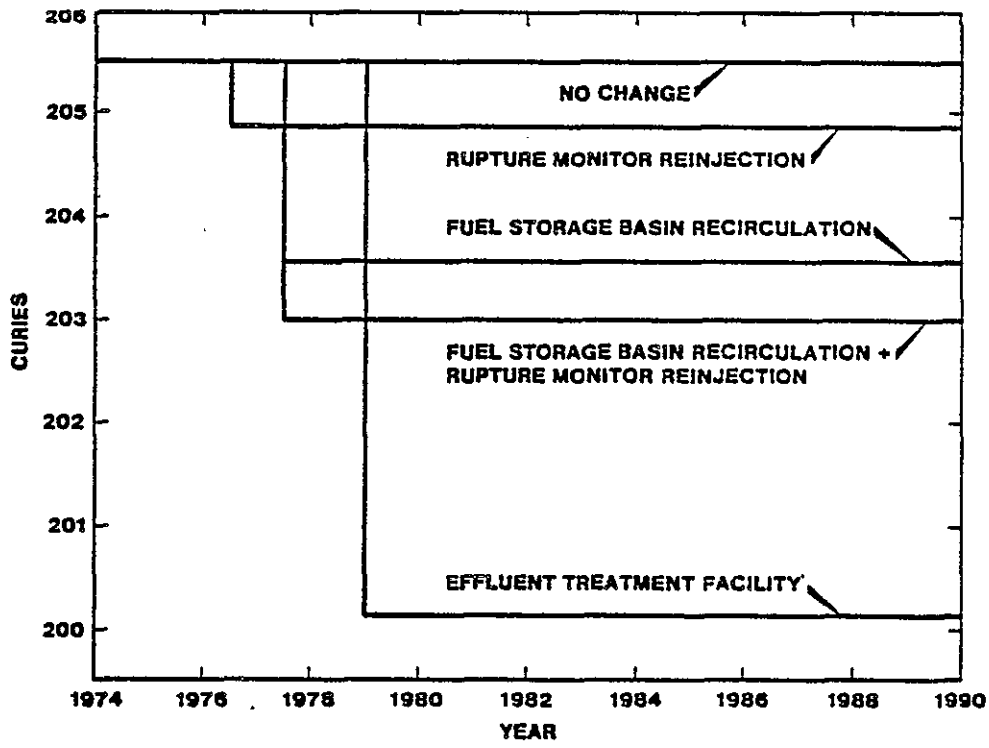

FIGURE V-3 RADIONUCLIDE (>66-hr HALF-LIFE) RELEASES TO THE RIVER FROM N REACTOR EFFLUENTS

TABLE V-8

EFFECTIVENESS OF ALTERNATIVES TO SATISFY REQUIREMENTS (100 AREAS)

ERDAM-0511 Requirement	Alternative 1	Alternative 2
0511-044a(1) ALATEP Personnel Exposures	No change. The annual whole body dose to the total population resulting from releases to the river is estimated to be 0.023 man-rem/yr. Approximately 45% of this dose is from ^{3}H. This compares to 27,000 man-rem/yr from natural background.	No change. Estimated 5% reduction to 0.022 man-rem/yr.
0511-044a(2) ALATEP Radioactivity Discharge	No reduction in radioactivity discharges occurs. An estimated 5400 Ci/yr of radionuclides with half lives greater than 66 hours will be discharged to crib through 1990.	Approximately 1000 Ci/yr reduction in shorter-lived radionuclides and 80 Ci/yr reduction in ^{60}Co (300 to 220).
0511-044a(4) Minimize the extent/degree of land contamination.	No additional land will be contaminated.	No additional land area will be contaminated.
0551-044c ASATEP - The use of soil columns for disposal of wastes with radiocontaminant concentrations greater than Table II, Annex A, ERDAM-0524 shall be replaced with other treatment.	The use of soil columns continues. The discharges to the crib exceed Table II, Annex A, ERDAM-0524 guides for uncontrolled areas. Crib inventory of radionuclides will increase from about 3300 Ci in 1974 to about 5500 Ci in 1990 and decay thereafter. ^{90}Sr and ^{137}Cs inventories would increase from 800 to 2000 Ci and ^{60}Co from 1300 to 2200 Ci in 1990.	The use of soil columns continues. The discharges to the crib would exceed Table II, Annex A, ERDAM-0524 guides for uncontrolled areas. Crib inventories will increase from about 3300 Ci in 1974 to about 5000 Ci in 1990 and decay thereafter. There would be no change in the inventory of ^{90}Sr and ^{137}Cs from Alternative 1, but the ^{60}Co inventory would increase to 1600 Ci (a reduction of 300 Ci) in 1990. About 1-yr reduction in decay time would be achieved over Alternative 1.
	Only ^{131}I concentration exceeds Table II, Annex A, ERDAM-0524 guides by about a factor of 5 at river bank springs. This area is now controlled, and control could be enhanced by rock cover to inhibit access to spring water prior to dilution with river water.	Only ^{131}I concentration exceeds Table II, Annex A, ERDAM-0524 guides by about a factor of 5 at river bank springs. This area is now controlled, and control could be enhanced by rock cover to inhibit access to spring water prior to dilution with river water.

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TABLE V-8 (Continued)

Alternative 3	Alternative 4	Alternative 5
Estimated 40% reduction to 0.014 man-rem/yr.	Estimated 45% reduction to 0.013 man-rem/yr.	Estimated 55% reduction to about 0.01 man-rem/yr.
Reduction in overall radioactivity discharged to the crib will be achieved, from 5400 to 3900 Ci. Discharge of long-lived ^{90}Sr and ^{137}Cs will be substantially reduced (110 Ci/yr to less than 10 Ci/yr), and ^{60}Co would be reduced about 70 Ci/yr (300 to 230).	Total discharges reduced from 5400 Ci/yr to 2800 Ci/yr with ^{90}Sr and ^{137}Cs reduced from 110 Ci/yr to substantially less than 10 Ci/yr and ^{60}Co from 300 to less than 150 Ci/yr.	Reduce radionuclide release to crib from about 5400 Ci/yr to about 300 Ci/yr; however, since Alternatives 3 and 4 significantly reduce the discharge of long-lived nuclides, little benefit from reduction of short-lived nuclides will be realized.
No additional land area will be contaminated.	No additional land area will be contaminated.	No additional land area will be contaminated.
The use of soil columns continues. The discharge to the crib would exceed Table II, Annex A, ERDAM-0524 for uncontrolled areas. Crib inventory of radionuclides will initially increase from 3300 Ci in 1974 to about 4000 Ci in 1978, then decrease to about 3100 Ci in 1990 and more sharply thereafter. The ^{90}Sr plus ^{137}Cs would increase initially but decrease about 20% after installation of facility to 1990. ^{60}Co would increase continuously about 24% (to 1700 Ci). About a 10-yr reduction in decay time would be achieved over Alternate 1.	The use of soil columns continues. The discharges would exceed Table II, Annex A, ERDAM-0524 guides for uncontrolled areas. Crib inventory would initially increase from 3300 Ci in 1974 to about 4000 Ci in 1978, then decrease to about 2500 Ci in 1990. The combined ^{60}Co, ^{90}Sr and ^{137}Cs inventories would increase initially but decrease about 20% after installation of facilities to 1990. About a 15-yr reduction in decay time over Alternative 1 would be gained.	The use of soil columns is terminated in 1980. Table II guides should be met at discharge to crib at that time. Crib inventory of radionuclides will initially increase from 3300 Ci in 1974 to about 4000 Ci in 1978 when Alternative 3 facilities are installed, then decrease to about 3300 Ci in 1979 when remaining Alternative 4 facilities are installed, then decrease to about 1300 Ci in 1990 and contine to decay thereafter. The ^{90}Sr and ^{137}Cs inventories would decrease about 20% after installation of facilities to 1990 and ^{60}Co would decrease 80% during the same time.
About a 10% reduction in ^{131}I would be achieved.	About a 10% reduction in ^{131}I would be achieved.	Table II guides would be met at river bank springs.

TABLE V-9

SUMMARY OF IMPACT/MERIT OF PROPOSED ALTERNATIVES (100 AREAS)

ERDAM-0511 Requirement	Alternative 1	Alternative 2
0511-044a(1) ALATEP Personnel Exposures	Very low population dose (0.023 man-rem/yr).	About a 5% reduction in the very low population dose (to 0.022 man-rem/yr).
0511-044a(2) ALATEP Radioactivity Discharge	No change.	Reduction of about 1000 Ci/yr of short-lived radionuclides and 80 Ci/yr ^{60}Co, with $600,000 capital cost.
0511-044a(4) Minimize the extent/degree of land contamination.	No change.	No change.
0551-044c ASATEP - The use of soil columns for disposal of wastes with radiocontaminant concentrations greater than Table II, Annex A, ERDAM-0524 shall be replaced with other treatment.	Use of crib treatment would continue with 2000 Ci inventory increase to 1983.	Use of crib treatment would continue with 1300 Ci inventory increase to 1990. Thereafter decay is same as Alternative 1.
	Table II guides exceeded for ^{131}I at river springs.	No change over Alternative 1.
CONCLUSION		Not economically justifiable for small reduction in short-lived radionuclide discharge.

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TABLE V-9 (Continued)

Alternative 3	Alternative 4	Alternative 5
About a 40% reduction in the very low population dose (to 0.014 man-rem/yr).	About a 45% reduction in the very low population dose (to 0.013 man-rem/yr).	About a 55% reduction in the very low population dose (to 0.01 man-rem/yr).
Reduction of about 1300 Ci/yr of short-lived radionuclides, 70 Ci/yr ^{60}Co, and >100 Ci/yr of ^{90}Sr plus ^{137}Cs with $2.2 million capital and $40 thousand annual operating costs.	Reduction of about 2300 Ci/yr of short-lived radionuclides, 150 Ci ^{60}Co, and >100 Ci ^{90}Sr plus ^{137}Cs with $2.8 million capital and $40 thousand annual operating costs.	Reduction of 4500 Ci/yr of short-lived radionuclides, 300 Ci/yr ^{60}Co, and >100 Ci ^{90}Sr plus ^{137}Cs with $22 million capital and $600 thousand annual operating costs.
No change.	No change.	No change.
Use of crib treatment would continue with 1000 Ci inventory decrease after facility installed in 1978 to end of operation in 1990. Equivalent to a 10-yr decay period reduction over Alternative 1.	Use of crib treatment would continue with 2600 Ci inventory decrease after facilities installed in 1978 to end of operations. Equivalent to a 15-yr decay period reduction over Alternative 1.	Use of crib treatment discontinued after 1979 with 3000 Ci inventory decrease after facilities are installed to end of operations. Equivalent to a 20-yr decay period reduction over Alternative 1.
About a 10% reduction in ^{131}I over Alternative 1.	About a 10% reduction in ^{131}I over Alternative 1.	Will meet Table II guides at springs.
Marginally economically justifiable on basis of reduction in discharge of long-lived radionuclides and reduction of 10-yr decay period but not on exposure reduction basis.	Possibly economically justifiable on basis of reduction in discharge of long-lived radionuclides and 15-yr reduction in decay period but not on exposure reduction basis.	Use of soil column treatment eliminated but at high cost. Cannot justify benefits on an economic basis over Alternative 1.

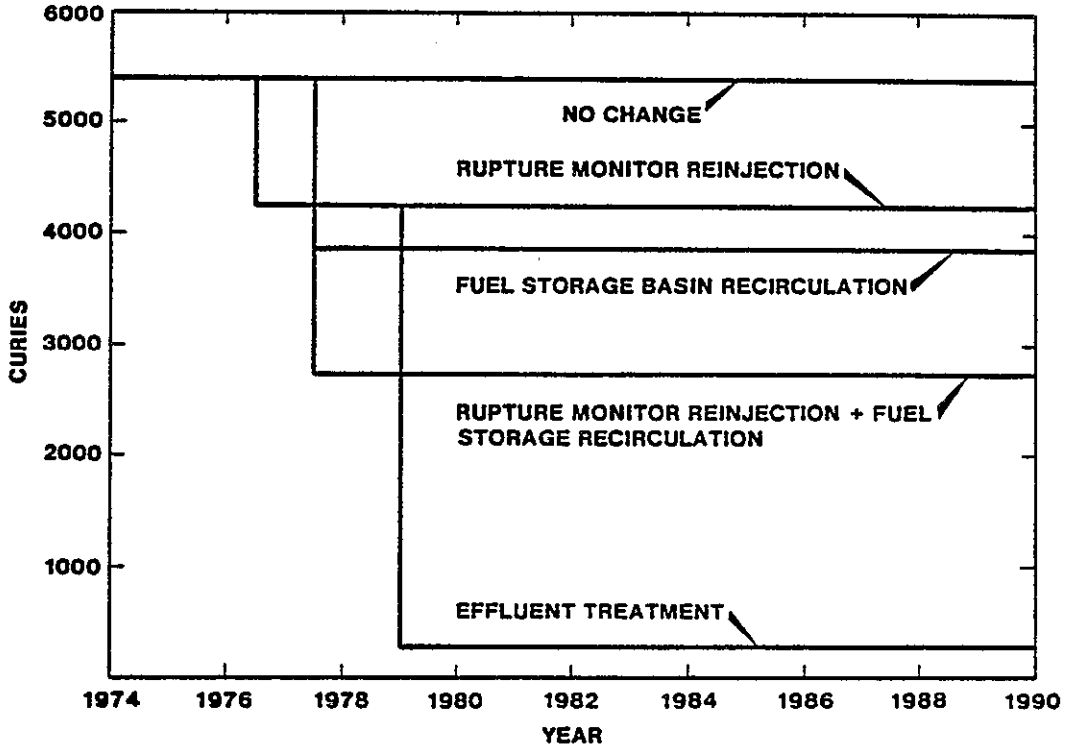

FIGURE V-4 RADIONUCLIDE (>66-hr HALF-LIFE) RELEASES TO THE SOIL

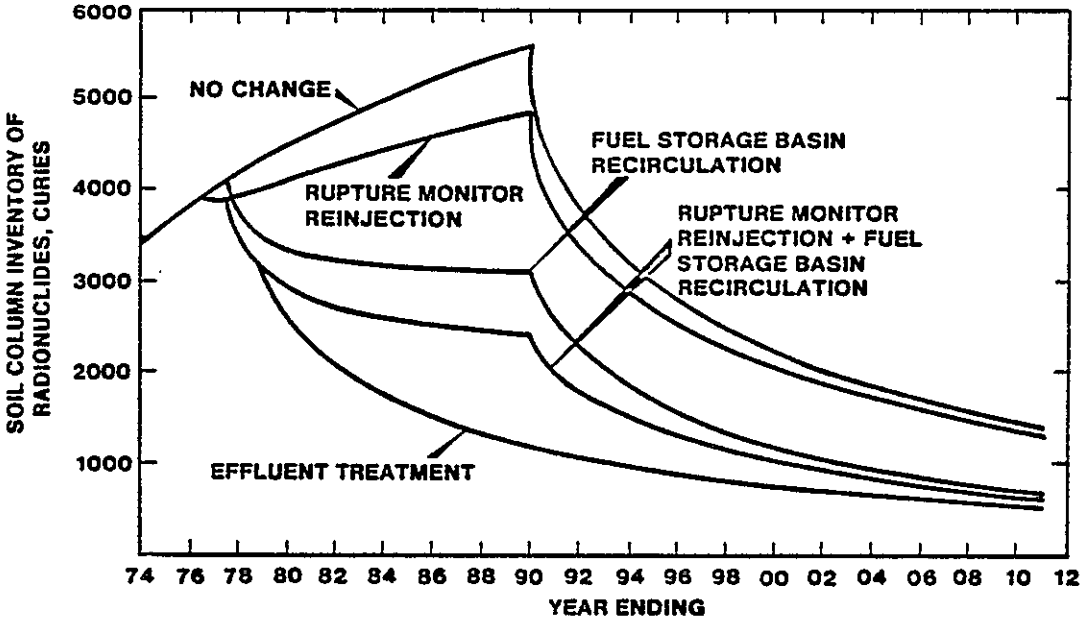

FIGURE V-5 INVENTORY OF RADIONUCLIDES (>66 hr HALF-LIFE) IN SOIL BENEATH CRIB (PROJECTED)

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alternative also cannot be justified on a basis of reducing the dose to the public but possibly can be justified on reducing the soil inventory of radionuclides and attaining a net decay mode of operation.

The fifth alternative would treat all liquid effluents by ion-exchange to meet Table II, Annex A, ERDAM-0524 concentration guides in addition to providing the facilities described in Alternatives 2 and 3. The dose rate to the population would be reduced about 55% from an already low population dose rate (0.023 to 0.01 man-rem per year). A reduction of about 99% in release of long-lived fission products (^{90}Sr, ^{137}Cs), as well as ^{60}Co, over the present operating mode would be achieved. The inventory of radionuclides in the soil would be reduced nearly 60% beginning after 1978 to the end of the operating period (1990). This results in about an additional 4-yr reduction in the decay of the inventory over Alternative 4 in the year 2000, but after a few additional years of decay, the residual radionuclide inventory in the soil is essentially identical for Alternatives 4 and 5. The cost for this option is about $22,000,000 capital and $600,000 annual operating for a total cost of nearly $30,000,000 through 1990. The cost appears excessive for the small gain in benefit over Alternative 4.

The relocation of N Crib and Trench further inland would result in the contamination of additional soil although at a very low level. This would not detectably reduce the population dose rate and would not change the total radionuclide inventory in the soil. It would place the radionuclides further from the Columbia River. The amount of radionuclides which would be deposited in the soil for decay further from the river would range between about 75% of the total for Alternative 1 (no change in effluent cleanup) to about 50% for Alternative 4 and less than 5% for Alternative 5 in the year 1990. For Alternatives 4 and 5 most of the radionuclides that would be deposited further from the river are relatively short-lived and after about the year 2000, more than 95% of the inventory would be located below the present crib and trench. Little incentive exists for moving the discharge point if Alternatives 3, 4 or 5 are adopted, but the move may be justificable if Alternatives 1 and 2 are adopted. The cost of relocation is expected to be about $500,000 to $1,000,000.

V.3.2.2 200 Areas

The four alternatives to treatment of water discharge streams containing radionuclides from the 200 Area facilities are given in Table V-10 along with the curies discharged, the cost estimate and the installation time for each alternative.

V.3.2.2.1 Alternative 1

Alternative 1 is the continuation of present operations with improvements, as shown in Table V-5.

The liquid waste streams currently released to the ground which exceed Table II, Annex A, ERDAM-0524 concentration guides are:

- AY, AZ Tank Farm Process Condensate
- 242-T Waste Evaporator Process Condensate
- B Plant Process and Steam Condensate
- Purex Ammonia Scrubber and Process and Steam Condensate

The AY, AZ Tank Farm waste stream will be routed to 242-A Evaporator-Crystallizer when that new facility is brought into operation in mid-CY-1976. The 242-T Waste Evaporator discharge will also cease at that time since the 242-T Evaporator will be shut down when the 242-A Evaporator-Crystallizer is brought on line. The radioactivity expected to be discharged annually from the remaining waste streams is shown in Table V-11. Current practice is to discharge these streams to existing crib sites; use of a specific crib site is discontinued when long-lived radionuclides (^{90}Sr, ^{137}Cs) are detected in the groundwater at these crib sites.

At the end of 1974 approximately 7000 curies total radionuclides are in the soil below the active cribs. All the cribs are now in a net decay mode except the cribs serving the B Plant discharges. These cribs have an inventory of less than 100 curies. The inventory is increasing about 20% per year through 1979 and less than 10% per year thereafter. Table V-12 provides an approximate (±30%) inventory of radionuclides in the soil at these active crib sites.

TABLE V-10

200 AREAS RADIOACTIVE WASTE DISCHARGE TREATMENT ALTERNATIVES

Alternatives	Average Radioactive Discharges Ci/yr			Costs, FY-77 $		Installation Time, Months After Funding
	^{90}Sr + ^{137}Cs	Tritium	Total	Capital	Annual Operating	
1. Continue present operations.						
B Plant	7	7	40	-	-	-
Purex	<0.2	12,000	12,000	-	-	-
2. Evaporate the B Plant process and/or steam condensate discharge streams by routing these streams to the 242-A and/or 242-S Evaporators.						
B Plant	<0.1	7	7	1,000,000 to 1,500,000	1,000,000	24
Purex	<0.2	12,000	12,000			
3. Evaporate Purex ammonia scrubber and/or process condensate discharge streams by routing these streams to 242-A and/or 242-S Evaporators. The two existing evaporators do not have the capacity to evaporate the remaining Purex discharge stream.						
B Plant	7	7	40	500,000 to 750,000	600,000	24
Purex	<0.1	12,000	12,000			
4. Evaporate all discharge streams by routing them to a new central evaporator facility.						
B Plant	<0.1	7	7	30,000,000 to 35,000,000	3,000,000	36
Purex	<0.2	12,000	12,000			

TABLE V-11

AVERAGE ANNUAL RADIONUCLIDE DISCHARGES - 200 AREAS (POST 1976)

Facility Stream	Total	^{3}H	^{90}Sr	^{137}Cs
B Plant Process Condensate	40	7	<3	<4
B Plant Steam Condensate	<1	<0.1	<0.1	<0.1
Purex Steam Condensate	5	<0.1	<0.3	<0.3
Purex Ammonia Scrubber	<190	<150	<0.1	<0.05
Purex Process Condensate	12,000[a]	12,000	<0.01	<0.02

(a) Total discharged other than tritium is less than 5 Ci/yr.
Note: "<" reflects the limit of analytical detection.

V.3.2.2.2 Alternative 2

Alternative 2 provides for evaporation of the B Plant discharge streams by routing these streams to the 242-A and/or 242-S Evaporators. The two evaporators do not have sufficient capacity to evaporate the remaining two Purex discharge streams.

The flow scheme to the evaporator and to the waste disposal sites is detailed in Figure V-6. The concentrations of the major radionuclides of concern and the relationship between the discharge concentrations and the guide discharge limits from ERDAM-0511 as related to ERDAM-0524 Table 2 for release to uncontrolled areas are given in Table V-13.

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TABLE V-12

B PLANT AND PUREX ACTIVE CRIB DECAYED INVENTORIES (12/31/74)

Crib	Inventory, Curies		
	Total Beta	^{90}Sr	^{137}Cs
216-B-55 - B Plant Steam Condensate	<65	10	20
216-B-62 - B Plant Process Condensate	<25	5	5
216-A-10 - Purex Proc. Condensate	2300	120	120
216-A-30 - Purex Steam Condensate	660	150	170
216-A-36B - Ammonia Scrubber	4000	490	500

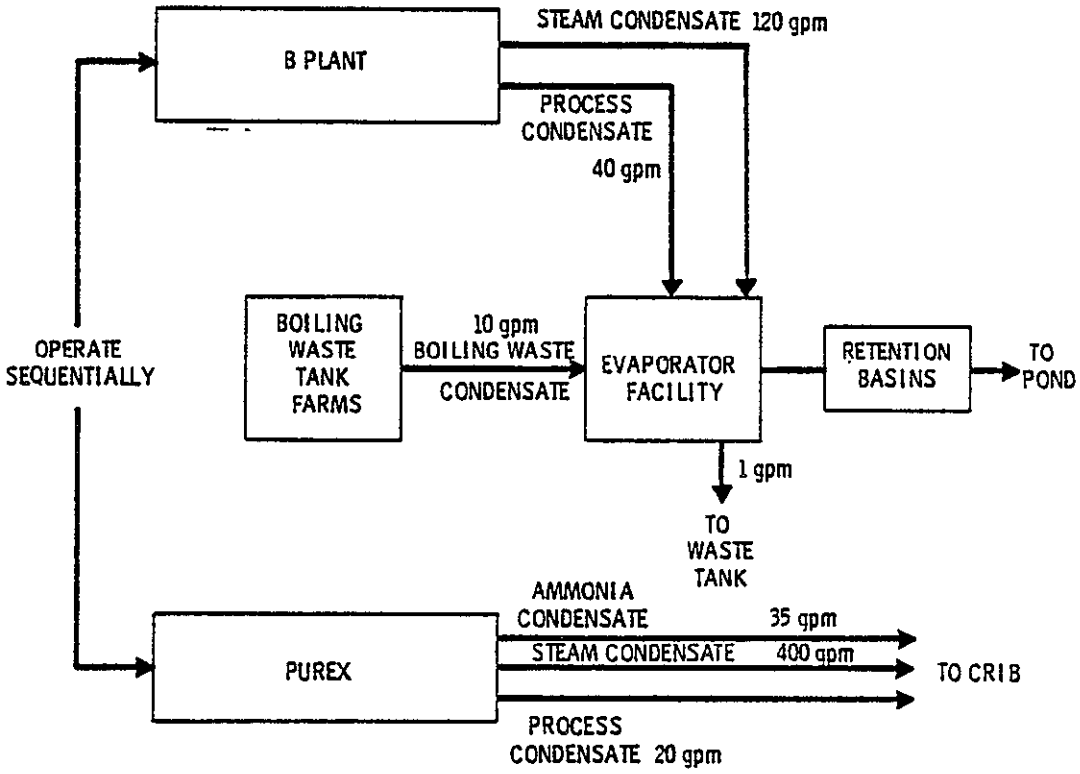

FIGURE V-6 EFFLUENT TREATMENT, ALTERNATIVE 2

This alternative could be operational about 2 years after funding is authorized. There would be no reduction in the essentially zero population dose ($\sim 1 \times 10^{-6}$ man-rem/yr) resulting from the discharge of liquid waste to ponds and cribs.

V.3.2.2.3 Alternative 3

Alternative 3 provides for evaporation of the Purex ammonia scrubber and/or process condensate discharge streams by routing these streams to an existing evaporator. The existing evaporators do not have the capacity to also evaporate the remaining Purex and B Plant discharge streams. This alternative could be operational about 2 years after funding is authorized. Implementation of this alternative would not reduce the essentially zero population dose ($\sim 1 \times 10^{-6}$ man-rem/yr) resulting from the discharge of liquid waste to ponds and cribs.

TABLE V-13

PRESENT RELEASES TO CRIBS UNDER CURRENTLY FUNDED PROGRAM

Stream		Flow Rate (gpm)	Radio-nuclide	Normal Conditions Concentration (μCi/ml)	Normal Conditions Factor of Guide[7]
Purex					
	Process Condensate	20	^{90}Sr	1×10^{-7}	<1
	Steam Condensate	400	^{90}Sr	2×10^{-6}	7
	NH_3 Condensate	35	^{90}Sr	5×10^{-6}	17
B Plant					
	Process Condensate	40	^{90}Sr	4×10^{-4}	1300
	Steam Condensate	120	^{90}Sr	1×10^{-5}	30
Tank Farms					
	242-S Process Condensate	40	^{106}Ru	1×10^{-6}	<0.1
	242-A Process Condensate	40	^{106}Ru	1×10^{-6}	<0.1
	241-A-AX-AY-AZ Process Condensate	10	^{90}Sr	1×10^{-7}	<1

V.3.2.2.4 Alternative 4

Alternative 4 provides evaporation of all discharge streams by routing them to a new central evaporator facility.

This alternative requires additional equipment, facilities, and modifications to reduce the amount of radioactive releases to cribs and ponds from the Hanford 200 Area operations by providing capability to monitor, control, or treat all process waste streams and by providing additional contamination confinement barriers. Radioactivity content of effluents would be reduced to below the guidelines of ERDAM-0524 for releases to uncontrolled areas.

This alternative would include:

- a multiple-effect evaporator sized for a 500 gallon-per-minute (gpm) boil-off for streams which are potentially acidic
- a multiple-effect evaporator sized for 75 gpm boil-off for streams containing dissolved ammonia
- an evaporator building to house all of the components of the evaporator system and to provide personnel and support facilities
- a 150,000-pound-per-hour addition to the existing 400,000-pound-per-hour steam plant
- a 16,000 gpm cooling tower with basin and circulating pumps
- three 1,000,000-gal, three 60,000-gal, nine 500,000-gal, three 200,000-gal, and six 100,000-gal retention basins for control, monitoring, and sampling of process streams before discharge to surface disposal
- closed circuit secondary cooling systems
- contamination confinement barriers
- a low-level laboratory for radiochemistry analysis of process streams
- a central control system for complete supervision of all operations.

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This project would 1) reduce the amount of radioactivity released to cribs and ponds from the 200 East and 200 West Area processes, 2) increase capability for monitoring effluents, 3) provide for early warning of increases in radioactivity in the effluents, 4) increase the number of barriers between the process material and the environment, and 5) generally strengthen control of process confinement systems. The proposed facilities, integrated with improvements funded in prior years, would provide capability to process, monitor, control, and dispose of process liquid streams which 1) routinely exceed disposal limits, 2) have a high risk potential of exceeding disposal limits, or 3) have a low but credible risk potential of exceeding disposal limits. Additional contamination barriers would be provided to protect the environment from radioactivity during both normal operations and maintenance activities. The low-level laboratory would provide the capacity required to conduct the extensive sampling and monitoring programs essential to total control of low-level radioactivity releases. At least 30 acres of new land would be required for the facilities. The flow scheme for this effluent treatment plan and the waste disposal sites is detailed in Figure V-7.

Adoption of this alternative would limit yearly releases to soil columns (for Purex processing 900 ton/yr of N Reactor fuel) to essentially zero for both plutonium and fission products. The concentrations of all effluent streams would be below ERDAM-0524 Table II limits for release to uncontrolled areas. The population dose of about 1×10^{-6} man-rem/yr would be reduced.

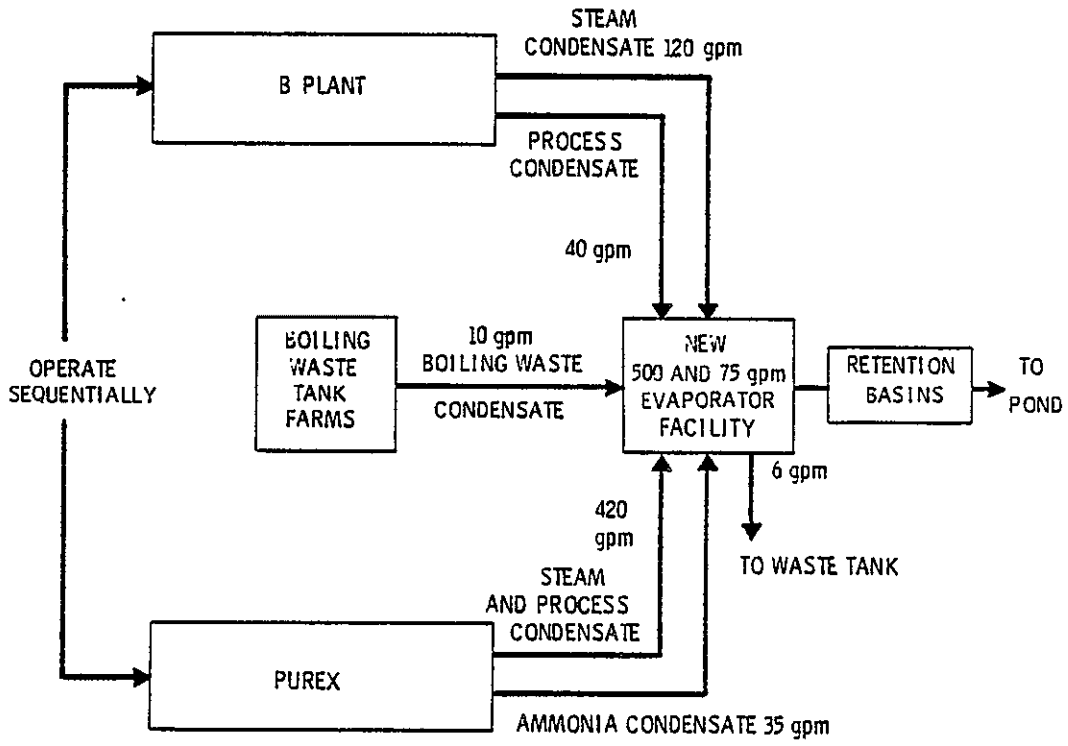

FIGURE V-7 EFFLUENT TREATMENT, ALTERNATIVE 4

V.3.2.2.5 Evaluation of Alternatives

The evaluation bases are the same as listed for the N effluent treatment alternatives in the preceding section.

Table V-14 compares the alternatives in respect to ERDAM-0511 criteria. Table V-15 summarizes the impact/merit of the proposed alternatives in respect to 0511 and cost. Figure V-8 shows the gross soil inventory of radionuclides at Purex and B Plant cribs for the four alternatives as a function of time. Figure V-9 shows the incremental soil inventory for the four alternatives.

TABLE V-14

EFFECTIVENESS OF ALTERNATIVES TO SATISFY REQUIREMENTS (200 AREAS)

ERDAM-0511 Requirement	Alternative 1	Alternative 2
044a(1) ALATEP personnel exposures	No change. Current assessments do not quantify an exposure dose to personnel due to liquid waste discharges to soil columns from 200 Area operations.	No measurable change. Current assessments do not quantify an exposure dose to personnel due to liquid waste discharges to soil columns from 200 Area operations.
044a(2) ALATEP radioactivity discharge	No reduction in radioactivity discharges occurs. An estimated 2000 curies of total beta activity plus tritium will be discharged to cribs by these waste streams through 1992. (Assumes N Reactor operates through FY-1990).	A reduction of about 500 curies of radioactivity discharged to cribs would be achieved.
044a(4) Minimize the extent/degree of land contamination.	If the existing crib sites continue to be usable, no additional land contamination will occur. The continued discharge of tens of curies per year to these crib sites will add approximately 1-1/2 years to their decay time (relative to the decay history associated with Alternatives 2 or 3 over a 500-yr period).	If the existing crib sites continue to be usable, no additional land contamination will occur. A small decrease in the extent of land contamination will also result. Approximately 2 years reduction in decay time of the involved cribs will be achieved relative to the decay time for Alternative 1.
044c ASATEP the use of soil columns for disposal of wastes with radiocontaminant concentrations greater than Table II, Annex A, ERDAM-0524 shall be replaced with other treatment.	The use of soil columns as treatment sites continues for all B Plant and Purex waste. The overall inventory of radioactivity in active cribs will decrease about 4400 curies to 1992, but the B Plant crib inventory will increase 200 curies during this time period.	The use of soil columns as treatment sites for Purex steam and process condensates (at concentrations exceeding Table II, Annex A, ERDAM-0524 guides) continues. The overall inventory of radionuclides in active cribs decreases about 4600 curies by 1992 and the B Plant crib inventory after 1979 will decrease about 170 curies by 1992.

Current environmental monitoring programs do not show radiocontaminant concentrations (except tritium) greater than Table II, Annex A, ERDAM-0524 in water systems interfacing with 200 Area cribbed waste. This will not be changed with Alternatives 2, 3 or 4. The same quantity of tritium (210,000 Ci) will be released with all four alternatives with groundwater immediately below the disposal crib being contaminated with tritium to above Table II guides. No uncontrolled access to the groundwater will occur as long as the tritium concentration exceeds Table II guides.

9 1 1 1 8 9 1 0 7 5 7

TABLE V-14 (Continued)

Alternative 3	Alternative 4
No measurable change. Current assessments do not quantify an exposure dose to personnel due to liquid waste discharges to soil columns from 200 Area operations.	No measurable change. Current assessments do not quantify an exposure dose to personnel due to liquid waste discharges to soil columns from 200 Area operations.
A reduction of about 400 curies of radioactivity discharged to cribs would be achieved.	A reduction of about 1000 curies of radioactivity discharged to cribs would be achieved.
If the existing crib sites continue to be usable, no additional land contamination will occur. In addition, a small decrease in the extent of land contamination will also result. Approximately the same decay time for all cribs as Alternative 1.	A new crib required for the new evaporator will result in very low contamination of this additional land area. No change in decay time for the cribs over Alternative 2 and approximately a 2-yr reduction in decay time over Alternatives 1 and 3.
The use of soil columns as treatment sites for Purex steam and process condensates (at concentrations exceeding Table II, Annex A, ERDAM-0524 guides) continues. The overall inventory of radionuclides in active cribs decreases about the same as Alternative 1 (4400 Ci) by 1992 and the B Plant crib inventory also increases 200 curies.	The use of soil columns as treatment sites for 200 Area liquid waste (at concentrations exceeding Table II, Annex A, ERDAM-0524) ceases. The overall inventory in active cribs decreases about 4600 Ci by 1992 and the B Plant Crib inventory after 1979 will decrease about 200 Ci by 1992. The inventory in the B Plant and Purex cribs will be about the same as Alternative 2.

Current environmental monitoring programs do not show radiocontaminant concentrations (except tritium) greater than Table II, Annex A, ERDAM-0524 in water systems interfacing with 200 Area cribbed waste. This will not be changed with Alternatives 2, 3 or 4. The same quantity of tritium (210,000 Ci) will be released with all four alternatives with groundwater immediately below the disposal crib being contaminated with tritium to above Table II guides. No uncontrolled access to the groundwater will occur as long as the tritium concentration exceeds Table II guides.

TABLE V-15

SUMMARY OF IMPACT/MERIT OF PROPOSED ALTERNATIVES (200 AREAS)

ERDAM-0511 Requirement	Alternative 1	Alternative 2
044a(1) ALATEP personnel exposures	No effect; no current indication of exposure.	No effect; no current indication of exposure.
044a(2) ALATEP Radioactivity discharge	No positive action, therefore no reduction.	About a 500-Ci discharge reduction at $1.0 million capital and $1.0 million annual operating costs.
044a(4) Minimize the extent/degree of land contamination	No positive action.	Small reduction in degree of contamination.
044c ASATEP the use of soil columns for disposal of wastes with radiocontaminant concentrations greater than Table II, Annex A, ERDAM-0524 shall be replaced with other treatment.	No positive action; continue current practice.	All except two plant discharge streams would meet Table II, Annex A, ERDAM-0524 guides.
Conclusion		Not economically justifiable for benefit of a 1 1/2-yr overall decay period.

TABLE V-15 (Continued)

Alternative 3	Alternative 4
No effect; no current indication of exposure.	No effect; no current indication of exposure.
About a 400-Ci discharge reduction of short-lived radionuclides at $500,000 to $750,000 capital and $600,000 annual operating costs.	About a 1000-Ci discharge reduction at $30 to 35 million capital and about $3 million annual operating costs.
No positive action.	Small area increase of very low contamination.
Three plant discharge streams would not meet Table II, Annex A, ERDAM-0524 guides.	All plant discharges would meet Table II, Annex A, ERDAM-0524 guides.
Clearly not economically justifiable since benefits are not significant over Alternative 1 but costs are about the same as Alternative 2.	Clearly not economically justifiable since benefits are in effect the same as Alternative 2 and costs are more than a factor of 4 greater.

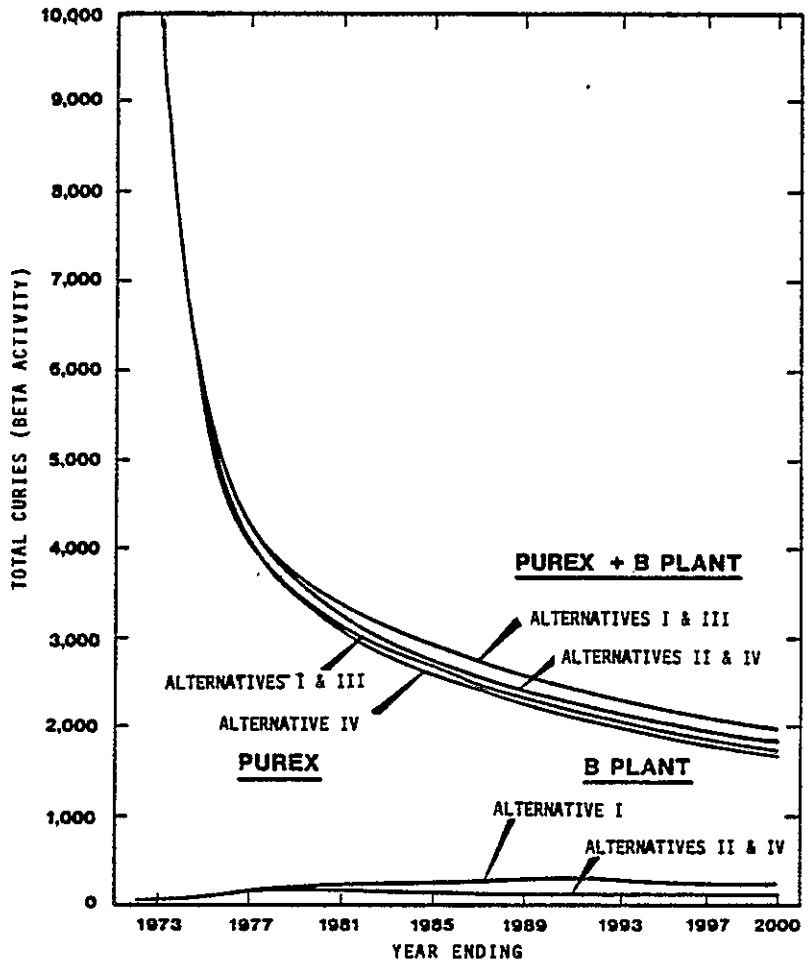

FIGURE V-8 INVENTORY OF RADIONUCLIDES IN SOIL COLUMNS IN ACTIVE 200 AREA CRIBS

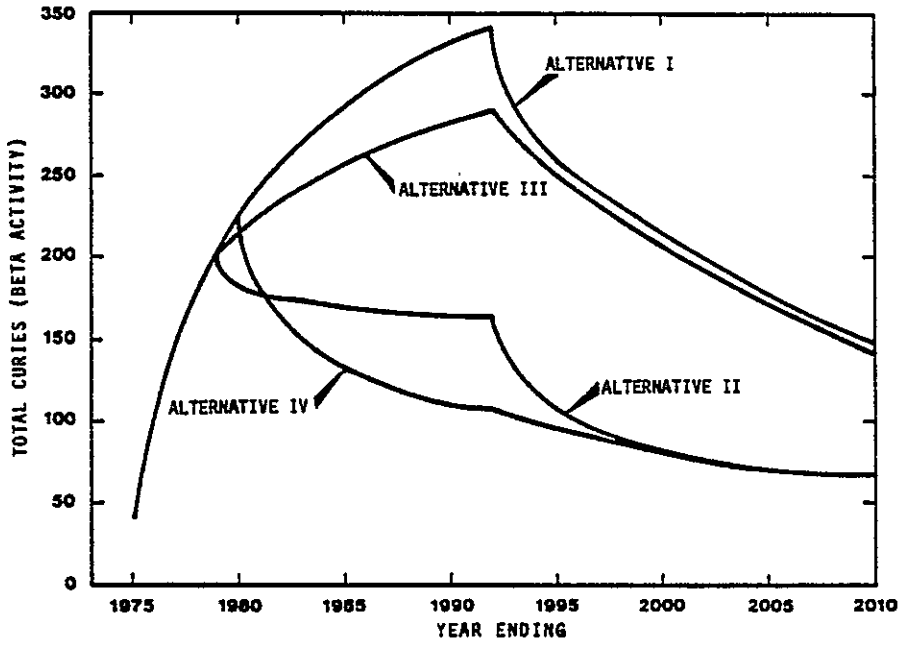

FIGURE V-9 INCREMENTAL SOIL COLUMN INVENTORY IN ACTIVE 200 AREA CRIBS

9 1 1 1 8 9 1 0 7 6 1

Continuing present operations at Purex would result in more than a 65% decrease in the soil radionuclide inventory (from about 7000 curies to about 2200 curies) at its active cribs through 1992 (last year of operation if N Reactor continues to 1990). Two of the three active cribs would decay to about natural background in about 200 years and the third in about 500 years. Continuing present operation at B Plant would result in about a 300% increase in soil radionuclide inventory at those two active crib sites through 1992 (from about 100 curies to about 300 curies). This inventory would decay to about natural background in approximately 100 years. No measurable radiation exposure to the general population results from these discharges.

Alternative 2 would result in a net decay of the inventory at the B Plant cribs beginning in 1979. The reduction in B Plant crib inventory from 1979 to 1992 is over 30% and over a 50% reduction in the inventory over Alternative 1 in 1992. The decay period required for the radioactivity to approach background would be reduced nearly 15%. However, the active B Plant crib cannot be isolated from other existing cribs (Purex, etc.). Thus, reducing the decay period of the B Plant cribs 15% has no overall benefit since some surveillance and land control of the area will need to be continued to a later time when radioactivity in other cribs has decayed out.

Figure 9 shows the soil inventory of radionuclides considering only the incremental discharge of radionuclides after CY-1974. Alternative 2 provides a 70% reduction of additional radionuclide inventory in the soil by 1992. The incremental radionuclide inventory in the soil is about the same as Alternative 4. The incremental costs for Alternative 2 are about $1,000,000 to $1,500,000 capital and $800,000 annual operating cost for a total cost of $10,000,000 to $11,000,000. The total cost through 1984 would be $5,000,000 to $6,000,000 (N Reactor operating through 1982).

Alternative 3 shows no significant improvement in soil radionuclide inventory over Alternative 1 since the radionuclides expected to be discharged from Purex are all relatively short-lived except tritium (for which no removal process exists). Considering only the incremental radionuclide discharges after 1974, the soil inventory is essentially identical to Alternative 1 after the year 2000. The incremental costs for Alternative 3 are about $500,000 to $750,000 capital and up to $600,000 annual operating cost for a total cost of $7,000,000 to $8,000,000. The total cost through 1984 would be $3,500,000 to 4,500,000.

Alternative 4 would result in about the same reduction in the inventory of radionuclides at B Plant and Purex cribs as Alternative 2 but at a greater cost. The costs for Alternative 4 are $30,000,000 to $35,000,000 capital and $3,000,000 annual operating for a total of about $70,000,000 to $75,000,000 through 1992. The total costs through 1984 are $45,000,000 to $50,000,000.

V.4 GASEOUS EFFLUENTS

V.4.1 Current Program

Gaseous radioactive waste is released to the air at four general locations on the Hanford Reservation, as summarized in Table V-16. In that table, each of the production areas on the Reservation is considered a single source since each of those areas is far enough from the closest residents that the radioactive gases from the numerous sources in an area are mixed enough to be treated as a single source by the time they reach nearby residents. This approach was used during the calculations of the radiation doses. The current treatment facility design and the remoteness of the facilities result in the low radiation doses shown in Table V-16; a maximum of 1.4 man-rem/yr results from N Reactor operations.

Most gaseous waste is treated by passing through one or more HEPA filters. No treatment or delay equipment is used for gaseous waste such as tritium, argon, krypton and similar gases. Iodine may be collected on silver reactors to avoid direct release to the atmosphere.

No sealed containers on the site are used for storing radioactive waste gases either as gases or liquids. The only storage locations for significant quantities of gaseous waste are the charcoal filters in the ventilation systems of the N Reactor. These filters separate iodine and noble gases and retain them long enough to obtain a significant amount of radioactive decay.

The objective of the current program is the reduction of radioactive material release in gaseous effluents to the lowest technically and economically practical levels. Table V-17 summarizes the programs planned and budgeted through FY-1975; a summary description of each of these programs is provided in Table V-18.

TABLE V-16

GASEOUS RADIOACTIVE WASTE RELEASED TO THE AIR

Location	Composition	Quantity/yr	Impact
105-N Ventilation	^{41}Ar, ^{3}H, ^{131}I, ^{133}I	100,000 Ci	1.4 man-rem/yr
144-F Ventilation Stack	^{239}Pu, ^{90}Sr	<5 μCi	$<10^{-3}$ man-rem/yr
200 Areas	Pu, U, f.p.[a]	1.1 Ci	$<10^{-2}$ man-rem/yr
	^{85}Kr	4×10^{5} Ci	$<10^{-1}$ man-rem/yr
300 Area	Th, U, Pu, f.p.	<0.02 Ci	$<10^{-4}$ man-rem/yr

(a) Excluding tritium

TABLE V-17

GASEOUS WASTE MANAGEMENT FACILITIES AND ACTIVITIES
PLANNED AND UNDER CONSTRUCTION FY-1973 THROUGH FY-1975

100 AREAS	
N Reactor Ventilation Loop Seal Improvement	$ 325,000
200 AREAS	
Waste Management Effluent Control	2,875,000
B Plant Vent System Ventilation Improvements	475,000
242-T Evaporator Effluent Improvements	200,000
222-S Laboratory Exhaust Ventilation Improvements	485,000
300 AREA	
325 Building Laboratory Ventilations Exhaust Addition	485,000
Total	~$4,800,000

TABLE V-18

DESCRIPTION OF GASEOUS WASTE MANAGEMENT FACILITIES AND ACTIVITIES
PLANNED AND UNDER CONSTRUCTION FY-1973 THROUGH FY-1975

100 AREA

N Reactor Ventilation Loop Seal Improvement $325,000

A redundant confinement valving system will be installed in the N Reactor building ventilation system to provide positive reliable secondary closures in the vent openings and thus assure containment of vapors and gases which would only be generated under unlikely conditions.

200 AREAS

Waste Management Effluent Control $2,875,000

Facilities will be provided to maintain and to extend protection against the accidental release of radioactivity in certain effluent streams from the Waste Fractionization Facility (B Plant) and the Chemical Processing Facility (Purex Plant). The facilities include: 1) a replacement ventilation filter for B Plant, including an underground concrete filter cell equipped with replaceable prefilters and two stages of HEPA filter banks and a corrugated metal instrument building above the cell; 2) improvements, including prefilters and HEPA filters for treating ventilation air from the sample gallery, and the organic treatment and acid fractionization cells of the Purex Plant; and 3) replacement of Purex canyon ventilation air filter design for a flow rate of 125,000 ft^3/min and consisting of a prefilter and secondary HEPA filters in a concrete cell with a corrugated metal instrument building above the cell.

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TABLE V-18 (Continued)

200 AREAS (Continued)

B Plant Vent System Ventilation Improvements $475,000

This project will provide 1) new ventilation exhaust fans and single-stage, HEPA filters for the ventilation exhaust from the B Plant operating, pipe and electrical galleries and 2) sampling facilities for the filtered vessel vent exhaust. These additions will reduce the potential risk of releasing radioactive materials from the operating areas to the environment. The vessel vent exhaust sampling system will provide for detecting filter failure. The gallery ventilation filters will protect the environment from potential release of contamination from the operating areas.

242-T Evaporator Effluent Improvements $200,000

In order to reduce the risk of releasing radioactive materials to the environment, the project provides the 242-T Building process cells (feed, evaporator, and condensate) with filtered supply and exhaust ventilation systems consisting of 1) supply air: preheater, two stages of roughing filters, and ductwork, and associated service piping, instrumentation and controls; and 2) exhaust air: preheater, prefilter, parallel two-stage, HEPA filters, parallel exhaust fans, stack, ductwork and associated service piping, instrumentation and controls.

222-S Laboratory Exhaust Ventilation Improvements $485,000

A new bank of HEPA filters will be installed in a new enclosure to further protect the environment by providing additional filtration of the exhaust air ventilation from contaminated and potentially contaminated zones of the 222-S Laboratory Building. New ductwork, fans, stack and accessories will also be provided.

300 AREA

325 Building Ventilation Exhaust Addition $485,000

The 325 Building Laboratory will be provided with new local exhaust filter plenums containing HEPA filters, fire detection sensors and fire suppression equipment, thus adding a second stage of filtration to the existing single stage system. Improved reliability will result and the potential for release of radioactivity via the ventilation system will be correspondingly reduced.

V.4.2 Gaseous Waste Treatment Alternatives

In addition to the facilities and activities planned and under construction for FY-1973 through FY-1975, several alternatives to release of the gaseous waste are: 1) install additional filters to remove particulates, 2) install additional chemical scrubbers to remove reactive gaseous radionuclides such as iodine, and 3) add cryogenic systems for removing nonreactive gaseous radionuclides such as xenon and krypton. Diversion of some exhaust air through existing, more effective systems also may be possible.

Selection of the optimum amount of gas treatment facilities requires a balance of: 1) the costs for installing and operating the treatment facilities, and 2) the effect of those gases on the general population. The cost of existing gas treatment facilities on the Hanford site is quite high because of the large volume of ventilation air (over 10^{12} ft^3/yr) that is handled and because the treatment facilities are designed to assure a low radiation dose to the general public. The remoteness of the 100 and 200 Areas also results in significant dilution of the gases and settling of particulate material before it leaves the site.

Reduction of the ^{41}Ar releases from N Reactor has not been studied in detail and a cost estimate for the necessary plant modifications has not been made. The cost probably would be in the tens of millions of dollars because of the difficulty of removing a dilute noble gas from a large air stream. A cryogenic separation system requiring refrigeration of a large fraction of the ventilation air probably would be necessary. The presumed high cost has not appeared justified by the resultant small reduction in radiation dose to the general public (a maximum reduction of 1.4 man-rem/yr).

Gaseous radionuclides (e.g., ^{3}H, ^{85}Kr, ^{129}I, ^{131}I) released during fuel element dissolution operations are discharged from the main Purex Plant stack. Radioiodine (^{129}I and ^{131}I) can be removed as necessary from dissolver off-gases by use of a silver reactor, which is capable of

removing 99.95% of the radioiodine present. Much of the radioiodine escaping the silver reactors is trapped in the acid recovery system and retained. Fuel elements presently scheduled for dissolution and processing in the Purex Plant will have been discharged from the reactor at least 6 months prior to dissolution. With an 8-day half-life, essentially all ^{131}I will have decayed away by the start of processing.

During dissolution of these fuels, emission of ^{129}I can be controlled at concentrations well below allowable limits for release to uncontrolled areas, even if silver reactors are not regenerated or efficiencies are well below 99.95%. Regeneration of silver reactors is a routine operational alternative immediately available if needed. Alternatives for off-gas treatment which have been used elsewhere in the nuclear industry for iodine include caustic scrubbers, charcoal absorbers, gas collection and storage. Based on Purex iodine release data, these would neither be needed nor justified from standpoints of high cost and the small impact of current operation, <0.01 man-rem/yr total-body dose and about 0.5 man-rem/yr thyroid dose. The most effective alternative is that of storing the fuels until the 8-day half-life ^{131}I has decayed away before processing is begun.

Currently, Purex has no capability for removing tritium (^{3}H) or krypton (^{85}Kr) from the dissolver off-gas waste stream. Approximately 5% of the tritium content of the fuel elements is discharged to the atmosphere via the dissolver off-gases. This means that at the maximum tritium content of the fuel elements dissolved at the maximum conceivable rate, approximately 10 Ci/day of tritium would be discharged to the atmosphere via the 200-ft tall Purex main stack. This would result in an average concentration in the offsite atmosphere of 3×10^{-12} µCi/ml, which is a factor of more than 65,000 below the ERDAM-0524[7] guide concentration of tritium for release to uncontrolled areas (2×10^{-7} µCi/ml). At the maximum krypton content of the fuel elements dissolved at the maximum achievable dissolution rate, approximately 8400 Ci/day of krypton would be discharged to the atmosphere via the 200-ft tall Purex main stack resulting in an average concentration of 4×10^{-9} µCi/ml in the offsite atmosphere. The guide concentration limit for uncontrolled areas in ERDAM-0524[7] is 3×10^{-7} µCi/ml.

Alternatives such as cryogenic gas recovery, selective absorption and membrane separation, could possibly be adapted for Purex use in the collection and retention of the noble gases. However, these would be very expensive (probably greater than 10 million dollars) and would take from 3 to 5 years to design and install. Recovery efficiencies for krypton would probably range from 90 to 99%, depending on the process, thus giving offsite atmospheric concentrations from 4×10^{-10} to 4×10^{-11} µCi/ml, compared to the guide concentration 3×10^{-7} µCi/ml.

V.5 SOLID RADIOACTIVE WASTE [11A]

V.5.1 Current Practice

Solid radioactive waste is placed into the ground at several locations in the 200 Areas from sources described in Table V-19. This waste is a miscellaneous mixture of solid materials ranging from floor sweepings to contaminated equipment and contains all ranges of radioactivity from essentially none to induced activity from reactor neutron irradiation.

Beta-gamma contaminated solids are packaged, sealed and buried in shallow trenches. The transuranics are segregated in special sealed containers to be retrievable contamination-free for 20 years and buried in controlled facilities. Large items of process equipment, too radioactive and too bulky for either transfer to 200 West Area (for decontamination) or burial, go into the railroad tunnel. Continued emphasis will be placed on reducing the amount of contaminated waste generated, and on packing more waste into each burial package to reduce the amount of trench usage needed.

V.5.2 Solid Waste Treatment Alternatives

Several alternatives relating to disposal of solid waste have been studied.

V.5.2.1 Compaction

Compaction of solid waste could reduce the total volume of the initial package. Compaction would not reduce, of course, the total radionuclides to be disposed of, and the corresponding reduction in the size of burial grounds would not appear to justify the cost of compaction units.

V.5.2.2 Storage in Deactivated Plants

Deactivated plants could be converted to waste storage "vaults." Modification of old plants to provide fire protection, ventilation and monitoring would be required and would probably cost many millions of dollars. The benefit would be a reduction of the commitment of additional land for storing solid waste. No changes in population dose would result.

TABLE V-19

SOLID RADIOACTIVE WASTE RELEASES TO THE GROUND

Location	Composition	Quantity: Currently Stored (ft^3)	Quantity: Future Storage (ft^3/yr)	Current Disposition Location	Primary Environmental Impacts
100 Areas	Miscellaneous Solid Waste	5.8×10^5	40,000	200 Areas	Total of 4 acres land use/yr; essentially zero population dose
200 Areas	Miscellaneous Solid Waste	5.5×10^6	93,000	200 Areas	
300 Area	Miscellaneous Solid Waste from fuel element manufacturing containing uranium and thorium and from research and development	7.5×10^5	56,000	200 Areas	
600 Area	Miscellaneous Solid Waste	(a)	0	200 Areas	

(a) Volume not known

V.5.2.3 Sorting and Classifying

A sorting and classification system for solid waste handling would develop instrumentation to nondestructively analyze the contents of packaged solid waste to assist in sorting. Identification and measurement of the radioactive content of waste is essential before determining its disposition. The measurements would determine whether the package could be treated as fission product-contaminated waste or would have to be handled as transuranic element-contaminated waste (alpha waste).

A centralized data reduction system has been developed, the Automatic Radioactive Inventory System (ARIS), which can identify 34 nuclides from one spectrum. Further efforts would be needed to develop the satellite package counting system and the in-plant measurement system using the central data reduction equipment. The satellite counting equipment would have to function under a wide variety of plant conditions. An estimated $400,000 would be needed to provide in-plant capability of sorting according to type of scrap or waste and level of radioactivity. If adopted, use of this nondestructive assay equipment would probably start in Z Plant about 2 years after funding was available. The equipment would provide good segregation of transuranic waste from fission product waste.

V.5.2.4 Transuranic Waste Storage

Pad storage for transuranic waste retrievable burial is currently being tested. This alternative provides protection of the metal containers from contact with the soil and allows sampling of the storage facility atmosphere for radioactivity and combustible gases, either of which would indicate container failure. Final evaluation of a retrievable burial system is expected in FY-1975 with routine use of the selected concept to follow.

The alternatives to storage of transuranic waste in V trenches, transuranic storage slabs, and caissons are 1) to store the waste in burial trenches or 2) to treat it to remove transuranics and then store the residual. Storage in burial trenches is not desirable because retrieval of the waste is difficult and costly. The waste previously disposed of by this method will require recovery. Such a practice would not maintain positive containment control for transuranics as does the current program.

Treating the waste to remove the transuranics generally would be quite costly because of the low concentrations of those radionuclides and because in some cases the waste already is being treated to remove as much of the transuranics as can be removed without excessive costs.

V.5.2.5 Equipment Reclamation

An equipment reclamation alternative would involve the recovery, i.e., the cleaning and repairing, of all contaminated process equipment for reuse, thus eliminating the need for burial. This type of work is current practice, but it is neither technologically nor economically feasible to recover all such equipment since, in many cases, costs in time, chemicals and radiation dose to employees would far exceed the value of the equipment and the costs of burial. Such extra cleanup would also produce significantly larger volumes of liquid waste requiring disposal.

V.5.2.6 Equipment Disposal

An equipment disposal alternative would involve one or more methods of consolidating large, bulky items, such as process equipment, hoods, structural members, etc., into forms readily dealt with. Items could be cut, melted, burned, disassembled, compacted, or they could be completely converted to liquid waste which could then be handled as part of the existing liquid waste inventory.

Currently, large items of failed equipment are placed in concrete boxes and buried. This volume would be expected to increase significantly under the long-range facilities decommissioning program. A study is under way to establish the technologies for converting the large items to consolidated forms and determine subsequent treatments. Cost estimates and schedules for possible alternatives have not been made.

V.5.2.7 Wet Oxidation

Two wet oxidation alternatives to incineration for waste volume reduction are being studied: 1) a wet oxidation process for disposing of spent solvent, solid waste and scrap, and 2) the sulfuric acid oxidation process. The goal of this development effort is to provide a plutonium-bearing oxidation product (ash). If this technology is attained, design of the proposed solid waste incinerator would be based on one of the above oxidation processes.

V.5.2.8 Burial Ground Selection

Evaluation of solid waste burial alternatives for long-term versus short-term burials may be considered. The study would be conducted over a 3-yr period (FY-1975 to FY-1979) at a cost of $500,000. Criteria for long-term burial would be developed and existing burial sites would be evaluated using these criteria. The evaluations would be expected to determine which burial grounds need stabilization, which need relocation, and which potential new sites would be acceptable for long-term storage.

An additional 3-yr study to develop the technology for acceptably relocating burial grounds has been proposed for FY-1977 to FY-1979 at a cost of $300,000. Should relocation of a burial ground be judged necessary, the technology or equipment would probably not be available prior to FY-1980.

V.5.2.9 Conclusions

Radioactive solid waste burials in the dry soil of the 200 East and 200 West Area plateau do not and are not expected to have an offsite environmental impact. Alternatives to present practices are being studied to determine a practical plan for long-term treatment, disposal and surveillance of this solid radioactive waste.

V.6 NONRADIOACTIVE WASTE

V.6.1 Chemical Releases to the Columbia River

Chemicals are released to the Columbia River in significant quantities shown in Table V-20 at three locations: 1) the 100-N Area, 2) the 100-K Area, and 3) the 300 Area. The current primary source of chemicals released to the river is the 100-N Reactor operations. In addition to these chemicals, the impurities removed from the river by the water treatment plants also are returned to the river. The effect of returning those impurities to the river can be considered to be negligible because essentially all of the purified water is returned to the river either in process sewers or as groundwater. As a result, the average chemical content of the river is essentially unchanged.

The alternatives to release of the chemicals to the river are 1) evaporation of the water to dryness and storage or reuse of the chemicals, and 2) release of the waste streams to ponds in which part of the chemicals would remain as a precipitate in the bottom of the ponds or be absorped on

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TABLE V-20

CHEMICAL RELEASES TO THE COLUMBIA RIVER

Materials	Quantity Discharged per Year (lb)			
	100-K	100-N	300 Area	Total
Aluminum sulfate,	17,500	337,000		
Chlorine,	4,000	28,000		
Polyacrylamide,	100	900	not	
Sodium Dichromate,	0	200		
Sulfuric Acid,	0	1,410,000	measured	
Ammonium Hydroxide,	0	266,000		
Hydrazine,	0	14,000		
Morpholine,	0	2,800		
Sodium Hydroxide,	0	463,000		
Total, lb	21,600	2,521,900	~960,000[a]	3,500,000 or 1,750 ton/yr

Quantity of dissolved solids in Columbia River = 13,000,000 tons/year.

(a) Assuming that all materials entering process pond eventually enter the river.

the soil column below the pond surface. The disadvantages of these alternatives are the additional cost and the solid waste disposal problem, which requires use of additional land. Such releases might also have an adverse effect on the water table.

Because the current practice of releasing the chemicals to the river has no detectable environmental impact, adoption of more costly land disposal does not appear justified.

V.6.2 Chemical Releases to the Land

Chemicals in liquid streams are released to the land at several locations; the primary release points are summarized in Table V-21. Solid chemicals placed in sanitary land fills and specific burial trenches are included in the discussion of nonradioactive solids released to land.

The primary reasons for release of chemicals to land are 1) to reduce pollution of the Columbia River and 2) to minimize the disposal cost of these chemicals. Because of the highly absorptive characteristics of the Hanford soils, the chemicals are generally retained in the ground above the water table and do not enter the water table or eventually the Columbia River. Part of those chemicals do not actually enter the land but remain in the disposal pond either dissolved in the liquid in the pond or as a layer on the bottom of the pond.

The primary alternatives to release of these chemicals to the land are 1) release to the Columbia River and 2) separation of the chemicals from the liquid streams and storage in sealed containers. Release to the river is not desirable because of the additional pollutant burden to the river.

Separation of the chemicals from the liquid streams probably would require large, costly evaporation plants or ponds. Many of the chemicals are highly soluble and cannot be readily removed by chemical treatment or ion-exchange processes. Detailed analysis of use of separation systems has not been made because of the low incentive for using such systems. The primary impact from ground disposal is the use of desert land for disposal ponds and ditches. In particular, most releases to the land are into ponds and cribs, which also contain radionuclides. The additional impact due to the chemicals can be considered to be negligible.

TABLE V-21

CHEMICAL RELEASES TO THE LAND

Project Region	Release Location	Primary Constituents	Annual Releases (Tons)
100-N	1301-N Crib	Calcium Magnesium Ammonium Sulfate	120
200 Areas	Cribs and Ponds	Salt Aluminum Sulfate	330
300 Area	Process Ponds	Chlorides Nitrates Sulfates Copper Fluorides Chromium+6 Uranium	480

V.6.3 Chemicals Released to the Air [X.24]

The three primary sources of chemical releases to the air are: 1) gases in fossil fuel plant exhaust gases, 2) gases in process stacks, and 3) gases in laboratory and experimental facility exhaust streams. A summary of the major annual releases is presented in Table V-22.

At present, no standards for release of nitrogen oxide from individual plants have been established. Discussion of alternatives does not appear justified because no adverse environmental impact is apparent for releases of nitrogen oxide in the sparsely populated Hanford region.

Sulfur dioxide released from all power plants is below the current standard of 2000 ppm SO_2 in the stack gas. As shown on Table V-22, the releases from the coal and oil-fired power plants are at about 25 and 40%, respectively, of the standards. When the standard decreases to 1000 ppm in 1975, these releases still are expected to be within the standards. The releases from the package steam plants currently are at about 10% of the standards because of the low sulfur content (0.2%) in the light fuel oil used in those plants.

Since the sulfur dioxide releases are well within standards and probably will remain within the future lower standards, detailed discussion of alternatives does not appear justified. All of the normal alternatives, namely 1) conversion to oil with a lower sulfur content, 2) conversion to natural gas, or 3) installation of sulfur dioxide removal equipment, result in higher costs. Use of other oils or natural gas is undesirable because of the current shortage of petroleum and natural gas.

Currently, obtaining heavy fuel oil with less than the desirable maximum of 1.5% sulfur is difficult. Because of the current petroleum shortage, some recent shipments have had sulfur contents as high as 1.8% sulfur. Although these high sulfur contents do not cause operation above the current standards, future operation may result in sulfur dioxide releases that approach the 1000 ppm standard. If releases were to exceed the established standard, suitable corrective action would be taken.

V.6.4 Chemical Waste Stored in Special Repositories

At Hanford, significant quantities of waste chemicals are stored in the radioactive waste storage tanks in the 200 Area. These chemicals are primarily fuel reprocessing chemicals in the radioactive waste streams from the 200 Area operations. Also included are any chemicals from 100 Area and 300 Area operations and from research and development activities that accompanied radioactive waste sent to the 200 Area for storage. These chemicals were not separated from the radioactive waste because the separation and subsequent storage or disposal costs were larger than the extra cost for storage with the radioactive waste.

The typical composition of these chemicals is common sodium salts, because sodium is the primary cation or metallic constituent of the process chemicals. The other metallic components generally are fission products or corrosion products from the process equipment.

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TABLE V-22

MAJOR CHEMICAL RELEASES TO THE AIR IN 1972

Chemical	Project Region	Release Source	Fuel Type	Annual Release (tons)	Percent of Standard (a) Current	Percent of Standard (a) 7/1/75
NO_x	100-N	Power Plant	#6 Oil	172	N.S.	N.S.
	200-E	Power Plant	Coal	428	N.S.	N.S.
	200-W	Power Plant	Coal	260	N.S.	N.S.
	300 Area	Power Plant	Coal	210	N.S.	N.S.
			#6 Oil		N.S.	N.S.
		333 Building	...	14	N.S.	N.S.
	100-D,F,K, and 200-E	Package Steam Plants	#2 Oil	29	N.S.	N.S.
			TOTAL	1113		
SO_2 (b)	100-N	Power Plant	#6 Oil	1002	40 to 50	80 to 100
	200-E	Power Plant	Coal	6500	25	50
	200-W	Power Plant	Coal	3990	25	50
	300 Area	Power Plant	Coal	120	25	50
			#6 Oil	269	20 to 40	40 to 80
	100-D,F,K, and 200-E	Package Steam Plants	#2 Oil	10	~10	~20
			TOTAL	2450		

(a) N.S. means no standard. SO_2 standard is 2000 ppm until 6/30/75, and 1000 ppm thereafter.
(b) The sulfur dioxide release data are conservatively computed for a fuel assumed to have a sulfur content higher than that of the fuel used in the listed power plants.

No acceptable alternatives to the storage of the chemicals in the 200 Area waste tanks are known. Waste tank storage provides isolation from the environment while control measures to assure radionuclide containment also provide chemical containment. The alternatives discussed earlier to improve radionuclide containment would also improve chemical containment.

The 100-H Area storage basins are to be used for interim storage of process chemicals from the 300 Area fuel fabrication facilities. While the waste is stored in these basins, the water will evaporate producing a sludge which could subsequently be processed to recover the uranium and copper.

The alternatives to this storage are to either release the material to waste ponds or install evaporators or other processing equipment to concentrate the solutions more rapidly before recovering the uranium and copper. Release to ponds would result in creation of additional undesirable release of radioactivity to the environment and loss of the uranium and copper values. Installation of concentration equipment would increase the cost of the uranium and copper recovery, probably enough to make the recovery uneconomical.

The primary environmental impacts that might result from storing these chemicals in the 100-H Area would be from spills of the chemicals during transportation and leakage out of the basins. Entry of the chemicals into the environment in these manners is not considered a significant impact because these chemicals have innocuous effects and can be easily cleaned up.

V.6.5 Sanitary Waste

Sanitary waste is created throughout the Reservation wherever there are facilities occupied by personnel more than a few minutes at a time. Two methods are used for disposing of this waste: 1) septic tank systems, and 2) chemical toilets. The material in the chemical toilets is disposed of periodically in the septic tank system. A summary of the locations and amount of waste handled in the septic tank systems is presented in Table V-23.

TABLE V-23

SANITARY WASTE FLOWS TO SEPTIC TANKS

Project Region	Gallons Per Day
100-B	180
100-D	2,400
100-F	2,700
100-K	2,700
100-H	0
100-N	22,500
200-E, 200-W	99,000
300 Area	491,000
Other[a]	9,000
TOTAL	692,000[a]
	= 440 gpm

(a) Does not include 60,000 gpd at the FFTF site or 10,000 gpd at the WPPSS Hanford construction site.

Septic tank systems operate quite satisfactorily. The arid climate and porous ground result in satisfactory drainage without surfacing of the waste because of ground saturation or plugging. Proper design of the tile fields results in ample disinfection before the liquids enter the water table and eventually the Columbia River. Much of the liquid does not enter the water table because the moisture in the ground at the shallow depths of the leach lines moves toward the surface due to evaporation and evapotranspiration.

The normal alternatives to septic tanks are connection to a municipal sewage system or installation of an extended aeration system. Connection to a municipal system would be quite expensive for most of the Reservation because of the long distance (up to 40 miles) to the nearest municipal system at Richland. This alternative might be feasible for the 300 Area, although even then the distance to the Richland sewer plant is about 7 miles.

In the extended aeration process, raw sewage continuously flows into an aeration tank where it is continuously air sparged to provide oxygen for the biological degradation of the organic components of the waste. The aeration tank is sized to provide approximately a 24 hour retention time for the sewage. The contents of the aeration tank continuously overflow into a settling tank that provides a minimum of 4 hours retention time. The scum and settled solids are returned to the aeration tank for further treatment, while the clarified effluent flows into a chlorine contactor for chlorination to kill any remaining pathogenic bacteria prior to release to the environment. Periodically, the excess sludge is removed to a landfill site.

Evidence indicates that the current septic tank systems are operating satisfactorily and in accordance with the state of Washington sanitation regulations. Hence, no apparent justification exists for the extra expenditures for either of the alternatives.

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V.6.6 Nonradioactive Solids Released to the Land

Large quantities of normal industrial trash and used equipment are generated on the Reservation. Materials of value, such as relatively pure metals and excess equipment, are sent to salvage yards, sorted and sold. The other materials are collected, compacted and transported to a central landfill site to be buried. The total volume of this waste is about 360,000 ft^3/yr requiring about 2 1/2 acres of land/yr.

The alternatives to disposal in the central landfill site are 1) disposal at scattered landfill sites, and 2) greater compaction and/or incineration prior to disposal in order to reduce the volume and noxious nature of the waste.

Disposal, with burning, at scattered landfill sites was the standard practice until 1972. Burning was stopped in accordance with an executive order. The current procedure of disposing of all material at one central landfill location was adopted in 1972 because a study of the costs for the various methods for waste disposal showed that transportation of all waste to one central site by use of a modern compactor truck would cost less than the existing system, and a landfill operation would cost much less than incineration.[8]

The waste is not compacted to greater density or incinerated because 1) ample land is available for disposal, 2) a considerable amount of compaction occurs at present during collection and covering of the waste, 3) degradation of the waste probably occurs more rapidly if it is not compacted to a greater amount, and 4) installation plus operation of incinerators designed in accordance with current air pollution regulations is more costly than the current practice.

V.6.7 Other Environmental Pollutants

The other environmental pollutants for which alternatives might need to be considered are heat, odor, and noise.

V.6.7.1 Heat to the Columbia River [X.15]

The one significant source of heat release to the Columbia River is the N Reactor operation. All other heat releases to the river are much smaller and contain only about 1% of the total releases to the river. The total heat input is about 470 MW when N Reactor is operating.

The 470-MW heat release to the Columbia River is via the 66-in. and 102-in. lines from N Reactor. Excess power over 470 MW is exported as steam to the WPPSS Hanford Generating Plant. At a full reactor power level of 3760 MW, 860 MW is converted to electrical energy and the remainder is dissipated to the Columbia River. The WPPSS loss to the river is approximately 2400 MW, and N Reactor's loss is 470 MW. The remainder of this heat is discharged by WPPSS electrical generator plant. The environmental impact of this action is not part of this statement. The discharges from WPPSS facilities are covered by the state of Washington for discharge permits. If WPPSS were not operating at the full power level of 3760 MW, then 3730 MW would be discharged to the river as heat.

At the minimum permissible river flow rate of 36,000 cfs, the routine release rate of about 500 MW increases the average river temperature by only 0.25°F. At the average river flow rate of 120,000 cfs, the average increase in river temperature is only about 0.08°F.

The primary alternatives to the current release of heat to the river are 1) installation of an open-cycle cooling system utilizing a cooling tower or lake for dissipating part of the heat to the atmosphere before the water is released to the river, or 2) installation of a closed-cycle cooling system using a cooling tower or pond. Although these alternatives have not been studied for the N Reactor, experience with other power reactors can be used to illustrate the costs.

The four most common designs for cooling towers and lakes are 1) mechanical draft towers, 2) natural draft towers, 3) large quiescent ponds and 4) spray ponds. Natural draft towers are not technically feasible at Hanford because an adequate draft does not occur during periods of low relative humidity. Data developed during investigations of cooling systems for the proposed adjacent WPPSS power reactor indicate that the installation costs for WPPSS would be from 20 to 30 million dollars. Since the cooling water flow at N Reactor is only about 40% of the flow for the proposed plant, such a cooling system for N Reactor probably would cost between 11 and 17 million dollars. Since the effect of the N Reactor heat releases on the Columbia River are considered insignificant (Section III.1), installation of a cooling tower or pond to eliminate these releases to the Columbia River cannot be justified.

V.6.7.2 Heat Released to Land

Heat is released to land whenever a water stream flows into a pond or a well or through a buried pipeline at a temperature higher than the temperature of the ground. It also may flow into the ground from buildings, tanks, and other facilities which are at a higher temperature than the ground. Flow of heat into the ground is of concern from an environmental standpoint only if the higher ground temperatures create a measurable change in habitat condition for plants or animals. Excessive temperatures can sterilize the ground or dehydrate it, making plant survival difficult.

All heat releases to the ground at Hanford are at relatively low temperatures and have no apparent effect on the vegetation or aquatic life. Therefore, discussion of alternatives does not appear justified.

V.6.7.3 Heat Released to the Air

Heat is released to the air primarily from cooling ponds, process facilities, and buildings. The primary effects on the environment are climatic through creation of heat islands and occasional local fogging. The total quantity of heat released directly to the air at Hanford is estimated in Table V-24.

The four primary sources of heat releases to the air at Hanford are 1) combustion of fossil fuels, 2) consumption of electricity, 3) decay of radionuclides, and 4) release of heat from N Reactor to the Columbia River. The heat released to the river eventually is transferred to the air at downstream locations.

TABLE V-24

TYPICAL HEAT RELEASES TO THE AIR AT HANFORD (1972)

Source of Heat	Annual Quantity	Average Heat Generation (MW)	Heat Content (Btu/yr)
Fossil Fuels			
Coal	103,000 tons	93	2.8×10^{12}
Oil	12,740,000 gallons	63	1.9×10^{12}
Electricity	3.2×10^{8} kW-hr	37	1.1×10^{12}
Radionuclides	$\sim 3.0 \times 10^{7}$ kW-hr	~4	1.2×10^{11}
	TOTAL	197	5.9×10^{12}

Because of the large area of the Reservation and the wide dispersion of these heat releases, a significant climatic effect has not been observed. A small increase in local fog probably occurs in the vicinity of the 200 Area cooling ponds and the Columbia River during the winter months, but this fog has an insignificant effect on the general public. The only location where this fog might affect the public is on Highway 240, which passes about one mile from the S-17 pond. An analysis of automobile accidents on Highway 240 between the Yakima Barricade and the Prosser Barricade roads reveals that none of the 68 accidents from January 1, 1967, to September 30, 1973, occurred during fog conditions.

V.6.7.4 Odors

No odor sources on the Reservation are noticeable at the boundaries. All of the chemicals used in large quantities either are odorless or are contained such that the odors are not noticeable except in the immediate vicinity.

V.6.7.5 Noise

No noise sources are on the Reservation that create a noticeable increase in noise levels at the boundaries in comparison to a normal urban environment. The only noticeable noises usually are traffic noises due to boats, trucks, trains, and automobiles. No construction activities are scheduled at locations close enough to the boundaries to cause significant impact.

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VI RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

VI.1 BACKGROUND

Continued waste management operations according to present ERDA policies and standards will protect the offsite environment and will contaminate a small fraction of the onsite environment for the long-term. Hanford Waste Management Operations to date have resulted in the establishment of certain areas on the Hanford site for continued use in waste disposal or storage. Additional areas of contamination will be small compared to those well-defined areas that are already contaminated from past waste management operations.

The areas that contain radioactive materials will remain contaminated for the foreseeable future even after operations cease. Most of the Reservation and all of the land, water, and air surrounding the plant are protected for possible long-term uses because the waste disposal and storage sites are few in number and are centrally located.

Large portions of the land on the Hanford site are being put to other productive uses:

- Arid Land Ecology Reserve
- Washington State Game Reserve
- Commercial Nuclear Power Plants
- Research and Development Facilities for Energy.

Changes of varying degree of impact have occurred within the dedicated portion of the Reservation. Installations of fences, telephone lines, and transmission lines are regarded as slight changes wherein construction effects were minor. The longer-term effects occurred only on the small portions of the rights-of-way actually occupied by the present structures that, in most cases, could be removed at moderate cost, allowing the land to revert naturally over a decade or two to its original state. Major changes include the erection of massive concrete buildings and, as a part of waste management operations, the installation of underground storage tanks and the discharge of radioactive materials to the ground. Restoration of the land thus occupied to its original condition would be extremely expensive and, for some portions, practically impossible. Intermediate changes over the past 30 years include the erection of buildings, the construction of paved roads (about 0.5% of the Reservation), and the laying of road beds for rail traffic (about 0.25% of the Reservation).

To place in perspective the changes on the 30 square miles of Reservation land requires a summary view of the use of Reservation land prior to 1942. Historically, the unmodified steppe ecosystem provided little food to man (although the Columbia River was an important food source). A minor but significant part of the Reservation was altered by irrigation, yielding agriculturally productive land, particularly near the river.

Considering all effects on man's environment, a small positive long-term effect is forecasted for the productivity of man's environment. The direct effects, while occasionally adverse, are not large. The total human population radiological dose from Hanford Waste Management Operations Program is only about 0.01% of the natural background dose sustained by the same population. The figure will drop substantially when N Reactor operations are completed. The loss of habitat for wildlife is not expected to be significant for a long time, if ever, in view of the preponderance of similar habitat on the Reservation and on adjacent lands. Man-made fires make an insignificant impact. Although metals and fluoride may to a small degree be incorporated by some waterfowl, no serious threat is made to higher terrestrial biota. Some biological uptake and dispersion of radioactive materials occur in waste management zones, but only at a low level. The release of small amounts of radioactive materials to the open terrestrial environment does not manifest an obvious impact on local biota.

Life in the Columbia River sustains only minor and very localized effects due to the discharge of heat. Impingement losses at the various intakes are small; no significant entrainment losses occur. Springs draining into the river at 100-N and 300 Area contain some chemicals. Aquatic populations in the river sustain no observed deleterious effects caused by Hanford radioactive effluents. The extent of genetic effects, if any, is unknown. Aquatic biota existing in other surface waters such as ditches and ponds are unlikely to involve offsite ecosystems in any important way. Consumptive use of Columbia River water is inconsequential at 550 cfs, about 0.4% of the average flow rate. The quantity of groundwater withdrawal is inconsequential in view of the total supply.

VI.2 EFFECTS OF PROPOSED ACTIONS

Future plans for the Hanford Reservation call for the continuation of its present use as an area dedicated primarily to nuclear energy activities. Thus, the use of man's environment will be long-term; there will be no short-term use. The relationship to be considered is that of long-term productivity of the environment.

Current use of the land has probably barred major irrigation projects from the Reservation because of their potential impact on the water table levels. Also, an inventory of mostly tritium and ^{106}Ru-Rh will remain in the groundwater under the Reservation and fission products in the soil columns under cribs, trenches and ponds for many centuries.

In the future, additional Reservation land may be dedicated to nuclear energy activities. On the other hand, some current activities will cease, therefore encroaching no further on man's environment. The direct net effect will probably be a slightly increased encroachment upon man's environment.

Assuming that the primary activities on the Reservation do meet their objective of benefiting man's social-economic environment, the Waste Management Operations Program will continue to be of benefit by reducing substantially the potentially inimical environmental effects that would result from unprogrammed releases of waste materials to man's environment.

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VII RELATIONSHIP OF PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS

The continued operation of the Hanford waste management facilities will not conflict with national, state, or local plans and programs. Implementation of the action proposed herein, i.e., a continuation of effluent and waste management practices at Hanford, calls for land use as described in Sections II and III. All land is and will be managed consistently with federal regulations to assure the safety and well being of the public. Specifically, as paraphrased from WASH-1202 (73), "Plan for Management of AEC-Generated Radioactive Wastes," and applicable to land use:

- Operate in such a manner as to ensure radiation exposures do not exceed established standards.
- Continue to reduce the amount of radioactivity released to the environment to the lowest level below established standards that is technically and economically practical.
- Continue to minimize radioactive contamination of real property and facilities for the purposes of protecting public health and safety.
- Discontinue the use of natural soil columns for storing intermediate-level waste as soon as technically and economically practical.
- Maintain records of locations of radioactive burial sites and the amount of radioactivity contained at each site.

Site use dictates the type of control necessary to ensure the safety and well-being of the public. Access to radioactive waste storage areas, for example, will continue to be controlled. Standards and requirements for the management of radioactive waste at Hanford are set forth in ERDAM-0510 "Prevention, Control, and Abatement of Air and Water Pollution," ERDAM-0511 "Radioactive Waste Management," ERDAM-0513 "Effluent and Environmental Monitoring and Reporting," and ERDAM-0524 "Standards for Radiation Protection."

Continued land use, in addition to effluent and waste management on the Hanford Reservation, includes 1) research and development associated with the Arid Land Ecology (ALE) Program, and various laboratory facilities in the 100, 200, and 300 Areas, 2) N Reactor and plutonium production facilities in the 200 Areas, and 3) the Fast Flux Text Facility. Some land north of the Columbia River will continue to be administered by the U.S. Bureau of Sport Fisheries and Wildlife, and the Washington State Department of Game. The State of Washington leases land on the 200 Area plateau for radioactive waste burial. Private leases of land include the Washington Public Power Supply System (WPPSS) steam plant operating at 100-N Area and the WPPSS Power Reactor now under construction.

Many future uses of Hanford Reservation land have been suggested, but no definite plans exist. Some of the suggested projects include a nuclear energy park, Liquid Metal Fast Breeder Reactor demonstration facility, waste handling and storage facilities for public power reactors, a uranium enrichment facility, Ben Franklin Dam, Columbia River navigation upstream to Wenatchee, and irrigated farmland. Although the proposed construction of Ben Franklin Dam received attention, the Corps of Engineers stated that completion of feasibility studies were delayed pending further consideration of environmental matters. A date for completion of the studies was not set, nor was a decision made as to whether or not the Corps will recommend authorization and construction of the project.

The potential environmental consequences and relationships of all specific proposed projects to the Hanford Effluent and Waste Management Operations Program are studied and considered. Environmental impact statements for future individual projects will be prepared, as appropriate. The impact and feasibility of each individually proposed program will be evaluated, including any potential impact on the Hanford Waste Management Operations.

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VIII IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

VIII.1 PERMANENT COMMITMENTS

The resources that are considered to be committed in an irretrievable and irreversible manner by the Hanford Waste Management Operations are 1) land and materials containing or used for storing radionuclides with a half-life longer than 10 years, 2) labor expended by construction and operating personnel, and 3) materials, such as fuels and chemicals, that are burned, diluted, or consumed during use.

Most land containing fission product radionuclides with long half-lives can be considered unusable for agricultural purposes for centuries. Although most of these radionuclides probably could be separated from the land, reduction of the concentration to a level which would permit unrestricted use undoubtedly would cost more than the value associated with normally expected uses. This land will require a commitment of both people and surveillance equipment until the radioactivity is essentially removed by processing or decay.

Land containing transuranic materials, particularly plutonium, can be considered unusable for any purpose for hundreds of thousands of years. Until any recovery program for the transuranic materials would be completed, this land will require a commitment of both people and surveillance equipment.

About half a million tons of fossil fuels and 50,000 tons of chemicals are expected to be irreversibly consumed by the Hanford Waste Management Operations. Some components of the concrete structures and equipment as well as about 6,000 acres of desert land are essentially irretrievable due to the practical aspects of reclamation and/or radioactive decontamination. Present operating practices will not require additional land usage for cribs.

VIII.2 TEMPORARY COMMITMENTS

Other resources and land are temporarily committed by the Waste Management Operations but cannot be considered to be irreversibly and irretrievably committed. As an example, some land currently is occupied by buildings, roads, and waste sites. As a general rule, that land could be retrieved by demolition of the buildings and roads, retrieval of the waste, dispersing the nonradioactive component materials to their original sources and storing radionuclides at locations where they have no effect on humans or the usefulness of the storage location. No land is considered to be irretrievably committed by use or disposal of pesticides, oils, and chemicals.

The use of the mobile portions of the environment (air and water) by the Waste Management Operations does not represent an irreversible or irretrievable resource commitment but rather a relatively short-term investment. The water and air above the surface of the earth are rapidly restored to essentially their original conditions by natural processes and dilution. The groundwater contains only a few isolated locations where the concentrations of radionuclides and chemicals are above the current concentration guides for drinking water. Dilution and radioactive decay will restore that water to a useful form.

Irretrievable damage or loss to the biota of the region is not expected to occur.

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IX COMPARISON OF COSTS AND BENEFITS [RPB, X.24]

This cost-benefit analysis is concerned only with the future costs and environmental impacts of the Hanford Waste Management Operations. The overall program objective is to accomplish waste management operations in a manner resulting in the best balance of costs and benefits.

IX.1 EVALUATION OF BENEFITS FOR THE WASTE MANAGEMENT OPERATIONS

IX.1.1 Minimum Radiation Dose

The current total radiation dose to the general public as a result of the Waste Management Operations activities is estimated to be about 2.5 man-rem/yr. When N Reactor operations are complete, this dose is expected to decrease to less than 0.01 man-rem/yr. These doses are low when compared to the naturally-occurring background dose of about 27,400 man-rem/yr for the persons living within 50 miles of the Hanford Reservation.

The maximum whole body dose received by an individual from Hanford operations during 1972 was estimated to be about 0.6 mrem/yr. The average individual whole body dose was about 0.01 mrem/yr. These individual doses are low when compared to the naturally occurring background dose to individuals of about 100 mrem/yr.

No attempt was made to estimate the reduction in radiation dose to the general public that resulted from having the present Waste Management Operations Program. The alternative of not having some program for managing waste which has already been generated has always been considered an unrealistic case.

IX.1.2 Minimum Chemical Pollution

Land and water pollution due to release of chemical waste is kept to a minimum by storing the waste in the high-level radioactivity waste tanks or by releasing the chemicals to controlled disposal sites. Only relatively small amounts of chemicals in comparison to the normal chemical content of the river are released into the Columbia River.

IX.1.3 Increased Technical Knowledge [X.24, X.25]

Research and development efforts are providing improved methods for handling radioactive waste and extending knowledge of the effects of radionuclides on terrestrial and aquatic biota. This knowledge helps establish the best balance between costs and environmental impacts for radioactive waste management programs.

IX.1.4 Employment

The Hanford Waste Management Operations requires continuing employment for about 700 to 1200 persons.

IX.2 EVALUATION OF COSTS FOR THE WASTE MANAGEMENT OPERATIONS

IX.2.1 Capital Cost

Future construction costs for the planned waste management facilities (described in Section II.1.1.2.4) through 1975 are estimated to be about $42,000,000 as outlined in Table IX-1. Table IX-1 shows the waste management facilities and activity (described in Section V.2.1) planned for FY-1976 and FY-1977 for the 200 Areas.

IX.2.2 Operating Costs

The operating costs for the waste management facilities are estimated to be about $35,000,000 per year.

IX.2.3 Land Use

Continuation of the Hanford Waste Management Operations Program will result in 1) occupancy of land by structures containing radionuclides and 2) restricted use of land containing radionuclides. The quantity of land committed will remain essentially constant for about 300 years because of the presence of ^{137}Cs, ^{90}Sr and transuranium materials in the burial grounds and crib sites unless major recovery and cleanup programs are initiated. After 300 years, the quantity of land required for such purposes will decrease to the lands which contain plutonium or other long-lived transuranics. Recovery of plutonium from stored waste would eliminate the need for long term control and surveillance.

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TABLE IX-1

WASTE MANAGEMENT FACILITIES AND ACTIVITIES PLANNED
AND UNDER CONSTRUCTION FY-1973 THROUGH FY-1975

	Cost
100 AREAS	
N Reactor Control Rod Coolant Dump System	$ 75,000
N Reactor Gravity Drain and Disposal Basin	445,000
N Reactor Ventilation Loop Seal Improvements	325,000
200 AREAS	
In-Tank Solidification Systems, Auxiliaries	2,500,000
Waste Management Effluent Control (B Plant)	1,000,000
Contaminated Soil Removal Facility	1,000,000
Purex Ammonia Scrubber Waste Concentration Facilities	405,000
Additional Waste Concentration and Salt Cake Storage Facilities	30,000,000
Purex Condensate Recycle	450,000
Groundwater Monitoring Wells	100,000
Encase Waste Lines 232-Z and 241-Z	115,000
Waste Management Effluent Control	3,300,000
B Plant Vent System Ventilation Improvements	475,000
242-T Evaporator Effluent Improvements	200,000
222-S Laboratory Exhaust Ventilation Improvements	485,000
300 AREA	
325 Building Ventilation Exhaust Addition	485,000
300 Area Liquid Waste Disposal	190,000
Replace and Upgrade 300 Area Contaminated Waste Line	400,000
Total	~$42,000,000

TABLE IX-1a

WASTE MANAGEMENT FACILITIES AND ACTIVITIES PLANNED
FY-1976 AND FY-1977 FOR THE 200 AREAS

Additional Waste Storage Tanks	$75,000,000
Groundwater Monitoring Wells	200,000
Waste Unloading Facility	1,500,000
Total	~$77,000,000

A summary description of the committed lands is presented in Table IX-2. The areas in that table include appropriate buffer zones for surveillance and prevention of disturbance of the radionuclides by nearby activities such as irrigation agriculture.

Commitment of some of the Hanford lands to waste management makes that land unavailable for other uses. Because there are tens of thousands of acres of similar desert land available throughout the Western United States, the dedicated land cannot be considered to have rare characteristics that result in a premium value, such as for residential or industrial use. Ample similar land is available nearby for any such uses foreseen.

IX.3 COST-BENEFIT ANALYSIS

The planned and budgeted changes for FY-1973 through FY-1975 and for FY-1976 through FY-1977 are summarized in Table IX-1 and Table IX-1a, respectively. When implemented, these programs will reduce the quantities of radionuclides released to air, water, and soils during both routine operations and potential abnormal operations. The changes to the 300 Area Liquid Waste

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TABLE IX-2

DEDICATED WASTE MANAGEMENT LANDS

General Location	Content[a]	Approximate Area (Acres)
100 Areas	Burial Grounds	70
200 Areas	Burial Grounds, Process Buildings, Tank Farms, Cribs, and Ponds	5,100
300 Area	Burial Grounds and Process Ponds	50
600 Area	Burial Grounds	10
Total		5,230[b]

(a) Excludes standby facilities.
(b) This is 1.4% of the total Hanford Reservation land area.

Disposal System ($190,000) and the N Reactor Control Rod Coolant Dump System ($75,000) will essentially eliminate the population dose contributions from these waste systems (about 0.1 man-rem/year). All other facilities where changes are being made to improve radionuclide containment (~$42,000,000) are already contributing essentially zero population dose.

In Section V, alternatives were discussed for several categories of waste with special emphasis placed on alternatives for the radioactive waste. Study of these various categories of waste reveals that none of the waste is currently causing a significant environmental impact on either the biota on or near the Hanford Reservation or on the general population. Essentially all releases of materials or energy are made in such a way that they comply with appropriate local, state, and national standards. The primary environmental impact, an annual radiation dose of about 2.5 man-rem/year to the population, will decrease to less than 0.01 man-rem/year following the shutdown of N Reactor.

The capital cost, time to adopt, potential release prior to earliest possible adaption, and changes in 1) radiation dose, 2) land use areas, 3) curies to the soil, and 4) releases to groundwater and to the Columbia River for the major alternative to the treatment and handling of high-level liquid waste, liquid effluents, and gaseous effluents are summarized in Table IX-3. Also in Table IX-3 is a compilation of total curies and ^{90}Sr, ^{137}Cs, and ^{60}Co curie reductions related to the costs of the alternatives. The radiation dose to the population and consequently the health effects are essentially independent of the alternatives chosen. There would be no detectable effects on aquatic or bird life and only minor habitat displacement for animal life by adopting any of these alternatives. Chemical releases to the atmosphere and to the Columbia River would change only slightly. Some reduction in atmospheric releases would occur if alternatives requiring minimum consumption of fossil fuels were adopted, particularly termination of the operation of the steam heated evaporators.

The existence of the current inventory of radioactive waste requires that a waste management operations program be continued. The alternatives to the present high-level waste management program cost considerably more than the current program would require at least twice as long to implement (thereby doubling the predicted curies that might be released to the soil due to tank leakage during time to implement the alternative); require the commitment of additional land to waste management and, after implementation, would provide no change in the radiation dose or the curies of radioactive material released to the soil compared to the current program. After considering the high-level liquid waste management alternatives, it is concluded that the current program of solidification to salt cake should proceed. This program will include the

TABLE IX-3

COST-BENEFIT SUMMARY

Alternatives	Capital Cost (millions)	Time to Adopt (years)	Predicted Curies to be Released[a]	After Alternative Adoption Change In: Radiation Dose (man-rem/yr)	Land Use Area acres	Curies[b] to Soils per yr	Total $/Ci/yr Not Stored on Soils $/Ci/yr	$/Ci/yr of ^{90}Sr, ^{137}Cs, ^{60}Co	For Period of Operations 1978-1990 Total $/Ci/yr Not Released to River $/Ci/yr	$/Ci/yr of ^{90}Sr, ^{137}Cs, ^{60}Co	For Periods of Operations 1978-1983 Total $/Ci/yr Not Released to River $/Ci/yr	$/Ci/yr of ^{90}Sr, ^{137}Cs, ^{60}Co
High-Level Liquid Waste												
Continue present program[c]												
Replace older single-wall tanks	30	3-4	8,000	0	5	-200	150,000	150,000	NA	NA	NA	NA
Replace all single-wall tanks	75	5	10,000	0	10	-2000	38,000	38,000				
Discontinue Solidification to Salt Cake[c]												
New double-wall tanks	300	~10	20,000	0	50	-2000	150,000	150,000				
Calcine	200	~10	20,000	0	30	-2000	100,000	100,000				
High Temperature Melt Formations	100	~10	20,000	0	30	-2000	50,000	50,000				
Insoluble Formations	130	~10	20,000	0	75	-2000	65,000	65,000				
Liquid Effluents												
200 Areas												
• Evaporate B Plant Streams	1-1.5	2	160	0	0	-30 [-7][d]	40,000	200,000				
• Evaporate Purex Ammonia Scrubber Streams	0.5-0.8	2	160	0	0	-30 [0.1][d]	20,000	>800,000				
• Evaporate All Discharge Streams	30-35	3	240	0	30	-60 [-7][d]	80,000	>4,000,000				
100 Areas												
• Reinject Rupture Loop	0.6	1	5,400	0	0	-1000 [-80][d]	600	7,500	100,000	>600,000	50,000	>600,000
• Closed Loop Cooling	2.2	2	11,000	<0.1	0	-1500 [-170][d]	1,500	13,000	200,000	>2,400,000	100,000	>2,400,000
• Provide both Reinject Rupture Loop and Closed Loop Cooling	2.8	2	11,000	<0.1	0	-2500 [-250][d]	1,100	10,000	170,000	>3,000,000	84,000	>3,000,000
• Total Effluent Treatment	22	3	16,000	<0.1	20	-5100 [-410][d]	4,300	54,000	850,000	>25,000,000	430,000	>25,000,000
Gaseous Effluents												
• N Reactor	10+	2-3	150,000	-1.4	0	0						

(a) Predicted curies to be released from present operations prior to earliest possible adoption of the alternative, tritium excluded.
(b) Excluding tritium, changes given are for after the alternative is operational compared to current operation.
(c) Assumes two 5000 gallon leaks.
(d) Reduction in ^{90}Sr + ^{137}Cs + ^{60}Co in soil.

replacement of some or all of the single-wall tanks with improved double-wall tanks as required. However, research and development will continue on methods for solidification of residual liquors as well as alternative insoluble formations.

The cost-benefit analysis for the liquid effluent alternatives for the 100 and 200 Areas is, at best, extremely difficult to quantify. The estimated dose to the public from future operations, without the adoption of any of the liquid effluent alternatives, is >0.1 per man-rem/year. This compares to 27,000 man-rem/year from natural background radiation. Also little difference in land usage exists between alternatives. Therefore, some criteria must be established to equate the costs of these alternatives to the benefits received from discontinuing use of the natural soil columns without regard to the estimated exposure to the public from radioactive materials. Such analysis clearly involves value judgements based upon a perception of benefits commensurate with risks, since there is no realistic numerical relationship between dollars spent and curies not released to the ground. Therefore, the analysis was performed on the basis of evaluating the costs of the reduction of radionuclides, particularly the long-lived radionuclides (^{90}Sr, ^{137}Cs, and ^{60}Co), and the effect such reduction would have on the decay period (i.e., time required for the current inventory of radionuclides in the soil to reach background levels) of the radionuclides already deposited in the soil.

As indicated earlier, adoption of any of the liquid effluent alternatives for the 100 and 200 Areas would not result in any material change in the dose to man. There would be no change at all for the 200 Area alternatives and less than 0.1 man-rem/year for the 100 Area alternatives. The dose to man from the current waste management practices is already well below prescribed standards.

On a dollar per curie not released to the soil basis, for both long-lived and short-lived radionuclides, the most cost effective option is the combined Reinject Rupture Loop and Closed Loop Cooling alternative (Table IX-3) for the N Reactor (100 Area). This combined project provides for a 2,5000 curie per year reduction of radionuclides released to N Crib, including a 250 curie reduction for the long-lived radionuclides (^{90}Sr, ^{137}Cs, and ^{60}Co) at a capital cost of $2.8 million and operating cost of $40,000 per year. The discharge of ^{90}Sr and ^{137}Cs would be reduced by more than 90% and ^{60}Co by more than 50%. This option results in a reduction in the N Crib decay period of about 15 years. Compared to this combined alternative, the Total Effluent Treatment alternative (Table IX-3) for the 100 Area would 1) reduce the curies released to the N Crib by a factor of 2 but at a capital cost of $22 million (a factor of 7 greater) and $600,000 annual operating cost (a factor of 15 greater) and 2) reduce the decay period of N Crib by only an additional five years.

If N Reactor operates only through 1978, none of the 100 Area liquid effluent treatment alternatives can be justified in view of the time required to implement. If N Reactor operates through 1983, or longer, the alternative that would provide both Reinject Rupture Loop and Closed Loop Cooling is marginally justifiable on the basis of the cost of the reduction of the decay period for N Crib. The Total Effluent Treatment alternative cannot be economically justified in view of the small additional curie reduction and decay gain compared to the combined alternative.

The alternatives for the 200 Areas liquid effluents cost hundreds of thousands to millions of dollars with only a very small reduction in radionuclides discharged (<60 Ci per year total and <7 Ci ^{90}Sr + ^{137}Cs + ^{60}Co). The adoption of any of the alternatives for the 200 Areas would reduce the overall decay period for existing cribs by only a few years, compared to the current program. These projects cannot be economically justified for the small reduction in crib decay period.

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X COMMENTS

The comment section is divided into two parts, 1) Report of the Presiding Board comments, other comments and ERDA responses and 2) full text of all comment letters (exhibits in subsection X.29). Section X.0 contains comments and recommendations of the Presiding Board of the Public Hearings held on the Draft Environmental Impact Statement (DEIS) in Portland, Oregon and Richland, Washington. Each of the incoming comment letters was serially assigned a number as it was received. The assigned numbers were used throughout the text to indicate topic areas where text changes were made as a result of comments. For example, Comment Letter 4 is identified as X.4. Any text changes made as a result of comments contained in Letter 4 are identified [X.4] in the text of the statement. The response to Comment Letter 4 in this section indicates "Text Change Made, Vol ___, Section ___." If a text change was not made, the ERDA response immediately follows the letter comment in this section. Page numbers referred to in the comment letters are those used in the DEIS issued September 1974, not this document. The comments presented by the Report of the Presiding Board [RPB] are identified in the same way throughout the text.

For the reader's convenience, the following index to the comment letters is provided.

Comment Letter		Comment and Response Page	Exhibit Page
X.1	Department of Agriculture	X-12	X-98
X.2	Concerned Californians	X-12	X-99
X.3	Jennifer Bromgren	X-12	X-99
X.4	Steven C. Sholly	X-13	X-101
X.5	Neal E. Wilson	X-20	X-106
X.6	H. W. Ibser	X-21	X-107
X.7	Eugene Future Power Committee	X-24	X-108
X.8	R. G. Wolfe	X-25	X-108
X.9	Department of Agriculture	X-28	X-111
X.10	Protect the Peninsula's Future	X-28	X-112
X.11	W. P. Metz	X-32	X-113
X.11A	W. P. Metz	X-33	X-114
X.12	National Science Foundation	X-40	X-117
X.13	Federal Power Commission	X-41	X-118
X.14	Department of Health, Education, and Welfare	X-41	X-119
X.15	Department of Commerce	X-43	X-120
X.16	Department of Defense	X-44	X-122
X.17	State of Oregon	X-44	X-122
X.18	Department of the Interior	X-45	X-126
X.19	Mrs. Ray Rodd	X-56	X-134
X.20	Betty Lagergren	X-56	X-134
X.21	Alan Stamwitz	X-56	X-135
X.22	Zero Population Growth	X-57	X-135
X.23	North Anna Environmental Coalition	X-57	X-138
X.24	Environmental Porteciton Agency	X-57	X-140
X.25	Natural Resources Defense Council, Inc. Oregon Environmental Council Friends of the Earth Sierra Club	X-78	X-155
X.26	Department of Transportation	X-95	X-205
X.27	Arthur S. Kubo	X-96	X-207
X.28	State of Washington	X-97	X-209

X.0 Comments from the Report of the Presiding Board (Members identified in Vol 1, Foreword)

X.0.1 What should the agency do next?

A large number of witnesses criticized the scope of the EIS. They argued that it was incomplete and did not deal effectively with the true, long term alternatives faced by the agency in managing high level, long lived waste materials at Hanford. Specific criticisms are listed below under substantive headings. Several witnesses suggested that the agency should adopt additional procedures to reconsider the EIS and the waste management program at Hanford.

(a) Several witnesses suggested (or endorsed the suggestion) that an impartial Committee, consisting of representatives of interested Federal and State agencies, universities, and other institutions, and the public be created "to assess the current status at Hanford." The Committee, it was proposed, would issue a public report, and recommend changes in policies and procedures to increase the margin of safety in waste management operations at Hanford.

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(b) It was suggested that the agency should order another hearing at which participants would have the opportunity to explore fully with agency witnesses the following areas:

(i) The extent of knowledge regarding the geological and hydrological conditions of the Hanford reservation, particularly with respect to the mobility and potential for release of the large store of radioactive materials that are now or will soon be in the soil;

(ii) The extent of retrievability of the high level wastes in shallow earthen burial sites; and

(iii) The extent of disclosure of competent, responsible criticisms and evaluations which are or have been in the possession of the agency. While the organization making this suggestion stated that it did not seek to saddle the agency with "unnecessary rigid procedural requirements," it did contemplate an opportunity for "full questioning." The justification given for this unusual procedure is that the Hanford waste management program presents "an unusual situation" in that the issues are complex, the agency is in effect evaluating its own performance over the previous 30 years, full disclosure of the margin of safety at Hanford involves heavily factual issues, and a full presentation of the technical and critical judgments and assessments of competent scientists is essential.

(c) It was suggested that the agency might issue a revised EIS and request further comment and submission of views by members of the public either in writing or through another legislative-type oral proceeding.

(d) The Environmental Protection Agency recommended that "a thorough independent review and assessment of the hydrogeological situation at Hanford be made" with the cooperation of other agencies such as the U.S. Geological Survey and EPA.

(e) Of course, the agency may simply issue a final EIS based on the information and suggestions presented by written submission and at these hearings, as is assumed in an Objection to Interrogatories filed on February 13, 1975 by the agency in litigation in the United States District Court for the Eastern District of Washington (Natural Resources Defense Council v. Ray, et al.).

With respect to these various alternatives, it might be observed that (1) the chief spokesman for the agency recognized that some portions of the EIS would have to be substantially expanded, and (2) the requests for additional procedures were made prior to the written responses to specific questions by the agency on February 26, 1975.

Response

Text Changes Made - Vol 1, Foreword and Section V

1. The purpose and scope of the statement as stated in the Foreword is to reassess the ongoing Hanford Waste Management Operations Program so as to avoid or minimize any future adverse environmental effects. This is not intended to be a statement on the ultimate disposal of the Hanford waste. EPA agreed that this was a proper scope for the statement (see Exhibit 24). As a result of the comments, more information has been provided on the current R&D programs for ultimate disposal (see Section V).

   (a) This suggestion raises questions in the area of responsibility for the control and management of the Hanford Waste Management Operations Program. That responsibility rests with the ERDA. Similarly, the responsibility for the preparation of the environmental impact statement rests with the ERDA. However, independent reviews of this program have been made in the past, including a review by the National Academy of Sciences. The General Accounting Office has also reviewed the Hanford Waste Management Operations Program. ERDA plans to continue to utilize the expertise and evaluation of recognized experts with respect to its waste management operations.

   (b) Text Changes Made - Vol 1, Section II.3.14 and Section V

   ERDA did not believe that an adversary-type proceeding would be in the public interest for the issues considered in the Hanford EIS. As Professor Robert W. Hamilton, Chairman of the Hearing Board, said at the Portland hearing in response to the request for an adjudicatory hearing: "I might observe in passing that I cannot imagine issues less well suited for a trial-type proceeding than scientific questions of this nature." (Transcript of hearing proceeding, Portland, Oregon, January 23, 1975, p. 204). The

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purpose of the DEIS is to obtain input from other sources. In addition to the usual commenting procedures, public hearings were held in Richland, Washington, and Portland, Oregon, to provide an additional opportunity for the public to comment on this statement. The areas of concern have been carefully considered and evaluated and the statement has been modified and expanded in areas where such action was appropriate; for example, the Hydrology Section of the impact statement has been substantially revised, a description of the current plans with respect to the retrievability of the plutonium and transuranic wastes in the soil has been included in Section V, and a review of the comments and evaluations that have been performed by independent organizations has been added to Section II.3.14.

(c) ERDA determined that the issuance of a revised DEIS was not warranted.

(d) Text Changes Made - Vol 1, Section II.3.8.2 and Vol 2, Appendix II.3-D

EPA's recommendations that a thorough independent review and assessment of the hydrological situation at Hanford be made will be seriously considered. Dr. Raul Deju, cited by EPA in support of that recommendation, was commissioned as a consultant to perform that very type of independent review and assessment of the hydrological situation at Hanford. Modifications of the hydrological monitoring program are currently being made in accordance with Dr. Deju's recommendations. The Hydrology Section has been substantially revised (Vol 1, Section II.3.8 and Vol 2, Appendix II.3-D) in response to the numerous comments on this subject.

X.0.2 The Continued Production of Salt Cake and Future Containment of High Level Waste.

Representatives of the agency stated that a major question raised by the EIS was whether the present practice of converting high level liquid waste into salt cake by removal of the highly radioactive strontium-90 and cesium-137 and extraction of as much liquid as possible should be continued. Witnesses at the hearing did not seriously question the desirability of continuing this practice as an interim measure to minimize leaks into the soil from existing tanks, though several expressed the view that production of salt cake might confuse and complicate the agency's long term disposal problems.

Concern was particularly expressed about the storage of sludge and salt cake in single wall tanks whose integrity is uncertain. It was suggested that such sludge and salt cake may be difficult or impossible to retrieve safely from such tanks, and that the effect of continuing the storage of salt cake in those tanks may constitute a de facto decision to maintain the wastes in their current storage tanks permanently, an "unacceptable" permanent solution. A witness suggested:

(a) The agency should immediately begin the construction of new double wall tanks (to the maximum extent practical) to replace all single wall tanks whose integrity may be in question before the implementation of a plan for permanent storage of such wastes;

(b) The interim storage of salt cake exclusively in double wall tanks;

(c) Abandonment of the plan to seal off single wall tanks if sealing complicates subsequent hydraulic removal of wastes; and

(d) Immediate consideration of the problem of retrieving salt cake and sludge from tanks (including the S-X tanks) whose integrity has been breached or is uncertain.

The witness also expressed concern that residual liquids that cannot effectively be removed from the salt cake may leak into the ground if present tanks are used for indefinite storage.

Response

Text Changes Made - Vol 1, Section V.2.1.1, Section V.2.1.3, Section V.2.5 and Section IX

2. Conceptual designs have been prepared to allow the recovery of the salt cake from the storage tanks using vendor supplied components developed for the mining and material handling industries. Section V.2.5 of Vol 1 provides a discussion of the research and development plans for ultimate disposal.

(a) Construction of three new one-million gallon double-wall tanks has been completed and construction of four more is in progress. In addition, construction of six more double-wall tanks is budgeted for 1976 and six for 1977. Some of these would replace single-wall tanks whose integrity may be uncertain.

(b) The consideration to replace all single-wall tanks with double wall tanks for the storage of high-level waste is an alternative discussed in Sections V.2.1.1, V.2.4.1 and IX of Vol 1.

(c) There is no plan to remove solidified waste from single-wall tanks by sluicing and, therefore, no complications are added to the removal of the waste if these tanks are sealed off. Liquid waste has been removed from all confirmed or suspected leakers (usually complete removal) to eliminate the potential of further leakage of liquids from these tanks to the soil. In those few cases where liquid remains, the liquid level has been pumped to below the level of leakage. Solids in the form of sludges remain in these tanks.

(d) A text change has been made in Section V.1 of Vol 1 to clarify that conventional sluicing and redissolving techniques will not be used to retrieve salt cake and sludges. These solids do not represent a threat for the environment. Technology is being developed for mining of salt cake and sludges.

X.0.3 The Development of Permanent Disposal Plans for High Level Waste.

Several witnesses and the Environmental Protection Agency felt that the major deficiency in the agency's waste management operations was its apparent failure to develop long term disposal plans for the high level radioactive salt cake and sludge currently being generated and stored in tanks. It was urged that a description of the agency's tentative plans, to the extent that it has them, should be included in the EIS. Concern was expressed that the development of a plan, first promised in 1973, has been delayed either to 1977 or 1981. Concern was similarly expressed about the failure to develop long term disposal plans for the encapsulated radio-strontium fluoride and radiocesium chloride now being held in the water-cooled storage facilities in or adjacent to B plant. [Additional information with respect to permanent storage plans was submitted by the agency in its response of February 26, 1975, including a statement that "there is no existing plan to convert the capsule storage basins (near B plant) to a 'final disposal site.'"]

In considering alternative plans for the handling of high-level waste at Hanford, it was suggested that the most desirable criterion should be not the minimum radioactivity released off the Hanford reservation (since such plans all involved essentially zero release) but removal of radioactive wastes from the environment per dollar of cost or the minimization of land perma-nently rendered unfit for other use.

Response

Text Changes Made - Vol 1, Section V and Section IX

3. The tentative plans and milestones for long-term handling and ultimate disposal have been expanded in Sections V and IX. As noted in the Foreword, EPA, in its comments dated January 23, 1975, suggested that at the conclusion of the ongoing effort to prepare impact statements for all major ERDA waste management operations (Hanford, Savannah River, and Idaho), ERDA should prepare a generic environmental statement addressing the long-range program for both interim storage and ultimate disposal of all ERDA generated high-level and transuranic wastes. ERDA is carefully considering EPA's suggestion and a statement or statements will be written during the research and development process before that process has reached the stage of investment or commitment likely to foreclose or restrict available alternatives.

   The long-term storage plans for the Waste Encapsulation and Storage Facility do not include any plan to convert the capsule storage basins to a "final disposal site." Corrosion test results show that ^{90}Sr and ^{137}Cs inner capsules will maintain their integrity for at least 600 years when stored under water. In this period, the radionuclide activity will have decayed to less than 200 millicuries per capsule. When a final disposal method for Hanford waste is available, these capsules can be included.

   The expanded Section IX includes cost/benefit data relating to lands used to store radio-nuclides as well as cost per curie of radioactivity removed from effluents before reaching the Columbia River.

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X.0.4 The Storage of Radioactive Waste in the Ground.

Many witnesses strongly urged that the EIS should consider the "mining" or removal of plutonium wastes in the soils at Hanford, particularly in the Z trenches and the shallow trenches used for solid wastes. The agency's response of February 26, 1975 states that the total amount of plutonium stored at the Hanford site is estimated to be 940 Kgs. [kg] ± 30 percent. Of this, approximately 39 percent is stored in solid sites, 21 percent in liquid sites, while the remaining 40 percent is in tanks.

The cost of removing and isolating this material should be calculated and compared to the costs of direct surveillance and loss of use of land entailed if the plutonium is left in the ground. The view was expressed that such removal should not be dependent on whether the plutonium recovered had commercial value but rather should be to eliminate a potential danger from the environment.* Concern was expressed as to whether the behavior of plutonium in soil was fully understood and in fact was now stabilized. [Reference was made at the hearing to the environmental impact statement relating to the plan to mine the Z-9 crib.]

In view of the long half life of plutonium, the probability (indeed, certainty) of major climactic [climatic] and other changes should be considered in evaluating the desirability of removing as much transuranic nuclides from the soil as possible. It was suggested that any of the following non-catastrophic events might ultimately lead to the release of radioactive waste into the environment:

(a) The construction of the Ben Franklin dam;

(b) Increased irrigation;

(c) The cumulative effect of creating a "nuclear park" at Hanford consisting of as many as 30 reactors;

(d) Increases in rainfall;

(e) Reduction in rainfall [it was argued that as the climate becomes drier, moisture may flow to the surface and nuclides may be distributed by wind erosion]; and

(f) Volcanic activity [it was argued that such activity might lead to additions of ash to the soil and a resultant change in flora types].

[The agency's response of February 26, 1975 indicates that information with respect to some of these events is available; presumably such information can be incorporated in the EIS.]

Response

Text Changes Made - Vol 1, Section II.1.1.4.4, Section II.1 References, Section V.2.5 and Section IX; Vol 2, Appendix II.1-H

4. Research and development programs to demonstrate the ability to recover plutonium from cribs and trenches is in progress. ERDA has now gone ahead with plans to mine the Z-9 Crib. This recovery effort will provide the practical knowledge on methodology, potential and actual problems, the economics involved and areas of needed research. The text provides additional information on measurement of plutonium in soils.

   (a) Although the U.S. Corps of Engineers has conducted a preliminary study on the proposed construction of the Ben Franklin Dam, the detailed studies that are necessary to determine the effect on the Hanford water tables have not been done. However, some studies of the effects on Hanford have been made (see Reference 15 of Section II.1). If a firm proposal to construct this dam is made, the effect will be studied and separate EISs prepared if necessary. Should the study indicate that the water table will be affected to a degree that it would threaten the containment of the radioactive wastes, either the dam would not be constructed or the radioactive wastes would be removed prior to construction.

*The agency's response of February 26, 1975 states that "it is technically feasible to retrieve essentially all of the plutonium, however, it may not be economically justifiable."

(b) Any irrigation or construction proposals of a magnitude to change the Hanford water table levels would be studied in the same manner as a proposal to construct the Ben Franklin Dam. Studies to broaden our knowledge of the movement of moisture in Hanford soils are continuing. The first work at Hanford directed toward investigation of moisture transport through partially saturated sediments concluded that precipitation could percolate from the ground surface to the water table, especially in areas where the distance to the water table was less than 20 feet (near the Columbia River). The amount of precipitation, if any, reaching the water table beneath the 200 Area was believed to be too small to measure. To resolve the question of whether precipitation on the 200 Area plateau reaches the water table, a field test facility was constructed in 1971 to measure moisture content and potential as a function of time and depth. The data obtained from this field site have not been collected for a sufficient length of time to conclusively resolve this question. However, all the data indicate that the moisture movement upward or downward is extremely slow.

(c) The consequences that may result from the construction of a nuclear park or even the addition of one reactor will need to be presented and evaluated in separately prepared EISs.

Those already prepared are: Environmental Statement Related to Construction of Washington Public Power Supply System Nuclear Projects 1 and 4 NUREG-75/012, March 1975

Environmental Statement Hanford No. 2 Nuclear Power Plant, December 1972

Fast Flux Test Facility Environmental Statement, USAEC, WASH-1510, 1972.

(d) See 4(b) above.

(e) See 4(b) above.

(f) The research areas under investigation as described in Vol 1, Section V include studies on the possible influences that flora types will have on plutonium uptake. These results will assist in evaluating the effect of changes in flora type if this should occur for any reason including volcanic.

X.0.5 The Tank-106 Leak and Other Accidental Leaks.

Closely related to point 4 is the suggestion that the EIS does not give adequate consideration to the possibility that the wastes leaked at Tank 106-T might move into the water table because of variations in soil moisture, vegetation or animals, and a rising water table. It was also suggested that similar consideration should be given for every other major leak. The statement of the Environmental Protection Agency and the Department of Interior both suggest that the hydrological data presented in the EIS does not conclusively show that these waste materials will remain permanently where they now are. At the hearing the views of the agency's hydrology consultant, Dr. Raul Deju, were also considered extensively. [Additional information relating to the limited movements of nuclides since discovery of the Tank-106 leak and to present and contemplated studies of the movement of nuclides in the Hanford soil is set forth in the agency's response of February 26, 1975.]

Response

Text Changes Made - Vol 1, Section III.2.2.2, and Section V.2.5.2; Vol 2, Appendix II.1-C, Part 5 and Section II.3-D.3

5. Immediately following the leak occurrence from the 106-T waste tank in June 1973, a number of vertical wells were drilled to permit monitoring of the migration of the radioactive materials in the soil beneath and surrounding the waste tank. The results from periodic monitoring of these wells indicate that more than a year and a half after the leak was discovered, the sediments near the tank still contain the waste in a region that is more than 100 feet above the water table. The data show that the movement downward is stabilized. Minor lateral movement was evident at only one monitoring well. Evaluation of the geology and hydrology of this particular well showed that such lateral spreading of the material would be expected. The peak count rates in monitoring wells are decreasing with time, consistent with the ruthenium decay curve.

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X.0.6 N-Reactor and the Purex Plant.

A number of witnesses addressed themselves to problems associated with the continued operation of this reactor and processing plant. The following views were expressed:

(a) The need for the plutonium created by N-Reactor was questioned and the view was expressed that this was really a nonconforming power reactor in disguise. The overall need for the continued operation of this reactor was questioned, and it was suggested that the reactor should be shut down immediately to end the intentional release of radioactive waste into the ground water and the Columbia River. [The agency's response of February 26, 1975 states that these views raise questions beyond the scope of the EIS.]

(b) It was suggested that if the N-Reactor is to operate after 1977, steps should be taken to eliminate all releases of radioactive waste to the environment. Because of the long lead time for such steps, it was urged that a prompt decision as to the future of this reactor was essential.

(c) It was suggested that consideration should be given to closing down the Purex plant immediately and storing the spent fuel rods generated by the N-Reactor until commercial processing plants are available. This also would substantially reduce the intentional storage of radioactive waste in the ground.

(d) Witnesses also testified that the EIS should discuss the following aspects of the N-Reactor-Purex plant:

(i) The possibility that the Purex plant will be used for commercial wastes;

(ii) The number of fuel ruptures or cladding failures at the N-Reactor, and the inadvertant release of radioactivity as a result [information on this question appears in the agency's response of February 26, 1975]; and

(iii) The possibility that this reactor could be brought into conformity with general commercial power reactors.

Response

Text Changes Made - Vol 1, Section III.1.1.8, Section V and Section IX

6. (a) The alternatives considered have included the impact of immediate shutdown of N Reactor as well as extension of operation throughout its useful life (1990). Continued operation is based upon the need to produce plutonium to meet ERDA requirements. Presented in Section V are alternatives with respect to effluent controls. The effect of both N Reactor continued operation and the operation of Purex through 1990 is considered in Vol 1, Section III.

(b) The text changes made in Sections V and IX of Vol 1 describe in detail the projects planned and under construction and other alternatives to further reduce N Reactor's release of radioactive material.

(c) Although the Purex plant is not currently operating, as spent fuel rods in N Reactor accumulate they will have to be processed to recover the plutonium produced. Commercial processing is not likely because of limited commercial reprocessing capacity and the substantial differences in chemically recovering plutonium from N Reactor's zirconium clad metallic fuel elements as compared to commercial fuel elements. For further discussions on Purex shutdown, see Section V.2.3.

(d)

(i) Purex plant is not now being considered for conversion to handle commercial waste.

(ii) During the past five years 28 fuel element cladding failures have occurred in N Reactor. The number of failures for each of these five years is shown below:

Year	No. of Failures
1970	5
1971	8
1972	7
1973	3
1974	5

In N Reactor, a sample of coolant from each of the 1003 process tubes is monitored for evidence of a fuel cladding failure. The reactor is promptly scrammed when such a failure occurs. With this practice, no increase in the releases of radioactivity to the crib from N Reactor was detected following 26 of the 28 failures. In two cases, an increase in radioactivity was detectable. The greatest release of activity that has occurred during the operation of N Reactor took place on April 10, 1974. Approximately 300 curies of mixed fission products* were released to the 1301-N crib as a result of this fuel cladding failure. The second detectable release to the 1301-N Crib occurred on December 7, 1973. Approximately 220 curies of mixed fission products* were discharged to the 1301-N Crib as a result of this failure.

(iii) N Reactor is not a commercial power reactor and was designed and built prior to the present commercial reactor performance requirements. The dose to people in the environment from N Reactor operations is about the same as that for commercial reactors.

X.0.7 The Old Reactors on the Columbia.

In view of the fact these unused reactors may at some time in the future be submerged by flood, it was suggested that consideration be given to the removal of these old reactors since they contain substantial radioactive contamination. [Information on this question appears in the agency's response of February 26, 1975.]

Response

Text Changes Made - Vol 1, Section II.1.1.2.5 and Section V

7. ERDA is in the initial phase of formulating decommissioning plans for all retired and radioactively contaminated facilities in the Hanford area. Alternatives for disposal of the retired reactors are currently under study and funded at a $300,000 level in FY-1975. Further details are presented in the decontamination and decommissioning addition to Vol 1, Section II.1.1.2.5.

X.0.8 Possible Catastrophic Events.

Witnesses suggested that the EIS should consider the impact of possible catastrophic events at the Hanford reservation, including:

(a) The simultaneous failure of the cooling system and backup system in boiling tanks and other tanks containing large amounts of strontium-90 and cesium-137;

(b) Sabotage;

(c) Total abandonment of site;

(d) The explosion of a megaton weapon over the tank farm area;

(e) A glacial-caused flood similar to those occurring 12,000-20,000 years ago including a comparison of the warning time and the time needed to remove radioactive wastes;

(f) The collapse of one or more major dams above the Hanford reservation;

(g) A deluge sufficiently great to cause migration of the nuclides now in the soil; and

(h) An earthquake close to B plant.

*Radionuclide with half-life of 67 hours or more.

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All of the foregoing events were considered to be "credible" in view of the extremely long half lives of the transuranic isotopes stored in the ground at Hanford.

Response

Text Changes Made - Vol 1, Section II.3.9.1, Section III.2 References, Section III.2.1, Section III.2.6, Section III.2.11, Section III.2.11.3 and Section V.1

8. (a) Section III.2.6 presents data from the safety analyses reports for B Plant.

   (b) Section III.2.1 includes sabotage and plant security data. Since the scenarios for military attack are unlimited and highly speculative, the inclusion of such scenarios in this statement would be unreasonable speculation.

   (c) The text changes in Section V.1 discuss the consequences of terminating waste management operations.

   (d) Acts of war are not considered; however, the effects of a nuclear weapon explosion at a tank farm location have been studied. The document reporting the results of these studies is given as Reference 17 at the end of Section III.2 of Vol 1.

   (e) The failure of upstream dams is considered (U.S. Corps of Engineers) as an incredible event and is not analyzed.

   (f) A text change has been made in Section II.3.9.1 to include rainfall prediction data.

   (g) The consequences of an earthquake as unexpectedly severe as Richter 6.8 magnitude have been analyzed in Vol 1, Section II.3.7 and Section III.2.11.2.1. See (a) above and Section III.2.11.

X.0.9 Consideration of Overall Hanford Operations.

The EIS is generally limited to the management of the wastes created as a result of the weapons program. It was suggested that the EIS should consider the waste created by all nuclear installations at Hanford, including commercial reactors and the fast flux facility. It was also suggested that the EIS should consider the total cumulative impact of all past management practices at Hanford.

Response

9. Separate environmental impact statements have been prepared for Washington Public Power Supply System Reactors, Documents NUREG-75/012 and the Fast Flux Test Facility, WASH-1510. Also, see previous comment regarding nuclear parks [X.0.4(c)].

   The annual environmental reports, issued publically since 1959, evaluate the cumulative impact of all past Hanford operations and any contributions from accidents. The levels found in the environment are now so low that the doses to people were estimated from emission or release data and exposure pathway models. The earlier reports are listed in a bibliography in Vol 2, Appendix III-G.

X.0.10 Miscellaneous Omissions in the EIS.

It was suggested that the EIS should be augmented to include information on the following:

(a) Radioactive exposure of employees [such information appears in the agency's response of February 26, 1975];

(b) The possible future use, if any, of the highly toxic actinides, e.g., neptunium, now stored at Hanford;

(c) The amount of seismic stress as well as seismic activity at the Hanford reservation [the agency's response of February 26, 1975 indicates that seismic stress has been monitored by the agency and presumably such information can be incorporated in the EIS];

(d) The role of contractors in creating, disposing of, or causing leaks of, radioactive waste;

(e) The identity of the authors of the various sections of the EIS; and

(f) A comparison with standards for storing commercial waste, and any differences justified or explained.

Response

Text Changes Made - Vol 1, Section II.3.7, Section III.1.1.7, Section III.2.2.1 and Section V.2.4

10. (a) The occupational exposures received by Hanford workers have been added to the text in Vol 1, Section III.1.1.7.

(b) The actinides, e.g., neptunium, are not waste materials but are product materials which are segregated and used for special product production.

(c) Additional data on seismic stress have been added in Vol 1, Section II.3.7.

(d) Actions taken by contractor management regarding radioactive waste materials are described in relationship to the 106-T tank leak in Vol 1, Section III.2.2.1.

(e) The responsibility for this document rests entirely with ERDA.

(f) Federal Regulations (10 CFR Part 50, Appendix F) require that a commercial fuel reprocessing plant's inventory of high-level liquid waste be limited to that produced in the prior 5 years, and that these wastes be converted to a dry solid - chemically, thermally and radiolytically stable - and placed in a sealed container prior to transfer to a Federal repository, no later than 10 years following separation of fission products from the irradiated fuel. To achieve these goals, the liquid acid waste from the process will not be neutralized but will be converted to solids in a calcination step. The solid product will be a mixture of stable oxides of fission products, actinides and other metals (iron, chromium, nickel, etc., from process chemicals and corrosion products). Approximately 2 cubic feet of solidified waste are anticipated to be formed from each metric ton of fuel processed.

Operation of chemical reprocessing facilities at Hanford was begun long before the technology was available to convert liquid waste to solids by calcination. Therefore, the liquid acid waste was neutralized with caustic (sodium hydroxide solutions) and stored in underground concrete tanks lined with carbon steel. As a consequence large volumes of waste have been accumulated at Hanford, with sludges containing insoluble hydroxides (or hydrated oxides), including fission product strontium, and supernatant liquids containing soluble salts, mostly sodium salts, but including fission product cesium.

With the beginning of tank failures - first noted in the late 1950s - a program was initiated to develop procedures to convert the Hanford waste to less mobile form. Calcination was not considered practicable because of the large volumes involved, and because the product of calcination would be principally sodium oxide - a soluble compound - not much less mobile than other sodium salts. Therefore, evaporation of the liquid to salt cake for in-tank storage was chosen in the early 1960s. However, the presence of long-lived, high-yield fission products ^{90}Sr and ^{137}Cs (each with half-lives of about 30 years) meant that the salt cake would be heated to high temperatures from decay-heat. Accordingly, removal of cesium and strontium from the more concentrated waste was initiated to remove this potential. Refer to Vol 1, Section V.2.4 for additional discussions.

X.0.11 Miscellaneous Criticisms of the EIS.

The EIS was criticized on several miscellaneous grounds:

(a) No consistent time period is established for the various events discussed;

(b) The figures and data used give an unrealistic impression of accuracy;

(c) Many statements in the EIS are conclusory [conclusive] and not adequately supported by factual data, e.g., the statement that the Hanford operations "have had no harmful effects on the migration or spawning of salmon" is unsupported, and even contradicted by factual information

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in the EIS [the agency's response of February 26, 1975 sets forth additional information relating to thermal effects on the Salmonid population of the Columbia River];

(d) The various uncertainties regarding margins of safety should be discussed;

(e) The estimates with respect to damage to health are not substantiated and in particular, reference is made to studies dating as far back as 1964 without giving any results of such studies;

(f) The EIS is difficult to follow and important information is buried obscurely in appendices or other portions of the EIS and not referenced in the more introductory or general parts of the EIS;

(g) The EIS is confusing because of the lack of consecutive pagination and the manner of numbering tables and appendices; and

(h) The EIS is confusing because of the failure to use consistent terminology and standards of measurement, e.g., the amount of plutonium in soil is sometimes measured in grams and sometimes in curies.

Response

Text Changes Made - Vol 1, Section II, Section III, Section V, Section IX and List of Abbreviations

11. (a) The various time frames established for differing events are included in both Section V under Ultimate Disposal and in Section IX under Cost/Benefits. The times to analyze, adopt, and implement various plans are predicated upon assuring at each step an adequate level of safety for the protection of the public and the Hanford workers.

(b) Much of the data, particularly in Volume 2, on inventory quantities, have been revised to be more consistent with the degree of accuracy.

(c) Based on comments, attempts have been made to add additional relevant data to the EIS, particularly in Sections II, III, V & IX where such items as effects on salmon, occupational exposures, plutonium in soil, decontamination and decommissioning, etc. were added.

(d) The accuracy of the data used has been indicated, where possible, throughout the revised statement. The Accident Section discusses consequences and probabilities of potential accidents over a full range of consequences.

The generally conservative assumptions associated with the accident analysis are presented in the text.

(e) The study referenced as dating back to 1964 is the ERDA Health Mortality Study, a long-term epidemiology study relying upon extensive morbidity and mortality statistics. Sufficient data upon which firm conclusions can be drawn are not yet available. Yearly progress reports referred to in the references have been and will continue to be published until the necessary data (particularly death data) become available.

(f) The summaries of each section are collected and presented as Vol 1, Section I, as required by the Council of Environmental Quality. A table of abbreviations has been added, as suggested, in Volume 1.

(g) The page numbering system was selected to correspond to the sections of the statement. Each section is numbered consecutively.

(h) The document has been reviewed and efforts made to further standardize the use of units consistent with the anticipated preference of the reader. Generally, in this particular scientific area, the metric system is preferred yet degrees Celsius for temperatures is apt to confuse some readers. Similarly the use of grams in lieu of curies is favored by some. Where simplification was possible, changes were made.

X.0.12 Miscellaneous Factual Inconsistencies in the EIS.

Several factual inconsistencies within the EIS are commented upon by the Environmental Protection Agency, the Department of Interior, the National [Natural] Resources Defense Council, and to a lesser extent, witnesses at the Portland hearing. Perhaps the most significant is the relationship between the time of discharge of effluent into the 1301-N crib by the N-Reactor and the time of appearance of radioactive nuclides in the Columbia River. The statement that "essentially no wheat or pasture land is irrigated with Columbia River water downstream of the Hanford project" is also incorrect. In general, however, the panel has made no attempt to isolate, and evaluate the significance of, such inconsistencies.

Response

Text Changes Made - Vol 1, Section II.1.1.2.1

12. The data referred to were correct, however the presentation has been revised.

For the cases mentioned, Section II.1.1.2.1 has been revised to clarify N Reactor effluent travel times. Since less than 3% of the downstream land is irrigated by Columbia River water, the statement is considered proper; however, it has been deleted to prevent any misinterpretations. The document has been reviewed and revised to correct any factual inconsistencies which were found.

X.1 COMMENT LETTER, United States Department of Agriculture, Forest Service, P.O. Box 3623, Portland, OR 97208

A response was not required.

X.2 COMMENT LETTER, Concerned Californians, 2912 Baywater Avenue, San Pedro, CA 90731

A response was not required.

X.3 COMMENT LETTER, Jennifer Bromgren, Seattle, WA

Comment

I realize and appreciate the tremendous amount of time and effort gone into studying and working to prevent the adverse effects of radioactive waste. It is impressive to read of the measures taken to control this. My prevailing emotion, however, is one of uncertainty. The safeguards, no matter how elaborate and refined, hold little space for human error and the likelihood of natural disasters. It seems to be the most advance system technology that is feasible. Yet, the language in the EIS contains reports of waste levels measurably higher on nearby bodies of water, etc. It states that so far no alternative has been found to the storage of certain wastes in underground tanks. The question on my mind is "What if...?" What if an earthquake or similar shock, unexpectedly severe, were to damage the facility? And if the reclaiming equipment was incapacitated? All sorts of nightmarish episodes, perhaps unjustified, perhaps not, come to the forefront of thought.

Response

Examples of a full range of credible accidents are presented in Vol 1, Section III.2. For the Hanford region an earthquake of Richter 6.8 magnitude is believed to be unexpectedly severe. The consequence of such an earthquake would be within the range of consequences analyzed in Section III.2.11.2.1. This document is not a statement on nuclear power in general. It is an assessment of a program involving wastes generated from plutonium production efforts.

Comment

As we shift into a new age when life and space, resources and energy are at a premium, I feel strongly that all irreversible moves be made with greatest caution. I know this is also your intention. But, as a citizen of a state that potentially plays a major role on the development of nuclear reactors, I oppose their construction if the means exist to either reduce energy demand (done well and with little sacrifice last winter during the power shortage) or to harness

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a means of energy production that holds less risk to the environment. I request that more funds be allocated to the study of geothermal, wind, and solar energy sources, etc., and less to development and construction of nuclear reactors.

Response

ERDA budget request has included substantial increases for research in geothermal, wind, and solar energy sources as well as others.

X.4 COMMENT LETTER, Steven C. Sholly, 1110 Rana Villa Avenue, Camp Hill, PA 17011

Comment

There is a lack of discussion, even in general terms, about the security arrangements at Hanford which deal with preventing unauthorized entry to the Reservation and its various facilities.

A general discussion of security arrangements at the Hanford Reservation is needed in the Final Statement. General discussions of cooperating arrangements with local law enforcement agencies, communicating systems, and alarm systems and response times should be included.

Response

Text Changes Made - Vol 1, Section III.2.1

Comment

There is a lack of discussion in the Draft about the impact of an attack on the Reservation by a foreign military power. The potential impacts of resultant attacks with both conventional and nuclear weaponry should be investigated and discussed. The Department of Defense should certainly be contacted and involved in such investigations.

Response

See reply to a similar question, X.0.8(b), in Report of the Presiding Board.

Comment

Although several vague references are made to it, there is no explicit discussion in the Draft of the impact of possible cessation of waste management operations at Hanford. Such a situation could come about as a result of a catastrophic radiological accident or as a result of political instability such as a civil uprising or overthrow of the government. While both of these possibilities appear, on surface examination, to be rather remote, the consequences of such occurrences could be great and should, therefore, be discussed in the Final Statement. The seriousness of this situation is pointed out in the Draft Environmental Statement WASH-1539, where on page 2.3-19 it is stated:

> "Because of the long period of time during which high-level waste must be confined, its storage in any man-made structures such as tanks or vaults, no matter how safe at present, requires a program of surveillance, with eventual repair or replacement, if the environment is to continue to be protected."

An estimation of the expected time lapse between cessation of waste management and the onset of unacceptable environmental consequences should be made. Also, the probability of reinstituting management practices after a protracted period of no such efforts should be discussed.

Response

Text Changes Made - Vol 1, Section V.1

Comment

There is a general lack of discussion about quality assurance programs and redundancy (defense-in-depth) features at the Reservation. Particular attention should be paid to quality assurance programs dealing with collection, processing, and evaluation of radiation monitor samples. The hearing of August 1973 about the Shippingport Atomic Power Station held by the special select committee appointed by Pennsylvania Governor Milton Shapp particularly emphasized this issue as being critical to the proper evaluation of health hazards associated with facilities handling radionuclides. Quality Assurance programs and redundancy features should be emphasized in the Final Statement.

Response

Test Changes Made - Vol 1, Section II.1.2.1

Comment

There are numerous instances in the Draft Statement of materials being cited in the text as evidence for a certain statement made by the authors of the Draft. Generally, the bulk of these materials is not readily available to the reader of the Draft for reference, either due to limited distribution of such documents, or their high cost. When it is necessary to refer to such a document in the Final Statement, it would be helpful if a summary of the relevant information from the document being cited would appear in the Final Statement. It would also be helpful if the reader would be told where and how he could obtain copies of the material cited in the text of the Final Statement. Citing material and incorporating them by reference only serves to confuse the issues, rather than clearly stating the situation in nontechnical language.

Response

In this statement the conclusions of the documents referenced are used but no attempt to summarize or extract material from each document is made. To include all pertinent material from the references would unreasonably enlarge the size of this statement. Conclusive statements from the referenced material should be more helpful to the reader than great detail. Readers interested in the details can secure the cited references from the sources stated in the Foreword.

Comment

The format of the Final Statement should be revised from that of the Draft Statement. Consecutive numbering of pages (i.e., 1-2-3-4-5-6- etc.) should be used rather than the somewhat confusing method used in the Draft Statement. In addition, summaries of each of the major sections of the Final Statement, appearing at the end of each section, would be helpful to the reader. A table of abbreviations used in the Final Statement would be helpful in order to avoid confusion.

Response

The numbering system was selected to correspond to the sections of the statement. Each section is numbered consecutively. The summaries of each section are collected and presented as Section I as required by the Council of Environmental Quality. A table of abbreviations has been added, as suggested, in Volume 1.

Comment

The use of such unqualified terms in the following should be avoided as much as possible in the Final Statement.

"reasonable"
"interim"
"small amounts of radioactivity"
"insignificant quantities"
"did not impact harmfully to any great degree"

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Response

These terms have only been used when it was not possible to quantify the data; efforts were made to avoid using them. The usual dictionary meanings are intended for the terms.

Comment

How were the figures (given on page 5 of Section I) arrived at? Calculations leading to these figures should appear as an appendix in the Final Statement. In addition, a list of similar figures for the last 15-20 years should be provided, if available, for determination of any trends involved with population doses caused by operations at Hanford. Increases within a few percent of normal doses should be explained along with any decreases of similar magnitudes.

Response

Detailed calculations, assumptions and mathematical models are given in Vol 1, Section III and in Vol 2, Appendix III-A.

Evaluation of radiation doses to persons in the Hanford environment have been made and reported in public documents since 1957. These evaluations were based on actual measurements of radionuclides in environmental media, supplemented by whole body counting of employees and residents including school children. In recent years the amounts of radioactive materials released from Hanford sources have been so low that environmental concentrations have in many cases decreased below analytical limits. Therefore, the dose evaluations presented are based on measured effluent releases and the mathematical models discussed in the Statement. The models used and parameter values used in the calculations are given in the Appendixes.

Comment

What about (population dose values and health effects) results for other years? Also, sub-lethal effects and synergistic interactions which apparently have been ignored, should be accounted for in the Final Statement. A tabulation of data for the last 15-20 years should be included.

Response

The evaluations of radiation doses to persons in the Hanford environment have been reported in public documents since 1957. The possible sublethal effects are included in Section III of this document in Table III.1-15 entitled, "Maximum Number of Health Effects for 1972 Environmental Dose Levels." At the very low dose levels encountered, no synergistic interactions are known. Data on the occupational exposures of Hanford workers were added to Vol 1, Section III.1.1.7.

Comment

The analysis of the accidents described (on page 7 of Section I) should be carried out in detail and fully described in an appendix in the Final Statement. All necessary parameters and as sumptions should be stated, and the reliability of the resultant data should be tested or at least estimated.

Response

The details of the accident analysis are presented in Vol 1, Section III.2.

Comment

Is the effluent stream (from the first nonboiling waste tanks) monitored for radioactivity? What is the efficiency of filtering system for relevent radionuclides?

Response

The text questioned applies to an early practice no longer in use. Years ago, certain nonboiling stored waste approached a temperature at which steam would be or was being released from the tank. To prevent the release of steam, air condensers were installed on these tanks. The temperature of the waste in these tanks is now far below the boiling point and the capability for

condensing vapors is no longer needed. Consequently, all of the air-cooled reflux condensers have top surface plates bolted in place. Thus, the units are not functional at the present time and there is no potential for release of radionuclides to the atmosphere.

The efficiency of the filter systems is presented in Section II.1.1.2.2.7 entitled, "Ventilation Equipment." These efficiencies are applicable to any location where filters of these types are used.

Comment

The (dry wells and laterals used to monitor waste tanks) should be described in more detail, with figures given for representative sampling frequencies.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Comment

The frequency of sampling and the procedures used for sampling and analysis of the samples of groundwater should be fully described in the Final Statement.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.5

Comment

What constitutes an "appreciable quantity" (of plutonium discharged to ground)? This quantity should be numerically described.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.5

Comment

When is (solid waste not covered with 10 to 20 feet of earth) this procedure not followed, and why?

Response

The exceptions are stated in the text, Vol 1, Section II.1.1.2.2.6.

Comment

The efficiency of the filters used (for the 200 Area gaseous waste) should be listed, as should be the name, form, half-life, and number of curies of each radionuclide which might be released.

Response

The filter efficiencies are listed in Vol 1, Table II.1-5. Radionuclides are listed in Vol 1, Section II.1.1.4 and Vol 2, Appendix II.1-B, C, and D. The radionuclides are listed as plutonium, uranium, and fission products (f.p.). A breakdown of radioactivity in gaseous effluents including each release point with typical and maximum releases of alpha and beta emitters plus ^{131}I is given in Vol 2, Table II.1-C-26. Quantities of individual radionuclides released are not measured. Rather, they are grouped as either alpha or beta emitters. Alpha emitters (primarily plutonium and uranium) are measured as ^{239}Pu. Beta emitters include cesium and strontium primarily and are measured as ^{90}Sr. Where ^{131}I is present, special sampling procedures are used for analyzing and controlling its release.

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Comment

When is it not practical (to filter exhaust gases from hood and cells near their source)? What is done in circumstances where it is not?

Response

Text Changes Made - Vol 1, Section II.1.1.2.3.1

Comment

How often are the filters checked after installation? What is their average lifetime? How long would it take to discover a filter failure?

Response

Text Changes Made - Vol 1, Section II.1.1.2.3.1

Comment

The listing (of radioactive waste stored in tanks in the 200 Area) should be projected through to the year 2000 A.D., rather than just to 1980.

Response

Text Changes Made - Vol 1, Section II.1.1.4.1.2

Comment

"After the aquifer area was divided into 1000-foot square cells, the amount of the contaminant in each cell was summed."

How many cells were there?

Response

Text Changes Made - Vol 1, Section II.1.1.4.3

Comment

"Fire in a remote laboratory facility released about 4 g of plutonium."

This incident should be described in detail in the Final Statement. Was any plutonium from the fire detected offsite?

Response

The accumulated impact of all past incidents, including the plutonium fire referred to in Section II.1.1.4.5 is reflected in current environmental measurements. Conclusions after evaluations of these and earlier results (Section III.1.1.1 and III.1.1.2.2) are that, except in the immediate vicinity of operating facilities, plutonium concentrations in soil are typical of arid western regions and reflect only regional fallout. The fire produced no detectable plutonium offsite. The fire occurred in a hood where the exhaust was filtered in a building designed to cope with such events.

Comment

The (100-year historical) record does not appear to me to be adequate for seismic risk prediction, especially considering the state-of-the-art in earthquake prediction. Perhaps a more conservative estimate of the maximum possible ground acceleration is in order. This possibility should be explored, and the advice of the U.S. Geologic Survey should be asked in this matter.

Response

Text Changes Made - Vol 1, Section II.3.7

The National Center for Earthquake Research of the USGS has participated in the establishment of the Design Basis Earthquake for facilities at Hanford.

Comment

How many tanks were involved with each type of failure?

Response

Each of the listed causes of leaks are credible mechanisms; some tank failures and subsequent leakages from each mechanism have been observed.

In most cases the failure is probably due to combined effects of corrosion and mechanical failure.

Comment

Why is (it believed that leaks as large as 106 T will not happen again)? The new procedures and precautions taken since the leak of tank 106-T should be detailed. What might be the size of the leak under abnormal plant operations conditions?

Response

Text Changes Made - Vol 1, Section III.2.2.1

Comment

"The shortest estimated groundwater travel time to the Columbia River from the 200 Areas under present water table conditions is 20 years."

What estimated travels times are predicted for other water table conditions (i.e., higher or lower water table levels)?

Response

The most accurate assessment of groundwater travel time from the 200 Areas to the Columbia River is based on measurement of trace quantities of radionuclides measured in the groundwater monitoring program. Predictive capabilities are being developed for estimating travel times at higher and lower water table levels.

Comment

The seal failure accident should be fully analyzed. Would the same types of radionuclides be released as in the dome failure accident with which the seal failure accident is compared? Would there be any difference in degree of dispersion? Is there any difference in probability of occurrence between dome failures and seal failures?

Response

Radioactive releases from an underground tank seal failure are small and would be less than radioactive releases from a tornado striking an underground tank system or from an underground tank dome failure. The same types of radionuclides would be released in each type of accident, dependent on the age (time since reactor discharge) of the stored waste. The degree of dispersion should be comparable for the seal failure and the dome failure. Dispersion would be much greater in the tornado accident case. The probability of occurrence of a simple seal failure is higher than a dome failure. No dome failures have been experienced to date. A seal failure on one of the underground tanks was experienced in 1964, resulting in a localized (minor) spread of radioactivity within the 200 East restricted access area. The seal failure accident was not analyzed because the forecasted release was less than that from a dome failure and because the actual experience with a seal failure accident confirms this forecast.

Comment

Accidents involving low-heat waste gaseous release systems should be fully analyzed to be certain that the consequences are, in fact, not as severe as with high-heat waste tanks. Numbers of tanks, probabilities of failures, and types of radionuclides involved should be considered in this analysis.

Response

Text Changes Made - Vol 1, Section III.2.3.2

Comment

"A life of 100 years and probably longer could be reasonably expected based on life of other reinforced concrete structures (bridges, dams, etc.)."

These other structures (bridges, dams, etc.) are not subject to radioactivity exposure as the waste storage tanks are. Could this fact have a bearing on the expected lifetime of the waste storage tanks? What could be the consequences of such a failure?

Response

Text Changes Made - Vol 1, Section III.2.4

Comment

Is the inventory (selected for a transfer line accident) representative of what would be encountered? A variety of situations should be analyzed for consequences.

Response

Text Changes Made - Vol 1, Section III.2.5

Comment

The safety analysis reports referred to should at least be summarized.

Response

Text Changes Made - Vol 1, Section III.2.6.1

Comment

The statement (relating to conservative operation of railroad shipments) should be expanded and expressed in more detail. The U.S. Department of Transportation should be requested to evaluate the manner in which the train shipments are operated and also the state of repair of the tracks.

Response

Text Changes Made - Vol 1, Section III.2.7.2

Comment

It is highly unlikely that the (earthquake probability) figures are correct considering the state-of-the-art in earthquake prediction. The means of deriving the listed probabilities should be described in detail, and an evaluation of these derivations should be performed by the U.S. Geologic Survey.

Response

See reply presented earlier to the question on earthquake prediction (Letter X.4).

Comment

Detailed Seismic analyses of the B Plant reinforced concrete ventilation exhaust stack have not been made, but little or no damage in stacks of this type after the 1971 San Fernando earthquake was noted.

It is quite possible that the experiences from the 1971 San Fernando earthquake have little bearing on the situation at Hanford. Epicentral distances and differences in basement rock and soil depth should be evaluated to check the relevance of this experience to Hanford.

Response

Some experiences from the San Fernando earthquake of February 9, 1971 may not be significant at Hanford because of the potential differences in bedrock nature, soil types, and in fact to the characteristics of the quakes themselves. More detailed seismic investigations and analyses are being conducted by USGS, University of Washington and consultants.

Comment

The facilities (listed in the last paragraph on Page III.2-60) should be analyzed for effects of the maximum credible earth acceleration. The results of these analyses should be included in the Final Statement. This is extremely important.

Response

The seismic resistance analysis is a continuing program at Hanford. However the listed facilities have not been analyzed. ITS 1 and ITS 2 Evaporators are now shut down.

X.5 COMMENT LETTER, Neal E. Wilson, 5 Brook Road, Enfield, CT 06082

Comment

The final edition of WASH 1538 definitely should address the problem of acid rain (as noted in the July-August, 1974, issue of Chemistry and in the Scientific American article, "Nutrient Cycles of An Ecosystem.") There are other articles that could apply to the problem, written by rabid anti-nuclear groups, but the two articles mentioned above, which appear in more moderate publications, should definitely be addressed.

Response

The emissions of sulfur dioxide and nitrogen oxides are monitored and currently are below effluent standards for these materials. Steps will be taken as necessary to assure future emissions of these materials continue to be below effluent standards. Emissions will be kept as low as reasonably can be attained. The use of school class personnel for surveys such as the measurement of "acid rain" as mentioned in your reference article appears to be a useful and educational way to collect national data of this type.

Comment

On page III.2-17, serious weakening of the tank domes is mentioned. How could this be detected?

Response

Text Changes Made - Vol 1, Section III.2.4.

Comment

The NRDC comments on page 116 with respect to the radioactive duck was not very well answered.

Response

The following extract from the annual Hanford environmental report for 1970* provides the best estimate of dose implication from the 100-K and N trench (hot ducks). Also see response to similar question in Letter X.10.

*Environmental Surveillance at Hanford For CY-1970, BNWL-1669, Battelle, Pacific Northwest Laboratories, Richland, WA, 1973.

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"Immediate consumption of 230 g (one-half pound--a normal meal) of duck flesh with the highest concentration, with consequent ingestion of about 30 μCi of ^{32}P, would have resulted in a calculated skeletal-bone dose to an adult of about 6 rem, four times the applicable annual dose standard. The associated whole body dose, including a contribution from ^{65}Zn, would have been about 250 mrem, or about 15% of the applicable annual dose standard.

Even were such a bird to be shot by a hunter, delays between the time a bird left a trench and time of shooting or as a result of the frequent practice of freezing gamebirds for later consumption would have permitted significant radioactive decay. This would further reduce the probability of consuming flesh containing the higher concentrations of ^{32}P. For the bird with the maximum concentration that has been considered here, any delays in consumption of more than four weeks would have reduced the skeletal bone dose to less than 1500 mrem (the annual standard).

The consumption of such a bird by any member of the public, however, is considered highly improbable in view of the facts that: (a) very few birds (out of some 200,000 in the area at that time) would have been likely to spend sufficient time on the trenches near the reactor areas to accumulate such large amounts of radioactive materials, and (b) concentrations of this magnitude have never been found in hundreds of birds sampled along the river for over 20 years. In our judgment, ducks collected on swamps, trenches, or ponds are not representative of those available to the general population, and dose estimates derived therefrom are not pertinent for inclusion in comparisons with the established dose standards."

Comment

One aspect that was not too well covered was the proposed methodology by which the unfortunate mismanagement of the 106-T tank leak can be averted in the future.

Response

Text Changes Made - Vol 1, Section III.2.2.1

X.6 COMMENT LETTER, H. W. Ibser, Physics Dept., California State University., Sacramento, Sacramento, CA 95819

Comment

"The objective of this program is to continue to maximize the isolation of the high-level waste from man's environment." I thought everyone agreed that some serious mistakes have been made at Hanford; such a comment jeopardizes the credibility of the Statement. (Emphasis added.)

Response

The waste management objective remains the same irrespective of tank leaks or other incidents. Although these leaks are undesirable, they have not and are not expected to result in radiation exposure to the public.

Comment

Commitment to long term (thousands of years) control is a process unfamiliar to most persons - details of the process of such commitment should be described. Also, the validity of the statement that the area committed for such control does not constitute a significant adverse effect to the Hanford ecological community cannot be evaluated without some indication as to how one judges what amounts to the elimination of a part of Earth. The surveillance required raises other interesting points. What is involved in providing for surveillance in CY 2974, for instance? What will a square mile of irrigable land be worth for the period between now and then?

Response

Text Changes Made - Vol 1, Section V.2.5

Note however that this EIS is not a statement on ultimate disposal.

Comment

Possible devitrification of glassy formations for radwaste solidification should be discussed.

Response

Text Changes Made - Vol 1, Section V.2.4.3

Comment

(IX-1 and elsewhere) Current total radiation dose to the "general public" is estimated to be 2.4 man-rem/yr. No rationale for excluding site employees and others is offered. I would suggest that total human exposure should be indicated. Not only are Hanford workers presumably human, but their genes will have plenty of time to blend with those of the "general public" before the Hanford episode is over.

Response

Text Changes Made - Vol 1, Section III.1.1.7

Comment

The tank dome failure rate estimate implies that the domes will continue to be reliable as now after - how long? 200 years? Nothing conservative about this estimate.

Response

Text Changes Made - Vol 1, Section III.2.4

Comment

Calculation of gross radiation dose as done here is probably not an adequate consideration of the hazard from dispersal of particulate transuranic elements.

Response

Text Changes Made - Vol 1, Section III.2.4.2

Comment

It is curious that this category (line leakage) where a few accidents have already occurred the reiterated policy of conservatism in calculating the possibilities of future occurrences seems to have disappeared.

Response

The accident analysis was for a 100,000 gallon leak whereas leaks of only a few tens of thousands of gallons have been actually experienced. Also, more double encased lines are now being used in the liquid transfer systems. No credit was assumed for this improvement. A relatively high wind was assumed to provide pick up and transfer from the wetted surface.

Comment

"Observable radiological effects?" Presumably "effects identifiable as being of radiological origin" is closer to the mark. Running through the whole statement, it seems, is a theme that exposure to radiation below guideline levels is "safe" or insignificant. Nothing in the history of the adoption and modification of radiation exposure standards leads to such a conclusion. It is apparently permissible to kill a few unknown people at unknown times and places.

Response

Text Changes Made - Vol 1, Section III.1.1.6 and Section III.1.1.8

Comment

Postulation of slow enough seepage to permit complete sorption of ^{90}Sr and ^{137}Cs seems to be other than the "conservative" approach claimed for the Statement.

Response

The seepage rate used is not an unfounded postulation but is based on observed fact. The liquid from leaks that have occurred have in fact moved "slowly" and the liquid did not reach the water table. In the use of cribs and trenches with continual liquid input and downward percolation, the ^{90}Sr and ^{137}Cs did, in fact, sorb from the liquid at the seepage rates used.

Comment

A possible conclusion: we are being incautious about the radiation hazards of jet aircraft flight. What were the authors conclusions, which are not stated? I hope not that a possible exposure to hazard voluntarily warrants exposing people to a hazard they have no control over; yet this seems to be implied.

Response

The statements of comparison were only made to help the nonexpert reader to relate radiation doses received from various activities to those received from the Hanford Waste Management Operations. The individual may evaluate and judge the significance of each mode of exposure.

Comment

Why call postulation (of) a hazard "unrealistic" because other greater and fluctuating hazards exist? It would be more candid to simply state that the authors consider the hazard insignificant.

Response

The staff does consider the hazard insignificant; therefore, to postulate any environmental effect deriving from the low dose resulting from Hanford operations would be unrealistic.

Comment

Perpetual surveillance? How can one propose it - recognize its need, that is - without an attempt to set forth the budgetary, etc., implications?

Response

Text Changes Made - Vol 1, Section V.2.5

Comment

It is disturbing that the radioactive river bank seepage is apparently to be allowed to continue.

Response

While this is the source of radionuclides to the river, it leads to only about 1 man-rem of exposure to the population. Considerable steps have been taken in the last several years to reduce the quantities of radionuclides released by river bank seepage. See Section V.3.1 for a more complete discussion of this subject.

Comment

The implication that some questionable radwaste storage tanks are continued in service is disturbing. How can we propose perpetual care while we can't now quickly set matters right at Hanford?

Response

Current operating policy at Hanford requires that tanks of questionable integrity be pumped out and removed from further service. Also, improved leak detection equipment has been added to most tanks. More leaks are expected to occur before new tanks and/or waste solidification is completed. But there is no evidence that past or future leaks have or will result in radiation dose to man.

Comment

"In the selection of ... assumptions ... a consistent attempt was made to be conservative in the analysis, that is -- to analyze the worst conditions credible."

It would be better if this were self-evident, as is far from the case. Obvious, simple, possibilities have been entirely ignored, e.g., failure to maintain the site as a result of actions of hostile military forces.

Response

Text Changes Made - Vol 1, Section III.2.1

Also see response to X.0.8.

X.7 COMMENT LETTER, Lynn Daly, Secretary, Eugene Future Power Committee, Eugene, OR

Comment

We feel that inadequate attention was given to obtaining public input on this statement. Richland is expensive to get to, out of the way, and too far for many people who are concerned and qualified to make comments about the document.

Response

The comment period was extended to nearly 4 months and hearings were held in both Richland and Portland as a result of public request.

Comment

No detailed plan is given for the permanent disposal of high-level radioactive wastes. This is essential and the document is unacceptable without it.

Response

This document is not an impact statement on ultimate disposal of Hanford waste. It is a statement on the current Waste Management Operations. An impact statement on the ultimate disposal of Hanford waste will be required prior to decision making on ultimate disposal concepts. An expanded description of the research and development in progress on ultimate disposal has been added as Section V.2.5.

Comment

The cost-benefit analysis is not detailed enough and does not include long-term permanent storage. More thorough attention must be given to this matter before this important policy question can be resolved.

Response

The cost-benefit analysis section discusses cost and benefits of current program options. It has been expanded. Ultimate disposal options and cost-benefit and analysis relating to such options will be the subject of a future statement.

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Comment

We continue to oppose disposal to the soil of significant amounts of liquid radioactive waste. This practice is not justified by data given and available.

Response

This practice is being curtailed as soon as economically and technically practical. The data given show the degree of transport and retention of the radioactive materials in the soil. The bulk of all radioactive waste does not result in exposure to man. The exposure that does result is low compared to other commonly encountered exposures and far below established guidelines. Also see alternatives presented in Section V.

X.8 COMMENT LETTER, R. G. Wolfe, Professor, University of Oregon, Eugene, OR

Comment

The statement is deficient in that it considers waste disposal on a relatively short time rather than on a permanent basis. The true cost of long term isolation from the environment is a relevant and important, in fact indispensable, aspect of environmental impact considerations. The environmental statement has little meaning without it.

Response

This document is not an impact statement on ultimate disposal of Hanford waste. It is a statement on the current Waste Management Operations. An impact statement on the ultimate disposal of Hanford waste will be required prior to decision making on ultimate disposal concepts. An expanded description of the research and development in progress on ultimate disposal has been added as Section V.2.5.

Comment

The cost-benefit should be extended to long term aspects.

Response

The cost-benefit analysis section discusses cost of current program options. Ultimate disposal options and cost-benefit analysis will be the subject of a future statement.

Comment

The substandard containment vessel on the N reactor should be discussed in sufficient detail to be informative in terms of increased risk related to continued operation.

Response

The EIS includes radioactive discharges in liquid and gaseous waste streams due to routine operations and operational fuel cladding failures; however, the N Reactor Nuclear Safety and any attendant radioactivity releases due to potential reactor accidents are considered to be outside the scope of the EIS. However, safety features including confinement system provide a protection equivalent to a containment vessel.

Comment

No discussion of analysis of management practice is given. The statement (DEIS page II.C-69) that, "...management practice analysis is a continuous ongoing responsibility..." does not make this topic beyond the scope of this statement. The track record of accidental release of radioactive wastes at Hanford has placed management practices in question. As this sort of event relates to environmental consequences, the management practice and policy are importantly related to environmental impact whether or not such practices are subject to continuous analysis within the AEC. This very relevant topic should not be swept under the rug with off-hand and arbitrary judgements.

Response

Text Changes Made - Vol 1, Section III.2.2.1

The management actions taken as a result of 106-T leak were added and presented in Vol 1, Section III.2.2.1. ERDA continually reviews management practices of all contractors and requires upgrading when deficiencies are discovered.

Comment

The report makes no mention of independent analysis of the data. In complex technical matters such as these, subjective interpretations are not uncommon. The draft report lacks sufficient detailed data for independent or adversary analysis. Matters as important as those discussed in this manuscript should not be limited in evaluation and analysis to one or a group of individuals under pressure to obtain, after the fact, arguments defending previous practices or policies. It is not realistic to expect possible "subjective internal bias" to be adequately challenged and analyzed gratis by qualified experts as a spare time effort. Independent analysis by qualified experts, encouraged to make and defend constructive criticism, is a realistic and preferable alternative to the apparent expectation that comments on EIS documents will accomplish this end adequately. The presence or absence of independent analysis has significant bearing on the quality of any EIS. Such independent criticism should be obtained and circulated for public comment along with the draft EIS. Your response to this criticism could also be included, and without such independent review, the EIS has little value.

Response

The NEPA charges each government agency with making an environmental assessment of any major action it plans to undertake. The draft EIS was circulated in accordance with the requirement of the Council on Environmental Quality guidelines and the regulations of the AEC. It appears a good cross-section of independent criticism has been received on the draft statement. Such criticism has been made a part of this final statement.

Comment

There is a significant inconsistency in that it is stated that ^{90}Sr does not reach the water table (DEIS page II.1-90). However, as shown in Figure II.1-C-35, this isotope is indicated at 10^{-3} μC at the water table (depth of 60 meters).

Response

The statement says "Cesium and strontium are tightly held by the soil, most being held within a few tens of feet below a typical crib." Strontium-90 and ^{137}Cs have reached the water table as shown in Table II.1-7.

Comment

Our comment (DEIS page II.1-C-67) regarding the possibility of migration of radioactivity to the surface has apparently been ignored completely. From the statement (II.3.8.2.2), "...the evaporation potential during the summer months greatly exceeds total precipitation..." it follows that there must be net flow of water to the surface at some finite rate by ion exchange migration. Since "...precipitation does not penetrate more than about 15 or 20 feet below the land surface..." (DEIS page II.3-D-50), there must be net migration from greater depths. Since the highest radioactivity levels occur near the surface at the points of release into the ground, it is conceivable, with relatively reasonable assumptions, that dangerous levels of radioactivity might migrate to the surface. There is no evidence found by this writer that this matter has been considered, studied or otherwise appreciated in any of the available documents. One wonders what the purpose of before-draft comments is if they can be ignored.

Response

Text Changes Made - Vol 1, Section II.3.14.1

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Comment

Since it is not possible to make quantitative accounting for released radioactivity, it is quite possible that high flow rate channeling to the Columbia River may occur or that such channeling will develop with continuing groundwater run-off. The presence of channeling is cited in at least one section of the statement [not related to radioisotope (tritium) distribution]. If studies designed to identify channeling in relation to radioisotope distribution have been made, it is not readily apparent in the draft statement. Statements to the effect that radioisotopes are safely contained lack credibility without appropriate measurements that exclude the above possibility.

Response

Groundwater flow rates on the Reservation are less than that required to move fine-grained sediment underlying the disposal areas. The channeling referred to in the impact statement is related to ancient river channel subsequently filled with glacial flood deposits. The identification of these berme channels is under investigation. Groundwater flow velocities in these channels are reasonably slow.

Comment

Insufficient data was given in DEIS Figure II.1-C-35 to support the stated downward migration rate of 1.5 meters per year.

Response

The important fact shown in DEIS Figure II.1-C-35 (now Figure II.1-C-36) is that the downward movement of moisture decreased significantly with the passage of time.

Comment

No mention is made of the possibility that nuclear power reactor fuel reprocessing might be necessary at Hanford because of the failure to complete the General Electric reprocessing plant due to design errors. It would seem that continuing fuel reprocessing at Hanford might influence very significantly the environmental impact statements made.

Response

Commercial fuel reprocessing is outside the scope of this statement. Conversion of Purex Plant to process commercial fuel does not now seem a likely course of action for the Hanford Purex Plant due to the cost of conversion and some processing complexities. Such a course would be a major Federal action requiring an impact statement of its own.

Comment

The page numbering and indexing of the draft statement is confusing and cumbersome. Similar numbering in the statement and Appendix should be avoided in the final draft.

Response

The numbering system was selected to correspond to the sections of the statement. Each section is numbered consecutively. The summaries of each section are collected and presented as Section I as required by the Council of Environmental Quality.

Comment

The statement in general is less quantitative than desirable, especially for the purpose of critical analysis.

Response

Quantitative data were presented whenever available and used in the analysis to the extent possible.

Comment

Value judgement words such as "appreciable" and "practical" are obfuscating and should be avoided where possible or substituted for by more quantitatively precise expression.

Response

These terms were used when it was not possible to quantify the data; efforts were made to avoid using them. The usual dictionary meanings are intended for the terms.

Comment

Once-a-century or 1000-years flooding should be considered exclusive of the behavior of the Columbia River. Considering the 24,000 year half-life of ^{239}Pu this is not an unreasonable consideration. Also, it should be recognized that such flooding or flash flood effects would not be moderated by the dam control features on the Columbia River.

Response

Text changes made in Section III.2.11.3 include additional data on floods.

Comment

The matter of guaranteeing the long term (hundreds of years) responsibility for maintaining isolation of wastes from the environment is a matter of considerable concern, particularly in relationship to the stability of human political institutions. This topic has apparently not been mentioned. It should be considered forthrightly.

Response

This document is not an impact statement on ultimate disposal of Hanford waste. It is a statement on the current Waste Management Operations. An impact statement on the ultimate disposal of Hanford waste will be required prior to decision making on ultimate disposal concepts. An expanded description of the research and development in progress on ultimate disposal has been added as Section V.2.5.

X.9 COMMENT LETTER, United States Department of Agriculture, Agricultural Research Service
Washington, DC 20250

A response was not required.

X.10 COMMENT LETTER, Protect the Peninsula's Future, Eloise W. Kailin, M.D., Rte. 1, Box 253
Sequim, WA 98382

Comment

Missing (from the statement is an) adequate discussion of the alternative of stopping the generation of further radioactive waste (replacement of nuclear fission technology with development of a solar energy farm at Hanford).

Response

This statement does not address the nuclear power industry's generation of electrical power. However, the ERDA budget for nonnuclear power source research has been very substantially increased.

Comment

What is the possibility that Hanford will become the dumping ground for wastes from all over the U.S. and foreign reactors as well? What will happen to reactor vessels, including the one at Hanford at the end of their useful life?

Response

Hanford is one of the sites being considered for storage of commercially generated waste. This storage action, should it actually be proposed for the Hanford site, will be covered by a separate environmental statement prior to making such a decision. Decommissioning of the site and final disposal of old reactors are under study (Vol 1, Section II.1.1.2.5).

Comment

Health effects are given in computer model terms with a few scraps of observation data.

Response

The maximum health effects are calculated from data in the BEIR report by the methods advocated by EPA and are presented in Vol 1, Table III.1-15. (The BEIR report has been adopted by EPA as the definitive study and summary of health effects based on the available human data. This statement did not attempt to derive dose health effect relationships but accepted those stated in the BEIR report). All data and methodology (for calculating the maximum health effect due to Hanford operations from the BEIR report) are given in the text and the appendixes. (The actual health effects are stated in Vol 1, Table III.1-15).

Comment

"At the very least minimum, maximum and standard deviation values should be supplied for radioactive materials found in autopsy material from persons residing at different places--the original reports should be appended especially in view of the tight time available for comment."

Response

Text Changes Made - Vol 1, Section III.1.1.2.2

Comment

"Why are there no reports on ^{90}Sr in bone or teeth of humans or animals in the Hanford area?"

Response

Text Changes Made - Vol 1, Section III.1.1.2.2

Comment

"Why no vital statistics on infant mortality, on cancer, on thyroid nodules, on ^{131}I in human or bovine thyroids?"

Response

Text Changes Made - Vol 1, Section III.1.1.2.2

Comment

"Background radiation data does not appear to take into consideration the reduced fallout characteristic of arid areas."

Response

The "background radiation" data presented are measured in the Hanford environs. The values reported take all such effects into consideration.

Comment

"Animal data reported do not consist of study of a reasonable target organ for ^{90}Sr in several of the tables (why muscle only and not bone?). Plutonium values also are reported for muscle rather than lung or bone."

Response

The data tabulated show what might be found in edible parts of animals related to exposure pathways of man; as a consequence, lung and bone were not reported.

Comment

Criticality accidents from plutonium accumulations are excluded from consideration on the basis that the k_{eff} rating would not exceed 0.5. But according to news articles the k_{eff} actually reached 0.97 or 0.98--almost at the explosive level. Were these reports in error? They were taken seriously at the time.

Response

The reports of k_{eff} of up to 0.98 were indeed taken seriously, particularly an apparent increase in the k_{eff} as a function of time over a period of approximately 10 years. In fact, these measurements were the basis for placing a cadmium nitrate solution, a neutron absorber (poison), in the plutonium-rich area of the Z-9 trench.

Additional studies* of the Z-9 system included plutonium distribution studies using various investigational methods, and analysis of data by the Savannah River Laboratory and the Los Alamos Scientific Laboratory which identified a possible equipment deficiency. Replacement of the 256 channel analyzer with a 4096 channel analyzer provided data for a more definitive analysis. The k_{eff} was established to be less than 0.8--probably less than 0.5 before, and less than 0.3 after, the neutron absorber was placed in the system.

Incidentally, a k_{eff} of 1.0 would not cause an explosion. Rather, a chain reaction of short duration releasing neutrons and gamma radiation with the probable release of some volatile fission products (mostly short-lived) would have been the expected result, consistent with criticality accidents that have been observed in other systems.

Comment

Please discuss costs in terms of waste generated per MW electricity generated, and how costs and storage requirements will be affected by MOX fuel and by servicing the Breeder reactor.

Response

The use of nuclear power for the generation of electricity and its associated waste problems are beyond the scope of this statement.

See WASH-1535 Dec 1974, Proposed Final Environmental Impact Statement for LMFBR for additional information.

Comment

We are told that 18 tanks are leakers and another 14 are suspect on the basis of excessive corrosion or pitting and "unexplained anomalies in leak detection measurement which might indicate leakage but which could not be confirmed as such". Current operating policy requires these to be emptied as fast as spare tank space is made available by the solidification program. How fast is this? How long before all 14 tanks can be emptied?

Response

Liquid waste has been removed from all confirmed or suspect leakers to the extent practical to eliminate the potential of further leakage of liquids from these tanks to the soils. The 14

*A. E. Smith, Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench, ARH-2915, Dec 1973.

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suspect tanks have been already removed from active status for liquid storage. In those few cases where liquid remains, the liquid level has been pumped to below the level where the tank failed. Surveillance is maintained on those tanks to assure that leakage is not occurring.

Solids in the form of sludges remain in these tanks. These solids do not represent a threat to the environment and will be left in the tanks until technology is developed for ultimate disposal.

Comment

Underground storage of wastes will be protected from uptake by plants by a plastic sheet over them and under the earth. How many years of protection will this afford relative to the time radioactivity is retained?

Response

Life of such plastic materials used in these applications cannot be predicted with accuracy but is believed to be decades. Reliance on the plastic material must be considered to be an interim protection, along with the use of herbicides and the stabilization of vulnerable surfaces with gravel.

Comment

Where is the quantitative data or estimation of the amount of radioactivity transferred offsite by migratory birds, insects, air emissions (total), and water releases deliberate and accidental, total? How can you say p. III.1-37 there is evidence of no significant amounts of radioactivity escaping the Hanford site boundary?

Table II.3-28 shows that Benton City and Western Richland Composite foods in 1972 have at least doubled the ^{131}I in milk and 3 times as much ^{90}Sr in local produce as compared with further sources. What has been the accumulative burden of the local population over the last 30 years?

Response

The environmental data and dose calculations are shown in Vol 1, Sections II.3.13, III.1.1 and III.1.2. The ongoing environmental program measures the levels of radioactive materials from all causes found offsite and does identify the principal offsite transfer mechanisms. These programs should detect any escaping radionuclides.

In evaluating the ^{131}I concentrations in milk samples shown in Table II.3-28, the definition of analytical limit must be emphasized, since the data are all near or below this limit. The analytical limit is defined as the minimum concentration observable, plus or minus 100%, with a confidence level of 95%. In Table II.3-28, the minimum observable ^{131}I concentration is approximately 0.002 ± 0.002 pCi/mℓ or a range from 0.0 to 0.004 pCi/mℓ. The random fluctuations of radiation counting equipment are such that a small percentage of samples will show slightly positive results even when no activity is present. The average ^{131}I concentration for the Benton City-West Richland composite as reported was 0.001 pCi/ℓ, or less than the analytical limit for a single sample. Valid or not, the indicated value is much less than that calculated from release data from Hanford Operations used for the dose calculations in Section III.1.

The ^{90}Sr in farm produce is actually from one sample from a Riverview farm (not Benton City-West Richland). Other data from the Riverview area (air, soil, vegetation) do not indicate statistically significant differences from other regional concentrations, and any ^{90}Sr concentrations in foodstuffs are attributed to weapons test fallout. The single value of 0.03 pCi/g for ^{90}Sr in farm produce is not adequate to draw conclusions of environmental significance. However, if a dose calculation were made using this concentration and the calculation methods used for Section III.1, a bone dose increment of 0.3 mrem for the past year dose would be calculated for a small fraction of the population.

Since ^{131}I has an 8-day radioactive half-life, no long-term accumulation occurs in the environment. Any accumulation of ^{90}Sr would add to and be accounted for in the results of environmental samples.

Comparison of radionuclide concentrations in the edible portions of waterfowl with concentrations for liquids derived from the basic FRC Radiation Protection Guides is invalid. The FRC Guides were derived with assumption of continuous daily quantities which are not valid for waterfowl or

other fish and game. A more valid comparison can be obtained with methods used by the FRC to determine the Protective Action Guides given in FRC Report No. 7. For a 70-kg adult, a calculated whole body dose of 60 mrad would result from a single intake of 1 μCi of ^{137}Cs. On this basis, consumption of one meal (one half-pound) of meat from a duck with the average concentration of 2.7×10^{-5} μCi/g (the 1972 average for U and Gable Ponds) would result in the intake of about 6 nCi ^{137}Cs, with a resultant whole body dose of less than 0.4 mrem. Furthermore, the season is limited for hunting waterfowl, miles of distance separates the ponds from public hunting areas, a huge dilution is afforded by the migrant waterfowl population in hunting areas during the hunting season, and especially no such concentration has ever been detected in the hundreds of waterfowl sampled from river locations in past years. In view of the above, to collect and consume a gamebird with a concentration as high as that used in this calculation would be a most unusual event. Such an evaluation should be based on FRC No. 7, which would require no action for the calculated dose.

Nonetheless, remedial action such as removal of vegetative cover and diking, removal and backfilling of contaminated soil has been taken in the past to reduce still further the probability of the concentration and dose potential discussed above.

Comment

A maximum flood was considered, but apparently no consideration was given to failure of an upstream dam. The latter is considered for reactor siting--why not for waste storage security?

Response

Major dam failures on the Columbia River are classified by the U.S. Corps of Engineers as incredible events and consequently were not analyzed.

X.11 COMMENT LETTER, W. P. Metz, 1303 Kimball, Richland, WA 99352

Comment

The statement discusses a number of now unused facilities which exist on the Hanford Reservation. There are no apparent plans to re-use those facilities, and the facilities are apparently contaminated with fission products and/or transuranics. It appears that a much higher emphasis should be placed on decontaminating and/or decommissioning those facilities.

Response

Text Changes Made - Vol 1, Section II.1.1.2.5

Comment

The statement discusses the high level waste management practices at Hanford for liquid storage and in tank solidification for high level wastes. In light of today's technology, as indicated to on Wash-1539 (draft EIS for the RSSF), this Hanford method of controlling radioactive wastes is not acceptable for wastes which will be produced in the future. Consequently, I feel that any future atomic processing efforts should, at a minimum, meet commercial atomic plant safety and environmental standards. That is, production (plutonium) reactors, thermal reactors, reprocessing plants, waste management programs should be subject to the private industrial controls and quality control. I am not advocating that those standards be applied to existing Hanford wastes, per say; I am advocating that no more wastes produced in the future be treated under this waste management program. I further feel that the existing wastes stored at Hanford should be subjected to a study and we become committed to rendering those wastes to a long term, vice short term, storage mode which is more environmentally acceptable.

Response

This document is not an impact statement on ultimate disposal of Hanford waste. It is a statement on the current Waste Management Operations. An impact statement on the ultimate disposal of Hanford waste will be required prior to decision making on ultimate disposal concepts. An expanded description of the research and development in progress on ultimate disposal and alternatives on stopping solidification have been added as Section V.2.5.

X.11A COMMENT LETTER, W. P. Metz, 1303 Kimball, Richland, WA 99352

Comment

DEIS Page iv:

Under "Current Program," the word "million" to read "approximately 47 million gallons..."

Response

Correction made.

Comment

DEIS Page v:

Second line, word "requires" is not necessarily appropriate. Those fuels could be stored indefinitely (as is done in Canada) or processed elsewhere.

Response

Reprocessing required to recover plutonium for ERDA commitments. See Vol 1, Section V.2.3.2.1 and Section V.2.3.2.2 for discussions of alternatives of shipping or storing fuel.

Comment

DEIS Page v:

Fourth line, N Reactor operation, production plans, foot note (a): For all practical purposes, N Reactor is now quasi-commercial generating facility (in spite of the legal niceties), thus N Reactor wastes are commercial grade wastes and should be treated as such.

Response

Since N Reactor is in fact operated for plutonium production, the N Reactor fuels receive less than 10% of the reactor exposure as commercial fuels. The N Reactor fuel is substantially different in burnup than power reactor fuel. N Reactor waste is separated from man's environment as described in this statement.

Comment

DEIS Page v:

Line 7: Should that date be 1979?

Response

No

Comment

DEIS Page v:

Lines 17 & 18: The high caustic recycle could be further evaporated at 242-S, but would not produce an acceptable salt cake. Suggested wording: "...remain which cannot be converted to an acceptable salt cake by further evaporation."

Response

Editorial - no basic change in concept.

Comment

DEIS Page v:

Line 21: Add "or stored in double-shell tanks as a concentrated liquid."

Response

Editorial - Foreword rewritten

Comment

DEIS Page vii:

Second paragraph: This paragraph implies that transuranic solids are all stored in a 20-year retrievable posture. That practice has only been in force for the past 3 or 4 years (see DEIS page I-2).

Response

The treatment of transuranic solids prior to adoption of the 20 year retrieval program is discussed in several places throughout the statement (Vol 1, Section II.1.1.2.2.6 and V.5.1). The trenches in which the transuranic solids were placed are now being studied to formulate actual trench inventories and recovery methods.

Comment

DEIS Page vii:

Under "Gaseous Effluents": Nonradioactive gaseous effluents have been omitted from this summary. There are sources of chemical gaseous effluents, i.e., the NO_x from AR Vault.

Response

Omission made for brevity in the Foreword. Data are in Vol 1, Tables II.1-8, -9 and -10.

Comment

DEIS Page I-1:

Last three lines should be:
". Four new double-wall...
. Three additional double-wall...

Response

Incorrect. See Vol 2, Appendix II.1-C

Comment

DEIS Page I-2:

First three lines: Two of the evaporators are in use now (242-T and 242-S); ITS 1 and ITS 2 are no longer operating.

Response

The above is a valid comment. However, ITS 1 and ITS 2 were operating at the DEIS report cut-off date of 12/31/72.

7 1 8 0 1 6 8 1 1 6

Comment

DEIS Page I-3:

Second line should read: "...to assure that radioactive gaseous emissions..." Line 9: Change "will" to "should"

Response

Change in text made.

Comment

DEIS Page I-3:

Middle of the page, point (1): Is this statement accurate as far as U.S. defense needs?

Response

Yes

Comment

DEIS Page I-4:

Third paragraph: Do the 1500 wells include tank farm monitoring wells? If so, the paragraph is not completely correct.

Response

Text Changes Made - Vol 1, Section I.2.3

Yes

Comment

DEIS Page I-5:

Top paragraph: It would be appropriate to mention Hanford winds and "dust devils."

Response

For the sake of brevity this has not been included in the summary but is discussed in Vol 2, Section II.3-E.4.1 and Section II.3-E.4.3.

Comment

DEIS Page I-6:

First Paragraph: How about the deleterious effects that rabbits and coyotes have shown as a result of the B-C Crib?

Response

While some rabbits and coyotes did encounter B-C crib area waste, no effects that detectably change the number of rabbits and coyotes in the area were noted. The spread of contamination that resulted from this encounter with the B-C crib area waste is described in the body of the statement (Section III.1.2.1).

Comment

DEIS Page I-9:

Last paragraph: "...and ponds for many hundreds of centuries."

Response

Text Changes Made - Vol 1, Section I.6

Plutonium discharge to soil will need to be recovered. The fission products will decay in "many centuries".

Comment

DEIS Page II.1-17:

All of the treatises on 200 Areas do not mention the 200-N, -P, -R Areas.

Response

See Vol 2, Table II.1-C-3 where the terminated and backfilled status of the 200 North Areas are summarized.

Comment

DEIS Page II.1-17;

Middle of page: "...in standby condition, is operated intermittently" perhaps should read "...is planned to be operated..." or "...may be operated..."

Response

Wording changed as recommended.

Comment

DEIS Page II.1-30:

Sixth line up: Z plant organic will not be processed in the in-tank solidification facilities.

Response

Text Changes Made - Vol 1, Section II.1.1.1.3.2.

Comment

DEIS Page II.1-33:

Last paragraph: ITS 1 and ITS 2 are not in operation.

Response

Text Changes Made - Vol 1, Section II.1.1.1.3.3

Comment

DEIS Page II.1-33:

Third line up: Word "permanently" should be struck. The units were supposed to be portable.

9 1 1 8 9 6 0 1 6 9

Response

Text clarified. See response to previous question.

Comment

DEIS Page II.1-36:

Figure II-1-21 shows mostly C Farm, not much of A, AX and AY. There should be a better photo around.

Response

Photo considered appropriate; it shows the general spacing between tank farms.

Comment

DEIS Page II.1-64:

Add "other" to "Source" column to indicate things like GE waste liners, etc.

Response

The table is intended to indicate the more significant sources of radioactive waste.

Comment

DEIS Page II.1-65:

Second paragraph: The discussion of cesium-strontium removal should be modified to clarify that only a good fraction of these isotopes are recovered (60 - 90%). The remainder is stored in underground storage.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.1

Comment

DEIS Page II.1-70:

First paragraph, line 5, should read "Plant was stored in part of the SX Tank Farm"

Response

Words have been added.

Comment

DEIS Page II.1-70:

Second to last paragraph: SX sludge cooler offgases are partially condensed. The tanks are supposedly being dried out. "Possibility of liquid leakage..." seems very probable since most of the SX ^{90}Sr sludges are in leaking tanks.

Response

The word "partially" has been added. If leakage points are located high in the tank, leakage would not occur with low sluicing volumes used. Sluicing is not planned if age of the tanks and high probabilities of leakage dictate otherwise.

Comment

DEIS Page II.1-70:

Second paragraph: "These tanks were vented to the atmosphere through air-cooled..." "Instrumentation was provided..."

Response

Wording changes made.

Comment

DEIS Page II.1-71:

Last paragraph: Does all of A Farm have laterals (horizontal dry wells)?

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.2

Comment

DEIS Page II.1-78:

Second paragraph: "...it is possible to transfer liquid to or from any tank in the system." This statement is really a poor one; we just don't have this capability.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.2

Comment

DEIS Page II.1-80:

Second paragraph under II.1.1.2.2.3: ITS 1 and ITS 2 are not in operation.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Comment

DEIS Page II.1-80:

Last paragraph: Process conditions for 242-S are not adequately described here. 242-S solids are formed in the crystallizer, not in tanks from cooling.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Comment

DEIS Pages II.1-81 and II.1-82:

The figures of ITS-1, 2 might be left out. Feed to ITS-1 (Tank 102-BY) came from 112-BY, not ITS 2 bottoms tanks (see Figure II.1-45).

9 1 1 8 6 1 0 8 2 1

Response

A valid comment when ITS 1 unit is used in a cooling mode.

Comment

DEIS Page II.1-83:

Figure 11.1-47: There is no neutralizer tank in the 242-T - Z Plant waste feed system. "CWS filter" on bottoms tanks should be "HEPA filter."

Response

Changes made in figure as suggested.

Comment

DEIS Page II.1-86:

Last line: "In-tank temperatures in some tanks are monitored every shift."

Response

Words added as recommended.

Comment

DEIS Page II.1-119:

"Waste Tank Leak Detection Laterals" - This paragraph should be deleted.

Response

Deleted.

Comment

DEIS Page II.1-142:

Paragraph II.1.1.6.1.2 200 Areas Add AR vault chemical effluents.

Response

AR vault effluents of concern are radioactive. They are described as radioactive in Vol 2, Table II.1-C-26.

Comment

DEIS Page II.2.1:

Lines 11 and 12: This sentence is misleading. The further operation of Purex will add substantial amount of new boiling waste.

Response

Currently stored waste is approximately 47 million gallons. Purex generates approximately 225,000 gallons/year which when solidified will result in less than 30,000 gallons/year.

Comment

DEIS Page III.2-4:

11th line: Typo: Isotope?

Response

No - isopleth is correct.

Comment

DEIS Page V.5:

Second last paragraph: Delete as before.

Response

Paragraph "Waste Tank Leak Laterals" deleted.

Comment

DEIS Page II.1-C-65:

Item 1 of table II.1-C-14: HSW from 234-5 Z to TA tank is a "pipe in pipe" containment.

Response

Change made.

X.12 COMMENT LETTER, Office of the Assistant Director for National and International Programs, National Science Foundation, Washington, DC 20550

Comment

The statement is made in Vol 1, Page iv, last paragraph, that "Approximately 47 gallons of liquid waste and 25 million gallons of solidified waste are currently stored . . . ." Is the 47-gallon figure correct?

Response

Text corrected to read 47 million gallons.

Comment

Environmentalists can pick out two types of generalization, in spite of the detailed studies and the year of writing that went into the document. One is probably insurmountable; the use of unquantified terms is too plentiful. What is a "high-level waste"? What are "the lowest levels technically and economically practical"? What are "significant quantities of radioactive and other waste materials"?

Response

The task of avoiding generalizations is great and not always possible. Every effort was made to quantify where possible without leaving the impression that the accuracy was better than it actually was.

Comment

Who judges the statement that "Over 1,000 years of operation would result in no more than one cancer death"?

Response

The health effect conversion factors from the BEIR Report as summarized by EPA were used. See Vol 1, Section III.1.1.2.6 - Maximum Health Effects. The calculation is simply a multiplication of the maximum number of health effects per year times 100 years resulting in a calculated health effect still less than one.

Comment

(Another) generalization is typified by a statement in Vol 1, DEIS page 1-6, middle of the page: "Studies show that the effluents from up to nine plutonium-production reactors have had no harmful effects on the migration or spawning of salmon . . . ." This may be true, but studies do show that the elevation of Columbia River water temperatures in the Hanford reach of the stream may interfere with the survival of the young salmon after hatching and with their ability to convert to a saltwater life. The increased use of that part of the stream as salmon spawning sites might also be associated with increased returns of hatchery-produced fish, not naturally reared fish. Only technically astute reviewers can discern this kind of statement treatment.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6

X.13 COMMENT LETTER, Federal Power Commission, Washington, DC 20426

A response was not required.

X.14 COMMENT LETTER, Office of Environmental Affairs, Department of Health, Education and Welfare

Comment

Based on information contained in the draft statement it may be concluded that the current exposures to and doses from radiation and radioactivity from these installations are minimal as are the resultant projected health effects. It is apparent, however, that operations are not conducted with the same degree of control as is required by commercial operations of the same type. The existing inventories of radioactivity in the tank farms, in the soils and ground waters underlying cribs and ponds, as well as in the ponds, as well as contaminated solid waste both buried and as contamination in or on existing structures and equipment present continuing health hazards which will need to be maintained under control and surveillance for the indefinite future.

Response

Control and surveillance is being provided and will be continued until the ultimate disposal program no longer requires it. Because there are no similar commercial operations (primarily because of the manner in which the program was started in the 1940's), it is difficult to make comparisons to commercial programs. The length of time for control and surveillance will be a function of timing for ultimate disposal, retrievability of transuranics, decommissioning of facilities and decay of fission products.

Comment

An early objective of operations at Hanford should be to assure that additions to this inventory in the environment are eliminated as early as practicable by improvements to the waste management program. The improvement program scheduled through fiscal year 1975 will be a step in this direction, but, although reducing the rate of increase of inventory to the ground and ground water, will still allow a build-up of these concentrated but relatively uncontrolled inventories. It is recommended that effluents from all facilities be reduced to conform to the "as low as practicable" criteria for commercial installations as have been adopted by the Atomic Energy Commission for licensed installations. It would also seem preferable to discharge these low-level effluents to the environment where they will be further dispersed rather than utilizing techniques such as cribs and ponds that will result in reconcentrations of the effluents thereby requiring long-term surveillance and monitoring of these concentrated sources in the soil and ground water. Although it appears that with few exceptions these releases to the ground are being confined at

the present time, it does not seem possible to predict what might happen to the geological and hydrological characteristics of this area over the protracted period of time that it will be necessary for these entrapped radionuclides to reach innocuous levels. Based on present knowledge, however, it would not seem advantageous from a cost-benefit stand-point to attempt to remove and treat all the contaminated soil or to remove and store it elsewhere.

Response

Continued reduction in the amount of radioactivity discharged to the ground is planned, and projects have been identified (although not currently funded) to reduce concentrations to levels consistent with drinking water quality. The inventories, except for tritium, ^{99}Tc and ^{129}I, are decaying at an impressive rate. The inventories in the soil for various time periods are shown in Vol 1, Section V.

ERDA does not agree that dispersal to the environment above drinking water standards would be a preferable handling plan. Current policy does not permit it. Most radionuclides except plutonium will decay within 500 to 800 years to innocuous levels. Removal of plutonium-containing soil from the underground disposal crib 216 Z-9 is already planned (see Vol I, Section V.2.5). Recovery of plutonium in the soil will be made at some time in the future.

Comment

The program of solidifying the high-level liquid waste in the tank farms after having removed the long-lived cesium and strontium isotopes is an important improvement. However, the resultant salt solids are undoubtedly relatively leachable and efforts to seek a suitable process for these solids to change them to a less leachable form, as discussed in the draft statement, should be pursued as expeditiously as possible. It is recognized that the ultimate disposal of these wastes will to a major extent be dependent upon decisions made following further review and evaluation of ERDA's proposed high-level waste storage and disposal program.

Response

Research and Development is funded and currently underway to arrive at these objectives in a timely manner.

Comment

There are certain conditions existent on the Hanford Reservation which are not covered in the projected 1975 improvement program which sould be considered as soon as possible. A review of the analytical results on radioactivity in ducks which have been taken from the ponds on the reservation indicate that they are assimilating a good deal of cesium. This shows particularly in those samples reported and taken from T Pond, U Pond, and Gable Pond where the levels exceed those which would be derived from the FRC basic dose recommendations. In other words, they fall within a level of concentrations within or above range 3 for cesium as extrapolated from the FRC recommendations. The level also exceeds the concentration guide being used generally in the report to evaluate the acceptability of discharges of liquids to the uncontrolled environment. This being the case, it is suggested that consideration be given to discontinuing the use of such ponds unless it can be assured that the waste water entering them do not contain significant levels of radioactivity. The existing ponds should either be backfilled in place or the contaminated top layers of soil be removed and buried elsewhere.

Response

This statement discusses the alternatives identified (Vol 1, Section V) to improve control over waste effluents. Discontinuing use of ponds and cribs is a part of the consideration. See discussion on similar question in X.10.

Comment

The second point of concern are releases directly to the Columbia River which exist in the 100-area. It was noted that the currently scheduled modification program will improve the quality of water being discharged through the 102 inch discharge line. However, no mention is made of attempting to reduce either the amounts or concentrations of discharges into the crib in this area which discharges into the Columbia River via the N area Riverbank Springs. It is noted

from the statement as well as the appendix that levels of iodine-131 in this discharge water exceeded both FRC Range 3 levels as well as the guidelines in both years 1972 and 1973. The strontium discharges exceeded these concentrations in 1972 but were reduced in 1973. It is not clear whether this is a random or a planned reduction.

Response

Text Changes Made - Vol 1, Section V.3.2

Facility changes were made to reduce the strontium releases.

X.15 COMMENT LETTER, United States Department of Commerce, The Assistant Secretary for Science and Technology, Washington, DC 20230

Comment

With regard to the impact of waste heat on aquatic biota, we question the validity of statements indicating that thermal discharges to the Columbia River have neither had, nor are presently having, an effect on these organisms.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6 and Section III.1.3.2.3.1

Comment

DEIS page I-5. It should be mentioned here that juvenile salmonids are subjected to temperatures that are potentially lethal and that adult salmonid populations are present in the area because all other historic spawning areas on the main stem of the Columbia River have been inundated through installation of hydroelectric dams. The Hanford area is the only remaining section of the middle Columbia River where spawning conditions are optimum for adult chinook salmon.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6 and Section III.1.3.2.3.1

Comment

This section indicates that the total heat input to the river is about 470 megawatts when the power plant is in operation. This figure appears to be inaccurate. It is our understanding that the total output is 4,000 MW, and that the plant produces 860 MWe, leaving 3,140 MW_{th} of heat lost from the plant.

Response

Text Changes Made - Vol 1, Section V.6.7.1

Comment

We question the statement that "Since the effect of the N Reactor heat releases on the Columbia River are considered insignificant (Section III.1), installation of a cooling tower or pond to eliminate these releases to the Columbia River cannot be justified." Heat effluent from the N Reactor has the capability of killing small fish. Krenkel and Parker (1969: 318-337) indicate that the N Reactor produces 4,000 MW_{th} and increases the ambient water discharge temperature into the river by about 19° to 47°F, depending on plant operating conditions. If the Columbia River water temperature is 60°F (which it is for approximately six months each year), and if the discharge water temperature is raised 40°F, this water, when discharged to the river would be capable of killing small salmon in a few seconds (Synder and Blahm, 1971; EPA, 1971). The question that remains to be answered is, in fact, how many juvenile fish are killed each year in this manner? Until this question is answered, conclusions will continue to be drawn suggesting that there is no demonstrable effect of heat from the N Reactor on juvenile fish, a conclusion that is subject to misinterpretation.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6 and Section III.1.3.2.3.1

X.16 COMMENT LETTER, Assistant Secretary of Defense, Washington, DC 20301

A response was not required.

X.17 COMMENT LETTER, Executive Department, Local Government Relations Division, Salem, OR 97310

Comment

Our concerns in aquatic resources in the Columbia River are for the preservation and palatability of fish life and associated food webs.

Response

The ecological studies and the general absence of observable biological effects of effluents discharged to the Columbia River by the Hanford facilities are discussed in detail in Vol 1, Section III. The detection of adverse impact of Hanford pollutants on the water quality and biota of the river and the preservation of the aquatic life were the principal objectives of much of the biological research conducted. One cannot state unequivocally that absolutely no change of the river ecosystem has resulted from operation of the Hanford facilities; on the other hand, careful research has been unable to detect these changes.

The palatability of the fish grown in the Hanford reach of the Columbia River has not been known to be a matter of concern. The stretches of the river immediately upstream and downstream of the Hanford Reservation that are accessible to the public continue to be popular sport fishing areas. No known degradation of the eating qualities of fish produced in this part of the river has occurred.

Comment

We question statements that no deleterious effects have been observed in Hanford's thirty years operation.

Response

Text Changes Made - Vol 1, Section I.3.1 and Section II.3.10.1.6

Comment

Juvenile salmonids are present in the Columbia River near Hanford and are potentially affected by temperatures in excess of their lethal range.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6 and Section III.1.3.2.3.1

Comment

Despite the large quantities of data and other information contained in the draft statement, the statement does not contain: 1) sufficient data and other information to permit adequate review; and 2) sufficient discussion of environmental impact on the Columbia River and the significance of calculated or measured contamination of the river resulting from Hanford operations.

Response

The data necessary to calculate doses to the public and to describe quantitatively the handling of waste are presented in detail. More discussions on the Columbia River impact have been added in Vol 1, Section II.3.10.1.6. The pertinent research reports on these matters have been freely referenced in the text.

9 1 1 8 9 1 0 8 2 7

Comment

All discharges to the Columbia River, including effluents, subsurface waters, riverbank springs and others, should comply with maximum permissible concentrations (MPC) for radionuclides. Liquid and solid waste management improvements should be undertaken to meet this goal in view of the importance of the Hanford reaches of the Columbia River.

Response

At the point of discharge into the Columbia River only one nuclide (^{131}I) exceeds drinking water standards. See Vol 1, Section V for liquid waste treatment alternatives.

Comment

Conclusions contained in the final paragraph of DEIS page IX-8 do not appear justified because there are only several general references in the draft statement relating to possible shutdown of the N Reactor and Purex. It is recommended that liquid waste management improvements, including N Reactor effluent treatment, relocation of N Reactor Crib to the 200 Area and improved treatment for 200 Area liquid wastes, be strongly considered unless there is a definite and clear commitment on the part of AEC (or its successor agency) to shut down N Reactor and Purex by 1979. Further, the planned facilities for N Reactor gravity drain and control rod coolant dumps should be incorporated in the liquid waste management improvements noted above.

Response

Liquid waste management improvements for N Reactor effluents are being seriously considered currently. Plans and alternatives are discussed in Vol 1, Section V including adoption of the gravity drain and control rod projects.

X.18 COMMENT LETTER, United States Department of the Interior, Office of the Secretary, Washington, DC 20240

Comment

One of the three most important elements of the basic proposal for waste management is the continuation of research and development of methods for solidification of residual liquors as well as alternative insoluble products (DEIS page IX-8, paragraph 2). However, very little information appears to have been provided on actual research now in progress toward those objectives. We feel it is essential to provide information of two principal types: (1) an adequate summary of current knowledge; and (2) an adequate summary of the research program in progress, planned, and recommended. Important information that appears to be needed is the solubility and other pertinent properties of the salt cake, similar properties of alternative solid forms, relative advantages and disadvantages based on present knowledge, and tentative costs and benefits. Without this type of information it is not possible to evaluate the likelihood that this important part of the proposed program will be achieved.

Response

Text Changes Made - Vol 1, Section V.2.5

Comment

Approximately 5 million cubic feet of radioactively contaminated solids are stated to have been buried on the Hanford Reservation since 1943, but only since May 1970 have transuranic wastes been segregated in special containers for retrieval. Questions relating to this are: (1) what measures are recommended for ultimate disposition of wastes in burial grounds that may contain unsegregated transuranic wastes; (2) which specific grounds are these, and what measures are required to maintain their surfaces to reduce deterioration of containers in case of a future decision to retrieve these wastes; and (3) what monitoring or other special actions are required to preserve the future option of ultimate retrieval of these wastes?

Response

Text Changes Made - Vol 1, Section II.1.1.2.5, Section II.1.1.2.5.5 and Section V.2.5

Vol 2, Appendixes describe the various burial grounds, their status and contents.

Comment

It is noted that an integral part of the waste management program is the provision of "high integrity tanks to contain the liquids in interim periods" (DEIS page v). It has also been noted that in the process of solidification by evaporators, resulting in the filling of the tanks with solid salt cake, ". . . the major portion of this liquid needs to be removed since the integrity of the tank liner and shell cannot be assumed for long periods" (DEIS page II.1-86). In spite of the use of screened well-points installed down to the tank floors, it is stated that the remaining interstitial liquor ultimately equals about 30 percent of the volume of the salt cake, and that the piping is sealed off after this degree of dryness is reached. It appears inevitable that the floor of the tank must remain in a wet condition, in contact with the concentrated residual radioactive liquor for the duration of storage. In view of the foregoing conclusion that tank integrity cannot be assumed for long periods, we are concerned about tank integrity in contact with the residual liquor during prolonged storage, and amounts of such concentrated liquor that might leak into the underlying soil prior to detection, and during the period required to flush out the contents of the tank.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Comment

Volume 2 provides detailed estimates of the quantity of radioactive material held in and beneath cribs, burial grounds, tanks, ponds, ditches, and other waste management facilities. However, little or no indication is given of the probable accuracy of the statistics, of the possible margin of error, or of the range of values that might exist as a result of incomplete accounting procedures, particularly during the early years of operation. In general, the method of calculation, particularly of radioactive waste inventories, should be explained further and the figures presented should indicate no greater accuracy than the circumstances warrant.

Response

Text Changes Made - Vol 1, Section II.1.1.4

The accuracy of waste inventories is estimated to be as shown below. These accuracy estimates can be applied to gross inventory data presented in Volume 1 or 2 of this statement.

Accuracy* of Radionuclide Accumulations

Cribs	±30%
Ponds and Ditches	±30%
Unplanned Line Leaks	+100% -50%
Solid Burials	+200% -50%
Tank Leaks	±20%

*Accuracy should not be applied to individual cribs, ponds, etc. without separate review.

Comment

Radioactive Waste Disposal

The plan for ultimate solidification of high-level liquid wastes is of considerable concern. It has been concluded that ". . . new facilities for solidifying the final residual liquid will be needed . . ." and that ". . . the residuum will be treated to produce a solid either by chemical addition or a special type evaporator . . ." (DEIS page V-2). It is stated that these alternatives are currently under development, but the current state of knowledge and the current research program have not been described. In addition, no proposed funded research program is recognizable as corresponding to this aspect, in spite of the description of wide-ranging research programs in many areas. This aspect of the waste-management program is of ultimate importance because nearly 10 million gallons of residual liquid are expected to require such treatment at the end of the program (DEIS page V-9). In the discussion of the ultimate disposal alternatives, one possibility considered is to leave the salt cake in the tanks where it was formed (DEIS page V-21). However, the discussion of this alternative fails to consider the long-term problem of the residual liquor that is included, and that would ultimately be subject to leakage. At least a tentative timetable for ultimate solidification needs to be discussed.

Response

Text Changes Made - Vol 1, Section V.2.5

Comment

The statement does not, but should, describe what is involved in this required control and how it could be assured of exercise for periods extending to thousands of years. A full discussion of consequences resulting from the potential breakdown of control is required. The adverse effects of the enforcement of perpetual control over the area should be specified. Finally, the full implications of perpetual control should be factored into alternatives that do not require this type of control.

Response

An evaluation of the advisability of removing plutonium bearing waste for storage elsewhere is underway. The fission product waste is decaying and will reach innocuous levels in 100 to 500 years. For example, the 3,500,000 curies of fission products disposed to cribs and ponds in the 200 Areas since 1944 have decayed to 134,000 curies. In 1973 about 5500 curies were added to all cribs while 21,000 curies were lost to decay. The Waste Management Operations Program hopes to place the material in a condition that will require minimal future surveillance. See Section V.2.5.1 for a discussion of ultimate disposal research and development.

Comment

Alternatives

It is stated at the outset that current standards stipulate that releases of radioactivity be "at the lowest levels technically and economically practical" (DEIS page ii, #1). By the end of the environmental statement a fairly convincing case appears to have been presented to support the conclusion that "the radiation dose to the population and consequently the health effects are essentially independent of the alternative chosen" (DEIS page IX-8, paragraph 1; see also Table IX-3). The basic rationale of the AEC staff appears to be that the standard of "as low as practical" release of radioactivity will have been complied with if the proposed waste management program cannot be shown to result in significantly greater releases of radioactivity than those resulting from one or more alternatives that have been evaluated. However, the evaluations of all alternatives, resulting in the radiation-dose changes summarized on Table IX-3, are evidently based on the assumption that virtually all long-lived radionuclides released to the ground beneath storage or infiltration facilities will be safely isolated from the biosphere until they decay to a harmless level.

The foregoing rationale provides little or no basis for choosing one alternative over another, because all alternatives are viewed as differing by only insignificant amounts in their degree of risk to the environment. One of the following alternative interpretations of the "as low as practical" principle would provide another useful basis for evaluation of alternatives, to supplement that of radiation-dose levels as estimated by the present statement: (1) to compare

the quantity of long-lived radioactive isotopes released to the soil and not positively isolated from the biosphere by an impermeable, accessible, and reparable barrier; and (2) to compare the amount of ground, expressed in terms of acres and cubic feet, that would be irretrievably committed to waste management and storage. It has been noted that "land containing transuranic materials, particularly plutonium can be considered unusable for any purpose for hundreds of thousands of years" (DEIS page VIII-1, paragraph 3) and that essentially 6,000 acres are considered irretrievably committed under the present waste-management program. The spirit of the "as low as practical" principle requires that the acreage and volume of earth irretrievably committed to containment of long-lived radionuclides be kept as small as practicable, and that this factor should be an important basis for evaluation of alternatives that are practically equal in terms of foreseeable radiation dose commitments.

Response

Text Changes Made - Vol 1, Section V

Comment

The significance of archeological resources on the Hanford Reservation has been seriously understated on DEIS page II.3-13. The Columbia River was one of the most densely inhabited regions in aboriginal North America, and its inhabitants possessed one of the most interesting lifeways of the continent. With the exception of the sites located on the Hanford reach of the Columbia, evidences of this lifeway have been virtually erased. Therefore, the remaining sites assume great significance and should be evaluated to determine if they should be preserved.

Compliance with Executive Order 11593, "Protection and Enhancement of the Cultural Environment," should be documented in the statement. This requires federal agencies to inventory historical and archeological remains, evaluate, with the aid of an appropriate professional, their significance, and nominate those eligible to the National Register. Presumably, the Atomic Energy Commission funded surveys and the Ben Franklin Reservoir survey would suffice for the inventory.

Response

Text Changes Made - Vol 1, Section II.3.5

Comment

Geology

Ion exchange with clay constituents in the soil appears to have been relied upon for containment of practically all long-lived radioisotopes in liquids that are deliberately disposed of by infiltration in cribs, ponds, and ditches as well as liquids accidently released from tanks and pipes. For example, it is stated that "the clays have good ion exchange properties and make good filter beds" in describing the section beneath a typical crib illustrated by Figure II.1-51. The underlying soil is generally described as "up to 50% silts and sand, having some clay content" (DEIS page II.1-88, paragraph 2). However, we have found no section beneath any disposal area described in sufficient detail to suggest that the soil contains a significant amount of clay in the uppermost 150 to 300 feet. Considering the critical importance assigned to the surficial geologic section in containing the hazardous radionuclides, we feel that representative sections beneath important disposal sites should be described in detail, including quantitative data on parameters closely related to containment. These parameters include especially the permeabilities of the underlying capacities of these materials, and what retardation factors or calculations support the foregoing conclusion that "the clays . . . make good filter beds."

Curves showing idealized sorption patterns for principal elements beneath a typical disposal crib are shown on Figure II.1-52. Among the assumptions evidently made is that the radioactive solutions would percolate uniformly downward through a homogeneous soil, a condition which does not exist in actuality. Because specific depths have been shown, it appears that certain assumptions were made with regard to the soil type or the time element, but these have not been discussed. The basis for preparation of the curves, and all underlying assumptions, should be explained.

Comparison of the foregoing idealized curves with the limited analytical data presented in the Appendices (Fig. II.1-C-36 to 40) casts doubt on the validity of the idealized curves as applied

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to the Hanford Reservation. For example, the idealized curves appear to suggest that maximum concentrations of radionuclides would tend to occur very close to the source, but test wells commonly showed maximum concentrations from 15 to 35 feet below the surface, and even as deep as 65 or 100 feet for cesium. It has been concluded that "the potential for leaching of sorbed radionuclides from beneath cribs and trenches down to the water table is nil under present climate conditions" (DEIS page II.3-D-51), which would presumably eliminate leaching as a cause for the higher concentrations of some radionuclides at depth. In general, since sorption of radionuclides has been depended upon for their containment, analyses of their actual distribution beneath major disposal sites should be related to geology, structure, clay mineralogy, ground water, or any other pertinent factors. Unless the present distribution of radionuclides is well understood, after 30 years or less of movement, there appears to be little hope of predicting their fate over periods ranging up to "hundreds of thousands of years" (DEIS page VIII-1).

The statement projects that fission products and Pu will remain in the soil columns under cribs, trenches, and ponds for many centuries (DEIS page I-9). However, evidence presented in the draft statement shows vertical migration of ^{137}Cs and ^{90}Sr at the 216-S 1 and 2 crib sites (Fig. II.1-C-33, DEIS page II.1-C-84, Vol. 2). The crib site was in service from January 1952 until January 1956 and received aproximately 39 x 10^6 gallons (1.5 x 10^8 liters) of waste liquid containing 750,000 Ci of mixed fission products including 3,000 Ci of ^{90}Sr and 2,000 Ci of ^{137}Cs. Following the termination of discharges to the site, a field study was undertaken (DEIS page II. 1-C-82) in 1956. The upper cross section in Figure II.1-C-33 indicates the migration of cesium and strontium in the soil column. Ten years later, in 1966, five additional wells were drilled at the crib site to determine the extent of radionuclide redistribution (DEIS page II.1-C-83). The results shown in the lower cross-section of Figure II.1-C-33 indicate that cesium and strontium both have extended laterally and vertically. It is true that most of the ^{137}Cs and ^{90}Sr is still contained in the soil column about 15 m below the cribs. However, this movement shown occurred during only a 10-year period compared to the several centuries that these wastes will be hazardous. From this evidence, it is doubtful that the radionuclides can be retained in the soil columns for many centuries as concluded in the statement. To carefully keep track of the wastes at Hanford, especially those radionuclides which have reached the soil, more intensive, detailed work needs to be done at the site.

Response

Ion exchange is relied upon for containment of most of the radionuclides that are found in the waste liquid discharged to the ground at the disposal sites in the 200 Areas. However, the clay constituents in the sediments are not the primary ion exchange medium. Tests of samples removed from cribs, as an example the 216-S-1 and -2 cribs, show that very little clay exists in the soil beneath this crib site. A number of laboratory tests were performed on sediment samples from selected wells over the Hanford Reservation. These tests include analyses of the sediments, pH, ion exchange capacities, calcium carbonate content, and the amount of moisture held in the sediments against fifteen atmospheres of negative pressure. A library of sediment samples from wells throughout the Hanford Reservation is available for evaluation.

The procedure used for discharging waste to ground at Hanford is to sample the liquid waste stream, determine the radionuclide content of the waste, determine the distribution coefficient of the sediments into which this waste liquid will be discharged, and determine empirically the volume of waste liquid that can be discharged into the ground, such that the long-lived radionuclide concentrations eventually reaching the water table will not exceed the U.S. Energy Research and Development Administration published guides for drinking water. The typical or idealized sorption curve shown in Vol 1, Figure II.1-52 is used to show the distribution beneath the typical disposal crib. This is not used to determine the volume of waste that is to be discharged at any particular disposal facility. Each disposal facility is evaluated on the merits of the radionuclides content in the waste stream, the chemistry of the waste stream, and the types of sediments in the partially saturated zone from beneath the crib to the underlying water table. The idealized curve would indicate that the maximum concentrations of radionuclides tend to occur very close to the source. The comment that the maximum concentrations of radionuclides have been found to occur 65 or 100 feet beneath the disposal site where cesium is found is incorrect. The cesium in the case of the 216-BY crib sites has the maximum concentration at the 20-foot level immediately below the bottom of the crib. In the case of the 216-A5 crib site, the high concentration of cesium at the 65-foot level was primarily a function of where the well was drilled from which the sediments were obtained. With respect to the distribution of the radionuclides in the cribs that have been used during the past 30 years, it appears that the radionuclides are being held within the soil column and relatively high above the regional water table. With the prevailing climatic conditions these sediments are expected to remain essentially in this position.

Comment

Seismicity

It has been stated that ". . . additional seismic resistance studies will be performed . . ." as a result of potential structural deficiencies revealed by review of design of components of B Plant (DEIS page III.2-59). Judging only from the partial information presented, it appears that the appropriate recommendation would be to evaluate seismic effects on those waste management structures that have not yet been analyzed (DEIS page III.2-60) and to strengthen those components found to be weakest. In view of the past history of tank leakage, the effects of ground displacement and severe ground accelerations on the various tanks of various designs should be analyzed in detail. Although the tanks constructed after 1971 are said to be designed on the basis of a horizontal acceleration of 0.25g (DEIS page III.2-57), the accelerations that the tanks constructed prior to 1971 will withstand should be discussed. This is important as most of the waste was produced prior to 1971. The possibility of ground displacement at the tank locations should be analyzed and the basis presented.

Response

Waste tanks constructed prior to 1971 have been analyzed by consultants and found to accommodate the current design standards for ground acceleration. Other comparable tanks have been qualitatively determined to accomodate these seismic accelerations. See Vol 1, Section II.3.7 and Vol 2, Appendix II.3-C.

Comment

There are two aquifers in the Hanford area, namely, the unconfined and the confined aquifers. The former consists of both glacio-fluviatile sand and gravel deposits and the Ringold silts, clays, and gravels. These materials are very heterogeneous and often greater lithologic differences appear within a given bed than between beds. The confined aquifer consists of basalt. These two aquifers are separated by a layer of clayey silt of the Ringold Formation. Certainly some "erosional windows" exist between the aquifers, therefore at certain areas hydraulic communication between the unconfined and confined aquifers is possible (DEIS p. II.3-35).

Response

The erosional window concept is not adequate to describe the interconnection between the confined and unconfined aquifer and was removed from the final statement. The geology of the Hanford Reservation is extremely complex with major vertical and horizontal heterogeneities. The unconfined aquifer was defined as the uppermost pervious layer composed of glacio-fluviatile materials and sediments of the Upper Ringold Formation. Beneath the unconfined aquifer, a layer of silt (Lower and Middle Ringold) or a layer of basalt may be found. In some areas there may be some connection between the unconfined aquifer and any confined aquifer below the top silt or basalt layer. Such a connection would be through an aquitard and would tend to be very slow. Vol 2, Section II.3-D.4 of the final statement was revised to include a fuller discussion of the unconfined aquifer. Present programs include the drafting of plans for an extensive analysis of the vertical interconnection of the various aquifers underlying the Hanford Reservation.

Comment

The data presented in the sections on hydrology in both the report and its overall appendix are not adequate to support the conclusions drawn.

Response

Text Changes Made - Vol 1, Section II.3.8 and Vol 2, Appendix II.3-D

The data presented in the sections on hydrology in both the statement and its appendix have been expanded.

Comment

The statement does not contain a location map and construction details of the sampling wells, description of methods of water sampling, or a detailed geological map of the disposal sites.

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Response

Vol 1, Figure II.3-13 is a Well Location Map. The section on the groundwater monitoring program (Vol 2, Section II.3-D.4.5) has been expanded.

Comment

Frequency of sampling is another factor that should be considered. It is necessary to determine whether the lower layer of clayey silt acting as confining bed is present at the disposal sites. If not, the radionuclides could move directly down to the confined basalt aquifer; if this occurs, then water from the confined aquifer should also be analyzed frequently. The statement fails to consider these important factors.

Response

Water samples are taken from both the unconfined and confined aquifers at Hanford as noted in Sections II.3-D.4.5 and II.3-D.5 of Vol 2. Some confining lenses occur under some of the disposal areas. Such geologic data are used in planning the wells to be used as part of the waste disposal sampling program.

Comment

The hydraulic conductivities of the glacio-fluviatile sediments range from 1,200 to 12,000 ft/day and only 6 to 200 ft/day for the Ringold Formation (DEIS p. II.3-37). However, no vertical hydraulic conductivity is mentioned. Given such extremely heterogeneous formations it is surprising that no vertical sections of geology or soil columns at the waste disposal sites are given in the discussion of liquid waste disposal. Since the velocities of ground water moving through the glacio-fluviatile sediments are different by several orders of magnitude from velocities in the Ringold Formation, detailed geological and sampling well location maps should be provided.

Response

Measurements of the vertical hydraulic conductivity of the glacio-fluviatile sediments and the Ringold Formation are not available. Geologic data and examination of samples indicate that in these formations the vertical hydraulic conductivity will always be less than the horizontal hydraulic conductivity, at times, as much as an order of magnitude less.

Detailed geological and sampling well location maps are provided in Vol 2, Appendix II.3-D.

Comment

The references indicate that pumping tests after the early 1950's appear to have been run without planning and with little care.

Response

After the early 1950's pumping tests required improvement. The present pump testing program is designed to provide better data.

Comment

Because of the heterogenous nature of the confined aquifer, it is necessary to have a well planned and detailed geophysical exploration which will establish glacial flow channels and the continuity of the confining bed.

Response

The geophysical program alluded to is presently underway (also see Vol 1, Section II.3.8.2.2 and Section II.3.8.2.3 and Vol 2, Appendix II.3-D).

Comment

It is necessary to carry out water-balance calculations at the site.

Response

Text Changes Made - Vol 2, Appendix II.3-D

Comment

Although the draft statement says that no information has been found which indicates that a hazard through the groundwater pathway presently exists as a result of the AEC waste operations at Hanford (DEIS p. II.3-D-77), the references clearly show that the authors of the reports did not endorse the operations.

Response

Text Changes Made - Vol 1, Section II.3.8.3 and Vol 2, Appendix II.3-D

Comment

Considering the nature of the base data on well monitoring, the reliability of the conclusions reached in the draft environmental statement cannot be demonstrated.

Response

Text Changes Made - Vol 1, Section II.1.2.2.3, Section II.3.8.2 and Section II.3.8.2.3 and Vol 2, Appendix II.3-D

Comment

The conclusion that the disposal of liquid waste into the ground at the Hanford Reservation does not endanger the hydrosphere in the area is made partly on the arbitrary and cursory assumption that soil columns will retain a large part of the radionuclides. This assumption is based partly on chemical analyses of water samples taken from some monitoring wells, and partly on the transport model.

Response

The assumption that soil columns will retain a large part of the radionuclides is based on experimental and field data (described in Vol 2, Section II.3-D.3).

Comment

Figures II.3-18, II.3-20, and II.3-21 are used again and again to show that the average nitrate, gross beta, and tritium concentrations in the groundwater near the surface of the unconfined aquifer during the period of July-December 1972 are either below the drinking water standard or the concentration guide, except in the area near the disposal site. The reliability of these figures is debatable. First, as mentioned above, there is neither a detailed geological nor a sampling-well location map. The statement fails to mention the sampling method and frequency and the construction of sampling wells (open intervals, etc.). Secondly, the movement of radionuclides both in the vertical and lateral direction are related to the rate of disposal, concentration of the waste, and groundwater levels. This is a dynamic system, yet the concentration map was compiled according to a calendar period instead of dynamic conditions.

Response

Text Changes Made - Vol 1, Section II.3.8.2.2

The referenced figures were revised, the data more clearly presented, and the discussion was expanded.

Comment

There is neither a location map showing springs along the river banks nor radiochemical records of the spring water in the draft statement. It is also possible that some springs may discharge directly into the river under water.

Response

The N Crib springs are located on the south river shore directly north of the N Crib. The top left-hand side of Figure II.1-B-3 and lower right corner of Figure II.1-A-1b identify the location of N Crib but the springs are not identified on these maps. The radionuclide content and chemical content of the springs were given in the DEIS as Table II.3-D-15 and Table II.3-D-16, respectively. Additional data have been added to the final statement (Vol 2, Section II.3-D.4.6). There may be undetected springs under the river. River monitoring has not been able to detect any radionuclide input from such a potential source.

Comment

Before any meaningful conclusion is made that the radionuclides will not move down to the groundwater body from their present location, it is necessary to study the probability of rainfall duration and intensity over a period of several centuries. The vertical permeability of the formation at the tank site also needs to be determined.

Response

Text Changes Made - Vol 1, Section II.3.9.1

Vol 1, Section II.3.9.1 now includes rainfall prediction data.

Comment

Floods. The potential effects of Columbia River floods are evaluated, assuming that the dam-regulated probable maximum flood was calculated by the Corps of Engineers, is the highest that could occur (DEIS page III.2-67). This is adequately conservative for most flood evaluations involving man-made structures. However, the Hanford Waste Management Program will require "long-term control (thousands of years) . . .", and the possibility that dam regulation as practiced today may not be assured over such lengths of time should be considered in addition to the flood effects of the potential failure of upstream dams. If unregulated floods or dam failures could reach other waste storage or burial areas, these should be specified as well.

Response

Major dam failures on the Columbia River are classified as incredible events and consequently were not analyzed. Also see Vol 1, Section V.2.5.

Comment

The consequences of the flooding of buried wastes are evaluated on the basis of the following simplifying assumptions: (1) all uncontained radionuclides are entrained during the peak 24 hours of the Columbia River flood; and (2) all are soluble and uniformly mixed into the quantity of water equal to 24 hours of peak flow. These assumptions are indeed conservative with respect to concentration of solutes (although "uncontained" has not been clearly defined and therefore cannot be evaluated). However, it is possible that the entrained soil and sludges will retain significant fractions of the radionuclides and that they will be moved as particulates. They could settle out in the streambed and be incorporated into the long-term bed environment of the Columbia River. The potential effects of this possibility should be considered.

Response

Particulate sediments in the Columbia River now are monitored and studied. There is no evidence that they are an important pathway of exposure to man or biota. Most sediments remain near the river bottom and gradually become covered with nonradioactive sediments.

This matter is discussed in Vol 2, Section II.3-D.2.1.

Comment

There is insufficient specific evidence to support the summary statements on DEIS page I-6 that there are no harmful effects of Hanford waste effluents on the aquatic ecosystem of the Columbia River. Annual counts of the numbers of spawning salmon in the Hanford reach, cited on DEIS page II.1-167 as a major criterion of impacts on anadromous fish, are a very remote index to thermal, chemical, and radioactive effects on different life stages of salmonids. Other Hanford area research not cited has demonstrated that the potential clearly exists under periodic conditions of river flow and temperature for lethal exposure of migrating juvenile salmonids to heated discarges. Some of the synergistic effects on salmonids resulting from interactions of temperature, disease, nitrogen supersaturation, toxic chemicals, and other influences have also been studied in the Hanford area and should be discussed and factually reported.

Response

"No deleterious effects to the numbers of or species of terrestrial or aquatic life have been observed during 30 years of Hanford operations," as worded, may convey an incorrect impression. The important difference is that the statement referred to studies of natural populations of Columbia River aquatic life, not to individual organisms. One-hundred percent of the plankton organisms taken in with water to cool the reactors were killed during treatment of the water prior to its passing through the cooling system. Some fish were also entrained and killed or trapped and killed at the intake structure. However, this mortality was so slight compared to the total populations of these organisms in the river, that ERDA ecological studies of natural river populations have not detected any changes at the community or population level attributable to reactor operation.

Comment

Objection is also made to the statement on DEIS page III.1-59 that "It is reasonable to conclude that if there is not a significant impact on salmonids, a significant impact on other species is not occurring." Certainly species differences in distribution, movement patterns, feeding, and thermal and chemical tolerances could result in varied response to thermal or chemical discharges.

Response

Text Changes Made - Vol 1, Section III.1.3.2.3.1

Comment

Effects on Wildlife

Radioactive effluent from N-Reactor operation flows into the 1301-N disposal crib and thence overflows into a 1,600-foot dispersal trench. The 100-N trench has been screened to exclude game birds and other larger animals, but smaller species such as mice can gain access. Section II.3.13.5 and Table II.3-24 of the statement report significant levels of radioactivity in mice collected at the 100-N trench. Included in the statement should be a discussion of the significance of the observed radionuclide concentrations in small mammals, the potential for these animals to enter the food chains of the several species of endangered, threatened, or status-undetermined birds of prey utilizing the Hanford Reservation as a refuge, and steps which should be taken to eliminate this source of radioactive contamination. In a broader sense, an overview of interpretation of the significance of the reported concentrations of radioactivity found in various organisms would be useful in understanding the environmental statement.

Response

Concentrations of several radionuclides in mice collected in the vicinity of the 100-N trench in 1973 are orders of magnitude higher than in mice collected in other locations. Whether the levels of radioactivity contained in these mice pose a potential hazard to raptorial birds which feed on them is unknown. No data are available on radioactive levels of these birds. A study of raptorial populations on the Hanford site in 1973 revealed that raptor nests were scarce in the area of the 100-N Reactor and along the southern border of the Columbia River. This does not imply that raptors do not feed in this area but the overall impact of these mice is not known. Ecological studies are continuing.

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Comment

In Volume 2, DEIS page C-133, it is mentioned that a duck was found in 1969 with an exceptionally high concentration of radioactivity and that if one-half pound of the duck were consumed by a member of the public, it would have resulted in radiation exposure nine and one-half times greater than the permissible amount recommended by the International Commission on Radiological Protection and the Atomic Energy Commission. While it may not be practical to exclude all mobile wildlife species, particularly waterfowl, likely to be consumed by man, the Service recommends screening project waters to exclude mobile species, from potentially high contaminated waters. The type of screening necessary was done on the 100-N trench that is mentioned in Volume 1, DEIS page II.3-70.

Response

N trench was the primary source of contamination for waterfowl and hence was screened to prevent their access. Other ponds are being studied and control of wildlife will be provided if appropriate. At this time surface water requiring this type of wildlife control has not been identified. See response to similar question in X.5.

Comment

Also in Volume (3), DEIS page III-A-102, second paragraph the statement is made "Essentially no wheat or pasture land is irrigated with Columbia River water downstream of the Hanford project." It is our understanding there are many acres irrigated below the Hanford project with Columbia River water.

Response

Text Changes Made - Vol 1, Section II.3.4

Actually, only a few percent of the total downstream acres are irrigated with Columbia River water.

Comment

The statement fails to mention the basic assumptions used to formulate the transport model and, therefore, it is impossible to judge the applicability of the model. However, results obtained from the model depend on the basic input data which are affected by the factors mentioned above. Since they are in question then so are the results predicted by the model.

Response

Text Changes Made - Vol 1, Section II.3.8.2.2 and Section II.3.8.2.3; and Vol 2, Appendix II.3-D

Assumptions Used in the Transport Model

- The algorithm developed involves a vertically-averaged form of the transport equation derived by performing a mass balance over a finite element of the system.
- The lateral components of dispersion are negligible in comparison with the longitudinal components.
- Solute transport and related chemical reactions occur sequentially within each time level of the simulation.
- The actual kinetic sorption effects can be characterized by a composite of many equilibrium states. On this basis, the fundamental "mass action" law is applied to derive an approximate relationship between liquid and solid phases of the micro-components.
- Water is treated as an incompressible fluid regardless of the ions in the solution.
- Velocity patterns are not a function of water quality.
- Chemical conditions in an aquifer are at near equilibrium at all times.

- The equations for each microion species are not coupled because they are only present in minute quantities.
- Microions can be added to or lost from the system only through sorption processes or radioactive decay.
- The microions do not affect the macroion chemistry.
- A microion does not affect another microion.
- Vertical transport is neglected.

Comment

If inaccurate transmissivity data collected in the field are fed into a transmissivity iterative model it will produce an inaccurate transmissivity map. With the inaccurate transmissivity map and insufficient knowledge of hydrologic boundaries, a mathematical groundwater model will yield inaccurate travel times. Considering the criticism of the reliability and adequacy of data discussed in the consultant's reports (refs. 64, 65, 66, and 67, DEIS page II.3-D-83, Vol 2), the applicability of results from these mathematical models is suspect.

Response

Text Changes Made - Vol 1, Section II.3.8.2.2 and Section II.3.8.2.3; and Vol 2, Appendix II.3-D

Comment

A clear summary of the basic proposal would be helpful at the outset, either on the Summary Sheet (now a separate attachment) or in the Summary, Section I. An adequate and concise summary is not now presented until the last page of the draft environmental statement (DEIS page IX-8, especially paragraph 2).

Response

A summary sheet is provided with the final draft.

Comment

Sections II.3.11.7 and II.3-6.8 state that all endangered, threatened, and status-undetermined birds found on the Hanford Reservation are raptors. This is incorrect since the long-billed curlew is not a raptor.

Response

Corrections made.

X.19 COMMENT LETTER, Mrs. Ray Rodd, 28240 20th Avenue South, Federal Way, WA 98002

A response was not required.

X.20 COMMENT LETTER, Betty Lagergren, 208 N. 27th Ave., Yakima, WA 98902

A response was not required.

X.21 COMMENT LETTER, Alan Stamwitz, 429 Chenault, Hoquiam, WA 98550

Comment

I feel it is virtually impossible to keep plutonium guarded for tens of thousands of years. There is no working solution in the works to recycle plutonium and they are finding many troubles and problems in building a successful recycling plant.

If this substance were to get into the Columbia River and be digested into the fish, it would be disastrous. A good deal of income comes from fishing in the Pacific Northwest, and it should not be ruined by plutonium infected fish. Once it gets into the water then all is lost.

Response

It is planned that plutonium will be recovered from the soils and sent to an approved ultimate disposal facility. The environmental evaluation program at Hanford does not indicate dose levels that would lead to ill health or death in the area closely surrounding the Hanford site. The amount of radioactivity in the Columbia River is monitored and found to be so low that no harm will occur to fish or people eating fish. Data are presented in Section II.1.1.2.5.

X.22 COMMENT LETTER, Zero Population Growth, Los Angeles Chapter, Los Angeles, CA 90064

Comment

Maintenance of national security requires that the solidified high-level waste now in admittedly interim storage at Hanford be expeditiously transferred to one or more deep underground repositories, there to be kept in retrievable form. Otherwise, even a single attack with conventional or nuclear bombs might disperse radioactive material sufficient to render impossible necessary maintenance and control of the site. While such transfer to safer storage is being arranged, the government should very seriously consider the temporary expedient of covering the locale of the present dehydrated underground tanks with several hundred feet of rock and/or soil.

Response

To cover the locale of the present dehydrated underground tanks with several hundred feet of rock and/or soil is not practical. Also see Vol 1, Section V.2.5 for a discussion of the current research and development on ultimate disposal.

X.23 COMMENT LETTER, North Anna Environmental Coalition, P.O. Box 3951, Charlottesville, VA 22903

Comment

"Many concerned citizens will be especially interested in the alternative means of handling radioactive waste, including the alternatives of not generating any additional radioactive waste."

Response

The alternative of not generating any more waste by shutting down N Reactor was discussed in the Alternative Section. A waste management program is required for the waste that is already generated. An alternative that does not require a management program for the already generated waste is not considered reasonable because abandonment of the waste in its current status would result in unacceptable environmental conditions.

Comment

How far may the plutonium disposed of in the Z-9 trench migrate during its 250,000 year toxic life?

Response

Text Changes Made - Vol 1, Section II.1.1.4.4 and Vol 2, Appendix II.1-H

X.24 COMMENT LETTER, Office of Federal Activities, Unites States Environmental Protection Agency, Washington, DC 20460

Comment

The draft statement is incomplete in its presentation of data from supporting hydrologic and geologic studies (with sufficient documentation and references), including the results of any

soil investigations related to waste retention in the unsaturated zone. The presentation of actual data in the draft statement, either in tabular, graphical, or figurative form is minimal, and, in the case of some maps, essentially illegible.

Response

Text Changes Made - Vol 1, Section II.3.8 and Vol 2, Appendix II.3-D

The sections on hydrology were revised; additional material and references are now included. An entire section on the unsaturated zone was added to Vol 2, Section II.3-D.3. The presentation of tabular and graphical data has been improved. The revisions include comments from consultants and on-site contractors.

Comment

The hydraulic interconnection of the confined and unconfined aquifers is not sufficiently discussed in the draft statement. There appears to be a clear interconnection, as evidenced by the erosional "windows" in the intervening aquitard (DEIS page II.3-435), the potential distribution beneath the 200 Area (1) and the tritium concentrations in groundwater from the basalt aquifer (DEIS page II.3-D-73). Contrary to what is stated on DEIS page II.3-38, the water table map presented is not adequate to characterize the present state of the unconfined aquifer. A series of flow system cross sections and supporting data concerning flow rates, volumes, and water quality are also necessary to characterize the existing situation.

Response

See response to similar comment in Letter X.18.

The discussion on the water table was expanded (Vol 2, Section II.3-D.4.2). A geologic cross section (Vol 2, Figure II.3-D-13) was added to show the water table elevations at three times during the history of the Reservation.

At Hanford the groundwater velocity vector is perpendicular to the water table contour lines, and it points in the direction of lower hydraulic potential. Therefore, for any groundwater potential map in an unconfined system, flow paths can be drawn illustrating the direction of groundwater movement at that specific time (Vol 2, Figure II.3-D-16).

Vol 2, Tables II.3-D-16, II.3-D-17, II.3-D-18, and II.3-D-19 show extensive water quality data for the unconfined aquifer.

Comment

The fifth paragraph on DEIS page II.3-38 incorrectly equates the groundwater potential map with a water table map. Discharge from the unconfined aquifer (DEIS page II.3-41) likely occurs not only by evapotranspiration but also by evaporation from either a free water surface (West Lake) or by vapor transport from areas having a high water table, as along the Columbia River. Furthermore, groundwater introduced into the basalt aquifer in the 200 Areas may discharge by upward leakage and movement to the unconfined aquifer and to the Columbia River, or it may move to other unspecified areas.

Response

Text Changes Made - Vol 2, Appendix II.3-D

The water table is that surface in an unconfined underground body at which the pressure on the water is atmospheric. The water table concept has been revised (Vol 2, Section II.3-D.4.2) in the final statement.

Vol 2, Section II.3-D.4.1 discusses the state of knowledge regarding discharge and recharge areas.

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Comment

In describing the effects of Columbia River bank seepage (DEIS page II.1-62), the draft statement does not consider the wastes retained in the sediments and non-measurable, diffuse discharge from the various sources to the river. Only part of the waste transport (by springs) is described for the present (1972) and under present hydrologic conditions. The final statement should consider other waste fluxes in the springs and the diffuse flow of groundwater from the same sources under different hydraulic conditions which are likely to occur in the future.

Response

Analysis of different transport rates are planned from the various disposal sites to the river under different water table conditions.

Diffuse flow by its nature moves very slowly allowing time for decay. The impact of diffuse flow is therefore less than that of the springs.

Comment

The discussion of Columbia River flooding (DEIS page III.2-64) considers only erosion and physical transport, whereas chemical transport by river water or by atypical groundwater conditions associated with flooding should also be considered in the final statement. This should be done in analyzing the impact of the various planning floods such as the Probable Maximum Flood (PMF) and the Standard Project Flood (SPF), and also for the lesser floods which may have an adverse impact on the wastes.

Response

The calculation did not consider the effects of recharging underground aquifers with contaminated flood waters. Doses received by secondary pathways are not significant when compared to a dose received by direct exposure via drinking water. Both are far less significant than the total destruction of communities caused by the flood.

Comment

On DEIS page II.3-D-65, it is stated that 90 wells have been drilled to the basalt. The final statement should indicate how many wells are drilled into the basalt, the silts, and the clays of the confined aquifer.

Response

The silts and clays of the Lower Ringold overlie the top basalt layer. Most wells penetrating into the basalt will pass through one or more silt or clay layers.

Comment

In discussing aquifer characteristics, several statements are made, on DEIS pages II.3-D-36 through II.3-D-43, relating to input data for assessing groundwater movement. Deju (2) was quite explicit about what he thought were inadequacies of the single well (versus multiple well) tests and time duration which could give questionable results, depending on the method of data analysis, for transmissivity and permeability. Resolution of differences between the values derived by Deju and those from AEC contractors for both of these parameters and the impact of changed values on the predicted movement of radionuclides should be fully explained in the final statement. We feel that these additional characteristics are also significant for evaluating any waste disposal program involving aquifers and should be included with those stated on DEIS page II.3-37. The use of single well tests for developing permeability and transmissivity data for input to the groundwater flow and transport models should be justified in the final statement.

Response

The final statement acknowledges that the data base for transmissivity and hydraulic conductivity can be substantially improved. A plan has been prepared for improving the data base by conducting multiple well pumping tests. This plan is being implemented and will take three to five years to complete.

Comment

The draft statement, on DEIS page II.3-D-37, states that the input data necessary for calculating the storage coefficient were not available and that techniques have not been developed for calculating this coefficient. Therefore, we feel that an assumed storage coefficient value, as a basis for estimating effective porosity, is not a valid foundation for model development. The final statement should include a detailed clarification of these and other basic assumptions, or indicate if a program is planned to obtain field-determined storage coefficient values relevant to the flow and transport models for saturated conditions. If available, sensitivity analyses relating the various parameters to model output should be included.

Since the storage coefficient is assumed rather than calculated from testing, and the values for hydraulic conductivity are in question, we believe that the validity of the computed groundwater flow velocities (DEIS page II.3-D-43) is also questionable. Deficiencies in the past and present monitoring system, unfortunately, do not permit the calculated velocities to be field verified.

Response

Text Changes Made - Vol 2, Appendix II.3-D

The storage coefficient is a difficult quantity to measure and requires the completion of multiple well pumping tests. Such tests are presently underway. The results of limited sensitivity analysis on the unconfined aquifer indicate that the flow in the aquifer is sufficiently greater than the rate of storage to make the calculations of hydraulic conductivity and flow velocities relative insensitive to the storage coefficient (Vol 2, Section II.3-D.4.4).

Deficiencies in the past and present monitoring system were recognized (Vol 2, Section II.3-D.7) and work is underway to improve that system.

Comment

The statements on DEIS pages II.3-D-47 through II.3-D-51, concerning digital modeling of groundwater flow and radionuclide transport in the saturated and unsaturated zones at Hanford are not complete enough to permit an independent assessment of the adequacy of the modeling program. Limited field data are acknowledged, but model testing using these data still remains incomplete. The comments by Deju (2) and Summers and Deju (1) for example, largely disagree with the reported state-of-development of the modeling program and the adequacy of the data base as implied in the draft statement and stated in staff discussions with the AEC. Additional information should be included to support the state-of-development of the modeling program.

Response

Text Changes Made - Vol 2, Appendix II.3-D

The discussion on modeling has been considerably expanded (Vol 2, Section II.3-D.4.4). All of the models are in the development stage and are presently undergoing review and revisions (Vol 2, Section II.3-D.7).

Comment

The final statement should clearly state whether average or actual travel times and flow velocities are used in all sections of the text (i.e., Figure II.3-D-16 and discussion on DEIS page II.3-D-44) describing actual or projected movement of radionuclides in the Hanford subsurface environment. The first arrival of a radionuclide determined on the basis of actual velocity is an important consideration in judging the acceptability of waste management operations. Reliance on average velocities and necessarily longer travel times may not always be realistic and may, in fact, be a very non-conservative operating policy with respect to minimizing adverse environmental impact.

Response

The discussion on travel times has been eliminated from the final statement pending completion of 1) studies presently underway to examine the model accuracy and 2) tests to enhance data coverage. The travel times that are used in various sections are used as arrival times unless otherwise stated.

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Comment

The environmental suitability of the Hanford reservation as a site for radioactive waste management activities relies partly on a determination that the Ringold Formation and Pasco Gravels are generally compact and undisturbed. Based on the draft statement, the Pasco Gravels may not be compact, as evidenced by their consistently low seismic (P) wave velocities of about 2,000 feet per second. The reported high load bearing capacity may not indicate compaction, but rather could be explained by the point-to-point contact between cobbles. A broader discussion of this issue should be included in the final statement.

Response

The environmental suitability of the Hanford Reservation referred to in this comment is in reference to the discussion on seismology (Vol 1, Section II.3.7). The statement from this section is as follows: "The siting of nuclear facilities over the synclinal troughs introduces the maximum distance from all hypothesized faults capable of earthquake generation. If, in addition, the Ringold Formation and Pasco Gravels are compact and undisturbed, the site is certain to pose few problems."

The primary reason for including these two comments in the Environmental Statement is to show that in the event a fault occurs beneath the Hanford Reservation, the displacement in the bedrock would not be propagated upward through the more than 500 feet of sediments lying between the waste management facilities and the bedrock causing ground rupture. The second point is with respect to compaction of the Pasco Gravels. The seismic (P) wave velocities are consistently low (about 2,000 feet per second), as stated in the comment. However, their load-bearing capacity, without undue settlement, is high (generally in excess of 6,000 pounds per square foot), even for materials directly at the ground surface. The high load-bearing capacity of the Pasco Gravels is attributed to the point-to-point contact between the cobbles, pebbles, and sand grains. The compact nature of the Pasco Gravels, relative to their load-bearing capacity, is the important point with respect to ground settling rather than the low seismic wave velocity. In the event of an earthquake the sediments would tend to be quite stable and would not rearrange their structure significantly. It is stated in the Environmental Statement, in Vol 2, Appendix II.3-C, that the Ringold Formation generally is saturated and the Pasco Gravels commonly are dry. Locally, however, the base of the Pasco Gravels is saturated. Consequently, the opportunity for reworking and compaction is minimal.

Comment

The draft statement indicates that periodic program reviews (other than Deju and Summers) have been made of the Hanford hydrology program. Specific references and results concerning all prior reviews should be included in the final statement.

Response

The following consultants used their expertise in some areas. They did not conduct a total program review. See Vol 1, Section II.3.14 and Vol 2, Section II.3-D.7.

Dr. D. W. Moeller	School of Public Health, Harvard	Review and consult on environmental relationships.
Dr. R. F. Harleman	Consulting Engineer MIT	Review and consult on hydrology.
Dr. N. T. Coleman	U of California Riverside	Review and consult on soil chemistry related to sorbtion of radionuclides in Hanford soils.
Dr. F. L. Parker	Vanderbilt U Nashville	Review and consult on chemical engineering
Dr. C. T. Webster	Fenix & Scisson, Tulsa, OK	Drilling engineer providing continuing consultation on methods of drilling and sampling basalt, unconsolidated materials and solidified waste.

Comment

In our opinion, the continuing discharge of chemical and radioactive wastes into a crib and trench at the N-Reactor is an environmentally unacceptable practice to follow in a hydrologically active regime like a river bank (DEIS page II.1-58). The practice also appears to conflict with the intent of the EPA Administrator's Decision Statement No. 5 ("EPA Policy on Subsurface Emplacement of Fluids by Well Injection") and Executive Order 11752. The assumption that radioactive species, such as strontium, cesium, and cobalt, will accumulate and be retained in the soil presupposes no removal by leaching associated from a rising water table concurrent with river flood stage or other causes.

Response

Environmental monitoring programs are conducted to evaluate the impact of this practice on the population. The doses to people in the environment are only small fractions of background radiation levels. Monitoring programs do not detect any leaching of this crib material due to river flood stage conditions.

Comment

Liquid effluents discharged to ponds and cribs on the Hanford site are reported in the draft statement as being generally low in radioactivity (<0.05 μCi/ml), except for tritium (DEIS page II.1-88). It is important to recognize that both the concentration and volume need to be considered in assessing the total impact of radioactivity discharged to the environment. The final statement should clarify this situation and present both concentration and volume data where applicable. Justification for the continued use of the cribs, despite the criticism by the National Academy of Sciences study (5), should be made.

Response

Total releases from the plant since startup, (decayed through 1972) for nuclides of interest, are presented in Vol 2, Table II.1-C-23.

The environmental impacts resulting from all waste disposal methods used are small, 2.5 man-rem dose from 1972 operations. The alternatives to continued crib use are presented in Vol 1, Section V.3.2 entitled "Liquid Waste Treatment Alternatives" and in the Cost-Benefit Analysis in Vol 1, Section IX.

Comment

Disposal of intermediate and low-level wastes in the 200 Areas, where high-level wastes are also stored, may create ground-water mounds and unnatural groundwater flow directions. This complicates the prediction of the flow directions for future operations should alternatives for handling low- and intermediate-level wastes be adopted. This situation should be recognized and addressed in the final statement.

Response

Text Changes Made - Vol 1, Section II.3.8 and Vol 2, Appendix II.3-D

The situation noted has been recognized and is the reason for the extensive modeling effort.

Comment

The chemical quality of ground water in the unconfined aquifer is not adequately monitored if, as indicated in the draft statement, only 14 analyses per year are collected on a semi-annual basis from eight (unspecified) locations, and incomplete analyses are performed. The presentation of chemical concentrations near the surface of the unconfined aquifer is necessary for characterizing an adequate flow system. Therefore, the steps to be taken to rectify this apparent weakness in the monitoring program, including a more complete chemical cation and anion analysis (sodium, potassium, calcium, magnesium, bicarbonate, carbonate, chloride, sulfate and nitrate), should be discussed in the final statement.

Response

Text Changes Made - Vol 2, Section II.3-D.4.5

Comment

Only part of the waste discharge permit applications (DEIS pages II.1-148 and II.1-150) are shown in Appendix II.1-D. Not shown are details concerning concentrations, flow volumes, and chemical species discharged. The practices described on DEIS page V-47, concerning chemical release to the Columbia River, are not acceptable to EPA and will have to be changed under the conditions of the forthcoming EPA permit to be issued under the National Pollutant Discharge Elimination System. Effluent limits for nonradioactive waste and an effluent monitoring program will very likely be required. The final statement should indicate that any changes in waste treatment practices needed to meet EPA permit requirements for the discharges described in Appendix D will be made.

Response

The discharge permit has been submitted to EPA Region 10 for review. The ERDA is working with the EPA during the review to meet permit requirements.

Comment

The maps provided on DEIS pages II.3-44, II.3-46, and II.3-47 are useful in depicting the general location of the chemical discharge plumes extending from the recharge areas. However, we feel that several large areas have not been adequately monitored, hence the shape and extent of the plumes are interpolated. The final statement should include the sampling methods utilized and should present the data obtained so that reviewers can reach a decision as to the adequacy of the groundwater monitoring program.

Response

Text Changes Made - Vol 2, Section II.3-D.4.5

Comment

At various places in the draft statement, movement of radionuclides towards the Columbia River from the 200 Areas is mentioned, but it is not clear what constituents are reaching the river now, have reached it in the past, or will reach it in the future. An earlier report by Brown and Haney (6) stated that six to seven percent of the ruthenium and 70 percent of the tritium from the 200-E Area reached the river. Lesser quantities were attributable to the 200-W Area. The final statement should provide information on the quantity of ruthenium that is in an ionic form, which is not retained in the soil (DEIS page II.1-90), an estimate of the quantity of ruthenium, tritium, and nitrate in the ground water, the time of introduction, and the concentration.

Response

The transport forecast was summarized in Vol 1, Section II.3.8 and Section III.1.1 and Vol 2, Appendix II.3-D. The fact that no measurable fluxes from the 200 Area plumes enter the river is mentioned. The Brown and Haney report is misquoted. It actually said less than 1% of the ruthenium and 70% of the tritium from the Purex cribs enter the river. The travel time assumed in 1958 was 6 to 7 years, which has been shown since to be 18 to 30 years.

Estimates of the inventory of ruthenium, tritium, and nitrate ion in the saturated groundwater of the unconfined aquifer are given in Vol 1, Section II.1.1.4.3. The time of introduction is covered by the operating histories of the various disposal facilities, summarized in Vol 1, Section II.

Table II.1-B-7 in Vol 2 contains estimated inventories from the 100 Areas cooling water leakage and disposal operations. Vol 2, Table II.1-B-9 presents the estimated discharges to the 100-N Area crib. Input chemical concentrations to the 300 Area pond are in Vol 1, Table II.1-26.

Quantities of radionuclides discharged to each disposal site associated with the 200 Areas are tabulated in a series of reports "Radioactive Liquid Wastes Discharged to Ground . . ." ARH-2757.

Comment

Estimates of gross beta, tritium, and nitrate quantities in the zone of saturation (unconfined only), as described on DEIS page II.1-130, are based on the assumption that concentrations at the water table are representative of the aquifer on the whole. This assumption should be substantiated in terms of other available data, as it presupposes complete mixing, no density stratification, and does not deal with the three-dimensional aspects of the groundwater flow system. The presence of tritium in the basalt aquifer, for example, is indicative of possible deep downward and lateral movement of radionuclides.

Response

The radionuclide concentrations found at or near the water table are the highest probable concentrations to be found in the aquifer. Such a conservative assumption allows the study of the "worst possible" case. Also see reply to similar comment in Letter X.18.

Comment

The illustrations shown on DEIS pages II.1-131 through II.1-133 are not legible enough to allow the reviewer to identify specific well locations. Concentration values from the individual wells which were used to create the maps should be provided in the final statement. In our opinion, it may be of more value to a reviewer to show contour lines or isopleths drawn on actual values for the delineation of zones rather than defining the zones as representing a certain percentage range of the Concentration Guide.

Response

Text Changes Made - Vol 2, Section II.3-D.4.5

A table of concentrations are provided in Vol 2, Section II.3-D.4.5 and contours are labeled on the maps.

Comment

Variations in concentrations at sampling points should also be stated to indicate variability in the system through time as well as space. Concentrations of radionuclides in groundwater beneath solid waste disposal sites in the 100 and 300 Areas appear to be missing from Table II.1-7 on DEIS page II.1-135 and should be included in the final statement.

Response

All concentrations in groundwater are reported in Vol 2, Section II.3-D.4.5. Historical data are voluminous. Solid waste sites are being studied for radionuclide migration.

Comment

The draft statement (DEIS page II.1-156) discusses the usefulness of the nitrate ion as an indicator of the extent of the radioactive waste plume. However, since nitrate is already present in several parts of the Hanford Reservation from past agricultural activities, it may not be possible to rely on nitrate ion measurements as being valid indicators of radioactive waste concentrations in the subsurface. The final statement should discuss the continued usefulness of the nitrate ion as an indicator.

Response

While recognizing the shortcomings of each, all indicators that are available are used. Some areas of nitrate ion in groundwater did not originate from Hanford operations; however, some nitrate ion was associated with most Hanford liquid waste discharged to ground. Since the nitrate ion moves without retention or hold-up in the groundwater system, it is a reasonable indicator of liquid waste movements.

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Comment

The presence of tritium in the confined aquifer(s) (DEIS page II.3-D-73) raises the possibility of either migration or modern recharge (since 1952) and would indicate the confined aquifer is part of a dynamic system. Therefore, the final statement needs a more complete explanation in terms of radionuclide migration in the subsurface and should also indicate on a map the location of the well which reportedly has the highest concentration (well 299-W11-2-P).

Response

The confined aquifer is a dynamic system with some artesian wells. Tritium was found in some wells penetrating this aquifer. Well 299-W11-2-P shows the highest concentration and is located in the north central part of 200 West Area.

Comment

Leakage from the 100-N Area disposal trench and crib may occur as both localized spring flow (seepage springs) and as general baseflow or diffuse ground water return flow. The statements on DEIS page II.1-5, and elsewhere in the draft statement, do not consider the latter mechanism for this area (100-N), the other 100 Areas, or the 300 Area. The final statement should consider this other pathway mechanism. There is also a need for more quantification of the mass or activity transported in waste materials, both radioactive and nonradioactive, from the AEC reservation to the river. Uranium from the 300 Area North Pond and farm wastes from the 100-F and 300 Areas are currently measured and reported at the source trenches and ponds rather than as a quantity being released to the river. Reliance is apparently placed on the detection of radionuclides in the river water or substrate and, therefore, dose assessment analyses take full advantage of dilution by the river. The presentation of only 1972 data for the 100-N, 100-F and 300 Areas (DEIS pages III.1-7 III.1-9) may be inadequate unless it can be shown that these are representative of past and projected conditions. In addition, the time it took the radioactive materials to reach the Columbia River (DEIS page II.1-141) should be included.

Response

Text Changes Made - Vol 1, Section V.3.2.1

Measurements of activity entering the river at 100-N Area were made at the several river bank springs and at well points between the crib and the river. The dose calculations used a value integrated from these measurements. The uranium concentrations from the 300 Area pond exceed the natural background uranium in the river (about 1 ug/ℓ) very close to the 300 Area river shoreline, are diluted very quickly, and cannot be detected above background at the Hanford Reservation boundary.

The dose calculations were based on estimated fractions of disposed materials that reached the river rather than on diluted river water analysis. These quantities are highlighted in Vol 1, Tables III.1-3 and III.1-4. Although the plutonium values actually were less than values used, for the purposes of dose calculations the plutonium values shown in the tables were conservatively assumed to be positive values. Also see Vol 1, Section V.3.2.1.

Comment

Wastes beneath the cribs and trenches are presented as being fixed in place. This, however, would not appear to be the case, since gravity drainage of the soils will continue to occur, admittedly at a very low rate, which eventually will continue to approach an equilibrium state. The draft statement does not appear to present enough information for the quantitative or semi-quantitative analysis of water and chemical transport through soil beneath the cribs for evaluating either the present situation or for predicting future behavior. The draft statement indicates a downward migration at Crib 216-S (DEIS page II.1-C-84) of both cesium-137 and strontium-90 some ten years after use of the crib was discontinued. This would indicate that these nuclides are not tightly bound to the soil column and could present a significant future impact. The causes of this migration, its estimated rate, and evaluation of the migration at other sites needs further discussion in the final statement.

Response

The 216-S-1 and -2 Cribs referred to in this comment were first studied in 1956. At that time three of the shallow wells located at this site were deepened, and six research wells were drilled through the contaminated sediments around this disposal site. In 1966, ten years after the first field exploration at the 216-S-1 and -2 Crib sites, five additional wells were drilled to determine the extent of radionuclide redistribution. This facility was in service from January 1952 until January 1956. During this four-year period, approximately 1 to 5 x 10^8 liters of waste liquid were discharged into the ground through the bottom area of this excavation. As a result of this large volume of waste being discharged into the ground, the entire sediment column beneath these cribs was nearly saturated. At the time the crib was removed from service, the moisture that was in the ground continued to migrate under gravity drainage toward the underlying water table. As time progressed, however, the amount of moisture that was moved toward the water table diminished. The logging data from the study that was made during this 10-year period indicated that very little change had occurred in the distribution of radionuclides within the sediment column beneath this crib site. The change in radionuclide distribution shown in Vol 2, Figure II.1-C-34, beneath the 216-S-1 and -2 Cribs was made based on the data from wells drilled through the cribs in 1956 and 1966. The data from these field investigations show that greater than 99.9 percent of the strontium and cesium curies discharged to this disposal site are contained within the first five to ten meters below the bottom of the two cribs.

The study also showed that small yet measurable amounts of strontium and cesium were moved downward from the zones of high concentration immediately below the crib to points deeper in the soil column. However, several explanations were given for the possible movement of these waste liquids or the higher concentrations at the lower depths. One explanation given was that perhaps liquid waste had channeled down one of the well casings to a deeper depth, with lateral spreading taking place above the caliche horizon known to be present there. Another explanation was that the liquid wastes containing very, very low concentrations of cesium and strontium were selectively exchanged on minerals present in the sediments at the greater depths.

The investigation further pointed out that the movement of moisture downward during the period of 1958-1959 was about 1.5 meters per year; but from 1959 to 1963, a 4-year period, the average rate dropped to about 0.9 meters per year. From 1963 to 1966, a 3-year period, the downward rate averaged less than 0.5 meters per year. It was stated in the original investigation that although these data are only approximate, they do show that the rates of movement appear to be decreasing with time, as would be expected with the drying out of the sediment column. Until the moisture content in the sediment column reestablishes the moisture contents existing in the sediments prior to disposal, the moisture and the radionuclides will continue to redistribute themselves within the soil column. However, this redistribution is expected to be so small as to be undetected by standard monitoring techniques. At other disposal sites where limited volumes of waste are discharged to the ground, referred to as specific retention sites, the waste liquid enters the sediments and moves laterally and horizontally through the dry sediments. The moisture content in these sediments is changed so slightly that the radionuclides are referred to as being fixed in place. Examples of specific retention disposal are cited in Vol 2, Appendix II.1-C, Part 5.

Comment

It appears from the draft statement, that there is no post-disposal monitoring performed within the soil profile, thus waste fixation in partially saturated soil is calculated on the basis of routine laboratory results rather than field observations. Apparently, field observations are limited to accidental spills, monitoring of radionuclides in the water table, and exploratory drilling/testing to determine antecedent conditions. The final statement should include a more detailed description of the waste volumes present in the unsaturated zone and their future environmental impact under various hydrologic conditions. Information on the distribution of radionuclides beneath two cribs (DEIS page II.1-C-81) may not be representative of all cribs used, and therefore, additional documentation is necessary.

Response

Geological studies of the Hanford site have provided information on the properties of the soil profiles at the waste disposal sites. Continuing field monitoring of groundwater levels and any contamination level found in the groundwater provide confirmation that the disposal sites are performing as anticipated. All wells monitoring liquid waste disposal sites are logged with a neutron probe to detect moisture concentrations in the sediments as a function of depth and with a scintillation probe to determine the location and concentration of gamma emitters. Data from

these studies are evaluated and the movement of moisture down through the partially saturated sediments and the redistribution of the gamma activity as a function of depth are monitored. The volume of waste liquid discharged to the ground at 42 of the major disposal sites, together with the curies of activity released, are given in Vol 2, Appendix II.1-C, Part 5.

Models to predict potential long-term movement of the water table levels and transport of radionuclides in groundwater continue to be developed and tested with the available field monitoring data.

Comment

The radioactivity estimate above the water table as presented on DEIS page II.1-129 may represent but a small fraction of the total inventory in the unsaturated zone. In liquid waste disposal areas, use has been made of the entire unsaturated soil column for radionuclide storage, yet the inventory in only the lower 50 feet has been calculated. A complete inventory of the entire unsaturated zone, including changes observed in the past and also any projections made for the future, should be included in the final statement.

Response

The data requested are provided in Vol 1, Section II.1.1.4.2. Also in Vol 1, Section II.1.1.4.3 is a special discussion of the inventory of radionuclides to be found within 50 feet of the water table.

Comment

To allow reviewers to form a clearer understanding of the environmental effects of past waste management practices, the final statement should state what cribs, by area, were used to the point of "break through" and indicate any studies which have been made to verify that the radionuclides are still bound to the soils near the point of entry to the groundwater system. The final statement should also explain how such binding will be affected if the water table rises or falls, and describe the continuing monitoring program which will be used to confirm the conclusions reached concerning the environmental acceptability of the use of these cribs.

Response

Twenty-one cribs were used for a sufficiently long time that long-lived radionuclides such as strontium, cesium, and uranium, were detected in the groundwater collected from wells drilled adjacent to these disposal facilities. Sampling of the groundwater at each of these sites continued until the concentration of the radionuclides was below the routine detection limit. When the radionuclides are no longer detectable in the groundwater samples adjacent to the site, sampling is continued for approximately a year and a half. Laboratory tests have shown that the long-lived radionuclides reaching the water table are exchanged on the sediments beneath the water table in the saturated zone and that these radionuclides do migrate slowly with the groundwater. At one of the major crib sites studied, the 216-S-1 and -2 Cribs, samples of sediments below the water table were collected and placed in columns in the laboratory for leaching tests. The results of this study show that after passing 50 column volumes of groundwater through the sediment samples, only 11% of the ^{137}Cs is removed. Continued leaching of these sediment samples by more than 500 column volumes of groundwater removes an additional 4% of the cesium. For ^{90}Sr, the data show that after passing 50 column volumes of groundwater through the sediments, 4% of the strontium is removed; 500 column volumes removes an additional 27%. Vol 2, Appendix II.1-C, Part 5, contains an inventory estimate of the radionuclides in the sediments at various distances above the regional water table. The water table elevation on the Hanford Reservation is monitored monthly and a careful check is made to determine the possible number of long-lived radionuclides that could possibly be inundated at any point in time. The groundwater throughout the Hanford Reservation is also monitored monthly or quarterly to determine radionuclide concentrations.

Comment

The average flow velocity from the 1301-N Crib to the River Bank Spring is stated in Table II.3-D-13 as 10.8 ft/day. The distance from the crib to the bank is given as 800 feet (DEIS page II.3-D-51), indicating a computed travel time of 74 days. However, the minimum travel time is stated as two to four days on DEIS page II.3-D-51. This disagreement in travel time values should be resolved

in the final statement, and any other calculations based on this value should be reviewed to determine whether they are significantly affected.

Response

There is nothing inconsistent with the reported travel times for effluents discharged to the N Crib. Twenty percent of the effluents reach the river in 2 to 4 days, and a total of 50% of the effluents reach the river in 4 to 10 days. There are also some portions of the effluents that reach the river through flow paths that take as long as 20 years to reach the river. With 50% of the effluent taking more than 10 days and some up to 7,000 plus days, it is not unreasonable for the average flow velocity to be 10.8 ft/day resulting in an average flow time of 74 days. The "3 to 5 days minimum" statement was in error since it should have been "2 to 4 days minimum." Twenty to fifty percent of the discharge does flow to the river in a time period of less than 10 days.

Comment

The distinction between liquid, sludge, and salt cake should be specified in the final statement in terms of liquid content and activity. For example, on DEIS page II.1-80, salt cake is referred to as an immobile solid, whereas on DEIS pages II.1-70 and II.1-86, salt cake is depicted as being partly liquid and mobile if a tank fails.

Response

Liquid is used in its normal dictionary sense. Sludge is a thick but fluid material. Salt cake occurs in various states. When first formed it contains considerable fluids and has some mobility. After the interstitial fluids have been removed, salt cake becomes more plastic in nature slowly occupying the space available to it but not fluid in the sense of flowing.

Comment

In the case of the SX tank farm, tanks too leaky or weak for sluicing are being used for waste storage (DEIS page II.1-70). Since the sludge contains a high percentage of liquid, changes in the liquid level are used for monitoring leaks (DEIS page II.1-78), the final statement should evaluate the environmental impact of continuing to use such weakened tanks for any waste storage.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Also see Section II.1.1.2.2.2.

Comment

The discussion of in-tank solidification (DEIS page II.1-86), states that gravity drainage of a "salt cake," which contains 30 percent interstitial liquid, can proceed for a time period of many years, hence the pumping endpoint (for interstitial liquors) is understandably indefinite. It is further stated that when the maximum amount of liquid is removed from the tanks filled with salt cake from the ITS system, the tank is considered stabilized for interim storage. The final statement should discuss how much liquid is expected to be present in the tanks at the time they are considered stabilized, and what environmental threat this liquid poses if tank integrity is lost.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Comment

On DEIS page II.1-7, it is stated that the SX farm tanks are enclosed by a complex of vertical and horizontal dry wells; yet, on DEIS page II.1-87, it states that these tanks have external leak detection systems rather than a network of dry wells. This apparent discrepancy should be resolved in the final statement.

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Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Comment

The final statement should discuss the difficulties involved in accurately measuring liquid levels in materials with a very high solids content and whether such levels can be reliably used to characterize the true hydrostatic head throughout the tank.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.2

Comment

The draft statement indicates that new storage tanks will be built for storage of salt-cake, but lacks sufficient discussion concerning actions to further process the salt-cake into a safer, more manageable and retrievable form. The draft statement does not clearly state what the AEC's intentions are relative to the conversion of the high-level waste to a form suitable for ultimate disposal. Therefore, since assurance that the high-level waste is in a form suitable for final disposal is mandatory for protection of public health and the environment, we believe this issue should be discussed in more detail in the final statement and an indication given of when conversion to a final form will be accomplished.

Response

This statement was not intended to address the ultimate disposal options in detail. An expanded section on ultimate disposal has been added (Vol 1, Section V.2.5).

Comment

On DEIS page II.1-55, it is stated that solid waste burial ceased in the 100 Area in 1973. The final statement should describe the wastes (type, activity) which are still buried there. Statements on DEIS pages II.1-58 and II.1-59 indicate that solid wastes from the 100-N Area are present in other 100 Areas. The final statement should also indicate the locations of these wastes as well as quantities by species and their proximity to the maximum and mean water table. These wastes are apparently located in what seems to be a ground water discharge area which would be characterized by a net upward migration of the water, either as vapor or, less likely, as liquid. The possibility of this occurrence and the effect on upward migration of wastes by diffusion or convective transport should be evaluated in the final statement.

Response

Waste inventories, by radionuclide, and locations for the 100 Areas are presented in Vol 2, Appendix II.1-B.

Geological studies and hydrological studies in both the 300 Area and 100-N Area disposal areas are continuing to determine the characteristics of these disposal sites in greater detail.

Distance to groundwater for the 100 waste disposal sites range from 30 to 65 feet. The ongoing environmental surveillance program includes detection of any movement of these materials into the Columbia River or the atmosphere. Also see Vol 1, Section II.1.1.2.5.

Comment

Solid wastes and solid residues from liquid wastes in the 300 Area as well as in the other reactor areas (DEIS page II.1-60) including the N-Reactor, present a large (DEIS page II.1-26) potential source of contaminants to the ground water and to the Columbia River. The vertical distance from the river, as well as the hydrologic characteristics of the intervening sediments, should be detailed in the final statement for these sites. An evaluation should be made of the susceptibility of the buried materials to not only erosion and physical transport, but also to

dissolution and convective movement in flood water or ground water. In particular, the effects of a rising water table, associated with maximum river stages or other causes, should be considered in conjunction with an assessment of waste solubilities. Monitoring programs associated with the terminated cribs, trenches, ponds, burial areas, and contaminated facilities in the inactive (100) Areas should be described in the final statement along with actual data from such programs.

Response

Text Changes Made - Vol 2, Appendix II.3-D and Appendix III-G

Comment

On DEIS page II.1-128, the draft statement indicates that the 1.9×10^5 grams of plutonium disposed of as liquid discharge to the soil represents 11,647 Ci. The final statement should indicate whether this plutonium is uncontrolled and irretrievably discharged and, if so, what the long-term environmental implications are for this amount of plutonium contained in the soil.

Response

Text Changes Made - Vol 1, Section II.1.1.4.4 and Section II.1.1.25 and Vol 2, Appendix II.1-H.

Comment

Since land containing transuranium waste is considered unusable for hundreds of thousands of years, an important aspect of waste management is control over such contaminated areas. The final statement should list those specific land areas which contain transuranics in soil or sediments in such forms and quantities that long-term control and surveillance is required.

Response

Text Changes Made - Vol 1, Section II.1.1.2.5, Section II.1.1.4.4 and Section V.2.5; and Vol 2, Appendix II.1-H

Sites on the 200 Area plateau within the 200-W and 200-E Areas are the designated locations for disposal of transuranic waste. Characterization studies are being made of other Hanford disposal sites which have received transuranic waste in the past. The largest inventories of plutonium waste are within the 200-W and 200-E Areas. The locations and sizes of all disposal sites are given in Volume 2 after the recovery of plutonium at some future date as part of the ultimate disposal plan. Control and surveillance will no longer be necessary.

Comment

Although recovery from some specific sites was mentioned in the draft statement, a more comprehensive plutonium recovery program seems to be a possible alternative to the current program. The attendant disadvantages and advantages of each approach, insofar as they can be estimated, should be presented in a discussion of these alternatives.

Response

Text Changes Made - Vol 1, Section II.1.1.2.5 and Section II.1.1.4.4; and Vol 2, Appendix II.1-H

Comment

Since transuranium-contaminated solid wastes have only been buried since 1970 in readily retrievable, contamination-free packages, (DEIS page II.1-97) more information should be supplied, in the final statement, concerning those transuranic wastes buried prior to 1970 in nonretrievable form. This information should include the long-term surveillance plans, ground water monitoring facilities, and the environmental impact resulting from leaving the wastes buried or recovering the wastes and repackaging them for shipment to a Federal repository.

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Response

Text Changes Made - Vol 1, Section II.1.1.2.2.6 and Section II.1.1.2.5

Also see response in Letter X.18

Comment

There are three burial grounds mentioned (Table II.1-E-1) in the 300 Area which are reported to contain fission products and plutonium (No. 1, 300 North and 300 Wye). The depth of the water table beneath these sites varies from 41 to 65 feet. The final statement should discuss the quantities of plutonium buried at these sites and also what potential exists for ground water contamination or translocation of the wastes to the surface due to loss of integrity of the packaging, and in addition, if any of these burial grounds contain liquid wastes.

Response

The estimated quantities of plutonium in these sites are 1500 grams in 300 Wye and 500 grams in 300 North burial grounds. Groundwater monitoring has shown plutonium is not in the groundwater at these locations.

Detailed characterization studies of these disposal sites are continuing; these include, but are not limited to:

- Ground penetrating radar surveys
- Acoustic profiling surveys
- Acoustic refraction and reflection surveys, using accelerometers, geophones, and hydrophones to obtain subsurface geophysical data
- Four instrumented wells have been installed for monitoring sediment fluid potential, sediment density and fluid migration.

Comment

The approach taken in the draft statement makes it difficult to identify the benefits of the program. Only a small portion, $265,000, out of a total of approximately $42,000,000 is apparently to be spent on improvements that will reduce population dose contributions for normal operations. The remaining expenditure is to improve radionuclide containment in facilities that "...are already contributing essentially zero population dose" (DEIS page IX-4). Therefore, the major costs of this program are not identified with reduced environmental factors, but are committed to a reduction in the potential for future leaks or accidents that could have environmental consequences. Reduction of environmental risk is of course a benefit of a waste management program; however, there is little discussion of this. Where benefits are referred to, they are discussed in the context of continuing the isolation of radioactive materials from man's environment (DEIS page I-3) or of maintaining control over waste materials (DEIS page I-11).

Response

Text Changes Made - Vol 1, Section IX

Comment

EPA believes that there is justification for upgrading waste management facilities at Hanford, but believes that the need for this upgrading could be better substantiated. An approach which would better identify benefits and facilitate the comparison of benefits and costs of alternative programs should be presented in the final statement.

Response

Text Changes Made - Vol 1, Section IX

Comment

Although the AEC has discussed the alternative programs for waste management, EPA does not consider the discussion of their merits to be adequate to justify the choice of the particular upgrading program being undertaken. This weakness stems at least partially from the inadequate treatment of benefits. However, even if the benefits (possibly defined to be a standard minimum level of environmental damage and a standard reduction of potential for future damages) were treated as given, alternative programs that meet these standards could be compared on a cost basis, with the least cost alternative being the preferred choice.

Response

Text Changes Made - Vol 1, Section IX.3

The alternatives were compared on the basis of their cost, time to implement and dose reductions to be realized. The low dose resulting from the current program and consequently the low dose reductions that might yet be achieved have led to comments requesting other means for comparison and choice. The cost-benefit table was expanded to include land usage and total curies released to the environment to provide some additional comparison parameters.

Comment

The brief discussion of the operating costs on DEIS page IX-2 does not indicate whether the 35 million dollars per year operating costs refer to the incremental costs of operating the upgraded waste management facilities, or whether they refer to something more than incremental costs. In either case, any increment to operating costs that are incurred in the use of any of the alternative programs for waste management should be included as a cost of each alternative. Since these incremental costs will continue into the future, their discounted present value must be added to the capital costs of each alternative before the cost of these alternatives are compared.

Response

Text Changes Made - Vol 1, Section IX

Comment

The discussion of land use does not explicitly state that there are changes in land use commitments associated with different waste management programs. All changes in land use, associated with alternative waste management programs, should be included as a part of the costs of each program.

Response

Text Changes Made - Vol 1, Section IX

Comment

The concepts and models for the 50-year dose commitment values listed in the draft statement are not adequately described. The model can only be inferred from equation 24 and three lines of text on DEIS page III-B-23 and from the concluding paragraph on DEIS page III-B-14. The dose calculated is the total dose to an individual over a 50-year period following the accumulation of long-lived nuclides within the body during the subject year of operation. While this integrated dose represents the total impact on the present population for the year's operation, it differs significantly from the EPA concept of an environmental dose commitment which considers the persistence and buildup of long-lived nuclides in the environment. The final statement should include a detailed discussion of the concepts and assumptions used to determine the 50-year dose commitment for the various nuclides.

Response

Text Changes Made - Vol 1, Section III.1.1.8

Appendix III-B discusses model and calculation methods. Several pages are used in the development of Equation 24. The EPA presented an environmental dose concept in EPA Document - 520/4-73-002, Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry, issued in February, 1974. An estimate of the Environmental Dose Commitment using all of EPA's assumptions and calculation methodology has been added to the final draft.

Comment

Section III.1.1.1 indicates that maximum release from routine operations can be expected to occur during the 1980's, yet doses from routine releases are calculated based on 1972 data. The final statement should indicate calculations based on projected levels for the 1980's.

Response

The increase referred to amounts of less than 10^{-6} mrem/yr from the 200 Area plume due to total tritium influx into the Columbia River in the 1980s.

Comment

In addition, the final statement should include dose estimates resulting from tornadoes, earthquakes, equipment-failure accidents, and a ruptured upstream dam, such as the Grand Coulee.

Response

The statement discusses the environmental impacts of a range of credible accidents.

The consequence of tornadoes, earthquakes, and equipment failure fall within the range of consequences calculated. The rupture of an upstream dam is not viewed as a credible event by the Corps of Engineers or ERDA and, hence, is not considered. The consequences of a 1.44×10^6 cfs flood are considered. A calculation of the dose if the radionuclides were through some mechanism released to the Columbia River is provided in answer to a question in X.25. There are no creditable mechanisms to give rise to such a release.

Comment

The iodine-131 dose conversion factors calculated for inhalation, based on the age dependent parameters presented in Table III-A-5, were compared with those in Table III-A-6, and with those in the Environmental Analysis of the Uranium Fuel Cycle Part II (EPA-520/9-73-003) Table 40. The following table presents this comparison.

Inhalation Dose Conversion Factor
(mrem/yr per pCi/m^3) for Iodine-131

Age	Calculated from Table III-A-5	Table III-A-6	Table 40 (EPA)
6 months			17.
1 year	17.9	12.5	
4 years	10.6	8.07	42.
14 years	8.57	6.76	15.
Adult	10.4	10.6	8.8

Although the differences between the EPA and AEC dose conversion factors might be explained by reasonable differences in the selection of the breathing rates, fractional uptake, effective half-lives, and organ masses for the various age groups not specified by the ICRP, NCRP or FRC, the internal inconsistencies between III-A-5 and III-A-6 should be explained in the final statement.

Response

The thyroid dose factors originally listed in Tables III-A-6, 7, 8 and 24 were not those used in the dose calculations. The current values are indeed those which can be derived from parameters in Vol 2, Table III-A-5 and footnotes to Tables III-A-6, 7 and 8.

The latter three tables have been corrected. The values in the program listing and sample runs were not changed but were footnoted to refer to the new correct values.

Comment

Only two age groups are presented in Table III-A-13, a 2-year-old and an adult. These values appear to be the ones actually employed for the calculations. The 2-year-old is assumed, without explanation, to have the same dosimetric characteristics as the 1-year-old in Table III-A-6. This would indicate that the dose assessment is based upon only two age groups rather than the four age groups implied by Tables III-A-5 and III-A-6. These inconsistencies should also be clarified in the final statement.

Response

See response to previous comment.

Comment

Should the migration of cesium and strontium, indicated in the draft statement (DEIS page II.1-C-84), be typical at all of Hanford's disposal sites, a long-term estimate of the impact should be presented in the final statement. Based on estimates using present EPA pathway models (7) and assuming no decay of the 1972 inventories of 35,000 Ci cesium-137 and 30,800 Ci strontium-90, (DEIS pages II.1-C-105, 106), a release of 1% of these inventories each year into the Columbia River could result in a yearly impact of 580 man-rem total body exposure. This is much greater than the Hanford estimate of 2.4 man-rem per year. Although the assumptions used lead to a "worst-case" estimate of the impact, the magnitude of the impact indicates that movement of these nuclides through the soil columns and aquifers could be a significant exposure pathway. The final statement should address this possibility.

Response

Text Changes Made - Vol 1, Section III.2.2.3 and Vol 2, Appendix II.1-C, Part 5

Also see discussion in response to Letter X.25.

Comment

The continuance or discontinuance of the N-Reactor is an important factor in any consideration of alternative waste management practices. It is stated on DEIS page v that the N-Reactor is scheduled for shutdown in 1977 or 1978. If this is true, it may be environmentally acceptable to continue operation with only minimal waste management improvements, since the time factor may make additional costs difficult to justify. However, if the N-Reactor were to continue operating for a much longer period, it may become reasonable to consider major modifications to the systems to reduce the liquid and gaseous effluent from the N-Reactor and associated facilities to the lowest level practicable. Due to the sensitivity of the decision making process to the operating lifetime of the N-Reactor, and the lead time requirements for making major system changes, it is imperative that the AEC carefully review the justification for any proposed extension of the N-Reactor's operating lifetime.

Response

Text Changes Made - Vol 1, Section V

Comment

In its evaluation of non-radioactive air quality aspects of Hanford Operations, the final statement should provide additional information.

Response

Text Changes Made - Vol 1, Section II.1.1.6.1.3

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Comment

The draft statement, on DEIS pages V-50 and V-52 indicates that when the SO_x emission standard is decreased to 1,000 ppm in 1975 the 100-N and 300 area power plants will be emitting concentrations approaching, if not in excess of, this reduced standard. The draft statement further states that no apparent adverse environmental impacts have been observed and, therefore, no apparent incentive exists for expenditures to reduce the current release rates. We believe that the AEC should prepare a plan to reduce the SO_x emissions from these facilities in the event that these power plants are unable to meet the new standard, or that low sulfur content fuel is not available.

Response

Text Changes Made - Vol 1, Section V.6.3

Comment

The final statement should include information on the perpetual care provisions for the land in which radioactive wastes have been emplaced to date. Regardless of future programs, commitments to these wastes must be made in terms of monitoring and land use.

Response

Text Changes Made - Vol 1, Section II.1.1.2.5 and Section V.2.5

Comment

The draft statement does not present a waste management plan for the disposal of contaminated equipment. Such a plan should be discussed in the final statement.

Response

Text Changes Made - Vol 1, Section II.1.1.2.5

Comment

The final statement should identify the criteria used in determining unusual releases of radioactivity. No unusual release to Gable Mountain swamp was listed in Table II.1-C-2, although it was stated on DEIS page II.1-C-99 that equipment malfunction has infrequently allowed some radiocontaminants to enter this and B pond.

Response

An unusual release is taken to be a short-term release of sufficient radioactive material to need special study, monitoring and/or corrective action. Low-level releases to Gable Mountain did require special study. Table II.1-C-2 lists 200 West Area tank farms and facilities only. Table II.1-C-27 lists unplanned releases to areas and sites not normally a part of waste management activities.

Comment

The continued disposal of large amounts of cooling water to open ponds maintains an opportunity for accidental releases of radioactivity to the aquatic environment. The environmental levels of radioactivity in the plants, sediments, waterfowl, mammals, etc., which could result from accidental releases, would be relevant to an evaluation of this disposal practice. Although routine sediment and biota sampling for 1972 are presented, information on environmental radioactivity from past accidental releases, and a discussion of the available controls on subsequent dispersion through waterfowl, etc., should be included in the final statement.

Response

Environmental sampling data reflect the total accumulation of radioactivity in the environment including any contributions from past routine Hanford operations as well as accidents. The monitoring results have been publicly reported in the Annual Hanford Environmental Reports since 1957. See response made to a similar comment in X.10.

Comment

The specific detection sensitivity of the road monitor described on DEIS page II.1-164 should be given in the final statement for the principal gamma emitting isotopes. Any available alpha and Pu-239 detection capability by road monitoring should also be discussed in the final statement, including the detection sensitivity.

Response

Text Changes Made - Vol 1, Section II.1.2.1

Comment

The AEC should evaluate the environmental consequences of the drying up of U-Pond and the exposure of the accumulation of long-lived nuclides on the bottom to the scouring actions of the wind. This area could contain as much as 5,000 kg of uranium nuclides, most presumably sorbed within a few centimeters of the pond's bottom. The final statement should contain the details and results of such an evaluation, along with a summary of long-term alternatives to maintaining the pond in its present condition.

Response

The U Pond will not be allowed to dry up unless special precautions and treatments are provided, such as retrieval of the radionuclides in the bottom sediments. The drying up of U Pond cannot occur rapidly but would require a period of several weeks. A wide variety of corrective actions could be taken during that time. The pond cannot be abandoned without treatment. The drying up of U Pond was not analyzed as a serious event because of the capability to take corrective actions before drying could take place. Also see Vol 1, Section II.1.1.2.5.

Comment

The source term for the assumed 800,000 gallon tank leak accident included 42,000 µCi of tritium per gallon of waste. Assuming 300,000 gallons of waste becomes trapped as interstitial water within the soil column, then 470,000 gallons, containing 19,000 Ci of tritium, could reach the water table. If this activity required 22 years to reach the Columbia River, the tritium would have decayed to about 5,700 Ci. This is two orders of magnitude higher than the value given on DEIS page III.2-13. Similar calculations for the other nuclides listed agreed with the activities presented. The final statement should address the apparent discrepancy in the tritium activity.

Response

The value of 4.2×10^4 µCi/gal. for tritium is correct. The released value was incorrectly given (typo) and has been corrected to 5,600 Ci. The 5,600 Ci value was used in the dose calculation. This calculation has been repeated with some changes due to updating of biological factors.

Comment

In its discussion of the Environmental Measurement Program there is no description of the analytical quality control procedures employed. Such a discussion should be provided in the final statement.

Response

Text Changes Made - Vol 1, Section II.1.2.1

Comment

Table II.3-9 contains two columns of soil measurements without any explanation of the reason for the two sets of values. An explanation clarifying this presentation should be included in the final statement.

Response

Table II.3-9 was changed. It originally attempted to give an indication of "fallout" on the leafy sample as compared to a total vegetation sample.

Comment

On DEIS page I-6, it is stated that "... chemical contamination and heat waste do not produce a significant impact on the Hanford reach of the (Columbia) river." The location of the river sampling points and some operating data for chemical and thermal effluents should be given in the final statement, particularly for the N-Reactor.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6 and Section III.1.3.2.3

Section III.1.3.2.3 - "Thermal and chemical effects on aquatic ecosystems" in Volume 1 is responsive to the comment.

Comment

On DEIS page II.1-87, the final statement should indicate where the external leak detectors are located in the SX, AX, AY, and AZ tank farms.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.2

Comment

Table II.3-D-15 of the draft statement lists Xe-133 as a discharge product in liquids. Since there is no significant retention of noble gases in a liquid medium this listing should be clarified in the final statement. The table also indicates that seepage data is not available for certain nuclides. The final statement should discuss why this data is not available.

Response

Text Changes Made - Vol 2, Table II.3-D-15b and Appendix II.3-D

Comment

EPA will have the responsibility for issuance of a discharge permit which will cover the N-Reactor activities at the site. From the analyses presented in the draft statement (DEIS page III.1-61), it appears that the guidelines for dilution zone size may not be met at all times at the N-Reactor discharge points. The final statement should present an analysis of the discharge plume configurations during periods of low river level, so that compliance with the above guidelines may be evaluated.

Response

No direct thermal studies of the 66-in. discharge line have been made. Battelle, Pacific Northwest Laboratories performed a study of the Washington Public Power Supply System discharge that did include useful information concerning the surface thermal discharge.* The extent of the thermal plume from the 66-in. line was shown on infrared photographs and scans taken over the area.

If necessary, changes will be made to the 66-in. lines near shore thermal discharge to meet the EPA discharge permit requirements. Also see response to previous question from your letter regarding waste permits.

*Field Determinations of Temperature Distribution in the Hanford No. 1 Condenser Cooling Water Discharge Plume, Washington Public Power Supply System, Richland, WA, November 1972.

X.25 COMMENT LETTER, Natural Resources Defense Council, Inc., 664 Hamilton Avenue, Palo Alto, CA 94301; Submitted on behalf of Natural Resources Defense Council, Inc., Oregon Environmental Council, Friends of the Earth and Sierra Club

Comment

The statement declares, "No deleterious effects to the numbers of or species of terrestrial or aquatic life have been observed during 30 years of Hanford operations." The implication that no harm has ever come to any living organism as a result of activities at Hanford is absurd on its face and is flatly incorrect, even being contradicted elsewhere in the impact statement (e.g., DEIS page III.1-61.) See also the Comments on the Hanford EIS by the Department of Interior.

Response

Text Changes Made - Vol 1, Section III.1.3.2.3.1

Also see response to a similar comment in Letter X.18.

Comment

The draft statement declares, "Extensive piping interties exist within and between tank farms so it is possible to transfer liquid to or from any tank in the system." Again, this appears to be a plain misstatement. In his comments, an employee of the contractor which operates the tank farms writes, "we just don't have this capability." Moreover, when the massive 115,000 gallon leak was discovered in Tank 106-T, the contractor had to lay emergency piping on top of the ground to pump the tank out.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.2

Comment

In commenting on the quality of the tests run in the unconfined aquifer at Hanford, Dr. Deju wrote that "no planning and little care was employed in running or supervising...tests" and that "Battelle's interpretation of the pumping tests is even poorer being based on techniques that are not applicable to the data collected." Similarly, Dr. Deju specifically observed that the pump testing techniques utilized by AEC contractor personnel at Hanford were done without benefit of necessary observation wells, that "most of the tests were run too short for any reasonably accurate interpretations," and that "given the poor quality of the tests, a comprehensive evaluation technique was not possible."

Response

Pumping tests have been conducted at Hanford at various times during the past 20 years. The majority of the tests used only the pumping well and did not involve the use of nearby observation wells. The interpretation of such pumping tests is very difficult because measurements taken at the pumping well site are affected by pump fluctuations and well-bore turbulence near the screen. The interpretation technique that was used in analyzing the pumping tests involved the Dagan method which is best applied to measurements at a certain distance from the well-bore. Unfortunately, only well-bore measurements were available.

To improve the regional description of the hydraulic conductivity of sediments underlying the Hanford Reservation, a program of pump testing was initiated during FY-1975 using multiple observation wells and the most advanced interpretation techniques. In addition, all data presently available have been reinterpreted and combined with driller logs and geophysical work to obtain the most accurate regional definition of hydraulic conductivity.

Comment

The discussion of possible ways to store permanently or dispose ultimately the long-lived hazardous radioactive wastes is so abbreviated and uninformative as to be virtually useless for decision-making purposes. No effort is made to formulate safety criteria, objectives, or a timetable for making decisions, and the Commission's current research priorities are neither explained nor justified. Furthermore, there is no systematic attempt to correlate the current

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practice of removing the high-heat generating isotopes, strontium-90 and cesium-137, and partially dehydrating the bulk salt wastes, to a satisfactory long-term storage means. As a result it is simply not possible to determine whether or not current policy is compatible with an acceptable long-term containment solution.

Response

Text Changes Made - Vol 1, Section V.2.5

This statement is not intended to address in detail the ultimate disposal options for the Hanford waste. The Foreword set forth the scope to be covered. An expanded section on the current status of ultimate disposal research and development has been added (Section V.2.5). Much research remains to be performed before the ultimate disposal options can be evaluated.

Comment

The draft contains virtually no cost/benefit or cost/risk analyses pertaining to the permanent storage or disposal of high-level and transuranic radioactive wastes and to the continued discharge of significantly contaminated liquid wastes to disposal facilities which rely upon soil columns to retain the radioactivity.

Response

The comment is correct in that this statement does not address ultimate disposal. The monitoring program and known parameters of the geological and hydrological conditions involving the use of soil columns were presented. See additional information in Vol 1, Sections V and IX.

Comment

There are no plans presented for the decomissioning of buildings and facilities significantly contaminated with long-lived radionuclides, such as the nine plutonium-production reactors along the Columbia River and the Purex Plant.

Response

Text Changes Made - Vol 1, Section II.1.1.2.5

Comment

Measures to mitigate the possible adverse effects of past practices of storing materials in the soil are not analyzed. Such measures, which are described in documents in the possession of the AEC, include, inter alia, removal of solid transuranic wastes from shallow earthen burial trenches and removal of plutonium from earthen, open-bottom cribs.

Response

Text Changes Made - Vol 1, Section II.1.1.2.5 and Section V.2.5

Comment

The discussion of land use restrictions that need to be imposed at the Reservation and surrounding areas is wholly inadequate. For instance, the draft fails to determine or analyze whether or not (a) the proposed Ben Franklin Dam can be constructed without interfering with radionuclides sorbed to the soil, (b) extensive irrigation can be permitted on lands around the Reservation, (c) a nuclear park, with up to 30 large nuclear power plants and supporting facilities could be established at Hanford without jeopardizing the safety of current waste management techniques, or (d) a so-called retrievable surface storage facility for the interim containment of commercially-generated radioactive wastes could be constructed without having to change existing waste management policies and facilities.

Response

All of the above proposals may be the subject of separate environmental impact statements. See response to similar comments in RPB X.0.

Comment

No consideration is given to the possibility -- indeed the probability -- that the N Reactor may operate beyond 1977 either in considering proposals to reduce radioactive releases from the N Reactor or in estimating the total wastes which will have to be managed at Hanford. Nor is there any evaluation of the consequences for waste management of reprocessing commercial spent fuels in the Purex Plant, even though that suggestion has been raised in recent Congressional hearings in response to the acute shortage of commercial spent fuel storage and reprocessing capacity.

Response

Text Changes Made - Vol 1, Section V.2.2

The consideration of the possibility that N Reactor would operate to the extent of its useful life (approximately 1990) has been added. However, any evaluation of the consequences to the Waste Management Program of reprocessing commercial fuels remains outside the scope of the impact statement. The Hanford site has not been designated to conduct commercial fuel reprocessing. Such a proposal may require its own assessment as part of the decision making process.

Comment

Although AEC regulations require that releases of radioactivity to the environment from any AEC installation be "as low as practicable", the draft statement provides no detailed criteria for applying this standard to the important effluent reduction projects which the AEC admits are technologically possible at Hanford.

Response

The individual and population doses arising from Hanford Waste Mangement Programs are indeed low and are only a small fraction of radiation doses received due to other activities of people living in the Hanford environment. Radionuclides released to the soils are not contributing to these doses. The wisdom of spending large sums of public money to reduce discharges of radionuclides to the soils is one of the principle decisions to be made based on this statement.

Comment

The cumulative and projected radiation exposures to Hanford workers are not considered at all. These exposures may account for most of the immediate radiological effects to humans resulting from operations at Hanford.

Response

Text Changes Made - Vol 1, Section III.1.1.7

Comment

Inaccurate and unreliable data is presented or used in discussion concerning the extent of radioactive contamination of the Hanford environment and the geohydrological conditions of the Hanford Reservation. For instance, recent findings and uncertainties about the mobility of plutonium in Hanford soils are not discussed.

Response

Text Changes Made - Vol 1, Section II.1.1.4.4

Extensive programs performed by experienced and qualified personnel have generated the data and analysis. Although studies are continuing and methods of measurement continue to be improved, the accuracy and reliability of the data presented are of high quality.

Comment

Inadequate techniques are used which probably seriously underestimate the adverse radiological effects of radioactive releases. In particular, there is virtually no consideration of the "environmental dose commitment" resulting from routine or accidental emissions of radioactivity.

Response

Text Changes Made - Vol 1, Section III.1.1.8

Comment

...the conclusion in the draft EIS that precipitation at Hanford does not percolate to the water table is not conclusively supported by recent documents in the AEC's possession.

Response

In 1971 a field test facility was constructed to measure moisture content and potential as a function of time and depth in soil beneath the 200 Area plateau. The data obtained from this field site have not been collected for a sufficient length of time to conclusively resolve this question. However, based on measurements made over three "rainy" years all incident moisture has returned to the atmosphere. In addition, below six meters in depth, the soils are highly dessicated indicating that on the average and for an extended period, loss of moisture from the soils has exceeded the amount replenished by precipitation. This condition persisted even during a rainy year when the total precipitation was about 170% of the average.

Comment

AEC has been informed previously by other governmental officials that its conclusion in the draft EIS that the thermal effluents from Hanford reactors have a benign effect on juvenile salmon in the Columbia River is illogical and unsupportable by scientific studies.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6

Comment

Professionally qualified, critical opinions about many aspects of Hanford operations are improperly omitted entirely. Specifically, no meaningful reference is made to the May 1966 National Academy of Sciences report, two General Accounting Office analyses and the evaluations of Dr. Raul A. Deju, a consultant to the Atlantic Richfield Hanford Company.

Response

Text Changes Made - Vol 1, Section II.3.14, and Vol 2, Appendix II.3-D

Comment

Conceivable major accidental releases of radioactive materials to the environment are improperly ignored either entirely or by categorizing them as "incredible" without further explanation. For example, there is no analysis of the prompt (accidental) release of radioactivity from the N Reactor.

Response

Release of radioactivity other than that properly associated with waste management operations is outside the scope of this statement. Failure of N Reactor containment has been fully analyzed and is contained in the safety analysis report for that operation. For analysis of cladding failure dose effect to the individual and the population see Vol 1, Section III.1.1 which included all releases due to fuel cladding failures in 1972. The annual environmental reports include the dose due to fuel cladding failures also as part of the total assessment. The dose due to fuel cladding failures was not separately stated. Major accidental releases from

Hanford Waste Management Operations are included in Vol 1, Section III.2. Unusual releases of radioactivity from 100 Area facilities are listed in Vol 2, Appendix II.B-12.

Comment

The potential consequences of terrorist or military attacks on the waste management facilities are not adequately evaluated. Instead, it is assumed without analysis that sabotage or attack would not result in any more severe effects than the small accidents which are considered.

Response

Text Changes Made - Vol 1, Section III.2.1

Comment

What is needed is a clear explanation in the Introduction or elsewhere of the various types of waste streams that come under the definition of high-level waste that has been used at Hanford since operations began. The information provided should include the types and concentrations of the critical radionuclide constituents in each type of waste stream, as well as the chemical composition of the waste streams.

Response

Text Changes Made - Vol 2, Table II.1-C-22a

The high-level liquid waste definition means the waste was contaminated to greater than 100 μCi/mℓ of mixed fission products or more than 2 μCi/mℓ of ^{137}Cs, more than 2 μCi/mℓ of ^{90}Sr or more than 2 μCi/mℓ of any combination of long-lived alpha emitters (transuranic elements) each measured on an individual basis. If any of the three are present in concentrations greater than 2 μCi/mℓ, the waste would be classified as high-level liquid waste. In Vol 2, see Table II.1-C-22 for the inventory and composition information. See Table II.1-C-22a for additional information on chemical composition.

Comment

"...the characterization of the different types of wastes at Hanford should have included the use of parameters that indicate the degree and time period of toxicity. Parameters that have been suggested include "inventory commitment" and the amounts of water or air required to dilute the waste to the maximum permissible concentration."

Response

The physical properties of the radionuclides and their permissible concentrations in air and water are presented in numerous books and reports. These values are available to the public and are not determined or developed at Hanford. While such data could, of course, have been added to the appendixes, its wide availability seems to make such redundancy unnecessary. From these standard references and the emission data given in this statement one may calculate the quantities requested. In most cases, the Hanford effluents are below the MPC's and there are no dilutions required.

Comment

The complete radionuclide inventory of each tank should have been listed to the extent currently known.

Response

Classification requirements prevent such a disclosure. The typical contents of tanks have been given. Even without classification problems, it is not practical to identify a particular inventory with a particular tank if the tank's contents are being processed.

Comment

The accumulated amounts of strontium-90 and cesium-137 that are currently stored in the B Plant and the Waste Encapsulation and Storage Facility are not given.

Response

The quantity (in curies) of ^{137}Cs and ^{90}Sr currently stored in B Plant and the adjacent encapsulation and storage facility is classified information, since this may reveal weapons production data. The objective is to convert all of the material to solid form; no long-term storage of liquid solutions is planned in either B Plant or the encapsulation facility.

Comment

There should have been an analysis of the chemical composition of the waste and the current status of each tank; e.g., Is the tank an identified or suspected "leaker"? Does it contain salt cake and/or liquid?

Response

Enumeration of the current inventory of each critical radionuclide in each tank provides a total inventory which is restricted by classification guidelines.

The chemical composition of waste in each tank farm was added as Vol 2, Table II.1-C-22a.

The current status of each tank and its content is detailed in ARH-CD-133D, "Production and Waste Management Division Waste Status Summary, October 1, 1974 through December 31, 1974", January 30, 1975.

Comment

For what period of time will the tank's integrity allow retrieval by sluicing?

Response

Text Changes Made - Vol 1, Section V

Tanks where integrity cannot be assured will not be sluiced.

Comment

The Commission must explain in detail why knowledge of prior weapons material production rates at Hanford -- a virtually abandoned facility in these terms -- would be inimical to the national security.

Response

Plutonium production rates at Hanford are classified in accordance with the provisions of USERDA classification policy.

Comment

It is necessary to estimate the amounts of wastes by category that may be generated and stored at Hanford in order to plan effectively for their containment. The draft statement fails to do this adequately.

Response

The statement does present the waste categories and volumes for both the already generated waste and for the yet to be generated waste under several future operating possibilities.

Comment

There is some discrepancy in estimates of the amounts of high level waste generated each year during operation of the N Reactor and the Purex Plant. At one place the draft states that " . . . the operation of N Reactor and the Purex processing plant results in the generation of approximately one million gallons of high-level waste each year." (DEIS page V-4) However, at other places it is estimated that approximately 600,000 gallons of liquid waste from the N Reactor are sent to the 200 Areas for in-tank storage each year (DEIS page II.1-58) and that the Purex Plant generates about 225,000 gallons of high-level waste per year (DEIS page V-12). This is a total of only about 825,000 gallons or roughly 17% less than the 1 million gallon estimate.

Response

The one million gallon figure was used in a qualitative sense to scope the waste volumes to be considered and was qualified with the word "approximately." This is not considered to be a discrepancy.

Comment

Obviously the possibility that the N Reactor and/or the Purex Plant will operate for longer than is now indicated in the draft statement should have been explored in detail.

Response

Text Changes Made - Vol 1, Section V.2.2

Comment

The dates of some leakages listed in the draft statement are different than the dates for the same tanks in the 1968 GAO Report, as follows:

(1) for 104-U tank, 1960 by GAO and 1958 in EIS;
(2) for 108-SX, 1964 by GAO and 1962 in EIS;
(3) for 115-SX, 1963 by GAO and 1965 in EIS.

Additionally, GAO lists the volume of the leakage from 113-SX as 35,000 gallons, while the leakage is given as 15,000 gallons in the EIS.

Response

The dates in the draft EIS are correct, except that the date for 104-U Tank appears to be a typographical error. The date for the 104-U Tank should be 1956 (vice 1958). Also, the leakage from 113-SX is 15,000 gallons, as indicated in the draft EIS. The differences in dates seem to arrive from assigning a date to the abnormality when noted and a date to the time when a leak was finally confirmed.

Comment

The efficiences of removal of these two radionuclides from the supernatants and sludges is not considered in the draft statement. In terms of Current Acid Waste the draft simply states that a "majority" is removed. (DEIS page II.1-61.) We note, however, that it is reported elsewhere that 70 to 90% of the cesium and strontium are removed during the fractionization of the high-heat wastes. (C.M. Unruh, A Preliminary Safety Analysis of Near Surface Storage of Radioactive Waste As Salt Cakes, BNWL-1194, p. 2 (January 1970)).

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.1

Comment

Evidently the sludge from the 15 SX tanks cannot be removed hydraulically due to their leaky and weak condition. (DEIS page II.1-70.) The draft statement is unclear about whether or not a

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similar situation arises with regard to other tanks. For instance, how many of the 14 tanks that are not longer in use because of suspected loss of integrity are in the SX Tank Farm? (DEIS page II.1-78.)

Response

Seven of the eight SX Tanks that formerly contained "self-boiling" waste are now confirmed leakers and the other (114-SX) has been removed from active liquid storage service. These tanks are presently connected to the SX Farm sludge air cooler. None of these formerly "self-boiling" SX Tanks are suitable candidates for sludge sluicing operations. The remaining SX Tanks have been used for storage of nonboiling waste and give no evidence of leakage.

Comment

The lack of adequate advanced planning is clearly demonstrated by the absence of a plan for storing these highly concentrated forms of cesium and strontium during the many hundreds of years that they will remain hazardous.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.1

Comment

A question arises about whether or not to categorize existing Hanford stock piles of purified neptunium (DEIS page II.1-20), americium (DEIS page II.1-30), and even the plutonium as high-level wastes. The current status and potential future use of these highly toxic actinides should be thoroughly discussed. Since the commercial nuclear industry could be generating huge quantities of these materials in the future, it is unclear whether or not the Hanford stock piles will ever be used.

Response

The materials are basic products and are not considered wastes.

Comment

The possible impacts of radioactive wastes should have been evaluated over a period of time approximating twenty half-lives of the critical radionuclides in the wastes.

Response

Text Changes Made - Vol 1, Section III.1.1.8

Comment

The draft statement does not describe, in detail, as it should, the "basic knowledge" that purportedly substantiates the Commission's opinion that the radionuclides will not move significantly far away from their existing location near the tank. Such an explication is needed because several mechanisms, physical and biological, could, in our opinion, lead to the dispersal of a significant fraction of the radioactivity during the hundreds of years that the radionuclides will be hazardous. For instance, soil moisture may be transported back and forth across the contaminated soil zone as different transport mechanisms alternately dominate. This movement of soil moisture may cause the radionuclides to migrate toward the surface and/or the water table at different times. Also, if vegetation is not prevented from growing on top of the tank farm area or if burrowing animals are not kept away from the soil contamination, these biological vectors could bring significant amounts of radioactivity to the surface, from whence it could disperse widely. In our opinion, other means, singly or in combination, by which the radionuclides could be moved include a rising water table due to increased recharge from agricultural irrigation, the ponding of cooling water from nuclear reactors, increased rainfall from cloud seeding for agricultural reasons the construction of the proposed Ben Franklin Dam. Furthermore, perched water could invade the contaminated soil and cause the radionuclides to migrate toward the River or the surface without the necessity of first migrating through the entire soil column above the water table.

In sum, a number of possible mechanisms could cause a significant fraction of the radionuclides in the soil near the 106-T tank to move away from their current position. The draft statement should have addressed this issue forthrightly and discussed these possible mechanisms in detail.

Response

Research in the fields of moisture transport in partially saturated sediments and uptake of radionuclides from sediments by plants and animals over extended periods of time are under study. At the present time, data indicate that radioactivity in sediments from tank leaks is essentially fixed on the sediments. Surveillance is provided to detect any movement of radionuclides. Routine surveillance in the tank farm areas is relied upon to control burrowing animals and plant growth.

The elevation of water table is being continually monitored to assure that water table changes possibly leading to inundation of contaminant sediments does not occur unknowingly. Predictive methods are under development to assess any postulated changes or mechanisms which would cause radionuclides to move from their present position in the sediments.

The impact of additional irrigation, possible changes in the water table and possible increases in rainfall can be examined using these predictive methods. Perched water bodies occur north of Gable Mountain and as very small lenses in other parts of the Reservation. No perched water bodies are known to exist in the 200 Areas.

Comment

In order to assess the potential environmental effects of radionuclides in the soil due to leaks in tanks, the possible mechanisms for release should have been analyzed separately for each tank due to the great heterogeneity in the composition of the soil in the waste storage areas. (DEIS page II.3-D-34.)

Response

The heterogeneity of the sediments underlying the waste storage areas contributes significantly to the waste liquid retention near the leak point. Changes in sediment types are responsible for the lateral spreading of the waste liquid reducing downward migration.

During the past several years ERDA has supported a program to characterize the geologic characteristics of sediments within the tank farms. The data obtained from this program are used by mathematical models to examine the impact of a given leak from a specific tank. Heterogeneity is considered in such an analysis.

Comment

The draft statement's failure to address thoroughly the long-term hazards posed by the leaked radionuclides. This is a greater omission than not considering the safety of storing salt cake in the underground tanks.

Response

The calculation of resultant dose due to total release of the radioactive materials in Hanford soils was made. See response to your later comment regarding potential effects of slow or catastrophic releases of radionuclides that are contained in the soil.

Comment

The draft statement additionally should have considered the possibility that even in the relatively near future the high-level wastes which are now at least partially protected by the tanks will be vulnerable to the same types of dispersal mechanisms as the leached wastes.

Response

Text Changes Made - Vol 1, Section II.1.1.2.2.3

Comment

Only a year and a half ago, the AEC stated that the "[e]valuation of long-term storage of salt cake in existing tanks [would be] completed" by fiscal year 1974, i.e., before July 1, 1974. Now in the draft statement it is stated that the "required investigation" will continue until fiscal year 1981, another seven years. (DEIS page V-21) The draft statement should contain a full explanation of the need for this substantial delay that the draft claims has become required within the past few months.

Response

It has been concluded that all alternatives for long-term storage and ultimate disposal should remain open until more information is developed. The schedules for developing this information may again change.

Comment

The draft statement should consider fully how leaving salt cake/sludge wastes in the soil permanently would be compatible with any acceptable set of national criteria.

Response

Until the research and development program for ultimate disposal of Hanford waste is complete and the impact statement prepared, it is highly speculative to assume the salt cake will be or will not be left in the soil. At this time there has been no decision to adopt a position.

Comment

The judgmental term "credible" is used without an explanation of its meaning in the context of accident analysis. This is necessary because whether or not the chance of a particular accident occuring is "credible" will undoubtedly vary from scientist to scientist. Of course, the best way to avoid the inherent ambiguity in the use of the word "credible" is to cite the probability with which the accident may occur. In the absence of such quantification of the probability, there should be at least a description of the process by which particular accidents were judged to be "credible" or "incredible."

Response

Text Changes Made - Vol 1, Section III.2.1

Comment

Although the discussion implies that for each type of accident the "worst case" was analyzed, other, more severe accidents seem to have been mentioned in other AEC documents and, furthermore, the "worst" conditions were not assumed for the accidents considered. For instance, in regard to the high-heat wastes concern has been expressed in the past that,

> "[i]f cooling action were discontinued, as by salt crystallation or by loss of liquid cover, the sludges [in the SX, A and AX tank farms contianing 120 million curies of strontium-90 and 150 kilograms of plutonium] would self-heat to temperatures that could calcine the salts, destroy the tank structure and volatilize some of the fission products."

The draft statement did not discuss whether or not this type of accident could still occur and, if so, what the long-term consequences would be. In particular, the draft statement should have analyzed such an accident for the one tank in the A-AX-AY-AZ tank farm complex generating sufficient decay heat to sustain boiling (DEIS page III.2-14) and all of the SX tanks, in which the sludges still contain heat-generating strontium. (DEIS page II.1-70.) Although cooling is evidently provided by fans for some tanks (DEIS pages II.1-70; III.2-14), the possibility that the fans, and their back-up fans, become inoperative during the approximately 50 years that they will be needed for cooling should be fully considered.

Response

A range of potential accidents were considered. The loss of cooling for A-AX-AY-AZ and SX tanks would result in a slow rate of heat up on the tank contents. The time to reach calcining temperature would be days if such temperatures were reached at all. Adequate time would be available to take corrective actions and get the fan cooling systems back into operation. Even if the heating occurred, the strontium and plutonium would not be released in quantities even near the quantities assumed for the dome failure accident. The consequences of the heatup of these tanks would be far less than the consequences analyzed for other accidents.

Comment

An example that the "worst case" conditions, in fact, are not assumed is the analysis of a major tank failure. Initially, the possible concentrations of radionuclides do not seem to have been maximized. For instance, the assumed concentration of plutonium-239 is listed as 0.14 μCi/gal. However, the concentration of plutonium-239 in the high-level liquid waste that leaked from the 106T tank had a plutonium concentration of 34 μCi/gal, or about 250 times higher than assumed. Furthermore, the worst possible soil conditions, which are known to be very heterogeneous (DEIS page II.3-D-54), are not assumed. Apparently, a "typical" amount of silt, which controls the percolation rate, was used in the calculation. How would the calculation have changed if the lowest known amount of silt in the storage areas had been used? Or, what if during the next several hundred years during which the wastes remain toxic, the hydrological conditions changed substantially from those assumed?

Response

The calculation assumed 800,000 gal. leaked, some 7 times the volume of the largest leak experienced to date. The plutonium concentration in the waste is not a factor determining the population dose for this tank leak, since plutonium even at a concentration of 34 μCi/gal in the leaked material would not be delivered to humans. Typical silt amounts were used as stated in the assumptions. The existence of thin silt and caliche layers under some tank farms were not used in the calculation. The 22-year travel time used does allow for heterogeneous soil conditions--being near the shortest travel times predicted for this area.

If 10 times as many curies of each radionuclide in Table III.2-1 reached the river, the resultant doses would be:

RADIATION DOSE FROM POSTULATED 800,000 GALLON TANK LEAK WITH 10 TIMES THE INVENTORY OF TABLE III.2-1 REACHING THE COLUMBIA RIVER

	Maximum Individual (rem)	Population (man-rem)
Whole Body	1.4×10^{-3}	2.9×10^{0}
G.I. Tract	4.0×10^{-3}	1.2×10^{1}
Bone	5.3×10^{-5}	2.0×10^{-1}
Thyroid	3.8×10^{-3}	7.9×10^{0}

Comment

The potential consequences of the assumed accidents are considered only for the very short-term. For instance, in the case of a tank-dome failure, could substantial radioactivity be released slowly as precipitation and soil moisture entered the exposed wastes or as the whole range of possible physical and biological dispersal mechanisms operated over time. Also, if remedial action were taken following a tank-dome collapse what would be the risk to workers?

Response

An accident such as a dome failure, or any other accident, would receive priority corrective action. The risk to workers would be controlled by use of appropriate personnel protective equipment and shielding. Exposures would be controlled to within applicable standards. Radionuclides involved in such accidents would be controlled to avoid dispersal by natural forces.

Comment

The Possibilities For Sabotage, Terrorist Or Military Attack, Or The Theft Of Special Nuclear Material Are Not Discussed

Response

Text Changes Made - Vol 1, Section III.2.1

Also see response to similar question in RPB X.0.

Comment

The advantages and disadvantages of each alternative are not considered over the entire time that the wastes must be securely protected.

Response

This statement is not a statement on ultimate disposal of Hanford waste; however, additional information on ultimate disposal has been added to Vol 1 as Section V.2.5.

Comment

The discussion of alternatives does not fully consider the possibility that selection of one option now, e.g., long-term storage of moist salt cake or sludge in single-walled carbon tanks, may, in practice, eliminate an opportunity to choose a safer alternative, e.g., solidification into a low-leachable solid and disposal in a deep geological formation, in the future.

Response

The selection of salt cake solidification was made to reduce the inventory of material that could leak to the soil. Much of the high-level waste has been solidified. The plan adopted for ultimate disposal will need to start with a salt cake formation for one of its waste inputs. The solidification program, per se, does not foreclose ultimate disposal options. It does, of course, provide a semisolid cake form to consider as a starting point.

Comment

The wrong standard -- immediate reduction of current population radiation exposures under existing conditions -- is used to discriminate between choices.

In previous AEC documents which pertained to the effluent reduction program, the number of curies of radioactivity eliminated from effluents into the environment per dollar cost was used to assess the comparative value of alternatives. Another parameter that may be particularly useful in assessing the long-term advantages of alternatives is the acreage of land, on and off the Reservation, on which activities must be controlled in order to preclude the possible release of radionuclides stored in the soil.

Response

Text Changes Made - Vol 1, Section IX.3

Comment

The draft statement fails to consider adequately the likelihood and potential effects of such slow or catastrophic releases of radionuclides that are contained in the soil and that continue to be discharged to the soil. By not fully analyzing these possible events the draft statement does not meet the NEPA standards for full disclosure and careful consideration of alternatives that may reduce environmental harm.

Response

There is no known mechanism that could lead to release of major fractions of the radionuclides discharged to the soil at Hanford. Nevertheless, the consequences of such an occurrence have been analyzed.

The potential radiation doses to a maximum individual which might occur if somehow the entire inventory of radionuclides currently present in the ground and groundwater as a result of deliberate and accidental releases of the 200 Areas liquid effluents are given below. These doses were calculated to include all contributions to dose including exposure to the shoreline. The shoreline contributions were not included in previous calculations of this dose. The 50-year dose commitments were also calculated. The dose calculations were performed for a hypothetical maximum individual rather than the average resident.

RADIATION DOSES TO A HYPOTHETICAL MAXIMUM INDIVIDUAL FROM SUDDEN INJECTION INTO THE COLUMBIA RIVER OF CERTAIN RADIONUCLIDES FROM THE 200 AREAS(a)

(rem)

Organ	First-Year Dose(b)	50-Year Dose Commitment(b)
Whole Body	0.3	0.8
GI Tract	0.05	0.3
Bone	0.4	2

(a) If all the radionuclides present in the ground and groundwater as a result of liquid disposal, tank leaks and the contents of the Z-9 trench were suddenly injected into the Columbia River and mixed with only one day's PMF flow (1.44×10^6 cfs = 3.53×10^{12} ℓ/day).
(b) Doses include 9×10^{-3} rem from exposure to contaminated shoreline for 500 hours during the first year following flood, uncorrected for radioactive decay or for any "environmental" removal process.
(c) Doses include 0.22 rem from 50 years' exposure to contaminated shoreline (at 500 hr/yr) corrected for radioactive decay but not for "environmental" removal, such as radionuclides being covered by clean sediment.

As explained in the EIS, the Maximum Individual is a hypothetical individual whose diet and recreational habits are chosen to maximize the radiation dose potentially received. In this particular instance, this person somehow manages to fish from the shoreline during and after the flood and to drink water drawn directly from the river (that is, without removal of radionuclides which normally occurs in the city water treatment plant).

The EIS addresses the potential effects of a Columbia River flood (1.44×10^6 cfs) which suddenly washes the entire contents of the 100 Areas and 300 Area disposal sites into the river. The potential radiation doses to the hypothetical maximum individual for such a flood were summarized in Vol 1, Table III.2-30.

As explained in the text accompanying the above table, the doses listed are for the first year following the flood and assume the radionuclides were soluble and diluted by only one day's flow of the river. However, the doses did include an overly conservative estimate of the contribution from one year's external exposure while fishing on the contaminated shoreline left after the flood receded.

The radiation doses were recalculated to more accurately model the shoreline dose and in addition to obtain the 50-year dose commitments. The newly calculated values are summarized on the next page.

The radiation doses given in these tables are for a Columbia River flood flow rate of 1.44×10^6 cfs. The radiation doses for an incredible 10 million cfs flood flow would be only 1/7, (viz. $1.44 \times 10^6/10 \times 10^6$), times those listed in the tables because of the extra dilution. There is no possible mechanism by which the events could occur which would lead to doses in the table involving radionuclides from the 200 Areas. The events required to lead to the doses from sudden movement of radionuclides in adjacent disposal sites to the Columbia River are extremely unlikely to occur.

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RADIATION DOSES TO A HYPOTHETICAL MAXIMUM INDIVIDUAL FROM SUDDEN INJECTION INTO THE COLUMBIA RIVER OF RADIONUCLIDES IN ADJACENT DISPOSAL SITES(a)

(rem)

Organ	First-Year Dose(b)	50-Year Dose Commitment(c
Whole Body	3×10^{-3}	6×10^{-3}
GI Tract	1×10^{-3}	5×10^{-3}
Bone	2×10^{-3}	6×10^{-3}

(a) If all of the nuclides currently present in the 100 Areas and 300 Area disposal sites were suddenly washed into the Columbia River and mixed with only 1 day's PMF flow (1.44×10^6 cfs = $3.5^3 \times 10^{12}$ ℓ/day).
(b) Doses include 4×10^{-4} rem from exposure to contaminated shoreline for 500 hours during first year following flood. Uncorrected for radioactive decay or "environmental" removal process.
(c) Doses include 3.4×10^{-3} rem from 50 years' exposure to contaminated shoreline for 500 hr/yr) corrected for radioactive decay but not for "environmental" removal, such as radionuclides being covered with clean sediment.

The suggestion has also been made that the impact of slow leaching of the radionuclides into the river, presumably at normal river flow rates, should have been evaluated. The EIS discussed the existing and projected migration into the river of radionuclides currently in the groundwater under the Hanford site. The estimated maximum rate of migration was given as 2×10^{-7} Ci/day of tritium and 2×10^{-10} Ci/day of gross beta activity in 1980 with a concomitant radiation dose of less than 10^{-6} mrem/yr to the maximum individual.

There is no feasible mechanism for migration into the river under other than extreme incredible flood conditions of the radionuclides held in soil or burial grounds within the Hanford site. However, assuming they could be transferred to the river and mixed with one day's average flow (1.2×10^5 cfs) then the doses listed in the tables above would be increased by a factor of 12, (viz. $1.4 \times 10^6/1.2 \times 10^5$).

If on the other hand the radionuclides entered the river slowly over a longer period, such as one year, then the amount of water available for dilution would be 365 times as much as that available in one day. The result would be environmental concentrations only 1/365 of those experienced from the sudden injection. Now, however, the residents would have available to them 365 days worth of contaminated diet so that the total internal dose received in the first year would be only slightly less than from the one day's injection (as a result of radioactive decay). The 50-year dose commitment would not change significantly.

The changes in the external dose from exposure to contaminated shoreline sediments are more complicated, but integration of the buildup and decay of the radionuclides on the sediments indicates that the dose in the first year is less from a slow release than a sudden release. This is because the sediment concentration only builds up slowly over the year and reaches a final concentration after 12 months which is less than the initial concentration resulting from the sudden release (again as a result of radioactive decay). Since the radionuclides of interest have radioactive half-lives of one year or more, the differences would be small. The 50-year dose commitments from a shoreline exposure would again be similar to, but slightly less than, those experienced from the sudden injection situation. However, there would be an opportunity for the consumption of irrigated foods if the release were chronic. Consideration of the radionuclides involved and comparison with the radiation doses listed in Vol 1, Tables III.1-7 and III.1-12 of the EIS indicate that this additional dose would add less than 20% to the total dose from liquid pathways. Coupled with the decreases noted above, which would result from radioactive decay, no significant net change in the radiological impact would occur if the release were chronic rather than sudden.

Comment

The strong criticisms in Dr. Deju's reports concerning the existing hydrogeological data, computer models, and hydrological testing and monitoring, are not fully reflected in the draft statement. In order to have met the full disclosure requirements of NEPA, they should have been thoroughly evaluated and considered.

Response

Text Changes Made - Vol 1, Section II.3.8.3 and Vol 2, Appendix II.3-C and Section II.3-D.7

Comment

The conclusion in the draft statement (DEIS page IX-8) not to reduce further the amounts of radionuclides in intermediate-level effluents discharged to the ground at Hanford is based on short-term economic savings and not on a full evaluation of the potential long-term costs and environmental effects of this continuing practice.

Response

The final statement presents additional analysis of the impacts of the various alternatives.

Comment

There should have been a full consideration of the possibility -- in our view, the almost certainty -- that the N Reactor and Purex Plant will operate far past 1977. By restricting the time frame to the date that the existing contract expires is misleading in light of the past extensions for operating the N Reactor and the great political and social pressure which has been and will continue to be applied to extend the operating life of the N Reactor.

Response

Text Changes Made - Vol 1, Section V.2.1

Comment

Under the alternative which assumes that the N Reactor will operate into the 1980's, the draft statement should have considered fully the need for N Reactor plutonium for nuclear weapons and specifically evaluated not reprocessing the N Reactor spent fuel in the near future.

Response

The plutonium is needed and is scheduled for use to satisfy ERDA requirements. Also see Vol 1, Sections V.2.2 and V.2.3.2.2.

Comment

The Guidelines of the President's Council on Environmental Quality (40 C.F.R. Part 1500) require (Appendix I) that draft environmental statements be accompanied by a Summary that reveals specific information. One of the informational requirements for the Summary is listing of the "[n]ame, address, and telephone number of [the] individual at the [responsible] agency who can be contacted for additional information about the proposed action or the statement." The Summary in this draft statement does not list such an individual and does not contain other information that is required.

Response

This information is on the Summary Sheet provided with the final statement as required by CEQ guidelines.

Comment

The presentation of data is frequently very imprecise, confusing and misleading. Virtually no estimates of accuracy or reliability of data or calculated values are given. In order for the values listed in the draft statement to have been meaningful, the best estimate of error in measurements should have been presented and there should have been descriptions of simplifying or other assumptions that were made in deriving various results. For instance, if radioactivity is measured by taking a "grab sample" -- a procedure that can give fallacious data -- the controls and checks that are performed to ensure that the sample is representative of the actual condition should have been discussed.

Response

Some information on the accuracy of the data has been added. The frequency and number of samples given are generally included in the statement or the references. The numerical values presented frequently are at or near the detection limit of measurement. Usually changes in the measured values by factors of 2, 5 or even 10 would not change the conclusions. Improvements are continually being made on the collection and analysis accuracy of environmental impact data.

Comment

The accuracy of numerical values should have been reflected in the way in which numbers are written, as is standard in scientific writing. For instance, the amount of plutonium in the bottom of the Z-9 crib is listed in Table III.2-26 (DEIS page III.2-51) as 38.0 kilograms, as if the last place were significant, i.e., as written in standard meaning is that the amount of plutonium is precisely 38.0 kilograms and not either 37.9 or 38.1 kilograms. However, a footnote indicates that the true value is unknown, but it is believed to be between 25 kilograms and 70 kilograms.

Response

Text Changes Made - Vol 1, Section III.2.10

Comment

The data presentation is frequently inconsistent in the use of units. For instance, in one section (II.1.1.4) which summarizes inventories of radioactive wastes, the amount of plutonium-239 in solid wastes buried in the ground at the 200 Areas is listed in grams, or units of mass. (DEIS page II.1-126) On the other hand, the amount of plutonium-239 estimated to be in underground tanks by 1980 in the 200 Areas is given in curies, or units of radioactivity. (DEIS page II.1-127)

Response

The document has been reviewed and efforts made to further standardize the use of units consistent with the anticipated preference of the reader. Generally, in this particular scientific area the metric system is preferred yet centigrade for temperatures is apt to confuse some readers. Similarly the use of grams in lieu of curies is favored by some. Where simplification was possible changes were made.

Comment

The same factual material (is reported) differently in different sections. For instance, even with regard to such a simple question as the number of underground tanks at Hanford, the draft statement is confusing. At DEIS page I-1, the draft lists 152 tanks existing and 4 more under construction, for a total of 156 tanks. But, Table II.1-4 (DEIS page II.1-72) mentions 151 existing tanks with two new tanks under construction, for a total of only 153 tanks. A few pages later on, the draft states that there are five new tanks under construction (DEIS page II.1-78). In the next chapter it is stated that there are 153 underground tanks existing (DEIS page III.2-2). While at DEIS page V-16, we are told that at present there are 152 tanks. Thus, depending on the section of the draft statement, there are from 151 to 153 existing tanks and from 2 to 5 tanks under construction.

Response

The text has been reviewed for inconsistencies and corrections made to show 152 tanks existing and 4 more tanks under construction.

Comment

At DEIS page II.1-57 the draft states that more than 50% of the discharge to the crib reaches the River in 4 to 10 days. In the next chapter, the draft changes to an assertion that the minimum travel time for radionuclides between crib and River is 3 to 5 days (DEIS page III.15). Yet a third formulation appears in the Appendix, where the draft estimates that about 20% of the discharge takes 2 to 4 days to reach the River. (DEIS page II.3-D-51)

These estimated periods for travel time between the crib and the River are, however, much shorter than the average flow time calculated on the basis of other information in the draft statement. By using 10.8 feet per day as the average flow rate of the groundwater (DEIS page II.3-D-44), and 800 feet as the distance from the crib to the River (DEIS page II.3-D-51), the average flow time should be about 74 days. Thus, the expected average flow time exceeds by a large amount the actual flow time for at least a major portion of the discharge.

In light of this seemingly contradictory information in the draft statement and information in previous studies which measured the travel time of tritium in the discharge to be 79 days, a full explanation is needed of how such a large fraction of the discharge and some of the radionuclides released to the crib can now arrive at the River so fast, compared to average groundwater flow rates. The draft statement should openly admit, if it is true, that severe channeling has taken place beneath the 1301-N crib and that 20% to 50% or more of the discharge flows fairly directly into the River, instead of moving through the soil in such a way as to retard significantly the migration of radionuclides. If, in fact, there is substantial channeling, then even under the most narrow interpretation of the AEC's regulations the discharge to the 1301-N crib is to an unrestricted area. The draft statement should have explained, in this case, why the discharges to the 1301-N crib do not meet the criteria for releases to controlled areas contained in AEC Manual Chapter 0524.

Response

See response to similar comment in Letter X.24.

Comment

In 1972, about 7000 curies of H-3 and about ten curies of mixed radionuclides were released via seepage from the 1301-N crib into the Columbia River. Additionally, in 1972, the large discharge pipe for the N Reactor's cooling water carried about 1400 curies of mixed radionuclides to the River. (DEIS page II.1-B-30) In 1973, according to the draft, about 480 curies of H-3 and five curies of mixed radionuclides seeped from the crib to the River (DEIS page II.3-D-52). For 1973, the draft also provides figures for the total number of curies actually released to the 1301-N crib itself, indicating that more than 5500 curies of mixed radionuclides (including about 480 curies of H-3) were discharged into the 1301-N crib from the Reactor. Assuming similar behavior of the radionuclides in traveling from the crib to the River each year, thousands of curies of mixed radionuclides must have been discharged to the crib in 1972 as well as in 1973.

To some extent these data are inconsistent. The fact that 7000 curies of H-3 appeared in crib seepage during 1972 implies that about 7000 curies were discharged to the crib. Yet in 1973 it is claimed that only 480 curies of H-3 were discharged to the crib, which then evidently seeped to the River. There is no explanation of this apparent difference in the apparent amount of tritium released to the crib from year to year in the draft statement.

Yet in assessing the potential reduction in radioactivity released to the crib and to the River if the N Reactor did not operate, the draft apparently assumes that the N Reactor is currently discharging and would discharge in the future (a) only 200 curies of presumably mixed radionuclides (not including H-3) to the crib, (b) less than 500 curies of H-3 to the groundwater (presumably meaning less than 500 curies of H-3 to the 1301-N crib), and (c) less than ten curies of presumably mixed radionuclides to the River. (DEIS page V-11) In other words, although the N Reactor has apparently been releasing thousands of curies of radioactivity in recent years to the crib and to the River, the draft assumes, without explanation, that a similarly large amount would not be released in any future year to either the crib or to the River if the N Reactor is

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operational. While this may be a convenient assumption for the Commission's argument that not much would be gained in terms of reducing radioactive releases if the N Reactor were shut down, we could find no justification of this assumption in the draft statement. For instance, there is no listing of an effluent control project for the N Reactor during Fy 1973 to Fy 1975 which would accomplish this reduction, although $42 million of waste management projects are described, including some for the N Reactor. (DEIS page V-25)

The only other reference we could find to any reduction in radioactive effluent is the simple assertion in a footnote to Table III.1-2 that, "The [total] annual discharges [from the N Reactor to the Columbia River] have been reduced to < 500 Ci/yr tritium and < 10 Ci/yr of all other radionuclides after CY-1973." (DEIS page III.1-7) To achieve this result thousands of curies of radioactivity would have to be removed from the cooling water discharged to the River and the bleed water to the crib.

At the least, there should have been an explanation of how this dramatic reduction in radioactive effluents by thousands of curies was accomplished. However, it seems to us that the favorable numbers are simply in error. On February 2, 1974, the Richland Operations Office, in answering one of our interrogatories,* stated that the current schedule was for 340 curies of mixed radionuclides with half-lives over 1 year and 200 curies of H-3 to be discharged to the 1301-N crib during the years 1974, 1975, 1976, and 1977.

Response

The numbers present in the impact statement are not inconsistent nor selected values. The data for 1972 and 1973 are based on effluent measurements. The large tritium reduction was realized by a change in irradiated products required by the Department of Defense which resulted in considerably less generation of tritium with no change in reactor facilities. Some reactor waste lines were rerouted to provide recirculating systems at nominal cost. The line changes resulted in some reduction in releases of fission products to N Crib. The lower quantity of tritium, 480 Ci released in 1973, is consistent with the < 500 Ci estimated not to be released if N Reactor shut down. The 200 Ci/yr not added to the N Crib is the difference in the net crib inventory per year if N Reactor was shut down and is consistent with the 340 Ci anticipated to be discharged to N Crib in 1974, 1975, 1976 and 1977. The difference, 340-200 = 140 Ci, is the decay of radionuclides with half-lives over one year that will occur in N Crib per year. The estimated 200 Ci of tritium estimated previously is the quantity expected to be released in future years and, in fact, is confirmed by the 1974 measurements which indicated 190 Ci discharged to the river.

Comment

The draft statement fails to point out that this "marked increase of spawners... is most likely related to displacement of fish due to inundation of previously productive areas." Thus, the conclusion that the thermal effluents were not deleterious, based solely on the observation that the spawning fish population increased, is unwarranted. Indeed, additional information presented within the body of the draft statement indicates that the thermal effluents can be detrimental to juvenile salmonids.

Response

Text Changes Made - Vol 1, Section II.3.10.1.6

X.26 COMMENT LETTER, U.S. Department of Transportation, Federal Highway Administration, Portland, OR 97204

Comment

If Hanford Reservation authorities are faced with a shut-down of the N Reactor and the Purex Chemical Processing Plant and nuclear fuel is shipped offsite for processing, then close coordination between AEC and the U.S. Department of Transportation would be required regarding transportation and handling of hazardous materials. This should be so indicated in the final environmental statement.

*Supplement to Defendents' Answers to Plaintiffs' Interrogatories dated February 22, 1974, at p. 3, Natural Resources Defense Council, Inc., et al. v. Ray, et al., Civil Action No. 3924, E.D. Wash. (filed Aug. 1, 1973).

We presume shipment would be by rail. The final environmental statement should indicate the method of shipment, how and what precautions would be observed in the transport of the irradiated fuel. The Federal Railroad Administration advises that the transportation of radioactive materials by rail is considered to be a safe method if all of the present federal regulations are complied with. This must be accomplished not only by the carrier involved but also the material must be properly prepared for shipment by the consignor.

If Hanford Reservation authorities are faced with the ultimate disposal of high-level wastes, packaging and shipment to an offsite repository (alternative #4, DEIS page V-22), then we recommend the final environmental statement indicate that any AEC investigations for such packaging and transport of wastes would be coordinated with the U.S. Department of Transportation. The draft environmental statement appears to indicate the transport mode cannot be determined at this time by AEC without completion of extensive research and development activities.

Response

Text Changes Made - Vol 1, Section III.1.1.4

Comment

The summary to the draft environmental statement, DEIS pages I-1 through I-12, did not contain a list of those agencies, groups and individuals to whom the statement was furnished for review and comment. We suggest this be shown in the final environmental statement pursuant to Council on Environmental Quality guidelines (p. 20557 of the August 1, 1973 Federal Register - Vol. 38, no. 147 - "Appendix I - Summary to Accompany Draft and Final Statements"). This would show AEC's coordination effort with those agencies having jurisdiction and special expertise on the transportation and handling of hazardous materials (p. 20558 of F.R. Vol. 38, No. 147 dated August 1, 1973).

Response

These are included in the Summary Sheet that accompanies the final statement as required by CEQ guidelines.

X.27 COMMENT LETTER, Arthur S. Kubo, LTC, EN, Assistant Professor of Nuclear Engineering, West Point, NY 10996

Comment

The EIS makes reference to the deteriorated condition of the waste tank liners; the short steel liner life; the interstitial, highly caustic residuum; and the difficulty of recovering solidified wastes from deteriorated tanks. These factors invite speculation on the unprobable though possible breach of containment and the sequence of actions that follow. Although alluded to (III.2.4 Salt Cake Storage Tank Dome Failure), no statement of definitive contingency planning is made in the EIS as to how the salt cake will be retrieved nor where such a large volume of highly toxic, friable and water soluble material will be stored.

Response

This document is not an impact statement on ultimate disposal of Hanford waste. It is a statement on the current Waste Management Operations. An expanded description of the research and development in progress on ultimate disposal has been added as Section V.2.5.

Comment

The proposal to continue reprocessing of spent N Reactor fuel should be reconsidered (V.2.1 and V.2.3.2.2). To be sure the incremental savings in storage requirements if reprocessing is discontinued is small, foregoing immediate reprocessing would preclude the production of the more difficult to manage neutralized wastes. Although requiring resolution of a few engineering obstacles, this course assists the overall scheme; it will (a) reduce the volume and storage requirement of diluted neutralized high-level wastes, (b) preclude strontium and cesium removal because of the longer preprocessing storage period, (c) leave open the option of transhipping the spent fuel to a commercial reprocessor, and (d) permit on-site reprocessing and direct solidification if the high temperature melt formation processes (V.2.4.3) are eventually utilized at Hanford.

Response

The N Reactor produced plutonium is needed by the U.S. Government, hence, it will be necessary to process the N Reactor fuels to recover the plutonium.

Comment

Of most serious concern is the unaddressed question, "Does this present solidification program permit the ultimate disposal alternatives 3 and 4 (V.2.5)?"

The ultimate waste disposal alternatives suggested for the Hanford Facility are unfortunate.

The taxonomy of alternatives appears based on an escalatory philosophy of decision making, one of minimizing the current cost subject to public acceptance. This view does not clearly address the totality of safety issues today and in the long-term future, long-term surveillance and monitoring requirements, and the anticipated total cost of each alternative that accounts for not only the large initial capital costs but properly reflects annual operating and maintenance costs plus capital replacement costs in perpetuity. This narrowing accentuates the fact that if waste management is not funded on a current basis (with on-going programs), after-the-fact costs distort the decision making process. This aspect has a close analogy in the commercial high-level waste management program, and I greatly fear that an acrimonious public debate on the utilization of interim storage facilities (as they were originally designated) as final disposal respositories will make current ERDA (AEC) argument on the creation of federally administered interim storage facilities less credible and even moribund. Much as the Lyons Repository had flaws, the idea of ultimate disposal in near surface storage tanks is egregious, technically, socially, and environmentally. In this matter I feel that ERDA would do well if it directly pursued alternative #3 (V.2.5) as a minimum rather than the more circuitous course of action proposed.

Response

Text Changes Made - Vol 1, Section V.2.5

Comment

The difficulties of altering the management scheme from in-tank solidification (alternatives 1 and 2) to out of tank solidification, packaging, and disposal (alternatives 3 and 4) have not been addressed. Ancillary to the waste recovery issue cited in 1(a) above, is the operational difficulty of removing the salt cake and decommissioning the storage tanks. The anticipated conditions of the carbon-steel tank liners cause standard sluicing and decontamination techniques to appear infeasible. A more complete analysis of this difficult transition is necessary prior to assuming that alternatives 3 and 4 are possible if current solidification practices continue.

Response

Until the research and development leading to an acceptable ultimate waste disposal program are completed, it is not feasible to make definitive judgments on the problems that salt cake reprocessing may or may not be present. It seems certain that salt cake can be recovered using solid material mining techniques. Development programs to define problems and technology for the mining of solidified waste are now in progress. Also see Vol 1, Section V.2.5.

X.28 COMMENT LETTER, State of Washington, Office of the Governor, Olympia, WA

A response was not required.

X.29 EXHIBITS

The comment letters are reproduced in full in this section as Exhibits 1 through 28.

EXHIBIT 1

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
PO Box 3623
Portland, Oregon 97208

8420

October 22, 1974

Mr. James Liverman
Atomic Energy Commission
Washington, D.C. 20545

Your September 29 letter to Dr. Tshirley of the Secretary of Agriculture's office asked for our comments on the draft environmental statement for waste management operations at the Hanford Reservation near Richland, Washington.

The proposed action is far removed from any National Forest land and should have no direct or secondary effects to National Forest administration. We have no comments to make on the draft statement.

Sincerely,

L. A. Fellows

LARRY A. FELLOWS
Acting Regional Forester

EXHIBIT 2

CONCERNED CALIFORNIANS
Active Statewide
Secretary - 2912 Baywater Avenue - San Pedro - CA 90731

November 4, 1974

Dr. James L. Liverman
Assistant General Manager
for Biomedical and Environmental Research & Safety Programs
United States Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Liverman:

Thank you for your letter of September 27, with comment guide and draft environmental statement on the Waste Management Operations on the Hanford Reservation.

The draft statement indicates thorough exploration of the project.

Our sole additional comment at this time is to suggest a note of geologic caution. Reference is had to a soil content of volcanic ash - indicating, of course, the presence of volcanic action at some point in time. There are three not-so-long dormant volcanic peaks within relatively close proximity to the Hanford site and, of course, this whole northwestern coastal area is situated on the seismic "Ring of Fire" which virtually encircles the North Pacific.

These factors might gain in significance if the period of waste storage at Hanford were to be extended into the far future.

We look forward with interest to the release of the final statement - and in the meantime wish to express appreciation for the efficient and courteous manner in which this matter has been handled.

Sincerely
CONCERNED CALIFORNIANS
by
G. H. Millar
Corresponding Secretary

EXHIBIT 3

Office of the Assistant Manager for
Biomedical and Environmental Research and
Safety Programs
U.S. Atomic Energy Commission,
Washington, D.C. 20545

Dear Sir:

Having studied the Draft EIS statements sent to me recently at my request, I have a few statements to make concerning the desirability of continuation and/or expansion of nuclear power generating facilities in this State or in any other.

I realize and appreciate the tremendous amount of time and effort gone into studying and working to prevent the adverse effects of radioactive waste. It is impressive to read of the measures taken to control this. My prevailing emotion, however, is one of uncertainty. The safeguards, no matter how elaborate and refined, hold little space for human error and the likelihood of natural disasters. It seems to be the most advanced system technology that is feasible. Yet, the language

EXHIBIT 3 (Continued)

in the EIS contains reports of waste levels measurably higher in nearby bodies of water, etc. It states that so far no alternative has been found to the storage of certain wastes in underground tanks. The question in my mind is "what if ...?" What if an earthquake or similar shock, unexpectedly severe, were to damage the facility? And if the reclaiming equipment was incapacitated? All sorts of nightmarish episodes, perhaps unjustified, perhaps not, come to the forefront of thought.

As we shift into a new age when life and space, resources and energy are at a premium, I feel strongly that all irreversible moves be made with greatest caution. I know this is also your intention. But, as a citizen of a state that potentially plays a major role in the development of nuclear reactors, I oppose their construction if the means exist to either reduce energy demand (done well and with little sacrifice last winter during the power shortage) or to harness a means of energy production that holds less risk to the environment. I request that more funds be allocated to the study of geothermal, wind, and solar energy sources, etc, and less to development and construction of nuclear reactors.

Evolution is a slow process. Could it be that the area may suffer more of a long-range impact than short term studies are given time to show? Even 30 years is very short in the history of the earth

I love the state of Washington and only desire to see its resources and lands protected to the fullest degree possible. It is my feeling as well that in this state lies tremendous potential for food production. Perhaps this is more the direction in which we should point our energies.

Realizing fully the seemingly small restraints reduced, in comparison to natural sources, I nevertheless believe in forging ahead to increase nuclear production only if no less threatening alternatives exist - and only if the need is genuine. If only energy consumption was reduced, we might find all of this to be unnecessary. And none (referring to pollution) is better than even a little.

Thank you for your time, for listening, and for your efforts. I appreciate the chance to state my views.

Very Sincerely,

Jennifer Blomgren

EXHIBIT 4

Steven C. Sholly
1110 Rana Villa Avenue
Camp Hill, PA. 17011
18 November 1974 (1)

Dr. James I. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Liverman:

Enclosed with this letter, please find my comments on the AEC's Draft Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington (WASH-1538).

I am deeply concerned about this particular phase of the nuclear industry, and I sincerely hope that these comments assist the Commission in the preparation of the Final Environmental Statement on this project.

The opportunity to comment on the Draft Statement is appreciated. Please send me a copy of the Final Statement as soon as it is available for distribution.

Sincerely,

Steven C. Sholly (2)

Steven C. Sholly

Comments Regarding WASH-1538

by Steven C. Sholly

I. General Comments on Inadequacies in the Draft Statement

There is a lack of discussion, even in general terms, about the security arrangements at Hanford which deal with preventing unauthorized entry to the Reservation and its various facilities. This is particularly important because of the chances of sabotage and/or acts of terrorism which could disperse large quantities of long-lived radionuclides over large areas of land.

The waste storage areas and the various fuel processing and reprocessing facilities at the Hanford Reservation represent inviting targets for potential saboteurs or terrorists. This situation has already arisen with the Oak Ridge National Laboratory area in Tennessee when a hijacker threatened to crash a large jetliner into the facilities there unless certain demands were met. There is no basis for any assumption that the Hanford Reservation possesses a special immunity from this or similar acts of terrorism and/or sabotage.

Another reason for a group desiring entry to the Reservation is to steal quantities of fissile materials for use in building a nuclear weapon. A recent book by Ted Taylor and Mason Willrich details the dangers inherent in this type of activity.

For these reasons, at least a general discussion of security arrangements at the Hanford Reservation is needed in the Final Statement. General discussions of cooperating arrangements with local law enforcement agencies, communications systems, and alarm systems and response times should be included.

There is a lack of discussion in the Draft about the impact of an attack on the Reservation by a foreign military power. The potential impacts of resultant attacks with both conventional and nuclear weaponry should be investigated and discussed. The Department of Defense should certainly be contacted and involved in such investigations.

I believe that it is readily apparent that such facilities as Hanford are on high priority lists for military targets in the United States. A normally less formidable nuclear power such as China becomes equal to the most powerfully armed nation in the world when one considers the potential consequences of a single nuclear weapon explosion at or near the waste storage facilities at Hanford. Although such an occurrence is, hopefully, highly improbable, one cannot simply dismiss the possibility by ignoring that it exists. The relative advantages and disadvantages of different types of waste storage and disposal methods should be discussed.

EXHIBIT 4 (Continued)

(3) Although several vague references are made to it, there is no explicit discussion in the Draft of the impact of possible cessation of waste management operations at Hanford. Such a situation could come about as a result of a catastrophic radiological accident or as a result of political instability such as a civil uprising or overthrow of the government. While both of these possibilities appear, on surface examination, to be rather remote, the consequences of such occurrences could be great and should, therefore, be discussed in the Final Statement. The seriousness of this situation is pointed out in the Draft Environmental Statement WASH-1539, where on page 2,3-19 it is stated:

> "Because of the long period of time during which high-level waste must be confined, its storage in any man-made structures such as tanks or vaults, no matter how safe at present, requires a program of surveillance, with eventual repair or replacement, if the environment is to continue to be protected."

An estimation of the expected time lapse between cessation of waste management and the onset of unacceptable environmental consequences should be made. Also, the probability of reinstituting management practices after a protracted period of no such efforts should be discussed.

(4) There is a general lack of discussion about quality assurance programs and redundancy (defense -in- depth) features at the Reservation. Particular attention should be paid to quality assurance programs dealing with the collection, processing, and evaluation of radiation monitor samples. The hearing of August 1973 about the Shippingport Atomic Power Station held by the special select committee appointed by Pennsylvania Governor Milton Shapp particularly emphasized this issue as being critical to the proper evaluation of health hazards associated with facilities handling radionuclides. Quality assurance programs and redundancy features should be emphasized in the Final Statement.

(5) There are numerous instances in the Draft Statement of materials being cited in the text as evidence for a certain statement made by the authors of the Draft. Generally, the bulk of these materials is not readily available to the reader of the Draft for reference, either due to limited distribution of such documents, or their high cost. When it is necessary to refer to such a document in the Final Statement, it would be helpful if a summary of the relevant information from the document being cited would appear in the Final Statement. It would also be helpful if the reader would be told where and how he could obtain copies of materials cited in the text of the Final Statement. Citing materials and incorporating them by reference only serves to confuse the issues, rather than clearl tating the situation in non-technical language.

(6) The format of the Final Statement should be revised from that of the Draft Statement. Consecutive numbering of pages (i.e., 1-2-3-4-5-6- etc.) should be used rather than the somewhat confusing method used in the Draft Statement. In addition, summaries of each of the major sections of the Final Statement, appearing at the end of each section, would be helpful to the reader. A table of abbreviations used in the Final Statement would be helpful in order to avoid confusion.

(7) The use of such unquantified terms in the following should be avoided as much as possible in the Final Statement:

> "reasonable"
> "interim"
> "small amounts of radioactivity"
> "insignificant quantities"
> "did not impact harmfully to any great degree"

II. Comments Regarding Specific Items in the Draft Statement

Item 1--Page I-5

> "The maximum dose to an individual from effluents released at Hanford in 1972 was 0.6 mrem/yr, while the dose to the average individual was 0.01 mrem/yr. The total-body dose to the population within 50 miles of Hanford was 2.4 man-rem/yr for 1972 which is only 0.01% of the naturally-occurring radiation background of 27,400 man-rem/yr."

COMMENT: How were these figures arrived at? Calculations leading to these figures should appear as an appendix in the Final Statement. In addition, a list of similar figures for the last 15-20 years should be provided, if available, for determination of any trends involved with population doses caused by operations at Hanford. Increases within a few percent of normal doses should be explained along with any decreases of similar magnitudes.

Item 2--Pages I-5 and I-6

> "A conversion of the population dose to health effects using the data from the National Academy of Sciences BEIR Report indicates that the maximum number of cancer deaths ascribable to 1972 Hanford operations is 0.0007 for the population living within 50 miles of the site. Since the total number of health effects is far less than one, it may be concluded that there are no health effects due to Hanford Operations for 1972."

EXHIBIT 4 (Continued)

COMMENTS: What about results for other years? Also, sub-lethal effects and synergistic interactions, which apparently have been ignored, should be accounted for in the Final Statement. A tabulation of data for the last 15-20 years should be included.

Item 3--Page I-7

Section I.3.2, Postulated Waste Management Accidents

COMMENT: The analysis of the accidents described in this section should be carried out in detail and fully described in an appendix in the Final Statement. All necessary paramenters and assumptions should be stated, and the reliability of the resultant data should be tested or at least estimated.

Item 4--Page II.1-71

"The first tanks were for nonboiling waste...These tanks are vented to the atmosphere through air-cooled reflux condensers."

COMMENTS: Is this effluent stream monitored for radioactivity? What is the efficiency of filtering system for relevant radionuclides?

Item 5--Page II.1-87

"These dry wells and laterals are monitored for radiation increases on a frequency determined by the status of the tank, e.g., whether the tank is active, inactive, in restricted use, etc."

COMMENT: This should be described in more detail, with figures given for representative sampling frequencies.

Item 6--Page II.1-90

"An extensive network of wells is provided for sampling groundwaters. Groundwaters associated with waste disposal sites are routinely sampled and analysed."

COMMENT: The frequency of sampling and the procedures used for sampling and analysis of the samples should be fully described in the Final Statement."

Item 7--Page II.1-94

"Currently no appreciable quantity of plutonium is discharged directly to the ground."

COMMENT: What constitutes an "appreciable quantity"? This quantity should be numerically described.

Item 8--Page II.1-97

"Solid waste is normally covered with 10 to 20 feet of earth to prevent uptake of radionuclides by plant life or disturbance by burrowing animals."

COMMENT: When is this procedure not followed, and why?

Item 9--Page II.1-103

"Gaseous effluents from the 200 Areas facilities are limited to airstreams containing relatively low concentrations of radionuclides, either in gaseous or entrained particulate form."

COMMENT: The efficiency of the filters used should be listed, as should be the name, form, half-life, and number of curies of each radionuclide which might be released.

Item 10--Page II.1-115

"Wherever practical, airborne radioactive materials are removed from exhaust gases near the hood, glove box, or cell in which they are generated."

COMMENT: When is this procedure not practical? What is done in circumstances where it is not?

Item 11--Page II.1-115

"The filters are tested following installation and on a scheduled frequency thereafter."

COMMENT: How often are the filters checked after installation? What is their average lifetime? How long would it take to discover a filter failure?

EXHIBIT 4 (Continued)

Item 12--Page II.1-127

"The estimated decayed inventory of radioactive materials stored in tanks in the 200 Area through 1980 are summarized below."

COMMENT: This listing should be projected through to the year 2000 A.D., rather than just to 1980.

Item 13--Page II.1-130

"After the aquifer area was divided into 1000-foot square cells, the amount of contaminant in each cell was summed."

COMMENT: How many cells were there?

Item 14--Page II.1-138

"Fire in a remote laboratory facility released about 4 g of plutonium."

COMMENT: This incident should be described in detail in the Final Statement. Was any plutonium from the fire detected offsite?

Item 15--Page II.3-24

(It is noted that the seismic risk maps in this section consider an historical record of about 100 years, during which the low population density of the area may have resulted in there being no record of small quakes an no damage.)

COMMENT: This record does not appear to me to be adequate for seismic risk prediction, especially considering the state-of-the-art in earthquake prediction. Perhaps a more conservative estimate of the maximum possible ground acceleration is in order. This possibility should be explored, and the advice of the U.S. Geologic Survey should be asked in this matter.

Item 16--Page III.2-1

(List of accidents considered under topic of waste management accidents.)

COMMENT: The list of the above-listed page does not include such items as airplane crash, military or industrial sabotage, or acts of war. These items should be included and discussed with appropriate detail.

Item 17--Page III.2-2

"The causes of leaks have been either corrosion of the carbon steel tank liner (general corrosion, pitting corrosion, or stress corrosion cracking) or mechanical failure of the steel liner (thermal expansion due to local overheating or buckling due to other causes)."

COMMENT: How many tanks were involved with each type of failure?

Item 18--Page III.2-3

"With the improved leak detection systems, procedures and increased frequency of monitoring and management attention, future leakage is expected to be detected at less than 30,000 gallons. It is not believed that a leak as large as the 106-T quantity of 115,000 gallons could occur again under normal plant operations."

COMMENT: Why is this belief held? The new procedures and precautions taken since the leak of tank 106-T should be detailed. What might be the size of a leak under abnormal plant operations conditions?

Item 19--Page III.2-12

"The shortest estimated groundwater travel time to the Columbia River from the 200 Areas under present water table conditions is 20 years."

COMMENT: What estimated travels times are predicted for other water table conditions (i.e., higher and lower water table levels)?

Item 20--Page III.2-15

III.2.3.1.3 Seal Failure in Exhaust Piping

COMMENT: The seal failure accident should be fully analyzed. Would the same types of radionuclides be released as in the dome failure accident with which the seal failure accident is compared? Would there be any difference in degree of dispersion? Is there any difference in probability of occurrence between dome failures and seal failures?

EXHIBIT 4 (Continued)

Item 21--Page III.2-16

III.2.3.2 Low-Heat Waste Tanks

COMMENT: Accidents involving low-heat waste gaseous release systems should be fully analyzed to be certain that the consequences are, in fact, not as severe as with high-heat waste tanks. Numbers of tanks, probabilities of failures, and types of radionuclides involved should be considered in this analysis.

Item 22--Page III.2-17

"A life of 100 years and probably longer could be reasonably expected based on life of other reinforced concrete structures (bridges, dams, etc.)."

COMMENT: These other structures (bridges, dams, etc.) are not subject to radioactivity exposure as the waste storage tanks are. Could this fact have a bearing on the expected lifetime of the waste storage tanks?

Item 23--Page III.2-17

"A dome failure of a tank filled with salt cake, while highly improbable, could be possible before ultimate disposal of the waste is accomplished."

COMMENT: What could be the consequences of such a failure?

Item 24--Page III.2-22

"An inventory of 5 year old waste with 95% of the strontium and cesium removed by B Plant processing was selected for consideration."

COMMENT: Is this inventory representative of what would be encountered? A variety of situations should be analyzed for consequences.

Item 25--Page III.2-27

(second paragraph on the page)

COMMENT: The safety analysis reports referred to should at least be summarized.

Item 26--Page III.2-37

"The train shipments are operated in a conservative manner and the tracks are maintained in a good state of repair."

COMMENT: This statement should be expanded and expressed in more detail. The U.S. Department of Transportation should be requested to evaluate the manner in which the train shipments are operated and also the state of repair of the tracks.

Item 27--Page III.2-57

(paragraph at the bottom of the page)

COMMENT: It is highly unlikely that these figures are correct considering the state-of-the-art in earthquake prediction. The means of deriving the listed probabilities should be described in detail, and an evaluation of these derivations should be performed by the U.S. Geologic Survey.

Item 28--Page III.2-60

"Detailed seismic analyses of the B Plant reinforced concrete ventilation exhaust stack have not been made, but little or no damage in stacks of this type after the 1971 San Fernando earthquake."

COMMENT: It is quite possible that the experiences from the 1971 San Fernando earthquake have little bearing on the situation at Hanford. Epicentral distances and differences in basement rock and soil depth should be evaluated to check the relevance of this experience to Hanford.

Item 29--Page III.2-60

(last paragraph on page)

COMMENT: These facilities should be analyzed for effects of the maximum credible earth acceleration. The results of these analyses should be included in the Final Statement. This is extremely important.

EXHIBIT 5

Enfield, CT
November 18, 1974

Office of Assistant General Manager
Biomedical & Environmental Research
& Safety Programs
USAEC
Washington DC 20545

Dear Sirs:

I have completed a review of WASH-1538. I have found few major areas of complaint, although there were numerous typographical errors which detracted somewhat from the apparent quality of the document. I especially found that Volume 3, with the Staff directory toward answers to specific questions very helpful.

The final edition of WASH 1538 definitely should address the problem of acid rain(as noted in the July-August, 1974, issue of Chemistry and in the Scientific American article, "Nutrient Cycles of an Ecosystem.). There are other articles that could apply to the problem, written by rabid anti-nuclear groups, but the two articles mentioned above, which appear in more moderate publications, should definitely be addressed.

On page III.2-17, serious weakening of the tank domes is mentioned. How could this be detected?

The NRDC comments on pg. 116 with reference to the radioactive duck was not very well answered.

One aspect that was not too well covered was the proposed methodology by which the unfortunate mismanagement of the 106-T tank leak can be averted in the future.

Thank you again for the opportunity to review WASH-1538. I would appreciate a copy of the final document, if possible.

May I please have a copy of each of the following?
The draft environmental statement on the NRTS(Idaho National Engineering Laboratory)management program?

The draft environmental statement on the Savannah River Plant management program?

Very truly yours,

Neal E. Wilson

Neal E. Wilson
5 Brook Road
Enfield, CT 06082

EXHIBIT 6

1974 November 22

James L. Liverman
Assistant General Manager for
Biomedical and Environmental Research
and Safety Programs
United States Atomic Energy Commission
Washington, D.C. 20545

Re: Draft Environmental Statement: Waste Management Operations, Hanford Reservation
Richland, Washington; WASH-1538

Although I have been unable to spend the time which would be required to write an adequate criticism of the subject Statement, I want to utilize the opportunity you have afforded me to make at least the following few objections of the many I have noted, concerning the portions of the Statement found on the pages cited.

1. (v) "The objective of this program is to continue to maximize the isolation of the high-level waste from man's environment." I thought everyone agreed that some serious mistakes have been made at Hanford; such a comment jeopardizes the credibility of the Statement. (Emphasis added.)

2. (IV-1) Committment to long term (thousands of years) control is a process unfamiliar to most persons - details of the process of such committment should be described. Also, the validity of the statement that the area committed for such control does not constitute a significant adverse effect to the Hanford ecological community cannot be evaluated without some indication as to how one judges what amounts to the elimination of a part of Earth. The surveillance required raises other interesting points. What is involved in providing for surveillance in CY 2574, for instance? What will a square mile of irrigable land be worth for the period between now and then?

3. (V-20) Possible devitrification of glassy formations for radwaste solidification should be discussed.

4. (IX-1 and elsewhere) Current total radiation dose to the "general public" is estimated to be 2.4 man-rem/yr. No rationale for excluding site employees and others is offered. I would suggest that total human exposure should be indicated. Not only are Hanford workers presumably human, but their genes will have plenty of time to blend with those of the "general public" before the Hanford episode is over.

5. (III.2-17) The tank dome failure rate estimate implies that the domes will continue to be as reliable as now after - how long? 200 years? Nothing conservative about this estimate.

6. (III.2-20) Calculation of gross radiation dose as done here is probably not an adequate consideration of the hazard from dispersal of particulate transuranic elements.

7. (III.2-22) It is curious that in this category (line leakage) where a few accidents have already occured the reiterated policy of conservatism in calculating the possibilities of future occurences seems to have disappeared.

8. (III.1-52) "Observable radiological effects?" Presumably "effects identifiable as being of radiological origin" is closer to the mark. Running through the whole statement, it seems, is a theme that exposure to radiation below guideline levels is "safe" or insignificant. Nothing in the history of the adoption and modification of radiation exposure standards leads to such a conclusion. It is apparently permissible to kill a few unknown people at unknown times and places.

9. (III.2-6) Postulation of slow enough seepage to permit complete sorption of ^{90}Sr and ^{137}Cs seems to be other than the "conservative" approach claimed for the Statement.

10. (III.1-31) A possible conclusion: we are being incautious about the radiation hazards of jet aircraft flight. What were the authors conclusions, which are not stated? I hope not that a possible exposure to hazard voluntarily warrants exposing people to a hazard they have no control over; yet this seems to be implied.

11. (III.1-31) Why call postulation of a hazard "unrealistic" because other greater and fluctuating hazards exist? It would be more candid to simply state that the authors consider the hazard insignificant.

12. (I.6) Perpetual surveillance? How can one propose it - recognize its need, that is - without an attempt to set forth the budgetary, etc., implications?

13. (III.1-5) It is disturbing that the radioactive river bank seepage is apparently to be allowed to continue.

14. (II.1-78) The implication that some questionable radwaste storage tanks are continued in service is disturbing. How can we propose perpetual care while we can't now quickly set matters right at Hanford?

15. (I.3.2) "In the selection of ... assumptions ... a consistent attempt was made to be conservative in the analysis, that is — to analyze the worst conditions credible." It would be better if this were self-evident, as is far from the case. Obvious, simple, possibilities have been entirely ignored, e.g., failure to maintain the site as a result of actions of hostile military forces.

In general, this description of the situation at the Hanford Reservation is deeply disturbing, as is the suggestion of continuing and even expanding activities there which would add to the enormous inventory of radioactive materials now hardly under control.

H. W. Ibser
Physics Dept.
Calif. State Univ., Sacramento
Sacramento, Calif. 95819

H W Ibser

EXHIBIT 7

November 23, 1974

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and Environmental Research
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Pennington:

The Eugene Future Power Committee would like to make the following brief comments on the draft Environmental Impact Statement, "Waste Management Operations, Hanford Reservation, Richland, Washington," (Wash 1538), September, 1974.

On procedural matters:

1. We feel that inadequate attention was given to obtaining public input on this statement. Richland is expensive to get to, out of the way, and too far for many people who are concerned and qualified to make comments about the document.

2. The document was often difficult to obtain and not widely distributed to interested parties. Nor was it distributed soon enough for people to study the document carefully. How long did it take how many full-time paid professionals to complete this draft statement? It is impossible for concerned citizens and professionals with other responsibilities to make careful, intelligent comments within a month.

On the document itself:

3. No detailed plan is given for the permanent disposal of high-level radioactive wastes. This is essential and the document is unacceptable without it.

4. The cost-benefit analysis is not detailed enough and does not include long-term permanent storage. More thorough attention must be given to this matter before this important policy question can be resolved.

5. We continue to oppose disposal to the soil of significant amounts of liquid radioactive waste. This practice is not justified by data given and available.

Thank you for the opportunity to comment on this draft statement. We hope our remarks and the comments of others will be fully considered in the final document.

Sincerely,

Lynn Daly

Lynn Daly, Secretary
Eugene Future Power Committee

EXHIBIT 8

UNIVERSITY OF OREGON

Department of [illegible]
[illegible]

Eugene, Oregon [illegible]
Telephone [illegible]

November 21, 1974

Mr. W. H. Pennington
Assessments and Coordination Officer
Division of Biomedical and
Environmental Research
Atomic Energy Commission
Washington, D. C. 20545

Dear Sir:

Enclosed please find comments on the draft Environmental Impact Statement (Wash 1538) titled, "Waste Management Operations, Hanford Reservation, Richland, Washington." September 1974. These comments relate in part to the coverage in the draft of previous comments submitted by the Eugene Future Power Committee prior to composing the draft statement.

We feel frustrated by the short time allowed to consider this document and by the fact that the deadline for comment was so close to that set for comment on Wash 1539. It is quite unrealistic to expect people with full-time professional responsibilities to make detailed analytical studies of these lengthy documents in spare time within a month or less.

We thank you for the opportunity to comment on this document and we hope that some of our remarks will encourage a more complete coverage of the subject in the final document.

Yours sincerely,

R. G. Wolfe

R. G. Wolfe
Professor

RGW:rs

EXHIBIT 8 (Continued)

COMMENTS ON DRAFT ENVIRONMENTAL STATEMENT, "WASTE MANAGEMENT OPERATIONS, HANFORD RESERVATION, RICHLAND, WASHINGTON."

(Wash 1538, September 1974) by R. G. Wolfe
November 21, 1974

1- The statement is deficient in that it considers waste disposal on a relatively short time rather than on a permanent basis. The true cost of long term isolation from the environment is a relevant and important, in fact indispensable, aspect of environmental impact considerations. The environmental statement has little meaning without it.

2- The cost-benefit analysis should be extended to long term aspects.

3- The substandard containment vessel on the N reactor should be discussed in sufficient detail to be informative in terms of increased risk related to continued operation.

4- No discussion of analysis of management practice is given. The statement (page C-69) that, "...management practice analysis is a continuous ongoing responsibilty..." does not make this topic beyond the scope of this statement. The track record of accidental release of radioactive wastes at Hanford has placed management practices in question. As this sort of event relates to environmental consequences, the management practice and policy are importantly related to environmental impact whether or not such practices are subject to continuous analysis within the AEC. This very relevant topic should not be swept under the rug with off-hand and arbitrary judgements.

5- The report makes no mention of independent analysis of the data. In complex technical matters such as these, subjective interpretations are not uncommon. The draft report lacks sufficient detailed data for independent or adversary analysis. Matters as important as those discussed in this manuscript should not be limited in evaluation and analysis to one or a group of individuals under pressure to obtain, after the fact, arguments defending previous practices or policies. It is not realistic to expect possible "subjective internal bias" to be adequately challenged and analyzed gratis by qualified experts as a spare time effort. Independent analysis by qualified experts, encouraged to make and defend constructive criticism, is a realistic and preferable alternative to the apparent expectation that comments on EIS documents will accomplish this end adequately. The presence or absence of independent analysis has significant bearing on the quality of any EIS. Such independent criticism should be obtained and circulated for public comment along with the draft EIS. Your response to this criticism could also be included, and without such independent review, the EIS has little value.

6- There is a significant inconsistency in that it is stated that Sr^{90} does not reach the water table (page II.1-90). However, as shown in Figure II.1-C-35, this isotope is indicated at 10^{-3} μC at the water table (depth of 60 meters).

EXHIBIT 8 (Continued)

7- Our comment (page C-67) regarding the possibility of migration of radioactivity to the surface has apparently been ignored completely. From the statement (II.3.8.2.2), "... the evaporation potential during the summer months greatly exceeds total precipitation...". it follows that there must be net flow of water to the surface at some finite rate by ion exchange migration. Since "...precipitation does not penetrate more than about 15 or 20 feet below the land surface" (II.3-D-50), there must be net migration from greater depths. Since the highest radioactivity levels occur near the surface at the points of release into the ground, it is conceivable, with relatively reasonable assumptions, that dangerous levels of radioactivity might migrate to the surface. There is no evidence found by this writer that this matter has been considered, studied or otherwise appreciated in any of the available documents. One wonders what the purpose of before-draft comments is if they can be ignored.

8- Since it is not possible to make quantitative accounting for released radioactivity, it is quite possible that high flow rate channeling to the Columbia River may occur or that such channeling will develop with continuing groundwater run-off. The presence of channeling is cited in at least one section of the statement [not related to radioisotope (tritium) distribution]. If studies designed to identify channeling in relation to radioisotope distribution have been made, it is not readily apparent in the draft statement. Statements to the effect that radio-

isotopes are safely contained lack credibility without appropriate measurements that exclude the above possibility.

9- Insufficient data was given in Figure II.1-C-35 to support the stated downward migration rate of 1.5 meters per year.

10- No mention is made of the possiblity that nuclear power reactor fuel reprocessing might be necessary at Hanford because of the failure to complete the General Electric reprocessing plant due to design errors. It would seem that continuing fuel reprocessing at Hanford might influence very significantly the environmental impact statements made.

11- The page numbering and indexing of the draft statement is confusing and cumbersome. Similar numbering in the statement and Appendix should be avoided in the final draft.

12- The statement in general is less quantitative than desirable, especially for the purpose of critical analysis.

13- Value judgement words such as "appreciable" and "practical" are obfuscating and should be avoided where possible or substituted for by more quantitatively precise expression.

14- Once-a-century or 1000-years flooding should be considered <u>exclusive of the behavior of the Columbia River</u>. Considering the 24,000 year half-life of Pu^{239} this is not an unreasonable consideration. Also, it should be recognized that such flooding or flash flood effects would not be moderated by the dam control features on the Columbia River.

15- The matter of guaranteeing the long term (hundreds of years) esponsibility for maintaining isolation of wastes from the

EXHIBIT 8 (Continued)

environment is a matter of considerable concern, particularly in relationship to the stability of human political institutions. This topic has apparently not been mentioned. It should be considered forthrightly.

To sum up, it is dismaying and frustrating to find that many of the comments on the draft EIS made previously by me (and perhaps others) and which I consider to be relevant, basic and indispensable, have not been alluded to at all in this document or have been treated in such unprecise and value-laden terms that their inclusion is without practical worth. It is my opinion that this EIS for Wash. Management Operations at Hanford does not fulfill its purpose as set forth in the Environmental Protection Act. I particularly stress the need to submit the statement for independent critical review and further public comment before adopting a final report.

EXHIBIT 9

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE
WASHINGTON, D.C. 20250

NOV 2 1974

Mr. James L. Liverman
Assistant General Manager for Biomedical and
Environmental Research and Safety Programs
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Liverman:

The Draft Environmental Statement, WASH-1538, Waste Management Operations, Hanford Reservation, Richland, Washington, is very comprehensive. The agricultural aspects appear to be correctly analyzed. The most serious agricultural concern is the irreversible commitment of land on which transuranic materials are stored. Although the 6000 acres of desert land that are identified with the Hanford operation would have relatively little impact on the national food production system, a proliferation of such irreversible land use commitments would be of considerable concern. The development of a recovery program alternative should certainly be given high priority.

Sincerely,

W. A. Raney
Acting Assistant Administrator

EXHIBIT 10

ELOISE W. KAILIN, M. D.
RTE. 1 BOX 253
SEQUIM, WASHINGTON 98382
AREA CODE 206
TELEPHONE 683-6644

November 25, 1974

James L. Liverman, Ass't. Gen'l. Manager for Biomedical and Environmental Research and Safety Programs
U.S. A.E.C.
Washington, D.C. 20545

Dear Dr. Liverman:

Obviously a great manyexpert man-hours has gone into the preparation of the Draft EIS for WASH 1538, Waste Management Operations at Hanford. We regret that we had so little time to analyze it. In listing omissions we may be in error due to ouRhaste in trying to meet your deadline. We will have to concentrate on the negative aspects of this report due to time constraints and our feeling that the positive aspects don't need to be changed.

First we wish to question the basic underlying assumptions that:

1. Present technology is adequate to continue generating radioactive wastes on an escalating scale.
2. The radiation standards set in 1972 or earlier give adequate protection. They antedate EPA input and the Cochran-Tamplin report which should be taken into account in 1974.
3. That monitoring equipment will continue to be functional and heeded to the indeterminate future.
4. Waste may be accumulated to an indefinite time and therefore to an indefinite total amount.
5. Human society can control itself so that sabotage will be successfully foiled or will have only negligible effects, the wastes will not fall into the hands of terrorists and wars will not either accidentally or purposefully cause "unplanned releases" of radioactive materials from stockpiles.
6. Governmental institutions and laws will continue to provide funds for safeguarding these wastes, will perform adequate security checks on personnel e[illegible]usted with these materials but will not create an oppressive police state in the [illegible]ne of security.

We note that in the last 30 years of experience with waste management there were numerous instances of human error and equipment failures with releases of radioactive materials to the environment. Some releases were even planned as part of someone's cost-benefit judgement. We question the ability of man

to contain this material for the next 500,000 years. Indeed major geologic changes are not at all considered in this document. But the last ice age was only 8-10,000 years ago and the landscape has been considerably rearranged. We agree that wastemanagement of existing stockpiles is a must and that the highest and best technology must be devoted to securing this as quickly as possible--we would urge without regard to retrieval.

MISSING:

1. Adequate discussion of the alternative of stopping the generation of further radioactive waste (replacement of nuclear fission technology with development of a solar energy farm at Hanford)
2. What is the possibility that Hanford will become the dumping ground for wastes from all over the U.S. and foreign reactors as well? What will happen to reactor vessels, including the one at Hanford at the end of their useful life?
3. Health effects are given in computer model terms with a few scraps of observation data. At the very least minimum, maximum and standard deviation values should be supplied for radioactive materials found in autopsy material from persons residing at different places--the original reports should be appended especially in view of the tight time available for comment. Why are there no reports on ^{90}Sr in bone or teeth of humans or animals in the Hanford area? Why no vital statistics on infant mortality, on cancer, on thyroid nodules, on I^{131} in human or bovine thyroids? Background radiation data does not appear to take into consideration the reduced fallout characteristic of arid areas. Animal data reported do not consist of study of a reasonable target organ for ^{90}Sr in several of the tables (why muscle only and not bone?). Plutonium values also are reported for muscle rather than lung or bone.
4. Criticality accidents from plutonium accumulations are excluded from consideration on the basis that the keff rating would not exceed 0.5. But according to news articles the keff actually reached 0.97 or 0.98--almost at the explosive level. Were these reports in error? They were taken seriously at the time.
5. Please discuss costs in terms of waste generated per MW electricity generated, and how costs and storage requirements will be affected by MOX fuel by servicing the Breeder reactor.

EXHIBIT 10 (Continued)

6. We are told that 18 tanks are leakers and another 14 are suspect on the basis of excessive corrosion or pitting and "unexplained anomalies in leak detection measurment which might indicate leakage but which could not be confirmed as such". Current operating policy requires these to be emptied as fast as spare tank space is made available by the solidification program. How fast is this? How long before all 14 tanks can be emptied?
7. Underground storage of wastes will be protected from uptake by plants by a plastic sheet over them and under the earth. How many years of protection will this afford relative to the time radioactivity is retained?
8. Where is the quantitative data or estimation of the amount of radioactivity transferred offsite by migratory birds, insects, air emissions (total), and water releases deliberate and accidental, total? How can you say p.III.1-37 there s evidence of no significant amounts of radioactivity escaping the Hanford site boundary?

Kailin for PPF to Liverman P.3

9. Table II 3-28 shows that Benton City and Western Richland Composite foods in 1972 have at least double the I^{131} in milk and 3 times as much Sr^{90} in local produce as compared with further sources. What has been the accumulative burden of the local population over the last 30 years?

10. A maximum flood was considered, but apparently no consideration was given to failure of an upstream dam. The latter is considered for reactor siting--why not for waste storage security?

We think you have a bear by the tail here. A great deal of radioactivity has been released on the world and it does not help any of the biota, including man to argue that since there is much floating around we should be indifferent to smaller increments because the effects as far as we know are cumulative. This volume thick as it is does not demonstrate the harmlessness of the Hanford operation although it certainly reiterates this point in many ways.

Yours truly,

Eloise W. Kailin

Eloise W. Kailin, President, Protect the Peninsula's Future
John Butler, Research Committee
Doris Thurston Research Committee

X-113

EXHIBIT 11

November 19, 1974
W. P. Metz
1303 Kimball
Richland, Washington
99352

Office of the Assistant General Mgr. for
Biomedical and Environmental Research
and Safety Programs
A.E.C.
Washington D.C. 20545

Richland Operations Office
Atomic Energy Commission
Richland, Washington 99352

Subject: COMMENTS ON THE DRAFT "ENVIRONMENT STATEMENT, WASTE MANAGEMENT OPERATIONS, HANFORD RESERVATION RICHLAND, WASHINGTON" WASH-1538

Gentlemen:

The following is submitted as a comment on the subject document Wash-1538.

First, however, I must indicate that I am intimately familiar with some of the Waste Management practices at Hanford due to my employment position. I am a MS chemical engineer employed by the Atlantic Richfield Hanford Company and have been assigned in the areas of waste management support and technology for the 200 Area wastes for more than four years now. In writing these comments, I am not, in any way, a spokesman for my employer. I write the comments as an informed and concerned citizen and technologist. My comments on the document, Wash-1538, are as follows:

There are, in the document, a number of what I consider rather serious technical errors. I recognize these errors due to my employment experience, and will not (indeed cannot) enumerate them. The corrections can be picked up via internal contractor channels and I am confident that they will be properly taken care of in the final issued statement.

The statement discusses a number of now unused facilities which exist on the Hanford reservation. There are no apparent plans to re-use those facilities, and the facilities are apparently contaminated with fission products and/or transurancis. It appears that a much higher emphasis should be placed on decontaminating and/or decommissioning those facilities.

The statement discusses the high level waste management practices at Hanford per liquid storage and in tank solidification for high level wastes. In light of today's technology, as indicated to on Wash-1539 (draft EIS for the RSSF), this Hanford method of controlling radioactive wastes is not acceptable for wastes which will be produced in the future. Consequently, I feel that any future atomic processing efforts should, at a minimum, meet commercial atomic plant safety and environmental standards. That is, production (plutonium) reactors, thermal reactors, reprocessing plants,

EXHIBIT 11 (Continued)

Richland Operations Office
Atomic Energy Commission
Richland, Washington 99352
Page 2
November 19, 1974

waste management programs should be subject to the private industrial controls and quality control. I am not advocating that those standards be applied to existing Hanford wastes, per say; I am advocating that no more wastes produced in the future be treated under this waste management program. I further feel that the existing wastes stored at Hanford should be subjected to a study and we become committed to rendering those wastes to a long term, vice short term, storage mode which is more environmentally acceptable.

I would be pleased to discuss those comments further, if need be. I appreciate the opportunity to comment of the draft of Wash-1538.

Very truly yours,

W. P. Metz

EXHIBIT 11A

December 19, 1974
W. P. Metz
1303 Kimball
Richland, Washington
99352

Office of the Assistant General Mgr. for
Biomedical and Environmental Research
and Safety Programs
A.E.C.
Washington, D.C. 20545

Richland Operations Office
Atomic Energy Commission
Richland, Washington 99352

Subject: COMMENTS ON THE DRAFT "ENVIRONMENT STATEMENT, WASTE MANAGEMENT OPERATIONS, HANFORD RESERVATION RICHLAND, WASHINGTON" WASH-1538

Reference: My letter of November 19, 1974, same subject

Gentlemen:

I have been requested to detail some of my comments from the reference letter concerning the subject draft document. I have compiled detailed comments on Wash 1538--those comments are attached. Please let me repeat that those are my personal comments and that I am not a spokesmen for my employer.

Further, I would like to express my gratitude for the concern and encouragement that has been afforded me about these comments. I appreciate the chance to make an input to this effort. Thank you very much.

Very truly yours,

W. P. Metz

EXHIBIT 11A (Continued)

COMMENTS ON WASH-1538 (W. P. Metz)

Page iv: Under "Current Program," the word "million" to read "approximately 47 million gallons...."

Page v: Second line, word "requires" is not necessarily appropriate. Those fuels could be stored indefinitely (as is done in Canada) or processed elsewhere.

Fourth line: N Reactor operation, production plans, foot note (a): For all practical purposes, N Reactor is now quasi-commercial generating facility (in spite of the legal niceties), thus N Reactor wastes are commercial grade wastes and should be treated as such.

Line 7: Should that date be 1979?

Lines 17 & 18: The high caustic recycle could be further evaporated at 242-S, but would not produce an acceptable salt cake. Suggested working: ".... remain which cannot be converted to an acceptable salt cake by further evaporation."

Line 21: Add "or stored in double-shell tanks as a concentrated liquid."

Page vii: Second paragraph: This paragraph implies that transuranic solids wastes are all stored in a 20-year retrievable posture. That practice has only been in force for the past 3 or 4 years (see page I-2).

Under "Gaseous Effluents": Nonradioactive gaseous effluents have been omitted from this summary. There are sources of chemical gaseous effluents, i.e., the NO_x from AR Vault.

Page I-1: Last three lines should be:

". Four new double-wall ....

. Three additional double-wall ....

2

Page I-2: First three lines: Two of the evaporators are in use now (242-T and 242-S); ITS 1 and ITS 2 are no longer operating.

Page I-3: Second line should read: ".... to assure that radioactive gaseous emissions ...."

Line 9: Change "will" to "should"

Middle of the page, point (1): Is this statement accurate as far as U. S. defense needs?

Page I-4: Third paragraph: Do the 1500 wells include tank farm monitoring wells? If so, the paragraph is not completely correct.

Page I-5: Top paragraph: It would be appropriate to mention Hanford winds and "dust devils."

Page I-6: First paragraph: How about the deleterious effects that rabbits and coyotes have shown as a result of the B-C Crib?

Page I-9: Last paragraph: ".... and ponds for many hundreds of centuries."

Page II.1-17: All of the treatises on 200 Areas do not mention the 200-N, -P, -R areas.

Middle of page: ".... in standby condition, is operated intermittently" perhaps should read ".... is planned to be operated ...." or ".... may be operated ...."

EXHIBIT 11A (Continued)

Page II.1-30: Sixth line up: Z Plant organic will not be processed in the in-tank solidification facilities.

Page II.1-33: Last paragraph: ITS 1 & 2 are not in operation.

Third line up: Word "permanently" should be struck. The units were supposed to be portable.

3

Page II.1-36: Figure II-1-21 shows mostly C Farm, not much of A, AX, and AY. There should be a better photo around.

Page II.1-64: Add "others" to "Source" column to indicate things like GE waste liners, etc.

Page II.1-65: Second paragraph: The discussion of cesium-strontium removal should be modified to clarify that only a good fraction of these isotopes are recovered (60 - 90%). The remainder is stored in underground storage.

Page II.1-70: First paragraph, line 5, should read "Plant was stored in part of the SX Tank Farm."

Second to last paragraph: SX sludge cooler offgases are partially condensed. The tanks are supposedly being dried out. "Possibility of liquid leakage ...." seems very probable since most of the SX ^{90}Sr sludges are in leaking tanks.

Page II.1-71: Second paragraph: "These tanks were vented to the atmosphere through air-cooled ...." "Instrumentation was provided ...."

Last paragraph: Does all of A Farm have laterals (horizontal dry wells)?

Page II.1-78: Second paragraph: ".... it is possible to transfer liquid to or from any tank in the system." This statement is really a poor one; we just don't have this capability.

Page II.1-80: Second paragraph under II.1.1.2.2.3: ITS 1 and ITS 2 are not in operation.

Same paragraph: The RL isn't doing much to get equipment to process organics.

Last paragraph: Process conditions for 242-S are not adequately described here. 242-S solids are formed in the crystallizer, not in tanks from cooling.

4

Pages II.1-81 & II.1-82: The figures of ITS-1, 2 might be left out. Feed to ITS-1 (tank 102-BY) came from 112-BY, not ITS 2 bottoms tanks (see figure II.1-45).

Page II.1-83: Figure II.1-47: There is no neutralizer tank in the 242-T -- Z Plant waste feed system. "CWS filter" on bottoms tanks should be "HEPA filter."

Page II.1-86: Last line: "In-tank temperatures in some tanks are monitored every shift."

Page II.1-119: "Waste Tank Leak Detection Laterals" -- This paragraph should be deleted.

Page II.1-142: Paragraph II.1.1.6.1.2: 200 Areas Add AR Vault chemical effluents.

Page II.2.1: Lines 11 and 12: This sentence is misleading. The further operation of Purex will add a substantial amount of new boiling waste.

Page III.2-4: 11th line: Typo: Isotope?

Page V.5: Second last paragraph: Delete as before.

Page II.1-C-65: Item 1 of table II.1-C-14: HSW from 234-5 Z to TA tank is a "pipe in pipe" containment.

12-13-74

EXHIBIT 12

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE
ASSISTANT DIRECTOR
FOR NATIONAL AND
INTERNATIONAL PROGRAMS

NOV 29 1974

Dr. James L. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Liverman:

The Foundation's Committee on Environmental Statements has reviewed the Draft Environmental Statement, WASH-1538 - Waste Management Operations, Hanford Reservation, Richland, Washington. The Committee's comments are enclosed. I hope that they will be useful to you in preparing the final statement.

Sincerely yours,

for T. O. Jones
Acting Assistant Director for
National and International Programs

Enclosure

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

nsf

OFFICE OF THE
ASSISTANT DIRECTOR
FOR NATIONAL AND
INTERNATIONAL PROGRAMS

NOV 29 1974

Dr. James L. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Liverman:

The Foundation's Committee on Environmental Statements has reviewed the Draft Environmental Statement, WASH-1538 - Waste Management Operations, Hanford Reservation, Richland, Washington. The Committee's comments are enclosed. I hope that they will be useful to you in preparing the final statement.

Sincerely yours,

/S/ K. G. Sandvad

for T. O. Jones
Acting Assistant Director for
National and International Programs

Enclosure

EXHIBIT 12 (Continued)

COMMENTS ON WASH-1538

The statement is made in Vol. I, Page iv, last paragraph, that "Approximately 47 gallons of liquid waste and 25 million gallons of solidified waste are currently stored . . . ." Is the 47-gallon figure correct?

Environmentalists can pick out two types of generalization, in spite of the detailed studies and the year of writing that went into the document. One is probably insurmountable; the use of unquantified terms is too plentiful. What is a "high-level waste"? What are "the lowest levels technically and economically practical"? What are "significant quantities of radioactive and other waste materials"? Who judges the statement that "Over 1,000 years of operation would result in no more than one cancer death"?

The other generalization is typified by a statement in Vol. I, Page 1-6, middle of the page: "Studies show that the effluents from up to nine plutonium-production reactors have had no harmful effects on the migration or spawning of salmon . . . ." This may be true, but studies do show that the elevation of Columbia River water temperatures in the Hanford reach of the stream may interfere with the survival of the young salmon after hatching and with their ability to convert to a saltwater life. The increased use of that part of the stream as salmon spawning sites might also be associated with increased returns of hatchery-produced fish, not naturally reared fish. Only technically astute reviewers can discern this kind of statement treatment.

In general, this is a very complete report. It clearly indicates AEC's commitment to continue long-term or perpetual surveillance, and to prepare EIS reports for any new developments in the waste disposal program.

EXHIBIT 13

FEDERAL POWER COMMISSION
WASHINGTON, D.C. 20426

IN REPLY REFER TO:

November 21, 1974

Mr. James L. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Liverman:

Thank you for the opportunity to review the Draft Environmental Impact Statement, WASH-1538-Waste Management Operations, Hanford Reservation, Richland Washington. This is to inform you that the Federal Power Commission has no comments to offer in regard to the action proposed in the Environmental Impact Statement.

Sincerely,

Carl N. Shuster

Carl N. Shuster, Jr.-Ph.D.
Acting Advisor on Environmental
Quality

EXHIBIT 14

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

DEC 4 1974

Mr. James L. Liverman
Assistant General Manager for
Biomedical & Environmental
Research & Safety
Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Liverman:

The opportunity to review the draft environmental statement on Waste Management Operations at the Hanford Reservation, Richland, Washington dated September 1974 (WASH-1538) is appreciated. This draft statement has been reviewed by this Department primarily from the standpoint of the health impact on populations due to radiation exposures and doses from current operations as well as the potential for such impacts based on the potential for future health effects as a result of the wide-spread radioactive contamination which exists in the environment as a result of operations over the past 30 or more years. Also considered are current standards and guidelines being applied to the commercial nuclear power industry for operations similar to those being carried on at the Hanford Reservation.

Based on information contained in the draft statement it may be concluded that the current exposures to and doses from radiation and radioactivity from these installations are minimal as are the resultant projected health effects. It is apparent, however, that operations are not conducted with the same degree of control as is required by commercial operations of the same type. The existing inventories of radioactivity in the tank farms, in the soils and ground waters underlying cribs and ponds, as well as in the ponds, as well as contaminated solid waste both buried and as contamination in or on existing structures and equipment present continuing health hazards which will need to be maintained under control and surveillance for the indefinite future.

An early objective of operations at Hanford should be to assure that additions to this inventory in the environment are eliminated as early as practicable by improvements to the waste management program. The improvement program scheduled through fiscal year 1975 will be a step in this direction, but, although reducing the rate of increase of inventory to the ground and ground water, will still allow a build-up of these concentrated but relatively uncontrolled inventories. It is recommended that effluents from all facilities be reduced to conform to

the "as low as practicable" criteria for commercial installations as have been adopted by the Atomic Energy Commission for licensed installations. It would also seem preferable to discharge these low-level effluents to the environment where they will be further dispersed rather than utilizing techniques such as cribs and ponds that will result in reconcentrations of the effluents thereby requiring long-term surveillance and monitoring of these concentrated sources in the soil and ground water. Although it appears that with few exceptions these releases to the ground are being confined at the present time, it does not seem possible to predict what might happen to the geological and hydrological characteristics of this area over the protracted period of time that it will be necessary for these entrapped radionuclides to reach innocuous levels. Based on present knowledge, however, it would not seem advantageous from a cost-benefit stand-point to attempt to remove and treat all the contaminated soil or to remove and store it elsewhere.

The program of solidifying the high-level liquid waste in the tank farms after having removed the long-lived cesium and strontium isotopes is an important improvement. However, the resultant salt solids are undoubtedly relatively leachable and efforts to seek a suitable process for these solids to change them to a less leachable form, as discussed in the draft statement, should be pursued as expeditiously as possible. It is recognized that the ultimate disposal of these wastes will to a major extent be dependent upon decisions made following further review and evaluation of AEC's proposed high-level waste storage and disposal program.

There are certain conditions existent on the Hanford Reservation which are not covered in the projected 1975 improvement program which should be considered as soon as possible. A review of the analytical results on radioactivity in ducks which have been taken from the ponds on the reservation indicate that they are assimilating a good deal of cesium. This shows particularly in those samples reported and taken from T Pond, U Pond, and Gable Pond where the levels exceed those which would be derived from the FRC basic dose recommendations. In other words, they fall within a level of concentrations within or above range 3 for cesium as extrapolated from the FRC recommendations. The level also exceeds the concentration guide being used generally in the report to evaluate the acceptability of discharges of liquids to the uncontrolled environment. This being the case, it is suggested that consideration be given to discontinuing use of such ponds unless it can be assured that the waste water entering them do not contain significant levels of radioactivity. The existing ponds should either be back-filled in place or the contaminated top layers of soil be removed and buried elsewhere.

EXHIBIT 14 (Continued)

Page 3 - Mr. James L. Liverman

The second point of concern are releases directly to the Columbia River which exist in the 100-N area. It was noted that the currently scheduled modification program will improve the quality of water being discharged through the 102 inch discharge line. However, no mention is made of attempting to reduce either the amounts or concentrations of discharges into the crib in this area which discharges into the Columbia River via the N area Riverbank Springs. It is noted from the statement as well as the appendix that levels of iodine-131 in this discharge water exceeded both FRC Range 3 levels as well as the guidelines in both years 1972 and 1973. The strontium discharges exceeded these concentrations in 1972 but were reduced in 1973. It is not clear whether this is a random or a planned reduction.

It is recommended and urged that every effort be made to meet the stated objective of the long-term waste management program of conforming to the standards which are being established for the commercial nuclear power program.

Sincerely yours,

Charles Custard

Charles Custard
Office of Environmental Affairs

EXHIBIT 15

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230

December 6, 1974

Mr. James L. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Liverman:

The draft environmental impact statement for "Waste Management Operations, Hanford Reservation, Richland, Washington (AEC)," which accompanied your letter of September 27, 1974, has been received by the Department of Commerce for review and comment.

The statement has been reviewed and the following comments are offered for your consideration.

General Comments

With regard to the impact of release of radioactive waste to the Columbia River, the statement presents an extensive review of scientific evidence supporting a case for a lack of effects--or at least a reduction in the amount of radionuclides released, because of the near termination of plutonium production. However, most of the studies discussed were concerned with the deposition of radionuclides in aquatic organisms as a pathway of exposure to man. The small amount of information presented concerning the somatic and genetic effects of long-term, low-level irradiation on populations of aquatic organisms emphasizes the need for conducting the kind of well-planned research advocated by Rice and Baptist (1974). With regard to the impact of waste heat on aquatic biota, we question the validity of statements indicating that thermal discharges to the Columbia River have neither had, nor are presently having, an effect on these organisms.

EXHIBIT 15 (Continued)

Specific Comments

I. SUMMARY
I.3 Environmental Impact
I.3.1 Environmental Effects of Routine Operation of Plant Facilities

Page I-5. It should be mentioned here that juvenile salmonids are subjected to temperatures that are potentially lethal and that adult salmonid populations are present in the area because all other historic spawning areas on the main stem of the Columbia River have been inundated through installation of hydroelectric dams. The Hanford area is the only remaining section of the middle Columbia River where spawning conditions are optimum for adult chinook salmon.

V. ALTERNATIVES
V-6 Nonradioactive Waste
V-6.7 Other Environmental Pollutants
V-6.7.1 Heat to the Columbia River

Page V-57. This section indicates that the total heat input to the river is about 470 megawatts when the power plant is in operation. This figure appears to be inaccurate. It is our understanding that the total output is 4,000 MW, and that the plant produces 860 MWe, leaving 3,140 MW_{th} of heat lost from the plant.

Page V-58. We question the statement that "Since the effect of the N Reactor heat releases on the Columbia River are considered insignificant (Section III.1), installation of a cooling tower or pond to eliminate these releases to the Columbia River cannot be justified." Heat effluent from the N Reactor has the capability of killing small fish. Krenkel and Parker (1969: 318-337) indicate that the N Reactor produces 4,000 MW_{th} and increases the ambient water discharge temperature into the river by about 19° to 47°F, depending on plant operating conditions. If the Columbia River water temperature is 60°F (which it is for approximately six months each year), and if the discharge water temperature is raised 40°F, this water, when discharged to the river would be capable of killing small salmon

in a few seconds (Synder and Blahm, 1971; EPA, 1971). The question that remains to be answered is, in fact, how many juvenile fish are killed each year in this manner? Until this question is answered, conclusions will continue to be drawn suggesting that there is no demonstrable effect of heat from the N Reactor on juvenile fish, a conclusion that is subject to misinterpretation.

Thank you for giving us an opportunity to provide these comments, which we hope will be of assistance to you. We would appreciate receiving a copy of the final statement.

Sincerely,

Sidney R. Galler
Deputy Assistant Secretary
for Environmental Affairs

Literature Cited

1. Krenkel, P.A. and F.L. Parker (eds.). 1969. Biological aspects of thermal pollution. Proceedings of the National Symposium on Thermal Pollution, sponsored by the Federal Water Pollution Control Administration and Vanderbilt University, Portland, Oregon, June 3-5, 1968. Vanderbilt University Press. 407 p.

2. Rice, T.R. and J.P. Baptist. 1974. Ecologic effects of radioactive emissions from nuclear power plants, p. 373-439. In: L.A. Sagan (ed.), Human and ecologic effects of nuclear power plants. C.C. Thomas, Springfield, Illinois.

3. Synder, G.R. and T.H. Blahm. 1971. Effects of increased temperature on cold-water organisms. J. Water Pollution Control Fed., 43 (5): 890-899.

4. U.S. Environmental Protection Agency. 1971. Columbia River thermal effects study. Vol.1: Biological effects studies. 102 p.

EXHIBIT 16

HEALTH AND ENVIRONMENT

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

8 DEC 1974

Mr. James L. Liverman
Asnistant General Manager
for Biomedical and Environmental
Research and Safety Programs
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Liverman:

We have reviewed the draft environmental impact statement (DEIS) "WASH-1538 - Waste Management Operations, Hanford Reservation, Richland, Washington," and have no substantive comments to offer.

H. R. Smith
Acting Deputy Asst Secretary of Defense
(Environmental Quality)

EXHIBIT 17

TOM McCALL
GOVERNOR

J. H. PEET
Director

EXECUTIVE DEPARTMENT

LOCAL GOVERNMENT RELATIONS DIVISION

240 COTTAGE STREET S.E. • • • • SALEM, OREGON 97310

December 5, 1974

Mr. James Liverman, Asst. General Manager
Biomedical & Environmental Research &
Safety Programs
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Liverman:

Subject: Draft Environmental Impact Statement for Hanford Reservation Waste Management Operations
Was - 1538
PNRS #7410 4 760

Thank you for submitting your draft Environmental Impact Statement for State of Oregon review and comment.

Your draft was referred to the appropriate state agencies. The attached comments offered by the Fish Commission, Health/Radioactive Prot. Service, Wildlife Commission and the Department of Environmental Quality should be addressed in the preparation of your final Environmental Impact Statement.

We will expect to receive copies of the final statement as required by the Council of Environmental Quality Guidelines.

Sincerely,

William M. Brown
Acting Administrator

WMB:lw

Attachments

EXHIBIT 17 (Continued)

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

Local Government Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Ph: 378-4732

DEC 3 1974

LOCAL GOVERNMENT RELATIONS DIVISION

RECEIVED
DEC 13 1974
FISH COMMISSION

PNRS STATE REVIEW

Project #: 7410 4 760 Return Date: NOV 12 1974

ENVIRONMENTAL IMPACT REVIEW PROCEDURES

1. A response is required to all notices requesting environmental review
2. OMB A-95 (Revised) provides for a 30-day extension of time, if necessary. If you cannot respond by the above return date, please call the State Clearinghouse to arrange for an extension.

ENVIRONMENTAL IMPACT REVIEW
DRAFT STATEMENT

( ) This project does not have significant environmental impact.

( ) The environmental impact is adequately described.

(✓) We suggest that the following points be considered in the preparation of a Final Environmental Impact Statement regarding this project.

( ) No comment.

REMARKS

We have reviewed the draft environmental statement for waste management operations at the Hanford Reservation at Richland, Washington (WASH-1538).

Our concerns in aquatic resources in the Columbia River are for the preservation and palatability of fish life and associated food webs.

We feel that in most cases adequate description and projections for various actions and events have been made.

We question statements that no deleterious effects have been observed in Hanford's thirty years of operation.

Juvenile salmonids are present in the Columbia River near Hanford and are potentially affected by temperatures in excess of their lethal range.

Agency Fish By Irving W. Jones

X-123

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

Local Government Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Ph: 378-4732

LOCAL GOVERNMENT RELATIONS DIVISION
NOV 6 1974

PNRS STATE REVIEW

Project #: 7410 4 760 Return Date: NOV 12 1974

ENVIRONMENTAL IMPACT REVIEW PROCEDURES

1. A response is required to all notices requesting environmental review.
2. OMB A-95 (Revised) provides for a 30-day extension of time, if necessary. If you cannot respond by the above return date, please call the State Clearinghouse to arrange for an extension.

ENVIRONMENTAL IMPACT REVIEW
DRAFT STATEMENT

( ) This project does not have significant environmental impact.

( ) The environmental impact is adequately described.

( ) We suggest that the following points be considered in the preparation of a Final Environmental Impact Statement regarding this project.

(X) No comment. (See below)

REMARKS

The Oregon Wildlife Commission will defer to the Oregon Department of Environmental Quality, Washington Departments of Ecology, Fisheries, and Game in the review of this Environmental Statement.

Agency Wildlife Commission By William E. Patnaty Chief Environmental Management Section 11/4/74

EXHIBIT 17 (Continued)

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE — GOVERNMENT RELATIONS DIVISION

Local Government Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Ph: 378-4732

PNRS STATE REVIEW

Project #: 7410 4 760 (WASH 1538) Return Date: Nov. 12, 1974

ENVIRONMENTAL IMPACT REVIEW PROCEDURES

1. A response is required to all notices requesting environmental review.
2. OMB A-95 (Revised) provides for a 10-day extension of time, if necessary. If you cannot respond by the above return date, please call the State Clearinghouse to arrange for an extension.

ENVIRONMENTAL IMPACT REVIEW
DRAFT STATEMENT

( ) This project does not have significant environmental impact.

( ) The environmental impact is adequately described.

(✓) We suggest that the following points be considered in the preparation of a Final Environmental Impact Statement regarding this project.

( ) No comment.

REMARKS

The Draft Environmental Statement "Wash 1538" on Hanford Waste Management Operations, Volumes 1, 2, and 3 dated September 1974, is an extremely long and complicated environmental impact statement. Inasmuch as the document, as it stands, requires a great deal of work in reviewing it adequately and inasmuch as the operation has been continuing for a period of 20 years, it is suggested that an extension of no less than 90 days should be given to more adequately review this particular document without any more significant environmental effects over that time period. I have written directly to the Atomic Energy Commission asking if an extension of time might be granted on this statement.

Agency Health / Radioactive Prot. Service By [signature]

EXHIBIT 17 (Continued)

DEPARTMENT OF ENVIRONMENTAL QUALITY

1234 S.W. MORRISON STREET • PORTLAND, ORE. 97205 • Telephone (503) 229-5353

TOM McCALL
GOVERNOR

KESSLER R. CANNON
Director

LOCAL GOVERNMENT RELATIONS DIVISION

State Clearinghouse
Local Government Relations Division
240 Cottage Street S.E.
Salem, Oregon 97310

November 8, 1974

Gentlemen:

Enclosed are the Department's comments on the draft environmental statement for AEC's Hanford waste management operations, PNRS #7410 4 760.

Please contact us if there are any questions regarding these comments.

Cordially,

KESSLER R. CANNON
Director

MHW:sa
Enc: (1)
cc: R.L. Gay

X-125

OREGON PROJECT NOTIFICATION AND REVIEW SYSTEM

STATE CLEARINGHOUSE

Local Government Relations Division
240 Cottage Street S.E., Salem, Oregon 97310
Ph: 378-4732

PNRS STATE REVIEW

Project #: 7410 4 760 Return Date: NOV 12 1974

ENVIRONMENTAL IMPACT REVIEW PROCEDURES

1. A response is required to all notices requesting environmental review.
2. OMB A-95 (Revised) provides for a 10-day extension of time, if necessary. If you cannot respond by the above return date, please call the State Clearinghouse to arrange for an extension.

ENVIRONMENTAL IMPACT REVIEW
DRAFT STATEMENT

( ) This project does not have significant environmental impact.

( ) The environmental impact is adequately described.

(x) We suggest that the following points be considered in the preparation of a Final Environmental Impact Statement regarding this project.

( ) No comment.

REMARKS

1. Despite the large quantities of data and other information contained in the draft statement, the statement does not contain: 1) sufficient data and other information to permit adequate review; and 2) sufficient discussion of environmental impact on the Columbia River and the significance of calculated or measured contamination of the river resulting from Hanford operations.

2. All discharges to the Columbia River, including effluents, subsurface waters, riverbank springs and others, should comply with maximum permissible concentrations (MPC) for radionuclides. Liquid and solid waste management improvements should be undertaken to meet this goal in view of the importance of the Hanford reaches of the Columbia River.

3. Conclusions contained in the final paragraph of page IX-8 do not appear justified because there are only several general references in the draft statement relating to possible shutdown of the N Reactor and Purex. It is recommended that liquid waste management improvements, including N Reactor effluent treatment, relocation of N Reactor Crib to the 200 area and improved treatment for 200 area liquid wastes, be strongly considered unless there is a definite and clear commitment on the part of AEC (or its successor agency) to shut down N Reactor and Purex by 1979. Further, the planned facilities for N Reactor gravity drain and control rod coolant dumps should be incorporated in the liquid waste management improvements noted above.

Agency: DEQ By: Patrick H. Hicks

EXHIBIT 18

United States Department of the Interior

OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240

In reply refer to:
PEP ER 74/1230

DEC 13 1974

Dear Mr. Liverman:

Thank you for your letter of September 27, 1974, requesting our comments on the Atomic Energy Commission's draft environmental statement on Waste Management Operations, Hanford Reservation, Richland, Washington.

Our comments are presented according to the format of the statement or according to subject matter.

Radioactive Waste

One of the three most important elements of the basic proposal for waste management is the continuation of research and development of methods for solidifcation of residual liquors as well as alternative insoluble products (p. IX-8, paragraph 2). However, very little information appears to have been provided on actual research now in progress toward those objectives. We feel it is essential to provide information of two principal types: (1) an adequate summary of current knowledge; and (2) an adequate summary of the research program in progress, planned, and recommended. Important information that appears to be needed is the solubility and other pertinent properties of the salt cake, similar properties of alternative solid forms, relative advantages and disadvantages based on present knowledge, and tentative costs and benefits. Without this type of information it is not possible to evaluate the likelihood that this important part of the proposed program will be achieved.

Approximately 5 million cubic feet of radioactively contaminated solids are stated to have been buried on the Hanford Reservation since 1943, but only since May 1970 have transuranic wastes been segregated in special containers for retrieval. Questions relating to this are: (1) what measures are recommended for ultimate disposition of wastes in burial grounds that may contain unsegregated transuranic wastes; (2) which specific grounds are these, and what measures are required to maintain their surfaces to reduce deterioration of containers in case of a future decision to retrieve these wastes; and (3) what monitoring or

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other special actions are required to preserve the future option of ultimate retrieval of these wastes?

It is noted that an integral part of the waste management program is the provision of "high integrity tanks to contain the liquids in interim periods" (p. v). It has also been noted that in the process of solidification by evaporators, resulting in the filling of the tanks with solid salt cake, ". . . the major portion of this liquid needs to be removed since the integrity of the tank liner and shell cannot be assumed for long periods" (p. II.1-86). In spite of the use of screened well-points installed down to the tank floors, it is stated that the remaining interstitial liquor ultimately equals about 30 percent of the volume of the salt cake, and that the piping is sealed off after this degree of dryness is reached. It appears inevitable that the floor of the tank must remain in a wet condition, in contact with the concentrated residual radioactive liquor for the duration of storage. In view of the foregoing conclusion that tank integrity cannot be assumed for long periods, we are concerned about tank integrity in contact with the residual liquor during prolonged storage, and amounts of such concentrated liquor that might leak into the underlying soil prior to detection, and during the period required to flush out the contents of the tank.

Volume 2 provides detailed estimates of the quantity of radioactive material held in and beneath cribs, burial grounds, tanks, ponds, ditches, and other waste management facilities. However, little or no indication is given of the probable accuracy of the statistics, of the possible margin of error, or of the range of values that might exist as a result of incomplete accounting procedures, particularly during the early years of operation. In general, the method of calculation, particularly of radioactive waste inventories, should be explained further and the figures presented should indicate no greater accuracy than the circumstances warrant.

Radioactive Waste Disposal

The plan for ultimate solidification of high-level liquid wastes is of considerable concern. It has been concluded that ". . . new facilities for solidifying the final residual liquid will be needed . . ." and that ". . . the residuum will be treated

EXHIBIT 18 (Continued)

to produce a solid either by chemical addition or a special type evaporator . . ." (p. V-2,4). It is stated that these alternatives are currently under development, but the current state of knowledge and the current research program have not been described. In addition, no proposed funded research program is recognizable as corresponding to this aspect, in spite of the description of wide-ranging research programs in many areas. This aspect of the waste-management program is of ultimate importance because nearly 10 million gallons of residual liquid are expected to require such treatment at the end of the program (p. V-9). In the discussion of the ultimate disposal alternatives, one possibility considered is to leave the salt cake in the tanks where it was formed (p. V-21). However, the discussion of this alternative fails to consider the long-term problem of the residual liquor that is included, and that would ultimately be subject to leakage. At least a tentative timetable for ultimate solidification needs to be discussed.

The primary benefit of the Hanford Waste Management Program, according to the statement, is the continued isolation of significant quantities of radioactive and other waste materials from man's environment (p. I-3). These wastes are presently either committed into the ground or stored in tanks from which leaks into the ground have occurred; such areas on the Hanford Reservation are ". . . committed to long-term control (thousands of years) . . ." (p. I-6). Control of much of the land on the Reservation is also required for a similar length of time to avoid changes in water-table levels (p. IV-1).

The statement does not, but should, describe what is involved in this required control and how it could be assured of exercise for periods extending to thousands of years. A full discussion of consequences resulting from the potential breakdown of control is required. The adverse effects of the enforcement of perpetual control over the area should be specified. Finally, the full implications of perpetual control should be factored into alternatives that do not require this type of control.

Alternatives

It is stated at the outset that current standards stipulate that releases of radioactivity be "at the lowest levels technically and economically practical" (p. ii, #1). By the end of the environmental statement a fairly convincing case appears to have

been presented to support the conclusion that "the radiation dose to the population and consequently the health effects are essentially independent of the alternative chosen" (p. IX-8, paragraph 1; see also Table IX-3). The basic rationale of the AEC staff appears to be that the standard of "as low as practical" release of radioactivity will have been complied with if the proposed waste management program cannot be shown to result in significantly greater releases of radioactivity than those resulting from one or more alternatives that have been evaluated. However, the evaluations of all alternatives, resulting in the radiation-dose changes summarized on Table IX-3, are evidently based on the assumption that virtually all long-lived radionuclides released to the ground beneath storage or infiltration facilities will be safely isolated from the biosphere until they decay to a harmless level.

The foregoing rationale provides little or no basis for choosing one alternative over another, because all alternatives are viewed as differing by only insignificant amounts in their degree of risk to the environment. One of the following alternative interpretations of the "as low as practical" principle would provide another useful basis for evaluation of alternatives, to supplement that of radiation-dose levels as estimated in the present statement: (1) to compare the quantity of long-lived radioactive isotopes released to the soil and not positively isolated from the biosphere by an impermeable, accessible, and reparable barrier; and (2) to compare the amount of ground, expressed in terms of acres and cubic feet, that would be irretrievably committed to waste management and storage. It has been noted that "land containing transuranic materials, particularly plutonium can be considered unusable for any purpose for hundreds of thousands of years" (p. VIII-1, paragraph 3) and that essentially 6,000 acres are considered irretrievably committed under the present waste-management program. The spirit of the "as low as practical" principle requires that the acreage and volume of earth irretrievably committed to containment of long-lived radionuclides be kept as small as practicable, and that this factor should be an important basis for evaluation of alternatives that are practically equal in terms of foreseeable radiation dose commitments.

EXHIBIT 18 (Continued)

Historical and Archeological Sites and Natural Landmarks

Cultural resources should receive the same treatment as other aspects of the environment. They should be described, impacts of the proposed undertaking should be assessed, and mitigative measures should be proposed.

To obtain the most current information on historical resources, there are two primary sources of information. First, the National Register of Historic Places" as published in the Federal Register of February 19, 1974, and monthly updates should be consulted. Second, the Washington State Historic Preservation Officer should be consulted to determine sites which are eligible for the National Register. The results of these consultations should be reported and documented in the final statement.

The significance of archeological resources on the Hanford Reservation has been seriously understated on page II. 3-13. The Columbia River was one of the most densely inhabited regions in aboriginal North America, and its inhabitants possessed one of the most interesting lifeways of the continent. With the exception of the sites located on the Hanford reach of the Columbia, evidences of this lifeway have been virtually erased. Therefore, the remaining sites assume great significance and should be evaluated to determine if they should be preserved.

Compliance with Executive Order 11593, "Protection and Enhancement of the Cultural Environment," should be documented in the statement. This requires federal agencies to inventory historical and archeological remains, evaluate, with the aid of an appropriate professional, their significance, and nominate those eligible to the National Register. Presumably, the Atomic Energy Commission funded surveys and the Ben Franklin Reservoir survey would suffice for the inventory.

Geology

Ion exchange with clay constituents in the soil appears to have been relied upon for containment of practically all long-lived radioisotopes in liquids that are deliberately disposed of by infiltration in cribs, ponds, and ditches as well as liquids accidently released from tanks and pipes. For example, it is stated that "the clays have good ion exchange properties and make good filter beds" in describing the section beneath a

typical crib illustrated by figure II.1-51. The underlying soil is generally described as "up to 50% silts and sand, having some clay content" (p. II.1-88, paragraph 2). However, we have found no section beneath any disposal area described in sufficient detail to suggest that the soil contains a significant amount of clay in the uppermost 150 to 300 feet. Considering the critical importance assigned to the surficial geologic section in containing the hazardous radionuclides, we feel that representative sections beneath important disposal sites should be described in detail, including quantitative data on parameters closely related to containment. These parameters include especially the permeabilities of the underlying capacities of these materials, and what retardation factors or calculations support the foregoing conclusion that "the clays . . . make good filter beds."

Curves showing idealized sorption patterns for principal elements beneath a typical disposal crib are shown on figure II.1-52. Among the assumptions evidently made is that the radioactive solutions would percolate uniformly downward through a homogeneous soil, a condition which does not exist in actuality. Because specific depths have been shown, it appears that certain assumptions were made with regard to the soil type or the time element, but these have not been discussed. The basis for preparation of the curves, and all underlying assumptions, should be explained.

Comparison of the foregoing idealized curves with the limited analytical data presented in the Appendices (fig. II.1-C-36 to 40) casts doubt on the validity of the idealized curves as applied to the Hanford Reservation. For example, the idealized curves appear to suggest that maximum concentrations of radionuclides would tend to occur very close to the source, but test wells commonly showed maximum concentrations from 15 to 35 feet below the surface, and even as deep as 65 or 100 feet for cesium. It has been concluded that "the potential for leaching of sorbed radionuclides from beneath cribs and trenches down to the water table is nil under present climate conditions" (p. II.3-D-51), which would presumably eliminate leaching as a cause for the higher concentrations of some radionuclides at depth. In general, since sorption of radionuclides has been depended upon for their containment, analyses of their actual distribution beneath major disposal sites should be related to geology, structure, clay mineralogy, ground water, or any other pertinent factors. Unless

EXHIBIT 18 (Continued)

the present distribution of radionuclides is well understood, after 30 years or less of movement, there appears to be little hope of predicting their fate over periods ranging up to "hundreds of thousands of years" (p. VIII-1).

The statement projects that fission products and Pu will remain in the soil columns under cribs, trenches, and ponds for many centuries (p. I-9). However, evidence presented in the draft statement shows vertical migration of Cs^{137} and Sr^{90} at the 216-S 1 and 2 crib sites (fig. II.1-C-33, p. II.1-C-84, vol. 2). The crib site was in service from January 1952 until January 1956 and received approximately 39 x 10^6 gallons (1.5 x 10^8 liters) of waste liquid containing 750,000 Ci of mixed fission products including 3,000 Ci of Sr^{90} and 2,000 Ci of Cs^{137}. Following the termination of discharges to the site, a field study was undertaken (p. II. 1-C-82) in 1956. The upper cross section in figure II.1-C-33 indicates the migration of cesium and strontium in the soil column. Ten years later, in 1966, five additional wells were drilled at the crib site to determine the extent of radionuclide redistribution (p. II.1-C-83). The results shown in the lower cross-section of figure II.1-C-33 indicate that cesium and strontium both have extended laterally and vertically. It is true that most of the Cs^{137} and Sr^{90} is still contained in the soil column about 15 m below the cribs. However, this movement shown occurred during only a 10-year period compared to the several centuries that these wastes will be hazardous. From this evidence, it is doubtful that the radionuclides can be retained in the soil columns for many centuries as concluded in the statement. To carefully keep track of the wastes at Hanford, especially those radionuclides which have reached the soil, more intensive, detailed work needs to be done at the site.

Seismicity

It has been stated that ". . . additional seismic resistance studies will be performed . . ." as a result of potential structural deficiencies revealed by review of design of components of B Plant (p. III.2-59). Judging only from the partial information presented, it appears that the appropriate recommendation would be to evaluate seismic effects on those waste management structures that have not yet been analyzed (p. III.2-60) and to strengthen those components found to be weakest. In view of the past history of tank leakage, the effects of ground displacement and severe ground accelerations on the various tanks of various designs should be analyzed in detail. Although the tanks

constructed after 1971 are said to be designed on the basis of a horizontal acceleration of 0.25g (p. III.2-57), the accelerations that the tanks constructed prior to 1971 will withstand should be discussed. This is important as most of the waste was produced prior to 1971. The possibility of ground displacement at the tank locations should be analyzed and the basis presented.

Hydrology

There are two aquifers in the Hanford area, namely, the unconfined and the confined aquifers. The former consists of both glacio-fluviatile sand and gravel deposits and the Ringold silts, clays, and gravels. These materials are very heterogeneous and often greater lithologic differences appear within a given bed than between beds. The confined aquifer consists of basalt. These two aquifers are separated by a layer of clayey silt of the Ringold Formation. Certainly some "erosional windows" exist between the aquifers, therefore at certain areas hydraulic communication between the unconfined and confined aquifers is possible (p. II.3-35).

From the description of the waste-management program at Hanford it is clear that the future fate of the disposed wastes depends primarily on the movement of water over long periods of time through the ground in the Reservation. Predictions of ultimate destination of wastes cannot be based simply on current distribution of waste or the rate at which the waste has moved since its commitment to the ground. Full understanding of the regional hydrology and its variability is one of the minimum requirements for making such predictions. Overall, the data presented in the sections on hydrology in both the report and its appendix are not adequate to support the conclusions drawn. Liquid wastes, both non-radioactive and radioactive (low-level and intermediate-level waste, less than 100 uCi/ml) are disposed into the ground through ponds, trenches, and cribs at 100 Area bordering directly on the Columbia River, 200 Area seven miles from the river, and 300 Area about one mile north of the Richland City limits on the bank of the Columbia River.

The cribs are operated as follows. Ground water associated with waste disposal sites is routinely sampled and analyzed. When long-lived radionuclides, such as Sr^{90}, Co^{60}, or Cs^{137} are detected in the ground water at concentrations approaching 1/10 of the concentration guide for drinking water, the crib site is deactivated, and the process effluents are routed to a new crib (p. II.1-90). Thus, during the operation, much depends on the adequacy of the ground-water-quality monitoring system.

EXHIBIT 18 (Continued)

However, the statement does not contain a location map and construction details of the sampling wells, description of methods of water sampling, or a detailed geological map of the disposal sites. A bucketed or bailed water sample from a well could represent merely stagnant water not representative of water in the formation if the water is bailed above or below the open interval. Alternatively, the sample may be an average for the entire open interval. A sample collected from a well open 10 feet may not be equivalent to one collected from a well open 100 feet. Thus, samples collected from wells constructed with different lengths of open interval are not necessarily compatible. Therefore, the open interval of sampling wells is extremely important for evaluation of the monitoring of water quality.

Frequency of sampling is another factor that should be considered. It is necessary to determine whether the lower layer of clayey silt acting as confining bed is present at the disposal sites. If not, the radionuclides could move directly down to the confined basalt aquifer; if this occurs, then water from the confined aquifer should also be analyzed frequently. The statement fails to consider these important factors.

The hydraulic conductivities of the glacio-fluviatile sediments range from 1,200 to 12,000 ft/day and only 6 to 200 ft/day for the Ringold Formation (p. II.3-37). However, no vertical hydraulic conductivity is mentioned. Given such extremely heterogenous formations it is surprising that no vertical sections of geology or soil columns at the waste disposal sites are given in the discussion of liquid waste disposal. Since the velocities of ground water moving through the glacio-fluviatile sediments are different by several orders of magnitude from velocities in the Ringold Formation, detailed geological and sampling well location maps should be provided.

From the data presented in the draft statement, it can be concluded that very little is known about the ground water movement in the highly heterogeneous aquifer at the Hanford Reservation. A recent comprehensive review of the ground water movement, environmental monitoring program, and mathematical models reaches the same conclusion (refs. 64, 65, 66 and 67, p. II. 3-D-83, Vol. 2). These references indicate that pumping tests after the early 1950's appear to have been run without planning and with little care. The data were gathered in many cases in a very inadequate fashion. Pump fluctuations precluded

the use of drawdown data for many of the tests. In addition, interpretation of the pumping tests is poor, being based on techniques that are not applicable to the data collected (ref. 64, p. II.3-D-83, Vol. 2). It also appears that possible glacial outwash channels and the interconnections between the confined and unconfined aquifer are probably clearly established throughout the reservation.

In summary, because of the heterogenous nature of the confined aquifer, it is necessary to have a well-planned and detailed geophysical exploration which will establish glacial flow channels and the continuity of the confining bed. Well-planned monitoring wells, of known location and open interval, should be established. A reliable sampling system, with particular attention to adequacy of sampling method, frequency, mass balance, reliability checks, and record-files, should be established. Detailed and well-planned investigation of vertical and lateral permeability of the soil at Hanford, especially at the waste disposal sites, should be performed. An intensive survey of springs, including locations, discharge, and chemical and radiochemical quality of water, should be made. Some efforts should be made to investigate whether there are underwater springs in the Columbia River. Because of liquid waste disposal and farm irrigation canals, a significant recharge has been found in 200 West Area (p. II. 3-D-26), therefore it is necessary to carry out water-balance calculations at the site. Because the radionuclides are long-lived, it is important to develop a long range precipitation forecast, including intensity and duration of precipitation. Detailed and well-planned investigations of ground water velocity (effective porosity), hydraulic dispersoin, and chemical distribution coefficients (Kd) are necessary. All mathematical models should be extensively checked with field observations.

Effects on Ground Water

Although the draft statement says that no information has been found which indicates that a hazard through the ground water pathway presently exists as a result of AEC waste operations at Hanford (p. II.3-D-77), the references clearly show that the authors of the reports did not endorse the operations.

EXHIBIT 18 (Continued)

On the contrary, the review report on the monitoring of radionuclide concentrations (ref. 67, p. II.3-D-83, Vol. 2) states that the basic documents are somewhat poorly organized, give only averages, or maxima, and seem to have selectively presented data. The wells from which the water samples were taken either filled in fully (that is, the measured depth of the well was above the top of the open interval), or partially plugged, or the total depth of the open interval or both are unknown. There has been little, if any, attempt to sample the same wells repeatedly. Moreover, the same constituents are not routinely analyzed. Thus, considering the nature of the base data, the reliability of the conclusions reached in the draft environmental statement cannot be demonstrated.

The conclusion that the disposal of liquid waste into the ground at the Hanford Reservation does not endanger the hydrosphere in the area is made partly on the arbitrary and cursory assumption that soil columns will retain a large part of the radionuclides. This assumption is based partly on chemical analyses of water samples taken from some monitoring wells, and partly on the transport model.

Figures II.3-18, II.3-20, and II.3-21 are used again and again to show that the average nitrate, gross beta, and tritium concentrations in the ground water near the surface of the unconfined aquifer during the period of July-December 1972 are either below the drinking-water standard or the concentration guide, except in the area near the disposal site. The reliability of these figures is debatable. First, as mentioned above, there is neither a detailed geological nor a sampling-well location map. The statement fails to mention the sampling method and frequency and the construction of sampling wells (open intervals, etc.). Secondly, the movement of radionuclides both in the vertifal and lateral direction are related to the rate of disposal, concentration of the waste, and ground water levels. This is a dynamic system, yet the concentration map was compiled according to a calendar period instead of dynamic conditions.

The statement strongly suggests that most of the radionuclides in the radioactive wastes discharged to the ground, except tritium and ruthenium, are adsorbed on or filtered by the soil column (p. I-2, II. 1-55). Tritium entering the Columbia River from the 200 Area source in 1972 is indicated to be less than the tritium in the river as a result of fallout of tritium from past weapon testing and natural sources. The quantities of tritium entering the river will probably increase in the future

as a result of the slow migration of ground water from the 200 Area disposal sites. A transport model simulation, referred to in the statement, forecasts that peak rates should be reached in the early 1980's and attain about 2×10^{-7} uCi/day of tritium and 2×10^{7} uCi/day of gross beta activity entering the Columbia River (p. III. 1-4).

In addition, it would appear that the radionuclides in the wastes disposed at 100 Area would reach the Columbia River in a very short time. The statement indicates "as of August 1974 the radioactivity in the riverbank seepage contributes the major fraction of total radioactivity entering the Columbia River. The major portion of the radionuclides reaching the Columbia River do so via the ground water from the 1301-N crib disposal site . . ." (p. III. 1-5). And further, ". . . the main sources of radioactivity presently entering the Columbia River are from the spring seepages along the banks below N reactor . . ." (p. III.1-40). There is neither a location map showing springs along the river banks nor radiochemical records of the spring water in the draft statement. It is also possible that some springs may discharge directly into the river under water.

High-level wastes need to be stored in tanks before they can be solidified. These tanks are subject to leaks even if they are double walled. Since 1958, there have been a total of 18 confirmed leaks. These leaks have varied in size from very small to 115,000 gallons for the 106-T tank in 1973 (p. IV.2-2). This 106-T tank leak discharged 40,000 Ci of Cs^{137}, 14,000 Ci of Sr^{90}, and 4 Ci of Pu into the ground (p. II.1-138). Soon after the leak was reported, 16 wells were drilled to delineate the contaminated zone. The deepest penetration observed in the wells drilled was 89 feet below ground surface or 115 feet above the water table. The statement concludes that, on the basis of the results of the study and the basic knowledge of liquid movement in Hanford sediments, further movement of the radioactivity from its present location will be negligible (p. III.2-4). This conclusion is without basis. These radionuclides take many centuries to decay below a safe level. A 55-year precipitation record shows that annual precipitation at the Hanford Meteorology Station reached 12 inches in 1950 (p. II.3-E-58, Vol. 2). From extrapolation of the 55-year records, annual precipitation having a 100-year frequency could reach 20 inches. Therefore, before any meaningful conclusion is made that the radionuclides will not move down to the ground water body from their present location, it is necessary to study the probability of rainfall duration and intensity over a period of several centuries. The vertical permeability of the formation at the tank site also needs to be determined.

EXHIBIT 18 (Continued)

Floods

The potential effects of Columbia River floods are evaluated assuming that the dam-regulated probable maximum flood as calculated by the Corps of Engineers is the highest that could occur (p. III. 2-67). This is adequately conservative for most flood evaluations involving man-made structures. However, the Hanford Waste Management Program will require "long-term control (thousands of years) . . .", and the possibility that dam regulation as practiced today may not be assured over such lengths of time should be considered in addition to the flood effects of the potential failure of upstream dams. If unregulated floods or dam failures could reach other waste storage or burial areas, these should be specified as well.

The consequences of the flooding of buried wastes are evaluated on the basis of the following simplifying assumptions: (1) all uncontained radionuclides are entrained during the peak 24 hours of the Columbia River flood; and (2) all are soluble and uniformly mixed into the quantity of water equal to 24 hours of peak flow. These assumptions are indeed conservative with respect to concentration of solutes (although "uncontained" has not been clearly defined and therefore cannot be evaluated). However, it is possible that the entrained soil and sludges will retain significant fractions of the radionuclides and that they will be moved as particulates. They could settle out in the streambed and be incorporated into the long-term bed environment of the Columbia River. The potential effects of this possibility should be considered.

Effects on Aquatic Biota

There is insufficient specific evidence to support the summary statements on page 1-6 that there are no harmful effects of Hanford waste effluents on the aquatic ecosystem of the Columbia River. Annual counts of the numbers of spawning salmon in the Hanford reach, cited on page II.1-167 as a major criterion of impacts on anadromous fish, are a very remote index to thermal, chemical, and radioactive effects on different life stages of salmonids. Other Hanford area research not cited has demonstrated that the potential clearly exists under periodic conditions of river flow and temperature for lethal exposure of migrating juvenile salmonids to heated discharges. Some of the synergistic effects on salmonids resulting from interactions of temperature, disease, nitrogen supersaturation, toxic chemicals, and other

influences have also been studied in the Hanford area and should be discussed and factually reported. Objection is also made to the statement on page III.1-59 that "It is reasonable to conclude that if there is not a significant impact on salmonids, a significant impact on other species is not occurring." . Certainly species differences in distribution, movement patterns, feeding, and thermal and chemical tolerances could result in varied responses to thermal or chemical discharges.

Effects on Wildlife

Radioactive effluent from N-reactor operation flows into the 1301-N disposal crib and thence overflows into a 1,600-foot dispersal trench. The 100-N trench has been screened to exclude game birds and other larger animals, but smaller species such as mice can gain access. Section II.3.13.5 and Table II.3-24 of the statement report significant levels of radioactivity in mice collected at the 100-N trench. Included in the statement should be a discussion of the significance of the observed radionuclide concentrations in small mammals, the potential for these animals to enter the food chains of the several species of endangered, threatened, or status-undetermined birds of prey utilizing the Hanford Reservation as a refuge, and steps which should be taken to eliminate this source of radioactive contamination. In a broader sense, an overview of interpretation of the significance of the reported concentrations of radioactivity found in various organisms would be useful in understanding the environmental statement.

In Volume 3, page c-133, it is mentioned that a duck was found in 1969 with an exceptionally high concentration of radioactivity and that if one-half pound of the duck were consumed by a member of the public, it would have resulted in a radiation exposure nine and one-half times greater than the permissible amount recommended by the International Commission on Radiological Protection and the Atomic Energy Commission. While it may not be practical to exclude all mobile wildlife species, particularly waterfowl, likely to be consumed by man, the Service recommends screening project waters to exclude mobile species, from potentially high contaminated waters. The type of screening necessary was done on the 100-N trench that is mentioned in Volume 1, page II.3-70.

EXHIBIT 18 (Continued)

Irrigation

Also in Volume 3, page III-A-102, second paragraph the statement is made "Essentially no wheat or pasture land is irrigated with Columbia River water downstream of the Hanford project." It is our understanding there are many acres irrigated below the Hanford project with Columbia River water.

Models

The draft environmental statement uses several mathematical models to compute ground water travel times and environmental radiation doses. Mathematical models are powerful tools to attack certain problems. However, all assumptions and basic principles used in the models should be sound. Beyond these basic conditions, the most important factor in making the results applicable is the reliability of the input data.

The statement fails to mention the basic assumptions used to formulate the transport model and therefore it is impossible to judge the applicability of the model. However, results obtained from the model depend on the basic input data which are affected by the factors mentioned above. Since they are in question then so are the results predicted by the model.

For example, if inaccurate transmissivity data collected in the field are fed into a transmissivity iterative model it will produce an inaccurate transmissivity map. With the inaccurate transmissivity map and insufficient knowledge of hydrologic boundaries, a mathematical ground water model will yield inaccurate travel times. Considering the criticism of the reliability and adequacy of data discussed in the consultant's reports (refs. 64, 65, 66 and 67, p.II.3-D-83, Vol. 2), the applicability of results from these mathematical models is suspect.

Minor Comments

1) A clear summary of the basic proposal would be helpful at the outset, either on the Summary Sheet (now a separate attachment) or in the Summary, section I. An adequate and concise summary is not now presented until the last page of the draft environmental statement (p. IX-8, especially paragraph 2).

2) On page iv, "47 gallons of liquid waste" should read, "47 million gallons."

3) On page III.2-22, line 6, "environmental input" should apparently read, "environmental impact."

4) Table V-3 should specify high-level waste management facilities.

5) Table V-5 should specify other radioactive liquid waste.

6) Sections II.3.11.7 and II.3-6.8 state that all endangered, threatened, and status-undetermined birds found on the Hanford Reservation are raptors. This is incorrect since the long-billed curlew is not a raptor.

7) The area in Figure II.1-A-1h that is designated "U.S. Fish and Wildlife Service" is now managed by the Washington Department of Game.

We hope these comments will be helpful to you in the preparation of the final environmental statement.

Sincerely yours,

Stanley R. Berrend

Deputy Assistant Secretary of the Interior

Mr. James L. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
Atomic Energy Commission
Washington, D. C. 20545

EXHIBIT 19

Dec. 18, 1974

Dear Sir,

Last night I attended a meeting held at our daughters Jr. Hi School. What I saw and heard frightened me.

I realize we have an energy crisis and there really is not one total solution to our world problem.

But I am very much against Nuclear Energy and I am very much against having the Radio Active waste stored at Hanford when there have already been leaks.

Nuclear Energy should be a no-no. It is much to dangerous an energy power for only about 30 years energy relief.

Please study the solar energy for our source of relief. But do not develop an energy source that could kill so many people. We are all humans and not perfect so there is no way any system can be guaranteed perfectly safe. So lets try for one with less killing agents.

Thank You
Mrs Kay Fuller
28240 20th Avenue South
Federal Way, Washington 98002

EXHIBIT 20

Jan. 6,1975
Betty Lagergren
208 N. 27th Ave.
Yakima, Wn. 98902

W. H. Pennington
Assessments and Coordinating Officer
Division of Biomedical and Environmental Research.
U.S. Atomic Energy Commission.

Dear Mr. Pennington:

Living as I do within the expendable area of a 50 mile radius of the Hanford plant, I am greatly concerned with your Waste Treatment plan.
Your plan is projected from 1940 to 1970 and here it is already 1975. Situations have changed in that other countries have been given atomic plants by the U.S. with the agreement of our accepting their waste products. What do you do with these foreign wastes? When your platted and fenced area at Hanford and others are filled with waste where do you go next? This is an obscene burden to put on any land unto the future generations for millenia. Don't you often wake up in the night bothered by this thought?

The number of leaks occurring at Hanford ~~that~~ are due to human error and are apparently uncontrollable. These leaks are reported with minimal concern from A.E.C. Each leak adds just that much more to the land, to the water and to the air to absorb and contaminate. There are many thoughtful people in this area who believe that there should be no more waste handling at Hanford, it has too much potential danger.

Your E.I.S. says that current and long range uses of this land rules out any agricultural irrigation uses in the future, as much land and some water is now contaminated. From 1975 and on we will need more land for agriculture. All nuclear plants should be shut down now at Hanford. The area can be used for solar and wind energy development plants and the remaining useable land for agriculture. This should be done before any more land is contaminated.

There is no mention of security measures against sabotage. These security measures are far different than those for nuclear accident. The general feel-ing in the U.S. at this time is that it could happen here all too easily.

I do not like the use , in the E.I.S., of the words," most, much, some, may, perhaps" These appear often in evaluations that must be more definitely worked out.

In a cost-benefit analysis the only alternative is to cut off all nuclear plants until man becomes wiser. There can never be any benefit to waste burial. You cannot possibly foretell 300,000 years into the future. Dangerous Area signs, and descriptive books about wastes can be destroyed by fire, flood, glaciers, and that 1-1,000,000 chanced earthquake.

None of this E.I.S. allays apprehensions of myself and thousands of other people. You have tried, but it just isn't good enough- there are too many unanswered and unanswerable questions remaining. And more will develop each year.

Sincerely,
Betty Lagergren
Betty Lagergren

EXHIBIT 21

Dear sir,

I'm opposed to the continued storage of radioactive wastes at the Hanford site. Public hearings were held on the 21 and 23 of January.

Plutonium is the most toxic substance known to man. One millionth of a gram has caused cancer in experimental animals. Plutonium has the potential of being made into bombs be terrorists and other nonconforming groups or individuals.

I feel it is virtually impossible to keep plutonium guarded for tens of thousands of years. There is no working solution in the works to recycle plutonium and they are finding many troubles and problems in building a successful recycling plant.

It has been found that nine miles from the Shipping port Nuclear Reactor, the mortality rate for infants is more than double in the rest of the state. Author H. J. Taub claims, "There is more than twice as much leukemia as the state average and infant diseases of all kinds amount to 156 % of the state average."

If this substance were to get into the Columbia River and be digested into the fish, it would be disastrous. A good deal of income comes from fishing in the Pacific Northwest, and it should not be ruined by plutonium infected fish. Once it gets into the water then all is lost.

Please gentlemen think of the future and what they will have to contend with from this generation. We are asking the future for too much and we are expecting them to gaurd a deadly substance for tens of thousands of years. It is not humanly possible.

Sincerely,

Alan Stanwitz

Alan Stanwitz
429 Chenault
Hoquiam, Wa. 98550

EXHIBIT 22

ZERO POPULATION GROWTH

January 15, 1975

Assistant General Manager
for Biomedical and Environmental
Research and Safety Systems
U. S. Atomic Energy Commission
Washington, D. C. 20545

Re: Draft WASH-1538

Dear Sir:

The draft WASH-1538 anticipates the continued storage of solidified high-level military radioactive waste in the original tanks pending the development of an ultimate storage method and site. The unprecedented hazard of such near-surface storage for high-level waste has been described in my earlier comments on the proposed Retrievable Surface Storage Facility (RSSF) (draft WASH-1539, September 1974). Thus I request that my enclosed comments on that document, entitled, National-Defense Implications of Proposed Radioactive Waste Storage Options, be made part of the public comment record on the draft WASH-1538 along with this letter.

Maintenance of national security requires that the solidified high-level waste now in admittedly interim storage at Hanford be expeditiously transferred to one or more deep underground repositories, there to be kept in retrievable form. Otherwise, even a single attack with conventional or nuclear bombs might disperse radioactive material sufficient to render impossible necessary maintenance and control of the site. While such transfer to safer storage is being arranged, the government should very seriously consider the temporary expedient of covering the locale of the present dehydrated underground tanks with several hundred feet of rock and/or soil.

Very truly yours,

L. Douglas DeNike

L. Douglas DeNike, Ph.D.

Enclosure:
National-Defense
Implications of Proposed
Radioactive Waste Storage Options

Los Angeles Chapter: 2315 Westwood Boulevard / Suite 2 / Los Angeles, California 90064
Telephone 213/474-2154

EXHIBIT 22 (Continued)

NATIONAL-DEFENSE IMPLICATIONS OF PROPOSED RADIOACTIVE WASTE STORAGE OPTIONS

Critique of Management of Commercial High Level and Transuranium-Contaminated Radioactive Waste (Environmental Statement). U.S. Atomic Energy Commission document WASH-1539 (draft), September 1974

Reviewed by L. Douglas DeNike, Ph.D.

CALIFORNIANS FOR NUCLEAR SAFEGUARDS
2315 Westwood Blvd., L.A., CA 90064
Telephone 213-474-3320

This document formally proposes the construction of a retrievable surface storage facility (RSSF) in which to manage all high-level radioactive waste from the commercial nuclear power industry. Methods are also proposed for interim management of wastes contaminated with long-lived alpha-emitting artificial elements such as plutonium.

The RSSF is anticipated to be in service over a period of as long as 130 years, from about the year 1980 until 2110, until such time as a proven permanent radioactive waste disposal method can be implemented. Three main options are presented for the RSSF design: (1) Water basin, in which one-by-ten-foot stainless steel waste canisters, each emitting 1 to 20 kilowatts of heat, will be stored under 20 feet of continuously cooled water 30 feet below ground level. (2) Air-cooled vault, in which waste canisters will be managed just below ground level in reinforced-concrete vaults cooled by passive natural-draft air currents. (3) Sealed cask concept, in which individual canisters jacketed by two inches of steel and 38 inches of concrete will be emplaced in the open air and cooled by natural atmospheric circulation inside the concrete radiation shields. Canister wall thickness is not specified, but does not appear to exceed ½ inch.

The three most likely sites for the RSSF as developed in the draft are the Nevada Test Site, the National Reactor Testing Station in Idaho, and the Hanford Reservation in the state of Washington. The document makes no recommendation among the three locales, nor among the three storage concepts.

The draft WASH-1539 contains no analysis whatsoever of vulnerability of the RSSF choices to acts of terrorism or war. Only sketchy consideration is given to the possibility of sabotage; fuller exposition on sabotage is promised in the final draft. Impacts by aircraft or "massive missile" (e.g., meteorite) are considered to be incredible and thus unworthy of analysis.

The gravity of these omissions becomes evident in consideration of the unique nature of the proposed facility. The prolonged period of service expected of the RSSF, the unparalleled hazard posed by its contents should they be dispersed in the environment, and the inclusion of waste from many foreign countries there will make the RSSF like no other installation in the world. By the year 2010, as many as 6,364.1 megacuries (6.3641 billion curies) of persistent fission products will be stored there. As many as 165 forced-draft cooling towers could be needed to dissipate the heat generated by this material, which could evacuate no less than one-fifth the land area of the 48 continguous states if widely dispersed.

- 2 -

During the lifetime of the RSSF, based upon the historical record we may expect the United States to undergo at least twenty years in which open warfare involving this country takes place. The sophistication of the weapons which will be utilized in those conflicts may be expected to increase, just as weaponry has been refined in the similar interval from 1845 to the present. The identity, strength, motivations, and rationality of our future adversaries can scarcely be predicted, given that our potential and actual military foes since 1945 were largely unforeseen at the close of World War II.

In light of these relatively obvious considerations, and in view of the obvious military advantages of targeting such an installation, the complete absence of the topic of war and terrorism in the draft ES is more than puzzling. It is baffling and alarming. Hopefully, the comments solicited from the Department of Defense will fill this gap. This hope cannot be stated with assurance, since at present DOD has only an advisory role in the protection of nuclear production and utilization facilities against enemy attack. As for the AEC, its Regulation 50.13 exempts its licensees from protecting against assault or sabotage by "...an enemy of the United States, whether a foreign government or other person." The net effect of the current situation is that no government agency has clear, specific, and active regulatory responsibility to protect civilian nuclear-industry facilities against terrorism or wartime attack, remarkable and unacceptable as that may be.

Recommendations: Studies must be undertaken with regard to each of the three favored site locations, establishing the maximum credible dispersion to the environment of stored contents for each of a variety of possible attacks upon the RSSF and transuranium-waste storage facilities. The following modalities should be considered, with regard both to present-day weapons capabilities and extrapolated improvements in those capabilities:

(A) Megaton-range thermonuclear devices detonated near, above, and on the ground surface of each conceptualized repository.

(B) Fission bombs one-tenth to one kiloton in yield, such as will soon be available to terrorists, exploded near, above, on the ground surface of, and within the structures of the storage facility.

EXHIBIT 22 (Continued)

(C) Effects of conventional high-explosive aerial bombing.

(D) Effects of sustained attack by conventional artillery and missiles.

(E) Effects of deliberate crash of the commercial or military aircraft having the largest multiplied weight and top speed in dive, making due allowance for later improvements in aircraft capabilities.

(F) Effects of terrorist attacks utilizing shaped explosive charges at maximally destructive points, assuming successful penetration into the facility.

(G) Effects of sabotage attacks other than those bent upon direct explosive dispersal of stored material; i.e., attempts to damage cooling-system machinery, to introduce corrosives into water-basin coolant, etc.

2. For each maximum credible malevolence-induced dispersion so identified and characterized, a contingency plan should be devised for satisfactorily preventing it and/or cleaning it up. If for any postulated dispersion substantial deposition of radionuclides requiring evacuation of offsite personnel is calculated, such a finding shall constitute an overriding criterion for rejecting the proposed RSSF design or site which gives rise to it.

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3. For credible dispersions involving radioactivity levels sufficiently high to largely preclude direct human participation in cleanup, plans should be set in motion for the design and construction of remote-controlled or totally robotized machinery capable of performing the necessary tasks. Adoption of a final construction plan for the repository should be contingent upon the successful prototype testing and letting of production contracts for such decontamination and cleanup machinery. Such machinery, together with all provisions for its use and later retirement without human servicing once contaminated, should be stored both at the site and redundantly at some distance from the site, lest attack damage at the repository prevent use of the equipment stored there.

4. In the design and public description of the security system for the facility, due recognition should be given to the fact that secret information about it can "leak out" and become known to public enemies over the course of many decades. Thus, to the fullest extent possible, the security system should be designed to rely minimally on secrecy. It is not advocated that details of security precautions be publicized unnecessarily. However, the system should be so intrinsically sound in its physical design that hypothetically, almost everything about it could be disclosed without significantly lessening the safety of the installation. It is most emphatically predicted that secrecy which momentarily masks the weaknesses of an inherently inadequate security system will only delay the day of its breaching, not prevent it.

5. On-surface or near-surface design options for the interim repository are unacceptable and must be rejected. This conclusion stems directly from recognition of the facility as a credible target for attack by nuclear weapons. This principle makes due allowance for the fact that our present chief adversaries appear to have no interest in attacking such an installation, or would fear retaliation in kind should they do so. As was pointed out above, the identity and strategic planning of enemies of the United States can be expected to change unpredictably over time. The conclusion stands independent of any international agreements which may be adopted which would declare civilian atomic facilities non-targetable in warfare. Treaties, and adherence to treaties, are not of the order of durability which is essential for the repository. The conclusion is unaltered by the fact that direct hits with large nuclear weapons would disperse most of the radioactive debris into the stratosphere, resulting in a fallout pattern that would be too widespread for military value. Attacks on any surface-emplaced atomic facility with nuclear weapons can be calculated so that the burst is sufficiently low in yield, off-target, and meteorologically timed so that devastating fallout effects may be achieved. Considering once again the century-plus period over which the repository must remain intact, advance allowance must be made for future refinement in missile accuracy and in weather information obtainable by an enemy.

6. A hardened deep-underground siting strategy for the interim waste repository appears indispensable if our national defense posture is to remain uncompromised. A working model of such a concept is provided by the North American Aerospace Defense Command headquarters at Cheyenne Mountain, Colorado. Although it is located beneath 1500 feet of granite rock, NORAD headquarters is already recognized as vulnerable to repeated direct hits with thermonuclear weapons. Notwithstanding, it epitomizes the presently attainable degree of protection against war damage. The cost of building, cooling, and maintaining such a deep-underground rock-sited facility would be small compared to the expected cost from a nuclear attack on a surface-built installation. Since the United States will build no more than two such repositories, there is no pressing need to economize. Since retrievability following attack does not inhere in surface-emplaced designs, possible loss of retrieval capability in a deep-underground site does not appear to constitute adequate grounds for rejecting it.

WHETHER NUCLEAR POWER IS PHASED OUT OR NOT,

radioactive waste storage sites will exist throughout your lifetime.

You want them to be just as safe as you can possibly get them.

Write to your Senators and Congressman urging consideration for the points raised here. Send a carbon copy to

Dr. Frank K. Pittman, Director
Division of Waste Management and Transportation
U. S. Atomic Energy Commission
Washington, D. C. 20545

An excellent booklet, Citizens' Guide: The National Debate on the Handling of Radioactive Wastes from Nuclear Power Plants, is available from Natural Resources Defense Council, $1.00 per copy, 664 Hamilton Avenue, Palo Alto, Calif. 94301. They won't object if you enclose a contribution when writing for it.

EXHIBIT 23

NORTH ANNA ENVIRONMENTAL COALITION

P.O. BOX 3951
CHARLOTTESVILLE, VIRGINIA 22903
(703) 832-3983 or (804) 293-6039
January 19, 1975

Dr. James L. Liverman,
Ass't Gen'l Mgr. for Biomedical & Environmental
Research and Safety Program,
U.S. Atomic Energy Commission,
Washington D.C. 20545.

Dear Dr. Liverman,

Thank you for sending me a copy of the Draft Environmental Statement of Waste Management Operations of the AEC Hanford Reservation and for the opportunity to comment.

Of great interest is Volume 3 of the EIS. The comments and suggestions therein, received by you, from people and organizations, indicate deep concern from all parts of the country, not just from the immediate area of Hanford. The Comment Guide with Reference Section Number provides a simple adequacy test.- Does the section in reference really answer the questions in a way to engender public confidence in the AEC's program?

In reviewing the EIS, I started with the references in answer to my own letter. The reference as to the safety of waste storage tells me that "The current program has as its continuing objective the reduction of radioactivity in all effluent systems to the lowest technical, economical and practical levels. "As low as practicable" , by now I know, means absolutely nothing relative to "public health and safety". It simply means that radioactive discharges to the environment will be as low as are able to be obtained... if it doesn't cost too much! If they aren't low enough for safety,well, what are a few thousand more cancers and birth defects? Nothing can be proved anyway. "Public Health and Safety" is expendable in exchange for the benefits of that wonderful "cheap" source of energy,Nuclear Power, and for a huge stockpile of nuclear weapons to keep the peace.

Again, relative to my hope for a safe final storage place for nuclear wastes, I am referred to Section V. Section V lets me know that "alternatives currently under consideration for ultimate storage are briefly discussed but additional research and development is required before the best waste form and storage location can be determined." More bluntly put,-- millions of gallons more of extremely dangerouse radioactive wastes per year are still expected to be produced in the weapons program alone, and added to the 72 million gallons already in existence... and still no ultimate storage known. No one person would have the temerity to shoulder the responsibility for this action alone. In an organization as large as the AEC, one person is responsible for such a small part that is far

EXHIBIT 23j (Continued)

Dr. James L. Liverman
January 19, 1975
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removed from the overall significence that he can appease his conscience by closing his eyes and "passing the buck". Yet to Terry Lash's statement "Many concerned citizens will be especially interested in the alternative means of handling radioactive waste, including the alternative of not generating any additional radioactive wastes" your answer was in Section V.I "the analysis of an alternative that does not require a waste management program is not considered reasonable. My answer to you is that common sense needs no analysis,

In the February 15, 1974 letter from the Natural Resources Defence Council I learned that "investigation into Z-9 Plutonium disposal trench indicates that a substantial amount of plutonium has migrated away from the bottom of Z-9 trench." Terry Lash asks that "An analysis be made of how far the plutonium may migrate during its 250,000 year toxic life."(I note that the words "250,000 year toxic life" was left out in quoting Lash's suggestion,- a favorite trick of the AEC, ignoring what they do not wish to answer. First Reference II 1-90 states "Plutonium is held very tightly by the soils, with essentially all of it held within 10 feet of the point of release." I assume the word " essentially" is the indefinite word that covers the part that " data disclosed had migrated away". In Reference II 1.94 "Currently no appreciable quantity of plutonium is directly discharged to the ground. My understanding of plutonium is that any amount is "appreciable" in terms of long-lasting radioactive contamination potential. Reference III 2-50 "Ground disposal for plutonium is no longer used." One hopeful statement! Still the problem of what "migrated away" from Z-9 trench! Reference III 2-52 "It is believed that other trenches, as they dry out will have a lesser reactivity increase than Z-9 or even a decrease in reactivity." Some ray of hope! 250,000 years in the future... there has not been that much recorded time, so, "It is believed" is just another indefinite ploy and a way of cover-up to soothe and lull the public fears.

There are many, many more comments I would like to make from the notes I have made in reviewing this EIS. With your permission, however, I will make only one more. I would like to tell you my interpretation of COST- BENEFIT.

COST is to the public in human suffering and burden they have no choice but to bear.

BENEFIT is to the huge AEC bureaucracy whose status is to be maintained and whose salaries are one more-COST to the public.

It is really ironic to think that our beautiful world could come to an end, destroyed either by the actual use of the Nuclear weapons we are making, ostensibly to keep the peace, or by being polluted out of existence through contamination produced in making these weapons or by the peacetime use of nuclear power. Either way we lose and future generations are robbed of their right to live.

EXHIBIT 23 (Continued)

Dr. James L. Liverman
January 19, 1975
Page 3

In closing, Dr. Liverman, I realize that these comments may not help much in formulating the Final Environmental Impact Statement of the Waste management Operations of the Hanford Reservation, but they will let you know what an increasing number of people are thinking about the Nuclear Weapons Program, about Nuclear Power for the production of energy and the AEC approach to both. Thank you for the opportunity to voice them.

Sincerely yours,

Margaret Dietrich

(Mrs. Arthur W. Dietrich)
Secretary

C. C. Terry Lash, Staff Scientist
Natural Resources Defense Council

The National Intervenors

EXHIBIT 24

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

23 JAN 1975

OFFICE OF THE ADMINISTRATOR

Dr. James L. Liverman
Assistant General Manager
for Biomedical and Environmental
Research and Safety Programs
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Liverman:

The Environmental Protection Agency has reviewed the AEC draft environmental impact statement for Waste Management Operations at the Hanford Reservation, Richland, Washington (WASH-1538) and our detailed comments are enclosed. We would like to thank you and your staff for the time spent in meeting with EPA staff members to discuss various aspects of the draft statement. These meetings were helpful to EPA in understanding the vast Hanford Reservation complex and its waste management operations. Recognizing the scope of the problems and the difficulty of addressing them at a level of detail not heretofore approached, we commend the AEC staff on their effort.

The stated purpose of the draft statement was to reassess the environmental aspects of the Hanford Waste Management Operations program in order to assure that further major actions have minimal adverse environmental impacts; to account for those environmental consequences that may not have been fully evaluated at the outset or at each stage of the waste management program; and to serve as a base for evaluating the environmental impact of future actions in relation to the existing environment at Hanford. EPA agrees that this is the proper scope for the statement. However, we hope that at the conclusion of the ongoing effort to conduct such analyses for all major AEC waste management operations, the AEC will prepare a generic environmental statement addressing the long-

EXHIBIT 24 (Continued)

range program for both interim storage and ultimate disposal of all government generated high-level and transuranium contaminated waste, similar in intent to that recently published for commercially generated waste (WASH-1539).

Our review of the draft statement confirms EPA's earlier findings, following the 106-T tank leak in 1973, that waste storage operations at Hanford to date have not caused an unacceptable hazard to man or the environment outside the site boundary. EPA's comments are focused upon the more difficult problem of assuring that present commitments and future operations will not result in adverse impacts on the environment or public health.

In its review, EPA has attempted to determine whether the information provided is complete and adequate to support the conclusion reached in the draft statement. In addition, we tried to evaluate whether the current AEC monitoring program is adequate to determine if contamination is presently reaching the environment (and if so, in what quantities), and if the AEC monitoring program has the capability to predict the present and future impact of the wastes on the environment.

Based on information from a variety of sources, including that presented in the draft statement, that received directly from the AEC, and that available in the reports of AEC consultants Dr. R.A. Deju and Mr. W.K. Summers, it is EPA's opinion that the hydrogeologic information presently available is not sufficent to permit a comprehensive evaluation to be made of the potential for environmental damage represented by the presently stored waste, either on a short-or long-term basis. To remedy this situation, EPA recommends that an independent comprehensive re-evaluation be made of the hydrogeology of the Hanford site.

EPA's principal conclusions relative to the adequacy of the Hanford Reservation waste management operations are that there is a need for more hydrogeological information (as mentioned above); a need to eventually eliminate reliance on soils to remove radioactivity from liquid wastes discharged to the ground; and a need to place more emphasis on determining an acceptable ultimate disposal form and method for the high-level wastes.

In light of our review and in accordance with EPA procedure, we have rated the Hanford waste management operations as ER (Environmental Reservations) and classified the draft statement as Category 2 (Insufficient Information). If you or your staff have any questions concerning our classification or comments, please do not hesitate to call on us.

Sincerely yours,

Sheldon Meyers

Sheldon Meyers
Director
Office of Federal Activities

Enclosure

EXHIBIT 24 (Continued)

U.S. Environmental Protection Agency
Washington, D.C. 20460

January 1975

Environmental Impact Statement Comments

D-AEC-A00108-WA

Waste Management Operations
Hanford Reservation
Richland, Washington
(WASH-1538)

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I. INTRODUCTION AND CONCLUSIONS

This report summarizes EPA's review of the AEC draft environmental statement, "Waste Management Operations, Hanford Reservation, Richland, Washington" (WASH-1538). The stated purpose of the draft statement is to reassess the environmental impact of the Hanford Waste Management Operations program, in order to assure that further major actions minimize adverse environmental consequences and to account for those environmental consequences that may not have been fully evaluated at the outset or at each stage of development of the waste management program during the past 30 years. EPA's comments on the recent AEC draft environmental statement concerning the management of commercially-generated radioactive wastes (WASH-1539), are also pertinent to this situation, especially the observation that "... the question of how to properly manage the hazardous waste produced ... remains one of the major unresolved issues."

EPA is primarily concerned with the long-term potential environmental hazards presented by these wastes. Complicating this problem is the fact that physical and administrative controls for this waste will have to be exercised over time periods which are extremely long in comparision to the relatively brief history of human social institutions. EPA believes that it is absolutely essential that these wastes be managed in a manner which will provide maximum assurance that there will be no unacceptable risk to the public health or environment either now or in the future.

The principal conclusions reached by EPA are as follows:

1. Based on the reported long-term monitoring of the environment around the site (drinking water, air samples, edible vegetation, etc.), we can conclude that, to date, there has been no significant radiological effect on the general public or the general off-site environment from the Hanford waste management activities. However, based on the limited amount of published and organized data addressing the on-site hydrogeological monitoring/surveillance program, we are not able to reach a firm conclusion as to the program's adequacy or ability to quantify and predict the movement of radioactive contaminants through the ground water system to the off-site environment in the future.

EXHIBIT 24 (Continued)

2. EPA also studied several reviews by two consultants to the AEC, Dr. R. A. Deju and W. K. Summers, who examined the hydrogeological program and data available at Hanford. Their findings substantiate EPA's concerns involving deficiencies in the data and monitoring programs, the hydrologic impact of waste disposal, the hydraulic properties of the aquifiers, and the usefulness of the modeling programs developed for Hanford. As recommended by the consultants, EPA believes an independent review and assessment should be made of the hydrogeological situation at Hanford.

3. The practice of using the favorable ion exchange properties of soils to remove radioactivity from liquid wastes, and thus to confine the radioactivity in soil columns, is a long established procedure. However, in using such a technique, the assumption is made that favorable environmental conditions will continue in the soil allowing activity trapped therein to decay to innocuous levels. Because of the long time periods over which these wastes will remain hazardous, there will be continuing requirements for control and surveillance. The AEC should consider eliminating these practices by requiring that all liquid radioactive wastes be treated to reduce the concentration levels to the lowest levels practicable before being discharged to the ground, if such ground discharge cannot be totally eliminated.

4. The continued use of underground waste tanks for storage of solidified high-level waste is acceptable only on an interim basis while the AEC is actively pursuing a program which will lead to the development of an environmentally acceptable ultimate disposal method and accompanying waste form. More information should be presented in the final statement concerning the AEC's program to accomplish this and what plans the AEC has for developing alternate storage methods if, in the interim, the tanks containing the salt cake fail.

5. The approach taken in the benefit/cost analysis presented in the draft statement makes it difficult to identify the benefits of upgrading the waste management program. The final statement should better document the basis for upgrading waste management facilities at Hanford, since the draft statement indicates that the waste management facilities are already contributing essentially zero population dose.

6. The concepts and models for the 50-year dose commitment values listed in the draft statement are not adequately described. While the dose presented indicates the total impact on the present population for that year's operation, it differs significantly from the EPA concept of an environmental dose commitment which considers the persistence and buildup of long-lived nuclides in the environment. The final statement should include a detailed discussion of the concepts and assumptions used to determine the 50-year dose commitment for the various nuclides.

7. The final statement, in its discussion of both the past and future environmental impact of Hanford waste management operations, should base its analyses on data accumulated from all past years, where it is available, and not just 1972 data.

II. GENERAL DISCUSSION

EPA became actively involved in evaluating the potential environmental effects of the Hanford waste management activities following the 106-T tank leak in 1973. EPA's basic concerns have remained essentially the same since that time, and may be summarized briefly as follows:

- Have the monitoring networks and data accurately documented the extent of underground contamination at Hanford?

- Do the available hydrogeological studies accurately describe the geologic framework of the Hanford site and the movement of water through it?

- Are the waste-soil/rock interactions and the movement of wastes through the ground sufficiently understood to allow valid conclusions to be drawn?

- Is contamination presently reaching the off-site environment and, if so, in what quantities?

- Can the AEC accurately predict the location of these wastes at the present time and will they be able to do so in the future?

Fundamental to any discussion of the past, present, and future operations at Hanford is a realization that the primary purpose of any waste management program is the protection of the public health and the environment. The hydrogeological portion of the draft statement was reviewed from that perspective with particular care because:

EXHIBIT 24 (Continued)

- Disposal into the ground has been in the past and continues to be a major waste management technique at Hanford.

- A large amount of radioactive waste (in volume and activity) has already leaked or been disposed of into the ground, and discharge of these wastes from the Hanford site into the Columbia River at an earlier time, or in larger quantities than predicted, could have adverse environmental and health consequences.

- Sorption and retardation of the radioactive wastes by the soil column beneath and around the storage tanks are the primary safety mechanism available if the integrity of a tank is lost.

- A clear and precise understanding of the geologic framework of the Hanford site, how water moves through it, and how wastes interact with this hydrogeological system is essential before reliable pathway analyses and dose assessments can be made.

With these facts in mind, the review by EPA concentrated on determining (1) whether contamination is presently reaching the off-site environment, and if so, in what quantities and (2) if the AEC monitoring program has the capability to adequately predict the present and future impact of the wastes on the environment and man. Critical parameters which were considered to be significant included: the amount and occurrence of ground water recharge; the geometry and physical, hydraulic, and chemical properties of the geologic framework; the hydrogeology of the site (the geologic framework and the liquids contained therein), including interrelation and interconnection of aquifers; interaction of the wastes with the system; changes to the system caused by fluctuations in the level of the Columbia River; extreme meteorologic events, orogenic activity, or climatic shifts which may occur in the future; the place, mode, and amount of discharge from the system; and representativeness and timeliness of sampling and monitoring data used in generating values for these critical parameters.

The AEC has stated that the radioactive wastes in the ground are not an environmental hazard at present, nor do they represent a potential environmental hazard in the future. This conclusion is primarily based on information from their hydrogeological studies, data from the monitoring networks, and mathematical models which predict the travel paths and

transit times of wastes through the subsurface. In spite of the many referenced studies and data, however, we feel that significant technical questions still exist that need to be resolved.

The draft statement relies on data from a base year (1972) to characterize the environmental impact of waste management activities at Hanford. This base year data is also used in estimating the potential environmental effects of future activities. It should be realized that the Hanford waste management operations are dynamic and the impact of wastes previously disposed of may be affected by natural or man-originated activities in the future. A baseline concept is useful, but the use of all past data and not just 1972 data would have more validity.

In preparing for this review, EPA directly requested from the AEC a large volume of technical information it thought necessary to perform an independent assessment of the environmental impact of operations at Hanford. The information was requested to support an independent assessment of : the geologic and hydrologic conditions at Hanford; the monitoring of wastes in the Hanford environment; and the ability to document present conditions and predict the future extent of radionuclide migration in the subsurface. The information supplied by the AEC, prior to the receipt of this draft statement, was not adequate to resolve all of our concerns. According to the AEC, some of the information requested was not available in the form desired or within the time period needed, and some did not exist. The AEC suggested that the most practical approach to resolving many of our concerns would be to hold extensive working meetings at Hanford between technical staff members of each Agency. Unfortunately, this could not be accomplished during the time allocated for reviewing this draft statement, but such a meeting may be held at a later date.

The usefulness of pathway analyses and dose assessments depend, to a great degree, upon the certainty with which the pathways and rates of movement of the wastes are known. Confidence in the ability to predict what will happen to the Hanford wastes in the future is an essential element in deciding on the long-term environmental acceptability of the Hanford waste management operations in the past, present and future. Much of the information previously requested by EPA and in these comments is specifically addressed to meeting this need and, we feel, is essential to support an independent conclusion concerning the ability of the Hanford site to safely contain the wastes stored there.

EXHIBIT 24 (Continued)

During our evaluation, we have studied the reviews by Dr. R. A. Deju and W. K. Summers, (1,2,3,4) consultants to the AEC, who examined the hydrogeological and hydrochemical reports and data available at Hanford. These investigators reported finding several deficiencies in the data from the water level and radiochemical monitoring program. These data are vital to an understanding of the regional hydrology, the definition of the hydrological impact of waste disposal, the hydraulic properties of the aquifers, and the usefulness of the mathematical model specifically developed for use at Hanford.

Based on the information available to EPA, including that presented in the draft statement, that received directly from the AEC, and that available in the reports of Deju and Summers, it is EPA's opinion that the hydrogeologic information presented is not sufficient to support a comprehensive evaluation of the potential for environmental damage presented by the presently stored waste, in both the near or long-term future. We have, however, found no indication that these stored wastes have presented an unacceptable environmental hazard to man or the environment up to the present time.

To reach an unqualified conclusion concerning the environmental safety related to the waste management activities at this site, EPA recommends that a thorough independent review and assessment of the hydrogeological situation at Hanford be made, as also recommended by Deju and Summers. Such a comprehensive study is even more imperative if this site receives further consideration for any other AEC waste programs, such as noted in the AEC's draft statement for their commercial high-level waste management program (WASH-1539). Cooperation of other agencies, such as the U.S. Geological Survey and EPA, should be sought by the AEC in organizing and conducting the recommended evaluation program.

More emphasis should be placed on the development of an environmentally acceptable system for ultimate disposal of these high-level radioactive wastes. This should include an adequate description of a program to develop such a system, the priority attached to such a program and an indication of the

resources required. As EPA commented on the commercial high-level waste management program, we believe that work on promising alternatives should be pursued concurrently because it is realized that there is a risk of failure in any research and development effort.

In our December 4, 1973 comments on the original outline for this draft statement (pages C-164 to C-193), EPA suggested that the AEC, in discussing the continued use of the cribs, trenches, etc., consider the "Recommended Data Requirements for Environmental Evaluation of Subsurface Emplacement of Fluids by Well Injection". These requirements, contained in the Administrator's Decision Statement No. 5 (ADS No. 5), dated February 6, 1973, establish the basic requirements for EPA review of subsurface fluid disposal practices. The information contained in the draft statement does not meet these data requirement and, therefore, no conclusion can be reached as to whether the intent of the EPA policy on this matter has been complied with. The final statement should reconsider this matter and supply the information necessary to resolve this uncertainty.

III. SPECIFIC HYDROGEOLOGY COMMENTS

The detailed comments that follow, taken together, indicate that in our judgment a general independent reanalysis of the Hanford hydrogeology is warranted.

1. The draft statement is incomplete in its presentation of data from supporting hydrologic and geologic studies (with sufficient documentation and references), including the results of any soil investigations related to waste retention in the unsaturated zone. The presentation of actual data in the draft statement, either in tabular, graphical, or figurative form is minimal, and, in the case of some maps, essentially illegible.

2. The hydraulic interconnection of the confined and unconfined aquifers is not sufficiently discussed in the draft statement. There appears to be a clear interconnection, as evidenced by the erosional "windows" in the intervening aquitard (page II.3-435), the potential distribution beneath the 200 Area (1) and the tritium concentrations in ground water from the basalt aquifer (page II.3-D-73). Contrary to what

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is stated on page II.3-38, the water table map presented is not adequate to characterize the present state of the unconfined aquifer. A series of flow system cross sections and supporting data concerning flow rates, volumes, and water quality are also necessary to characterize the existing situation.

3. The fifth paragraph on page II.3-38 incorrectly equates the groundwater potential map with a water table map. Discharge from the unconfined aquifer (page II.3-41) likely occurs not only by evapotranspiration but also by evaporation from either a free water suface (West Lake) or by vapor transport from areas having a high water table, as along the Columbia River. Furthermore, ground water introduced into the basalt aquifer in the 200 Areas may discharge by upward leakage and movement to the unconfined aquifer and to the Columbia River, or it may move to other unspecified areas.

4. In describing the effects of Columbia River bank seepage (page II.1-62), the draft statement does not consider the wastes retained in the sediments and the non-measurable, diffuse discharge from the various sources to the river. Only part of the waste transport (by springs) is described for the present (1972) and under present hydrologic conditions. The final statement should consider other waste fluxes in the springs and the diffuse flow of ground water from the same sources under different hydraulic conditions which are likely to occur in the future.

5. The discussion of Columbia River flooding (page III.2-64) considers only erosion and physical transport, whereas chemical transport by river water or by atypical ground water conditions associated with flooding should also be considered in the final statement. This should be done in analyzing the impact of the various planning floods such as the Probable Maximum Flood (PMF) and the Standard Project Flood (SPF), and also for the lesser floods which may have an adverse impact on the wastes.

6. On page II.3-D-65, it is stated that 90 wells have been drilled to the basalt. The final statement should indicate how many wells are drilled into the basalt, the silts, and the clays of the confined aquifer.

7. In discussing aquifer characteristics, several statements are made, on pages II.3-D-36 through II.3-D-43, relating to input data for assessing groundwater movement. Deju (2) was quite explicit about what he thought were inadequacies of the single well (versus multiple well) tests and time duration

which could give questionable results, depending on the method of data analysis, for transmissivity and permeability. Resolution of differences between the values derived by Deju and those from AEC contractors for both of these parameters and the impact of changed values on the predicted movement of radionuclides should be fully explained in the final statement. We feel that these additional characteristics are also significant for evaluating any waste disposal program involving aquifers and should be included with those stated on page II.3-37. The use of single well tests for developing permeability and transmissivity data for input to the ground-water flow and transport models should be justified in the final statement.

8. The draft statement, on page II.3-D-37, states that the input data necessary for calculating the storage coefficient were not available and that techniques have not been developed for calculating this coefficient. Therefore, we feel that an assumed storage coefficient value, as a basis for estimating effective porosity, is not a valid foundation for model development. The final statement should include a detailed clarification of these and other basic assumptions, or indicate if a program is planned to obtain field-determined storage coefficient values relevant to the flow and transport models for saturated conditions. If available, sensitivity analyses relating the various parameters to model output should be included.

9. In our opinion, since the storage coefficient is assumed rather than calculated from testing, and the values for hydraulic conductivity are in question, we believe that the validity of the computed groundwater flow velocities (page II.3-D-43) is also questionable. Deficiencies in the past and present monitoring system, unfortunately, do not permit the calculated velocities to be field verified.

10. The statements on pages II.3-D-47 through II.3-D-51, concerning digital modeling of groundwater flow and radionuclide transport in the saturated and unsaturated zones at Hanford are not complete enough to permit an independent assessment of the adequacy of the modeling program. Limited field data are acknowledged, but model testing using these data still remains incomplete. The comments by Deju (2) and Summers and Deju (1) for example, largely disagree with the reported state-of-development of the modeling program and the adequacy of the data base as implied in the draft statement and stated in staff discussions with the AEC. Additional infor-

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mation should be included to support the state-of-development of the modeling program.

11. The final statement should clearly state whether average or actual travel times and flow velocities are used in all sections of the text (i.e., Figure II.3-D-16 and discussion on page II.3-D-44) describing actual or projected movement of radionuclides in the Hanford subsurface environment. The first arrival of a radionuclide determined on the basis of actual velocity is an important consideration in judging the acceptability of waste management operations. Reliance on average velocities and necessarily longer travel times may not always be realistic and may, in fact, be a very non-conservative operating policy with respect to minimizing adverse environmental impact.

12. The environmental suitability of the Hanford reservation as a site for radioactive waste management activities relies partly on a determination that the Ringold Formation and Pasco Gravels are generally compact and undisturbed (page II.3-25). Based on the draft statement, the Pasco Gravels may not be compact, as evidenced by their consistently low seismic (P) wave velocities of about 2,000 feet per second (page II. 3-C-14). The reported high load bearing capacity may not indicate compaction, but rather could be explained by the point-to-point contact between cobbles. A broader discussion of this issue should be included in the final statement.

13. The draft statement (page II.3-D-77) indicates that periodic program reviews (other than Deju and Summers) have been made of the Hanford hydrology program. Specific references and results concerning all prior reviews should be included in the final statement.

IV. SPECIFIC WASTE MANAGEMENT COMMENTS

1. In our opinion, the continuing discharge of chemical and radioactive wastes into a crib and trench at the N-Reactor is an environmentally unacceptable practice to follow in a hydrologically active regime like a river bank (page II.1-58). The practice also appears to conflict with the intent of the EPA Administrator's Decision Statement No. 5 ("EPA Policy on Subsurface Emplacement of Fluids by Well Injection") and Executive Order 11752. The assumption that radioactive species, such as strontium, cesium, and cobalt, will accumulate and be retained in the soil presupposes no removal by leaching associated from a rising water table concurrent with river flood stage or other causes.

2. Liquid effluents discharged to ponds and cribs on the Hanford site are reported in the draft statement as being generally low in radioactivity ($< 0.05 \mu Ci/ml$), except for tritium (page II.1-88). It is important to recognize that both the concentration and volume need to be considered in assessing the total impact of radioactivity discharged to the environment. The final statement should clarify this situation and present both concentration and volume data where applicable. Justification for the continued use of the cribs, despite the criticism by the National Academy of Sciences study (5), should be made.

3. Disposal of intermediate and low-level wastes in the 200 Areas, where high-level wastes are also stored, may create ground-water mounds and unnatural groundwater flow directions. This complicates the prediction of the flow directions for future operations should alternatives for handling low-and intermediate -level wastes be adopted. This situation should be recognized and addressed in the final statement.

4. The chemical quality of ground water in the unconfined aquifer is not adequately monitored if, as indicated in the draft statement, only 14 analyses per year are collected on a semi-annual basis from eight (unspecified) locations, and incomplete analyses are performed. The presentation of chemical concentrations near the surface of the unconfined aquifer is necessary for characterizing an adequate flow system. Therefore, the steps to be taken to rectify this apparent weakness in the monitoring program, including a more complete chemical cation and anion analysis (sodium, potassium, calcium, magnesium, bicarbonate, carbonate, chloride, sulfate and nitrate), should be discussed in the final statement.

5. Only part of the waste discharge permit applications (pages II.1-148 and II.1-150) are shown in Appendix II.1-D. Not shown are details concerning concentrations, flow volumes, and chemical species discharged. The practices described on page V-47, concerning chemical release to the Columbia River, are not acceptable to EPA and will have to be changed under the conditions of the forthcoming EPA permit to be issued under the National Pollutant Discharge Elimination System. Effluent limits for nonradioactive waste and an effluent monitoring program will very likely be required. The final statement should indicate that any changes in waste treatment practices needed to meet EPA permit requirements for the discharges described in Appendix D will be made.

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6. The maps provided on pages II.3-44, II.3-46, and II.3-47 are useful in depicting the general location of the chemical discharge plumes extending from the recharge areas. However, we feel that several large areas have not been adequately monitored, hence the shape and extent of the plumes are interpolated. The final statement should include the sampling methods utilized and should present the data obtained so that reviewers can reach a decision as to the adequacy of the groundwater monitoring program.

7. At various places in the draft statement, movement of radionuclides towards the Columbia River from the 200 Areas is mentioned, but it is not clear what constituents are reaching the river now, have reached it in the past, or will reach it in the future. An earlier report by Brown and Haney (6) stated that six to seven percent of the ruthenium and 70 percent of the tritium from the 200-E Area reached the river. Lesser quantities were attributable to the 200-W Area. The final statement should provide information on the quantity of ruthenium that is in an ionic form, which is not retained in the soil (page II. 1-90), an estimate of the quantity of ruthenium, tritium, and nitrate in the ground water, the time of introduction, and the concentration.

8. Estimates of gross beta, tritium, and nitrate quantities in the zone of saturation (unconfined only), as described on page II.1-130, are based on the assumption that concentrations at the water table are representative of the aquifer on the whole. This assumption should be substantiated in terms of other available data, as it presupposes complete mixing, no density stratification, and does not deal with the three-dimensional aspects of the groundwater flow system. The presence of tritium in the basalt aquifer, for example, is indicative of possible deep downward and lateral movement of radionuclides.

9. The illustrations shown on pages II.1-131 through II.1-133 are not legible enough to allow the reviewer to identify specific well locations. Concentration values from the individual wells which were used to create the maps should be provided in the final statement. In our opinion, it may be of more value to a reviewer to show contour lines or isopleths drawn on actual values for the delineation of zones rather than defining the zones as representing a certain percentage range of the

Concentration Guide. Variations in concentrations at sampling points should also be stated to indicate variability in the system through time as well as space. Concentrations of radionuclides in ground water beneath solid waste disposal sites in the 100 and 300 Areas appear to be missing from Table II.1-7 on page II.1-135 and should be included in the final statement.

10. The draft statement (page II.1-156) discusses the usefulness of the nitrate ion as an indicator of the extent of the radioactive waste plume. However, since nitrate is already present in several parts of the Hanford reservation from past agricultural activities, it may not be possible to rely on nitrate ion measurements as being valid indicators of radioactive waste concentrations in the subsurface. The final statement should discuss the continued usefulness of the nitrate ion as an indicator.

11. The presence of tritium in the confined aquifer(s) (page II.3-D-73) raises the possibility of either migration or modern recharge (since 1952) and would indicate the confined aquifer is part of a dynamic system. Therefore, the final statement needs a more complete explanation in terms of radionuclide migration in the subsurface and should also indicate on a map the location of the well which reportedly has the highest concentration (well 299-W11-2-P).

12. Leakage from the 100-N Area disposal trench and crib may occur as both localized spring flow (seepage springs) and as general baseflow or diffuse ground water return flow. The statements on page II.1-5, and elsewhere in the draft statement, do not consider the latter mechanism for this area (100-N), the other 100 Areas, or the 300 Area. The final statement should consider this other pathway mechanism. There is also a need for more quantification of the mass or activity transported in waste materials, both radioactive and nonradioactive, from the AEC reservation to the river. Uranium from the 300 Area North Pond and farm wastes from the 100-F and 300 Areas are currently measured and reported at the source trenches and ponds rather than as a quantity being released to the river. Reliance is apparently placed on the detection of radionuclides in the river water or substrate and, therefore, dose assessment analyses take full advantage of dilution by the river. The presentation of only 1972 data for the 100-N, 100-F, and 300 Areas (pages III.1-7 III.1-9) may be inadequate unless it

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can be shown that these are representative of past and projected conditions. In addition, the time it took the radioactive materials to reach the Columbia River (page II.1-141) should be included.

13. Wastes beneath the cribs and trenches are presented as being fixed in place. This, however, would not appear to be the case, since gravity drainage of the soils will continue to occur, admittedly at a very low rate, which eventually will continue to approach an equilibrium state. The draft statement does not appear to present enough information for the quantitative or semi-quantitative analysis of water and chemical transport through soil beneath the cribs for evaluating either the present situation or for predicting future behavior. The draft statement indicates a downward migration at crib 216-S (page 11.1-C-84) of both cesium-137 and strontium-90 some ten years after use of the crib was discontinued. This would indicate that these nuclides are not tightly bound to the soil column and could present a significant future impact. The causes of this migration, its estimated rate, and evaluation of the migration at other sites needs further discussion in the final statement.

14. It appears from the draft statement, that there is no post-disposal monitoring performed within the soil profile, thus waste fixation in partially saturated soil is calculated on the basis of routine laboratory results rather than field observations. Apparently, field observations are limited to accidental spills, monitoring of radionuclides in the water table, and exploratory drilling/testing to determine antecedent conditions. The final statement should include a more detailed description of the waste volumes present in the unsaturated zone and their future environmental impact under various hydrologic conditions. Information on the distribution of radionuclides beneath two cribs (page II.1-C-81) may not be representative of all cribs used, and therefore, additional documentation is necessary.

15. The radioactivity estimate above the water table as presented on page II.1-129 may represent but a small fraction of the total inventory in the unsaturated zone. In liquid waste disposal areas, use has been made of the entire unsaturated soil column for radionuclide storage, yet the inventory in only the lower 50 feet has been calculated. A complete inventory of the entire unsaturated zone, including changes observed in the past and also any projections made for the future, should be included in the final statement.

16. To allow reviewers to form a clearer understanding of the environmental effects of past waste management practices, the final statement should state what cribs, by area, were used to the point of "break through" and indicate any studies which have been made to verify that the radionuclides are still bound to the soils near the point of entry to the groundwater system. The final statement should also explain how such binding will be affected if the water table rises or falls, and describe the continuing monitoring program which will be used to confirm the conclusions reached concerning the environmental acceptability of the use of these cribs.

17. The average flow velocity from the 1301-N crib to the River Bank Spring is stated in Table II.3-D-13 as 10.8 feet/day. The distance from the crib to the bank is given as 800 feet (page II.3-D-51), indicating a computed travel time or 74 days. However, the minimum travel time is stated as two to four days on page II.3-D-51. This disagreement in travel time values should be resolved in the final statement, and any other calculations based on this value should be reviewed to determine whether they are significantly affected.

18. The distinction between liquid, sludge, and salt cake should be specified in the final statement in terms of liquid content and activity. For example, on page II.1-80, salt cake is referred to as an immobile solid, whereas on pages II.1-70 and II.1-86, salt cake is depicted as being partly liquid and mobile if a tank fails. In the case of the SX tank farm, tanks too leaky or weak for sluicing are being used for waste storage (page II.1-70). Since the sludge contains a high percentage of liquid, changes in the liquid level are used for monitoring leaks (page II.1-78), the final statement should evaluate the environmental impact of continuing to use such weakened tanks for any waste storage.

19. The discussion of in-tank solidification (page II.1-86), states that gravity drainage of a "salt cake," which contains 30 percent interstitial liquid, can proceed for a time period of many years, hence the pumping endpoint (for interstitial liquors) is understandably indefinite. It is further stated that when the maximum amount of liquid is removed from the tanks filled with salt cake from the ITS system, the tank is considered stabilized for interim storage. The final statement should discuss how much liquid is expected to be present in the tanks at the time they are considered stabilized, and what environmental threat this liquid poses if tank integrity is lost.

20. On page II.1-7, it is stated that the SX farm tanks are enclosed by a complex of vertical and horizontal dry wells; yet, on page II.1-87, it states that these tanks have external leak detection systems rather than a network of dry wells. This apparent discrepancy should be resolved in the final statement.

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21. The final statement should discuss the difficulties involved in accurately measuring liquid levels in materials with a very high solids content and whether such levels can be reliably used to characterize the true hydrostatic head throughout the tank.

22. The draft statement indicates that new storage tanks will be built for storage of salt-cake, but lacks sufficient discussion concerning actions to further process the salt-cake into a safer, more manageable and retrievable form. The draft statement does not clearly state what the AEC's intentions are relative to the conversion of the high-level waste to a form suitable for ultimate disposal. Therefore, since assurance that the high-level waste is in a form suitable for final disposal is mandatory for protection of public health and the environment, we believe this issue should be discussed in more detail in the final statement and an indication given of when conversion to a final form will be accomplished.

23. On page II. 1-55, it is stated that solid waste burial ceased in the 100 Area in 1973. The final statement should describe the wastes (type, activity) which are still buried there. Statements on pages II. 1-58 and II. 1-59 indicate that solid wastes from the 100-N Area are present in other 100 Areas. The final statement should also indicate the locations of these wastes as well as quantities by species and their proximity to the maximum and mean water table. These wastes are apparently located in what seems to be a ground water discharge area which would be characterized by a net upward migration of the water, either as vapor or, less likely, as liquid. The possibility of this occurrence and the effect on upward migration of wastes by diffusion or convective transport should be evaluated in the final statement.

24. Solid wastes and solid residues from liquid wastes in the 300 Area as well as in the other reactor areas (page II. 1-60) including the N-Reactor, present a large (page II. 1-26) potential source of contaminants to the ground water and to the Columbia River. The vertical distance from the river, as well as the hydrologic characteristics of the intervening sediments, should be detailed in the final statement for these sites. An evaluation should be made of the susceptibility of the buried materials to not only erosion and physical transport, but also to dissolution and convective movement in flood water or ground water. In particular, the effects of a rising water table, associated with maximum river stages or other causes, should be considered in conjunction with an assessment of waste solubilities. Monitoring programs associated with the terminated cribs, trenches, ponds, burial areas, and contaminated facilities in the inactive (100) Areas should be described in the final statement along with actual data from such programs.

25. On page II. 1-128, the draft statement indicates that the 1.9×10^5 grams of plutonium disposed of as liquid discharge to the soil represents 11,647 Ci. The final statement should indicate whether this plutonium is uncontrolled and irretrievably discharged and, if so, what the long-term environmental implications are for this amount of plutonium contained in the soil.

26. Since land containing transuranium waste is considered unusable for hundreds of thousands of years, an important aspect of waste management is control over such contaminated areas. The final statement should list those specific land areas which contain transuranics in soil or sediments in such forms and quantities that long-term control and surveillance is required. Although recovery from some specific sites was mentioned in the draft statement, a more comprehensive plutonium recovery program seems to be a possible alternative to the current program. The attendant disadvantages and advantages of each approach, insofar as they can be estimated, should be presented in a discussion of these alternatives.

27. Since transuranium-contaminated solid wastes have only been buried since 1970 in readily retrievable, contamination-free packages, (page II. 1-97) more information should be supplied, in the final statement, concerning those transuranic wastes buried prior to 1970 in non-retrievable form. This information should include the long-term surveillance plans, ground water monitoring facilities, and the environmental impact resulting from leaving the wastes buried or recovering the wastes and repackaging them for shipment to a Federal repository.

28. There are three burial grounds mentioned (Table II. 1-E-1) in the 300 Area which are reported to contain fission products and plutonium (No. 1, 300 North and 300 Wye). The depth of the water table beneath these sites varies from 41 to 65 feet. The final statement should discuss the quantities of plutonium buried at these sites and also what potential exists for ground water contamination or translocation of the wastes to the surface due to loss of integrity of the packaging, and in addition, if any of these burial grounds contain liquid wastes.

V. SPECIFIC BENEFIT/COST ANALYSIS COMMENTS

1. The approach taken in the draft statement makes it difficult to identify the benefits of the program. Only a small portion, $265,000, out of a total of approximately $42,000,000 is apparently to be spent on improvements that will reduce population dose contributions for normal operations. The remaining expenditure is to improve radionuclide containment in facilities that "... are already contributing essentially zero population dose" (p. IX-4). Therefore, the major costs of this program are not identified with reduced environmental factors, but are committed to a reduction in the potential for future leaks or

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accidents that could have environmental consequences. Reduction of environmental risk is of course a benefit of a waste management program; however, there is little discussion of this. Where benefits are referred to, they are discussed in the context of continuing the isolation of radioactive materials from man's environment (page I-3) or of maintaining control over waste materials (page I-11).

2. EPA believes that there is justification for upgrading waste management facilities at Hanford, but believes that the need for this upgrading could be better substantiated. An approach which would better identify benefits and facilitate the comparison of benefits and costs of alternative programs should be presented in the final statement.

3. Although the AEC has discussed the alternative programs for waste management, EPA does not consider the discussion of their merits to be adequate to justify the choice of the particular upgrading program being undertaken. This weakness stems at least partially from the inadequate treatment of benefits. However, even if the benefits (possibly defined to be a standard minimum level of environmental damage and a standard reduction of potential for future damages) were treated as given, alternative programs that meet these standards could be compared on a cost basis, with the least cost alternative being the preferred choice.

4. The brief discussion of the operating costs on page IX-2 does not indicate whether the 35 million dollars per year operating costs refer to the incremental costs of operating the upgraded waste management facilities, or whether they refer to something more than incremental costs. In either case, any increment to operating costs that are incurred in the use of any of the alternative programs for waste management should be included as a cost of each alternative. Since these incremental costs will continue into the future, their discounted present value must be added to the capital costs of each alternative before the cost of these alternatives are compared.

5. The discussion of land use does not explicitly state that there are changes in land use commitments associated with different waste management programs. All changes in land use, associated with alternative waste management programs, should be included as a part of the costs of each program.

IV SPECIFIC DOSE ASSESSMENT COMMENTS

1. The concepts and models for the 50-year dose commitment values listed in the draft statement are not adequately described. The model can only be inferred from equation 24 and three lines of text on page III-B-23 and from the concluding paragraph on page III-B-14. The dose calculated is the total dose to an individual over a 50-year period following the accumulation of long-lived nuclides within the body during the subject year of operation. While this integrated dose represents the total impact on the present population for the year's operation, it differs significantly from the EPA concept of an environmental dose commitment which considers the persistence and buildup of long-lived nuclides in the environment. The final statement should include a detailed discussion of the concepts and assumptions used to determine the 50-year dose commitment for the various nuclides.

2. Section III.1.1.1 indicates that maximum release from routine operations can be expected to occur during the 1980's, yet doses from routine releases are calculated based on 1972 data. The final statement should indicate calculations based on projected levels for the 1980's. In addition, the final statement should include dose estimates resulting from tornadoes, earthquakes, equipment-failure accidents, and a ruptured upstream dam, such as the Grand Coulee.

3. The iodine-131 dose conversion factors calculated for inhalation, based on the age dependent parameters presented in Table III-A-5, were compared with those in Table III-A-6, and with those in the Environmental Analysis of the Uranium Fuel Cycle Part II (EPA-520/9-73-003) Table 40. The following table presents this comparsion.

Inhalation Dose Conversion Factor
(mrem/yr per pCi/m^3) for Iodine-131

Age	Calculated from Table III-A-5	Table III-A-6	Table 40 (EPA)
6 months			17.
1 year	17.9	12.5	
4 years	10.6	8.07	42.
14 years	8.57	6.76	15.
Adult	10.4	10.6	8.8

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Although the differences between the EPA and AEC dose conversion factors might be explained by reasonable differences in the selection of the breathing rates, fractional uptake, effective half-lives, and organ masses for the various age groups not specified by the ICRP, NCRP or FRC, the internal inconsistencies between III-A-5 and III-A-6 should be explained in the final statement.

4. Only two age groups are presented in Table III-A-13, a 2 year old and an adult. These values appear to be the ones actually employed for the calculations. The 2 year old is assumed, without explanation, to have the same dosimetric characteristics as the 1 year old in Table III-A-6. This would indicate that the dose assessment is based upon only two age groups rather than the four age groups implied by Tables III-A-5 and III-A-6. These inconsistencies should also be clarified in the final statement.

5. Should the migration of cesium and strontium, indicated in the draft statement (II.1-C-84), be typical at all of Hanford's disposal sites, a long-term estimate of the impact should be presented in the final statement. Based on estimates using present EPA pathway models (7) and assuming no decay of the 1972 inventories of 35,000 Ci cesium-137 and 30,800 Ci strontium-90, (page II.1-C-105, 106), a release of 1% of these inventories each year into the Columbia River could result in a yearly impact of 580 man-rem total body exposure. This is much greater than the Hanford estimate of 2.4 man-rem per year. Although the assumptions used lead to a "worst-case" estimate of the impact, the magnitude of the impact indicates that movement of these nuclides through the soil columns and aquifers could be a significant exposure pathway. The final statement should address this possibility.

VII. OTHER COMMENTS

1. The continuance or discontinuance of the N-Reactor is an important factor in any consideration of alternative waste management practices. It is stated on page v that the N-Reactor is scheduled for shutdown in 1977 or 1978. If this is true, it may be environmentally acceptable to continue operation with only minimal waste management improvements, since the time factor may make additional costs difficult to justify. However, if the N-Reactor were to continue operating for a much longer period, it may become reasonable to consider major modifications to the systems to reduce the liquid and gaseous effluent from the N-Reactor and associated facilities to the lowest level practicable. Due to the sensitivity of the decision making process to the operating

lifetime of the N-Reactor, and the lead time requirements for making major system changes, it is imperative that the AEC carefully review the justification for any proposed extension of the N-Reactor's operating lifetime.

2. In its evaluation of non-radioactive air quality aspects of Hanford operations, the final statement should provide the following additional information:

- The BTU/hr heat input rating of all fossil fuel combustion equipment.
- The BTU/hr value, and sulfur and ash content, where relevant, for all fuels.
- The hourly fuel use rate for each unit.
- Stack height and internal exit diameter for all release points.
- Exit velocity and temperature for all stack effluents.

3. The draft statement, on pages V-50 and V-52 indicates that when the SOx emission standard is decreased to 1,000 ppm in 1975 the 100-N and 300 area power plants will be emitting concentrations approaching, if not in excess of, this reduced standard. The draft statement further states that no apparent adverse environmental impacts have been observed and, therefore, no apparent incentive exists for expenditures to reduce the current release rates. We believe that the AEC should prepare a plan to reduce the SOx emissions from these facilities in the event that these power plants are unable to meet the new standard, or that low sulfur content fuel is not available.

4. The final statement should include information on the perpetual care provisions for the land in which radioactive wastes have been emplaced to date. Regardless of future programs, commitments to these wastes must be made in terms of monitoring and land use.

5. The draft statement does not present a waste management plan for the disposal of contaminated equipment. Such a plan should be discussed in the final statement.

6. The final statement should identify the criteria used in determining unusual releases of radioactivity. No unusual release to Gable Mountain swamp was listed in Table II.1-C-2, although it was stated on page II.1-C-99 that equipment malfunction has infrequently allowed some radiocontaminants to enter this and B pond.

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7. The continued disposal of large amounts of cooling water to open ponds maintains an opportunity for accidental releases of radioactivity to the aquatic environment. The environmental levels of radioactivity in the plants, sediments, waterfowl, mammals, etc., which could result from accidental releases, would be relevant to an evaluation of this disposal practice. Although routine sediment and biota sampling for 1972 are presented, information on environmental radioactivity from past accidental releases, and a discussion of the available controls on subsequent dispersion through waterfowl, etc., should be included in the final statement.

8. The specific detection sensitivity of the road monitor described on page II.1-164 should be given in the final statement for the principal gamma emitting isotopes. Any available alpha and Pu-239 detection capability by road monitoring should also be discussed in the final statement, including the detection sensitivity.

9. The AEC should evaluate the environmental consequences of the drying up of U-Pond and the exposure of the accumulation of long-lived nuclides on the bottom to the scouring actions of the wind. This area could contain as much as 5,000 kg of uranium nuclides, most presumably sorbed within a few centimeters of the pond's bottom. The final statement should contain the details and results of such an evaluation, along with a summary of long-term alternatives to maintaining the pond in its present condition.

10. The source term for the assumed 800,000 gallon tank leak accident included 42,000 μCi of tritium per gallon of waste. Assuming 300,000 gallons of waste becomes trapped as interstitial water within the soil column, then 470,000 gallons, containing 19,000 Ci of tritium, could reach the water table. If this activity required 22 years to reach the Columbia River, the tritium would have decayed to about 5,700 Ci. This is two orders of magnitude higher than the value given on page III.2-13. Similar calculations for the other nuclides listed agreed with the activities presented. The final statement should address the apparent discrepancy in the tritium activity.

11. In its discussion of the Environmental Measurement Program there is no description of the analytical quality control procedures employed. Such a discussion should be provided in the final statement.

12. Table II.3-0 contains two columns of soil measurements without any explanation of the reason for the two sets of values. An explanation clarifying this presentation should be included in the final statement.

13. On page I-6, it is stated that "... chemical contamination and heat waste do not produce a significant impact on the Hanford reach of the (Columbia) river." The location of the river sampling points and some operating data for chemical and thermal effluents should be given in the final statement, particularly for the N-Reactor.

14. On page II.1-87, the final statement should indicate where the external leak detectors are located in the SX, AX, AY, and AZ tank farms.

15. Table II.3-D-15 of the draft statement lists Xe-133 as a discharge product in liquids. Since there is no significant retention of noble gases in a liquid medium this listing should be clarified in the final statement. The table also indicates that seepage data is not available for certain nuclides. The final statement should discuss why this data is not available.

16. EPA will have the responsibility for issuance of a discharge permit which will cover the N-Reactor activities at the site. From the analyses presented in the draft statement (page III.1-61), it appears that the guidelines for dilution zone size may not be met at all times at the N-Reactor discharge points. The final statement should present an analysis of the discharge plume configurations during periods of low river level, so that compliance with the above guidelines may be evaluated.

EXHIBIT 24 (Continued)

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EXHIBIT 25

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January 21, 1975

Dr. James L. Liverman
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U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Liverman:

Pursuant to 40 F.R. 1116, the Natural Resources Defense Council, Oregon Environmental Council, Friends of the Earth and the Sierra Club hereby submit the enclosed comments on the draft environmental statement, Waste Management Operations, Hanford Reservation, Richland, Washington (WASH-1538).

Sincerely yours,

Terry R. Lash

Terry R. Lash, Ph.D
Staff Scientist

TRL:kc

Enclosure

cc: Russell W. Peterson, Chairman
Council on Environmental Quality
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Comments of the

Natural Resources Defense Council, Inc.

on the

Atomic Energy Commission's

Draft Environmental Statement

WASTE MANAGEMENT OPERATIONS

Hanford Reservation

Richland, Washington

(WASH-1538)

Submitted on behalf of:

Natural Resources Defense Council, Inc.
Oregon Environmental Council
Friends of the Earth
Sierra Club

Submitted by:

Richard Cotton, Esq.
Terry R. Lash, Ph.D.

January 21, 1975

EXHIBIT 25 (Continued)

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I

INTRODUCTION AND SUMMARY

The Natural Resources Defense Council, Inc. (NRDC) submits these comments on behalf of itself, the Oregon Environmental Council, Friends of the Earth and the Sierra Club on the Atomic Energy Commission's draft programmatic environmental impact statement (EIS), Waste Management Operations, Hanford Reservation, Richland, Washington (WASH-1538).

Though written under the compulsion of a court order[1/] the draft environmental statement on the AEC's waste management program at its Hanford Reservation offered the AEC a unique opportunity to substantiate its frequently voiced assurances that the large quantities of radioactive wastes at Hanford are managed responsibily and safely without unduly risking serious public health and environmental problems. In addition in pre-draft comments to the AEC we pointed out that

1/ The Natural Resources Defense Council, Inc. (NRDC), Oregon Environmental Council (OEC), Friends of the Earth (FOE), Committee for Nuclear Responsibility (CNR) and A. Donald Ray are co-plaintiffs in a lawsuit (Civil Action No. 3924) filed on August 1, 1973, in the United States District Court for the Eastern District of Washington, which sought a court order requiring the AEC (1) to file an environmental impact statement on its radioactive waste management practices at Hanford and (2) to cease immediately releasing significantly radioactive liquids to the environment. The Plaintiffs and the AEC subsequently entered into a court-approved stipulation which required the preparation and issuance of the draft environmental statement. It is pursuant to the court order based on that stipulation that the present draft environmental statement (WASH-1538) was prepared and issued.

(Continued on following page)

EXHIBIT 25 (Continued)

1/ (Continued from previous page.) NRDC is a national organization dedicated to the protection of a healthy and safe environment. NRDC has about 10,000 members and contributors in the United States. Among the methods NRDC uses to achieve its objectives are: (1) monitoring the activities of governmental agencies to make sure that environmental values are fully considered in decision-making; (2) improving federal agency decision-making which affects the environment by commenting, furnishing information, participating in administrative proceedings, and bringing lawsuits where legal duties are not being fulfilled; (3) providing information and assistance -- both legal and technical -- to individuals and organizations interested in making governmental agencies more responsive to environmental values.

The OEC represents 75 conservation, planning and sportsman organizations throughout Oregon and also has an additional 2,000 individual dues-paying members. For some time, OEC, in its efforts to protect the Oregon environment, has been involved with issues concerning the proper management of nuclear wastes. The Council has worked in conjunction with the Oregon Department of Environmental Quality and the Oregon Nuclear and Thermal Energy Council regarding problems in the transportation and storage of nuclear wastes in Oregon. It has actively participated in two years of hearings on the Trojan Nuclear Power Plant which is located adjacent to the Columbia River, near Portland, Oregon.

FOE is devoted to the enhancement and preservation of environmental values throughout the world. One of the primary functions of FOE is to provide the public with understandable scientific information on matters of public concern. To preserve the environment and inform the public, FOE carries out research, publishes reports, and engages in litigation. Since its founding in 1969, FOE has been concerned about the threat to the public health and safety posed by the disposal and storage of radioactive wastes on the Hanford Reservation.

CNR has conducted a long-standing program of informing the public of the potentials and hazards of nuclear power. It has prepared and distributed numerous educational pamphlets within the United States and around the world; has supplied educational materials for the Congressional Record at the request of congressmen; has testified at several congressional hearings; and has participated in environmental litigation. Several members of CNR have been awarded the Nobel Prize in various scientific fields. In addition, a number of CNR scientists have been elected to the U.S National Academy of Sciences.

2/ NEPA, 42 U.S.C. §§ 4321-4347 (1970).

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> ". . . the programs at Hanford, NRTS, and SRP are the only models by which to judge the AEC's ability to handle safely over hundreds of years the vast quantities of radioactive wastes that will be generated in licensed nuclear power plants. Unless the public can be fully assured that the relatively smaller amounts of wastes generated by nuclear weapons production can be safely managed in perpetuity, there will be no basis for public confidence in the AEC's proposed programs for the containment of radioactive wastes produced in the private sector."

Moreover, by honestly discussing the difficult problems involved and by opening to public scrutiny operations which had been held tightly secret for 30 years, the Commission could have sought to gain needed public confidence in its own competence and reliability. Regrettably, after carefully examining the document which the AEC has produced, we believe the Commission has failed to achieve these objectives.

-3-

A. Major Defects Affecting The Entire Statement Render The Draft Inadequate

The draft statement reveals that the AEC -- despite 30 years of operating experience at Hanford -- has yet to formulate a coherent plan for safely isolating the Hanford radioactive wastes from the biosphere. Furthermore, the draft demonstrates that the Commission has not yet undertaken the inquiry mandated by the National Environmental Policy Act of 1969 2/ to evaluate alternative courses of action and to assess the relative environmental impact of all reasonable alternatives.

EXHIBIT 25 (Continued)

Any program for managing radioactive wastes must acknowledge and confront their two central characteristics: (1) the wastes are extremely toxic to man and (2) they will remain dangerous for periods ranging from hundreds of years to hundreds of thousands of years. As it must, the AEC has acknowl-

edged this fact, in theory at least, by agreeing that "the current inventory of radioactive wastes would be enough to kill several billion people if they could be distributed and administered to those people."[3] The Commission has sought to minimize the danger, however, by arguing that "isolation . . . is the very purpose of the AEC's waste management program," and "it is only to the extent that . . . containment is lost that the degree of toxicity of the materials becomes important."[4]

We agree that the fundamental issue of radioactive waste management is the unavoidable necessity, once such wastes are produced, of containing them over extraordinarily long periods of time. Yet the draft statement submitted on the Hanford waste management program rarely, if ever, considers and evaluates the program from that perspective. The bulk of the statement consists of a general description -- often inaccurate and misleading -- of the Hanford environment and the AEC's experience over the past 30 years at Hanford which has brought the situation to its critical situation today. While the information provided is welcome in raising a 30-year curtain of secrecy, and in affording some basis to assess the acceptability of various waste management practices, the primary purpose of an environmental impact statement is to present in detail decisions which must be made and to assess alternative solutions to the problems

in terms of the potential effects on the quality of the human environment. It is here that the Hanford statement fails most profoundly.

Analytically the Commission must consider four distinct though interrelated problems. First, it must consider and evaluate, in light of its goal of confinement of radioactive wastes, its practices which presently release such wastes to the environment. Second, it must consider whether remedial action must be taken to remedy dangers caused by long-lived wastes already released to the soil at Hanford, both intentionally and accidentally. Third, it must consider all alternatives for the interim storage of wastes for which a long-term disposal plan does not yet exist; these interim plans must be evaluated primarily from the standpoint of their compatibility with acceptable permanent disposal plans. Fourth, and most importantly, the statement must present the alternatives being considered for ultimate disposal. Yet the draft statement virtually does not discuss questions of long-term disposal or

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3/ AEC, Draft Environmental Statement, Management of Commercial High-Level And Transuranium-Contamined Radioactive Waste, WASH-1539, p. 2.3-3 (September 1974). [emphasis in original]

4/ Id.

EXHIBIT 25 (Continued)

remedial action. Its consideration of effluent reduction programs and interim storage plans, though at least presented, falls far short of what is required.

-6-

1. The Draft Completely Fails To Confront The Central Question Of Long-Term Disposal

The primary concern of an effective radioactive waste management program must be to ensure that certain high-level and transuranic radioactive wastes remain isolated from the biosphere for hundreds, or in some cases, hundreds of thousands of years. This is the central issue concerning the management of radioactive wastes at Hanford. Yet the draft statement never confronts this question seriously or systematically. It does not set out the criteria and objectives for a final disposal plan. It presents no analysis of the reasonable alternative means of storing or disposing of the long-lived radioactive wastes until they decay to innocuous levels. And it presents no decision-making plan to provide assurance that an ultimate disposal means for these wastes will be found in time to protect the public health and safety and ensure an environment reasonably free of radioactive contamination.

To the contrary, the Hanford draft environmental statement reveals that the AEC has no plan for permanent containment of the Hanford wastes. In the past, temporary budgetary expedience has clearly been the primary basis for decision-making with little or no consideration given to the paramount issue of long-term disposal. In 1971 the Government Accounting Office formally criticized the AEC for giving "priority to . . . weapons, production, and reactor development activities. . . and to the safe containment of radioactive wastes on an interim basis" while "[a] lesser degree of management emphasis and priority have been given to the activities dealing with the long-term management of such waste."[5/]

5/ General Accounting Office, Progress And Problems In Programs For Managing High-Level Radioactive Wastes, B-164052, p. 68 (January 29, 1971.) [Hereinafter "Progress".]

It is precisely this type of decision-making which NEPA now forbids. And it is precisely this type of decision-making which, for example, created the indefensible dilemma in which the AEC finds itself today in managing the Hanford high-level wastes currently in deteriorating, near-surface storage tanks. To reduce the cost of storage, the AEC initially chose to use carbon steel tanks and to treat the wastes in ways which now make their ultimate disposal more difficult. Budget considerations dictated that no new tanks be built even though the Commission knew that its old tanks had reached the end of their useful lives. By 1967 (and in fact much earlier), the AEC was told by its contractors that many storage tanks were in desperate condition:

> "The integrity of the tanks containing the self-boiling wastes has been significantly impaired. The tank liners are known to be subject to stress corrosion cracking. The re-inforced concrete in tanks at high temperature is under severe stress; the concrete in all of these tanks is almost certainly cracked, and some of the reinforcing steel is probably stressed to the yield point. Five of the SX and one of the A Farm tanks have leaked. Four of these tanks are still in use. . .."6/

6/ P.W. Smith and R.E. Tomlinson, Hanford High Level Waste Management Reevaluation Study, ISO-981 DEL, p. 41. [Hereinafter "Hanford HLW Reevaluation Study.]

Indeed, the 1967 report warned:

> Of major concern is the potential for failure of the underground tanks now in service . . . . While no sound basis has been found for predicting future failures, it seems prudent . . . to conduct operations as though the failure of any given tank is imminent." 7/

Rather than build new tanks, however, the AEC chose to process the wastes by removing the radiocesium and radiostrontium whenever possible and solidifying the remaining liquid waste into a "moist salt cake" in the old tanks. Not surprisingly, in the years while the solidification program has been underway, hundreds of thousands of gallons of the high-level wastes have leaked from the tanks to the soil. Today, as more and more of this waste is solidified in the old tanks which continue to deteriorate, great doubt exists whether -- within a very short time -- the AEC will be able to retrieve the wastes from the tanks. Yet virtually no one believes that leaving the highly leachable salt cake in the near-surface tanks represents the safest permanent disposal method. Indeed, such a solution for permanent disposal would violate virtually every standard the AEC itself has set for disposal of high-level wastes from the commercial sector. Yet AEC officials themselves have acknowledged that its near-term solidification program is working at cross-purposes with the

7/ Id. at 14.

need to provide for a safe, long-term disposal:

> "He [F.P. Baranowski, Director, Division of Production and Materials Management] is. . .carrying out this program of forming salts in the tanks so all the material that is in there is in a salt form with no liquid at all to leak out. Every time he makes it more difficult to leak out he makes my long-range problem more difficult, but this is necessary."8/

Inexplicably and inexcusably the draft statement never evaluates -- in terms of the implications for ultimate disposal -- the dilemma of whether to proceed with the solidification program or to build new tanks. The draft never analyzes the extent to which the wastes are presently retrievable and the period of time during which they will remain retrievable. Thus, the AEC continues its refusal to confront publicly the fundamental issue of long-term disposal -- a delay which is gradually foreclosing options and creating potentially serious hazards, as this one example graphically illustrates.

Moreover, the AEC does not discuss in the impact statement a range of other major long-term problems, including, for example, the ultimate disposal of (1) the large amounts of radiostrontium fluoride and radiocesium chloride accumulating in B Plant storage facilities; and (2) the hundreds of kilograms of plutonium in the soil in the Z-trenches and in the shallow trenches for solid wastes.

By not squarely facing in the draft statement the question

8/ Frank K. Pittman, Director of the AEC's Waste Management and Transportation Division, Hearings before a Subcommittee of the Committee on Appropriations, House of Representatives, 93rd Congress, 1st Session, Part 4, Atomic Energy Commission, p. 176 (April 5, 1973).

of how to contain these highly toxic materials over the necessary centuries or millenia of their toxic lives the AEC has ignored the criterion which should in fact be the primary basis for the decisions.

This crucial and pervasive failure of the draft -- since it lies at the heart of any radioactive waste management program -- by itself requires a new draft EIS, not merely to satisfy NEPA's legal requirement, but because the time for stalling and pretense is now most emphatically past. It is long overdue for the AEC to devise a plan to isolate these wastes safely. To date it has evaded that responsibility. NEPA has now provided the legal tool to force the Commission to act: it must publicly present the alternatives under consideration, publicly present and justify its research program and priorities, and publicly state and commit itself to a decision-making timetable which it can demonstrate will safeguard the public interest.

If the AEC, or its successor ERDA, does not rewrite this draft statement to live up to these responsibilities, NRDC firmly believes the federal courts stand ready to enforce this obligation.

2. Use Of Inappropriate Time Periods To Evaluate Alternatives Improperly Short Circuits The Required Analysis, And Typifies The AEC's Refusal To Fulfill NEPA Requirements

Even when it analyzes shorter-term issues, the draft statement consistently fails to evaluate problems in an appropriate time frame. For example, the AEC declares in the draft that it will not even today cease its long-criticized practice of

EXHIBIT 25 (Continued)

discharging significantly radioactive liquids directly to the soil. But it artificially short-circuits analysis of construction proposals to reduce these radioactive releases from the N Reactor and the Purex Plant by asserting that these facilities will cease operations before the new pollution control facilities could be completed. Yet the scheduled shut-down dates for both facilities have been repeatedly extended on an ad hoc basis in the past, and the Commission has publicly acknowledged it is considering operating both for a longer period of time. The draft's refusal to analyze the obvious possible alternative that these facilities may operate beyond 1977 and to analyze the effluent reduction alternatives in the event they do fails to comply with NEPA's mandate to consider all reasonable alternatives. It also represents an affront both to common sense and to any effort at rational planning.

This short-sightedness and decision by unexplained fiat typifies the draft statement and reflects the AEC's apparent unwillingness to treat the NEPA process seriously and to treat the draft statement as a decision-making document. The AEC knows what such a document would look like. The Hanford HLW Reevaluation Study provided the type of analysis necessary to choose among various alternative methods for treating the high-level wastes. Examination of documents produced by the AEC and by its contractors emphasizes that the AEC does not lack the ability or the know-how to write such a document; its failure to do so suggests rather the AEC's unwillingness to face up to potentially expensive

decisions under the accountability of public scrutiny.[9/]

3. Throughout The Draft, Analysis of Available Alternatives Is Totally Inadequate

Throughout the draft statement, the AEC consistently fails to provide an appropriate analysis of the reasonable alternatives open to the Commission. The discussion of alternatives should be presented coherently and consistently, with a detailed comparison of the costs and benefits of each alternative together with a complete assessment of the environmental impact of each. Yet, no attention is ever paid in the draft, for example, to analyzing whether the selection of one alternative at one point in the decision-making process will affect subsequent options. The draft never analyzes how the alternatives posed for handling the AEC's radioactive wastes at Hanford compare with the methods and standards being developed for handling radioactive wastes generated by commercial nuclear power stations. It consistently appears that the AEC applies considerably less rigorous standards to its own waste disposal problems

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9/ Nowhere is this reluctance more apparent than in the Commission's continued foot-dragging in even writing environmental impact statements in the first place. A federal lawsuit was required to produce the present programmatic statement. Although the present draft statement claims EIS's on individual projects will be prepared as required by NEPA (pp. viii, I-11, VII-2), the Commission provides no indication as to what activities will require an EIS. Interestingly, the draft identifies several major projects that apparently have not been assessed in individual EIS's, e.g., (a) Waste Encapsulation and Storage Facility [p. II.1-65], (b) Effluent Control - B Plant [p. V-25] and (c) retrievable burial system for transuranic waste [p. V-45]; while it fails to mention the two EIS's which the Commission has prepared on Hanford projects: a new high-level waste evaporator (WASH-1521) and the proposal to dig up the Z-9 trench (WASH-1520).

than it does to the commercial sector; no explanation or justification for the difference in treatment appears in the draft.

Moreover, the draft never places the decisions to be made in a coherent structure. Most options involved require substantial lead time for research, construction and implementation. Decisions will have to be coordinated, and the consistent failure of the draft to present clearly what the decisions are that have to be made, when they have to be made, what criteria and objectives the choice should be based upon, and the extent to which each alternative satisfies these criteria and objectives further marks this draft statement as little more than an effort to satisfy the form of NEPA's requirements without engaging in the solid substantive analysis which the Act mandates.

4. The Draft's Extensive Factual Presentation Consistently Fails To Assess Cumulative Effects, Contains Misstatements, and Utilizes Potentially Unreliable Data

In short, it is our view that the draft statement confirms beyond question that during the past 30 years at Hanford the AEC has been largely guided by a desire not to spend money and an obstinate refusal to heed responsible criticism. Indeed, the draft statement strongly suggests that this perspective continues unabated today. By implication, however, the draft statement does defend as safe the AEC's waste management practices at Hanford. This defense lies in the mass of detail purporting to show that the Commission's practices have not yet and will not ever lead to the escape of significant quantities of radioactive materials from the Reservation.

In our judgment, the Commission has not only failed to make its case, but it has also stretched, manipulated, at times misstated and too frequently ignored the available evidence in its attempt to put a good face on a questionable record. The draft statement fails to assess fully and fairly the cumulative adverse effects of past waste management activities and never discloses the substantial uncertainties regarding the margin of safety in continuing current waste management operations at Hanford. Through the misrepresentation of misleading, controversial and inaccurate allegations[10/] as facts, the AEC tries to give

10/ For example, first at p. I-6, the statement declares, "No deleterious effects to the numbers of or species of terrestrial or aquatic life have been observed during 30 years of Hanford operations." The implication that no harm has ever come to any living organism as a result of activities at Hanford is absurd on its face and is flatly incorrect, even being contradicted elsewhere in the impact statement (e.g., p. III.1-61.) See also the Comments on the Hanford EIS by the Department of Interior. Second, at page II.1-78, the draft statement declares, "Extensive piping interties exist within and between tank farms so it is possible to transfer liquid to or from any tank in the system." Again, this appears to be a plain misstatement. In his comments, an employee of the contractor which operates the tank farms writes, "we just don't have this capability." Moreover, when the massive 115,000 gallon leak was discovered in Tank 106-T, the contractor had to lay emergency piping on top of the ground to pump the tank out.

EXHIBIT 25 (Continued)

the impression that it has adequately protected the public interest in the past and that it will continue to minimize risks to the public health and safety and keep the release of radioactive materials to the environment at an acceptable level in the future.

However, the draft statement's factual presentation never indicates the extent to which there are the usual measurement uncertainties about the accuracy of data and the extent to which contrary or conflicting data or opinion exists. On the basis of our examination of the draft statement and the additional information to which we have had access, we believe that the AEC has not and cannot demonstrate on the basis of existing evidence that the radionuclides in the Hanford soil will not migrate to the Columbia within their toxic lives. Indeed its unqualified effort to do so in the draft statement, without admitting the real uncertainties which exist, highlights its apparent willingness to distort and stretch data far beyond the limits of accuracy in order to justify its viewpoint.

Even more disquieting, however, are the continuing indications that at least some of the basic data which the Commission has developed are unreliable and that old conclusions are repeated even in the face of recent contradicting evidence. For example, an assessment of the threat posed by the massive amounts of radioactive material currently stored in the Hanford

soil obviously depends fundamentally on a determination of whether that contamination will ever reach the groundwater. In a series of reports to the AEC, the existence of which are mentioned only in passing deep in an appendix to the draft statement, Dr. Raul Deju, an independent university scientist, has sharply criticized the accuracy and reliability of the AEC's information on the hydrology and geo-hydrology of the Hanford Reservation and the AEC's groundwater testing programs.

In commenting on the quality of the tests run in the unconfined aquifer at Hanford, Dr. Deju wrote that "no planning and little care was employed by Battelle in running or supervising . . . tests" and that "Battelle's interpretation of the pumping tests is even poorer being based on techniques that are not applicable to the data collected."[11/] Similarly, Dr. Deju specifically observed that the pump testing techniques utilized by AEC contractor personnel at Hanford were done without benefit of necessary observation wells, that "most of the tests that were run are too short for any reasonably accurate interpretations," and that "given the poor quality of the tests, a comprehensive evaluation technique was not possible."[12/]

11/ R. Deju, Draft Report "The Hanford Field Test Program," p. 14 (May 1974). [emphasis in original.]

12/ Id.

In general, we find that this draft statement represents mainly a not terribly successful attempt to justify past and current policies and activities instead of the fair, detailed analysis required by NEPA. In enacting NEPA, Congress intended to improve agency decision-making by requiring full disclosure of the environmental effects of all reasonable alternatives available to an agency to facilitate choices appropriate to the new national policy to preserve a clean environment for future generations. This draft statement frustrates NEPA's purpose by obfuscating the issues instead of highlighting, as it should, the crucial decisions that have to be made if the vast quantities of radioactive wastes on the Hanford Reservation are to be safely contained. In short, the draft statement represents a public relations document which never provides either the information or the analysis that would be useful for decision-making purposes.

B. Specific Omissions And Inadequacies Further Violate NEPA's Requirements Of Full Disclosure

Specifically, the following major deficiencies exist in the draft statement:

1. The discussion of possible ways to store permanently or dispose ultimately the long-lived hazardous radioactive wastes is so abbreviated and uninformative as to be virtually useless for decision-making purposes. No effort is made to formulate safety criteria, objectives, or a timetable for making decisions, and the Commission's current research priorities are neither explained nor justified. Furthermore, there is no systematic attempt to correlate the current practice of removing the high-heat generating isotopes, strontium-90 and cesium-137, and partially dehydrating the bulk salt wastes, to a satisfactory long-term storage means. As a result it is simply not possible to determine whether or not current policy is compatible with an acceptable long-term containment solution.

2. The draft contains virtually no cost/benefit or cost/risk analyses pertaining to the permanent storage or disposal of high-level and transuranic radioactive wastes and to the continued discharge of significantly contaminated liquid wastes to disposal facilities which rely upon soil columns to retain the radioactivity.

3. There are no plans presented for the decommissioning of buildings and facilities significantly contamined with long-lived radionuclides, such as the nine plutonium-production reactors along the Columbia River and the Purex Plant.

4. Measures to mitigate the possible adverse effects of past practices of storing radioactive materials in the soil are not analyzed. Such measures, which are described in documents in the possession of the AEC, include, inter alia, removal of solid transuranic wastes from shallow earthen burial trenches and removal of plutonium from earthen, open-bottom cribs.

5. The discussion of land use restrictions that need to be imposed at the Reservation and surrounding areas is wholly

inadequate. For instance, the draft fails to determine or analyze whether or not (a) the proposed Ben Franklin Dam can be constructed without interfering with radionuclides sorbed to the soil, (b) extensive irrigation can be permitted on lands around the Reservation, (c) a nuclear park, with up to 30 large nuclear power plants and supporting facilities could be established at Hanford without jeopardizing the safety of current waste management techniques, or (d) a so-called retrievable surface storage facility for the interim containment of commercially-generated radioactive wastes could be constructed without having to change existing waste management policies and facilities.

6. No consideration is given to the possibility -- indeed the probability -- that the N Reactor may operate beyond 1977 either in considering proposals to reduce radioactive releases from the N Reactor or in estimating the total wastes which will have to be managed at Hanford. Nor is there any evaluation of the consequences for waste management of reprocessing commercial spent fuels in the Purex Plant, even though that suggestion has been raised in recent Congressional hearings in response to the acute shortage of commercial spent fuel storage and reprocessing capacity.

7. Although AEC regulations require that releases of radioactivity to the environment from any AEC installation be "as low as practicable", the draft statement provides no detailed criteria for applying this standard to the important effluent reduction projects which the AEC admits are technologically possible at Hanford.

8. The cumulative and projected radiation exposures to Hanford workers are not considered at all. These exposures may account for most of the immediate radiological effects to humans resulting from operations at Hanford.

9. Inaccurate and unreliable data is presented or used in discussions concerning the extent of radioactive contamination of the Hanford environment and the geohydrological conditions of the Hanford Reservation. For instance, recent findings and uncertainties about the mobility of plutonium in Hanford soils are not discussed.

10. Inadequate techniques are used which probably seriously underestimate the adverse radiological effects of radioactive releases. In particular, there is virtually no consideration of the "environmental dose commitment" resulting from routine or accidental emissions of radioactivity.

11. Controversial, false or misleading allegations are scattered throughout the statement. Two examples are representative: (a) the conclusion in the draft EIS that precipitation at Hanford does not percolate to the water table is not conclusively supported by recent documents in the AEC's possession; (b) the AEC has been informed previously by other governmental officials that its conclusion in the draft EIS that the thermal effluents from Hanford reactors have a benign effect on juvenile salmon in the Columbia River is illogical and unsupportable by scientific studies.

12. Professionally qualified, critical opinions about many aspects of Hanford operations are improperly omitted entirely. Specifically, no meaningful reference is made to the May 1966 National Academy of Sciences report, two General Accounting Office analyses and the evaluations of Dr. Raul A. Deju, a consultant to the Atlantic Richfield Hanford Company.

13. Conceivable major accidental releases of radioactive materials to the environment are improperly ignored either entirely or by categorizing them as "incredible" without further explanation. For example, there is no analysis of the prompt (accidental) release of radioactivity from the N Reactor.

14. The potential consequences of terrorist or military attacks on the waste management facilities are not adequately evaluated. Instead, it is assumed without analysis that sabotage or attack would not result in any more severe effects than the small accidents which are considered.

C. Recommendations: Independent Review Is Required

In spite of the fact that this draft statement was a year in preparation at substantial cost to the public[13/] it is virtually useless for its intended purposes. In our opinion, the AEC or its succesor, the Energy Research and Development Administration (ERDA), does not have the will and/or the capability to start anew and prepare an adequate draft environmental impact statement. Bluntly, it seems unlikely to us that the individuals

[13/] It was estimated that $1 million and 15-20 man-years of effort would be needed to prepare the environmental statement. (p. C-199).

and organizations who have been responsible for operating the waste management programs at Hanford can fruitfully be asked to investigate and evaluate their own work.

But the problems at Hanford are serious and need to be analyzed quickly and thoroughly. Therefore, we urge that ERDA fund an independent interagency task force with a strong mandate to review comprehensively and assess in detail the adequacy of the entire radioactive waste management program at Hanford. This task force should include representatives from the States of Oregon and Washington, the general public and knowledgeable university scientists, as well as the relevant federal agencies, including the Department of the Interior (especially the United States Geological Survey), the United States Environmental Protection Agency, the Department of Defense, the Department of Health, Education and Welfare and the National Marine Fisheries Service within the Department of Commerce. Such a task force should conduct a one year intensive study of the Hanford waste management program and report publicly to the Administrator of ERDA its findings and recommendations. This report would then provide the basis for ERDA to prepare an adequate EIS, and would assist the National Regulatory Council (NRC) in its deliberations on the licensability of any facilities at Hanford which are intended for the long-term storage of high-level radioactive wastes. Such a report would also make a valuable contribution to the developing national debate over the appropriate method of disposing of radioactive wastes.

EXHIBIT 25 (Continued)

We hope ERDA chooses to break from the AEC's insular and defensive past and seek, as we have suggested, objective, outside consultation both to assure the selection of the best course of action as well as to gain for itself some much needed public credibility. But regardless of ERDA's choice, the agency has a heavy responsibility to meet under the Atomic Energy Act to protect the public health and safety and under NEPA to minimize environmental degradation. Moreover, under the Energy Reorganization Act of 1974, ERDA no longer has a free hand to proceed as it alone chooses in formulating a waste management program. All long-term storage facilities at Hanford must be the subject of a licensing hearing by the Nuclear Regulatory Commission to determine their safety. The necessary predicate to ERDA's fulfillment of its responsibility under all of these statutes is the preparation of a new draft environmental impact statement which meaningfully addresses the issues.

In the following sections we discuss some of the more specific and technical omissions and analytic failures which render the statement inadequate as a programmatic impact statement by the standards which have been established under NEPA.

II

THE DISCUSSION OF HIGH-LEVEL WASTE STORAGE AT HANFORD IS INCOMPLETE, MISLEADING AND DOES NOT ADEQUATELY CONSIDER THE CUMULATIVE ENVIRONMENTAL EFFECTS OF THE PRESENT PROGRAM AND THE REASONABLE ALTERNATIVES

Most of the radioactivity in wastes at Hanford is located in the more than 150 underground tanks (p. II.1-127) and in the above-surface water-cooled basins within the B Plant and its adjacent Waste Encapsulation and Storage Facility (p. II.1-65). Therefore, the focus of the draft statement should have been to describe for these wastes the alternative ways of providing ". . . the greatest assurance practicable of isolation from man's environment, with little reliance on human surveillance and intervention, for the period of time the radioactivity in the waste will be biologically hazardous."[14/]

The alternatives to be considered in the draft statement for the long-term storage or disposal of the high-level wastes must be consistent with the following overall objective of the AEC's policy for the management of its own radioactive wastes:

> "The basic and fundamental objective of this Plan is to handle these wastes at all times in a manner: (1) that will not endanger the health and safety of

14/ AEC, Plan For The Management Of AEC-Generated Radioactive Wastes, WASH-1202 (73), p. 4 (July 1973). [Hereinafter, AEC Plan]

> its employees or the public; (2) that will not have an adverse impact on man's environment or on the ecology; and (3) that will be accepted by the public."15/

The draft statement does not set forth such a plan. Rather the statement is restricted to a general discussion of the interim storage of these high-level wastes for the next few years. Thus, the draft statement is deficient at the most basic level, both in terms of complying with the Commission's overriding general waste management policy and in meeting the requirements of NEPA for detailed evaluation of the long-term potential cumulative environmental effects of a proposed program and its reasonable alternatives.

The draft statement describes the current program at Hanford as follows:

> "The solidification of the liquid waste along with the use of high integrity tanks to contain the liquids in interim periods is considered to be the current program for the high-level waste. The objective of this program is to continue to maximize the isolation of the high-level waste from man's environment.
>
> The current waste management program also includes research and development to determine the best ultimate disposal method for the salt cake by focusing on alternative solid forms and storage methods which would have minimum dispersability characteristics over very long periods of time."(pp. v-vi)16/

15/ Id. at 6.

16/ Unless otherwise indicated, page numbers refer to pages in WASH-1538.

This program clearly does not meet the stated goals and objectives as articulated in the AEC Plan, and, furthermore, is internally inconsistent. First, simply storing liquid and moist salt cake/sludge wastes in near-surface tanks that have essentially reached the end of their useful life times does not satisfy the objective of assuring the greatest practical isolation of the in-tank wastes throughout their hazardous periods without significantly relying on human surveillance and intervention. Simply put, the tanks themselves cannot be relied upon to contain the wastes any longer. Therefore, virtually complete reliance will have to be placed upon the geohydrological properties of the Hanford Reservation17/ and the maintenance of a permanent work force to monitor the possible movement of the wastes and, when necessary and if possible, to take corrective measures to minimize human exposure due to dispersal. This aspect of the program, then, is not consistent with the overriding criterion for "little reliance" on continued human action to maintain the wastes safely, and

17/ Despite the necessary reliance of any in-tank storage program on the geohydrological properties of the Hanford Reservation, AEC personnel publicly deny such reliance:

> "There is no deliberate use of favorable characteristics of any environment in planning high-level waste management programs by the AEC. Positive containment of the wastes continues to be the design objective for all facilities which handle high-level wastes."
> W. Lennemann, Chief, Chemical Processing Branch, Division of Production and Materials Management, US AEC, "Management of Radioactive Aqueous Wastes from USAEC's Fuel Reprocessing Operations, Experience, and Planning," at p. 12(1972).

EXHIBIT 25 (Continued)

certainly cannot be seen as the way "to maximize the isolation of the high-level waste from man's environment."

Second, the objective of the past Hanford program is grossly misrepresented by the description of the waste management program in the draft statement. Historically, the short-term safety of storing high-level liquid wastes at Hanford has been increased by the ion exchange capacity of the soil overlying the ground water. No serious attempt has been made in the past "to maximize the isolation of the high-level waste from man's environment."[18/] If that, in fact, had been the goal in the past at Hanford, the high-level liquid wastes would have been removed from the near-surface tanks, solidified into a low-leachable form and placed in a deep geologic formation many years ago. And, this would have been accomplished before nearly 450,000 gallons of high-level liquid wastes, containing over 200,000 curies of cesium-137 alone, leaked out into the soil -- certainly part of man's environment. (p. II.1-C-134.)

In sum, the draft statement describes a waste management program at Hanford that is inconsistent with the long-range goals and objectives which the Commission has stated elsewhere for the storage of AEC-generated wastes. Additionally, that description is seriously inaccurate regarding the past and current goals of the Hanford program. Furthermore, there is no detailed discussion of the Hanford research and development

18/ Emphasis added.

program to support the claim in the draft statement that there eventually will be a determination of "the best ultimate disposal method for the salt cake."

The draft statement also fails (1) to characterize adequately the existing high-level wastes and to project the possible future generation of wastes beyond 1977; (2) to describe clearly the relationship of the current program to possible permanent storage or disposal options; (3) to assess fully the cumulative environmental effects of Hanford's 30-year practice of storing high-level wastes in tanks; (4) to assess fully the possible future environmental impact of the current program; and (5) to consider in detail all reasonable alternatives to the separable parts of the program.

A. The Draft Statement Should Have Characterized In Meaningful Terms The Nature And Amounts Of The High-Level Waste Materials That Must Be Contained Now And In The Foreseeable Future

To state what should be obvious, it is necessary to set forth clearly and precisely the nature and magnitude of the problem under consideration. This draft statement never does that.

1. The Definition Of Wastes And The Description Of Existing Waste Inventories Are Inadequate

Because the focus of the draft statement is the management of radioactive wastes, at the outset, special care should have been taken to characterize the nature of the various kinds of wastes generated at Hanford. Of particular importance, of course, are the high-level wastes. Unfortunately, the Glossary does not provide enough guidance to understand the precise nature of the wastes described as high-level in the draft.[19/]

What is needed is a clear explanation in the Introduction or elsewhere of the various types of waste streams that come under the definition of high-level waste that has been used at Hanford since operations began. The information provided should include the types and concentrations of the critical radionuclide constituents in each type of waste stream, as well as the chemical composition of the waste streams.

Furthermore, the characterization of the different types of wastes at Hanford should have included the use of parameters

19/ "high-level liquid waste -- fluid materials, disposed of (by storage in underground tanks) from Hanford operations, which are contaminated by greater than 100 μ Ci/ml of mixed fission products or more than 2 μCi/ml of ^{137}Cs, ^{90}Sr, or long-lived alpha emitters." (p. C-8.)

that indicate the degree and time period of toxicity.[20/] Parameters that have been suggested include "inventory commitment"[21/] and the amounts of water[22/] or air required to dilute the waste to the maximum permissible concentration.[23/]

After clearly defining all the categories of wastes at Hanford, the draft statement should have presented in detail the existing locations and amounts of each category of waste. While this was done to some extent, particularly in regard to relatively low level solid wastes and heavily contaminated soil, important information is missing about the high-level wastes, the wastes of principal concern. For instance, the complete radionuclide inventory of each tank should have been listed to the extent currently known. Instead, only the total amounts of strontium,

20/ See A. S. Kubo and D. J. Rose, "Disposal of Nuclear Wastes," Science 182, p. 1205 (December 21, 1973).

21/ See, AEC, draft environmental statement, Management of Commercial High Level and Transuranium-Contaminated Radioactive Waste, pp. A.2-7 et seq. (September 1974).

22/ M. J. Bell and R. S. Dillon, The Long-Term Hazard of Radioactive Wastes Produced By The Enriched Uranium, Pu-^{238}U, and ^{233}U-Th Fuel Cycles, ORNL-TM-3548 (November 1971).

23/ See, Battelle Pacific Northwest Laboratories, High-Level Radioactive Waste Management Alternatives, BNWL-1900, p. 3.43 et seq. (May 1974).

EXHIBIT 25 (Continued)

cesium, and plutonium anticipated to be in all of the tanks in 1980 are presented. (p. II.1-127 and II.1-C-103.)[24/] Furthermore, the accumulated amounts of strontium-90 and cesium-137 that are currently stored in the B Plant and the Waste Encapsulation and Storage Facility are not given.[25/]

Parelleling this enumeration of amounts of each critical radionuclide in each tank, there should have been an analysis of the chemical composition of the waste and the current status of each tank; e.g., Is the tank an identified or suspected "leaker"? Does it contain salt cake and/or liquid? For what period of time will the tank's integrity allow retrieval by sluicing?

Presumably, the detailed information about the amounts of strontium-90 and cesium-137 in the underground tanks and in the B Plant basin is not presented on national security grounds. However, the mere assertion that "[s]pecific details that would reveal classified weapons material production rates are, of course, not included" is wholly inadequate as a reason for not providing information in a NEPA statement. The Commission must explain in detail why knowledge of prior weapons material production rates at Hanford -- a virtually abandoned facility in these terms -- would be inimical to the national security.

As was recognized well over two years ago, "To declare the existing tank waste storage system adequate for the long term requires a comprehensive understanding of the waste and its present and possible environment."[26/] Because this type of information is not in the draft statement, a detailed assessment of what needs to be done to contain the underground tank wastes safely during an interim or longer storage period and the difficulties in retrieving the wastes at some future time cannot be determined in detail.

2. There Are No Detailed Projections Of Wastes That May Be Produced At Hanford In The Future

Essential to planning for the storage or disposal of wastes at Hanford is an assessment of the magnitude of the problem that may be faced. It is necessary to estimate the amounts of wastes by category that may be generated and stored at Hanford in order to plan effectively for their containment. The draft statement fails to do this adequately.

24/ The computer print-out (Appendix II-D) of a hypothetical inventory of waste radionuclides generated in the N Reactor is of little assistance in this regard because the actual wastes in the tanks came from various sources under significantly different conditions than assumed in the example.

25/ It has been reported that 10,700 gallons of cesium-137 and 13,500 gallons of strontium-90, both as highly concentrated solutions, are stored in the B Plant. This volume of strontium-90 evidently represents approximately 40 million curies. (Hill Williams, "Radioactive Garbage out of sight but not out of mind," The Seattle Times, p. A8 (September 26, 1973).

26/ A. E. Smith, "Technology Development for Long-Term Storage Tanks," in Forsman and Schmidt, Management of High Level Radioactive Wastes at the Hanford Site, p. 47 (September 1972).

While no estimates of future accumulations of radioactive solid wastes and releases of the various kinds of radioactive liquids and gases are provided, the draft does project that the Purex Plant will generate an additional 4 million gallons[27/] and that unspecified research and development projects will generate another 5 million gallons through the end of FY-1978 (p. V-16). This estimate is evidently based on the assumption that the N Reactor will permanently cease operating in 1977 or 1978 (p. v) and that the Purex Plant will close down after processing the inventory of spent fuels from the N Reactor.[28/]

However, this is not the only possible scenario. In fact, it seems unlikely that the N Reactor will after all shut down in the near future. Previously, projected termination dates for the N Reactor operations have been consistently extended. After Dr. Glenn T. Seaborg, in his capacity as Chairman of the AEC, announced on January 28, 1971, the immediate shut down of the N Reactor,[29/] extensive discussion with the Governor and other officials of the State of Washington and the Washington Congressional Delegation led to the extension of the N Reactor operation to July 1, 1974. Subsequently, N Reactor operation was extended twice more, first to July, 1975, and then to November , 1977. The existing contract, at the option of the utility customers, permits still another extension of N Reactor operation to July, 1978.[30/]

The Pacific Northwest utilities foresee a shortage in generating capacity through the early 1980's. On November 21, 1973, Senator Jackson wrote to the AEC about this problem and requested an early commitment to an extension of the N Reactor:

> "The Northwest is facing electrical power shortages throughout the decade of the 1970's and into the 1980's. It does not seem appropriate that such a valuable energy resource as the NPR should be shut down during that energy shortage."

Indeed, the utilities and the Bonneville Power Administration are planning on WPPSS obtaining an "indefinite" extension of N Reactor operation as part of the second phase of the Hydro Thermal Power Program.[31/]

27/ There is some discrepancy in estimates of the amounts of high level waste generated each year during operation of the N Reactor and the Purex Plant. At one place the draft states that " . . . the operation of N Reactor and the Purex processing plant results in the generation of approximately one million gallons of high-level waste each year." (p. V-4) However, at other places it is estimated that approximately 600,000 gallons of liquid waste from the N Reactor are sent to the 200 Areas for in-tank storage each year (p. II.1-58) and that the Purex Plant generates about 225,000 gallons of high-level waste per year (p. V-12). This is a total of only about 825,000 gallons or roughly 17% less than the 1 million gallon estimate.

28/ The time required to process the existing inventory and the irradiated fuel produced through FY-1978 evidently would be about six years. (p. V-13).

29/ Hearings before the Joint Committee on Atomic Energy, 92nd Cong. 1st Sess., February 3,4, and March 2, 1971, Part 1, at 53.

30/ Washington Public Power System, Environmental Report, "WPPSS Nuclear Project No. 1, 1300 MW Nuclear Power Plant, Relocated Site," Amendment 1, July 1974, p. 1.0-2.

31/ General Accounting Office, Pacific Northwest Hydro-Thermal Power Program -- A Regional Approach To Meeting Electric Power Requirements, B-114858, p. 31 (June 5, 1974).

Thus, the history of previous extensions strongly suggests that the N Reactor will operate far beyond 1977, particularly in light of the substantial political pressure to do so. The continued operation of the N Reactor is significant not only in terms of the generation of more high-level wastes, but also in terms of the continued discharge of substantial quantities of radionuclides into the environment.

Similarly, an argument can be made that the Purex Plant may operate substantially longer than indicated in the draft statement. If the N Reactor operates past 1977, it is highly likely that the operating life of the Purex Plant will also be extended. Additionally, the Purex Plant may be put into service to process commercial spent fuels.

Since no commercial spent fuel reprocessing capacity will exist for at least another two years, former Congressman Craig Hosmer suggested that "there now appears little alternative but for AEC to reopen its Purex facility at Hanford."[32/] Due to the substantial economic and technical difficulties the private sector is encountering in building operational reprocessing plants, the expense and time required to modify the Purex Plant to process commercial spent fuels may be much less than the cost of building an entirely new facility. Obviously the possibility that the N Reactor and/or the Purex Plant will operate for longer than is now indicated in the draft statement should have been explored in detail.

32/ Nucleonics Week, July 25, 1974, p. 1.

The importance of projecting future waste generation in order to plan adequately was emphasized by an AEC spokesman as follows:

> ". . .management of radioactive wastes cannot be on a year by year or short term basis but must be anticipated, analyzed and planned years in advance."[33/]
>
> * * *
>
> "[T]he effect of operations on waste generation and waste management projects must be considered and analyzed years in advance so facilities and equipment will be there when needed.
>
> It takes several years to fund, design and construct a set of waste tanks. (For instance, it takes the AEC about five years.) Many things which can influence waste generation and consequently the requirements for additional waste tanks can occur in the meantime. Fuel loads change and equipment may operate better or worse than expected, that is, on stream time may change. There can be process upsets or improvements, technological and flowsheet changes, etc. In planning for additional waste tanks, all of these possibilities have to be evaluated and alternative situations assessed and analyzed."[34/]

It is regretable that the Commission refuses to do the kind of advanced planning that is required by NEPA and that is necessary to manage properly the radioactive wastes at Hanford.

33/ Lennemann, op. cit., p. 1

34/ Id., p. 17.

B. The Draft Statement Should Have Described Clearly The Relationship Of The Current Program To Possible Permanent Storage Or Disposal Options

1. From The Beginning The High-Level Waste Management Program Has Suffered From Lack of Planning And Adequate Funding

The first high-level radioactive liquid wastes were poured into "soft" carbon steel underground tanks at Hanford during 1944.[35] More chemically resistant stainless steel was not used for those first tanks at Hanford because it was substantially more expensive and not readily available during the war years.[36] Then, having established what was thought to be a satisfactory interim storage means -- alkaline slurries in carbon steel tanks -- the system was not changed even though the chemical process waste streams changed dramatically during the early 1950's. (p. II.1-20.) During the first decade of operations at Hanford very little thought evidently was given to the long-term high-level waste storage problem. Thus, when new carbon steel tanks were used, "[t]here was no consideration involving subsequent waste handling and treatment because no such methods had been developed."[37]

It was not until 1957 that the development of a long-range waste management program at Hanford was initiated.[38] By that time, however, the situation was already rapidly deteriorating. The first tank leak is reported to have occurred in 1958.[39] There were four more leaks by the end of 1960. The seriously weakened state of some of the high-level waste tanks has been described as follows:

> "Analyses of the stresses induced in heated reinforced concrete tank structures have revealed that some of the reinforcing steel is being stressed beyond design limits. While a modification of operating procedure was sufficient to hold the stress within acceptable limits in the nonboiling

[35] General Accounting Office, Observations Concerning The Management of High-Level Radioactive Waste Material, B-164052, p. 47 (May 29, 1968). [Secret Classification was cancelled December 18, 1970.]

[36] Lennemann, op. cit., p. 13.

[37] Id.

[38] J. H. Warren, "General Site Description and Waste Management Summary" in R.W. Harvey, Editor, Management of Radioactive Wastes at the Hanford Plant, p. 13 (June 1969). (It has been reported that the development of this long-range plan was perhaps stimulated ". . . by a classified study by the U.S. Geological Survey in 1953 which labeled the waste storage tanks a 'potential hazard' . . . ." Wayne Thompson, "At Hanford: Secrecy, mismanagement, misunderstanding.. . but no danger," The Oregonian (Forum), p. 1 (September 2, 1973).)

[39] The dates of some leakages listed in the draft statement are different than the dates for the same tanks in the 1968 GAO Report, as follows:

(1) for 104-U tank, 1960 by GAO and 1958 in EIS;
(2) for 108-SX , 1964 by GAO and 1962 in EIS;
(3) for 115-SX, 1963 by GAO and 1965 in EIS.

Additionally, GAO lists the volume of the leakage from 113-SX as 35,000 gallons, while the leakage is given as 15,000 gallons in the EIS.

EXHIBIT 25 (Continued)

tanks, current analyses by the Illinois Institute of Technology have revealed that the A, AX and SX structures [containing the selfboiling wastes] are being stressed well beyond accepted design limits." 40/

In 1968, the General Accounting Office concluded that

". . . Richland was faced with a potentially serious situation with respect to the condition of its existing tanks. The operating contractor has estimated that the expected life of the 20 Richland tanks equipped to accommodate selfboiling wastes is probably no more than 20 years or could be as little as 10 to 15 years. Eleven of the 20 tanks have been in service for 10 years or more. Further, recent studies have cast doubt upon the wisdom of reusing such tanks after they have been emptied, regardless of their age. In this regard, it appears that in the last half of 1969, Richland may be confronted with a situation of having only used tanks available as spare tanks for high-level selfboiling waste storage." 41/

At the beginning of the planning process, the importance of short-term cost considerations in evaluating potential remedial action is clear.

"The developing [waste management] program was largely influenced by a few overriding considerations . . . . The 250,000 tons of contaminated salts now contained in the wastes to be processed provided a strong incentive to develop a process that can be used with low unit cost. Significant quantities of radioactivity are sorbed on the soil outside the tanks, and the removal of these materials to another site would be very expensive -- probably hundreds of millions of dollars. In view of these factors, a low cost means was sought to immobilize the bulk of the wastes on-site." 42/

One high AEC official has publicly indicated that financial costs were given at least as much importance as safety in appraising alternatives for preventing substantial leaks of high-level wastes to the soil:

"During the early 1960's, the AEC considered the financial and safey implications of continuing with tank storage of liquid wastes in comparison with conceptual alternatives. However, it was felt that storing the high-level wastes in underground tanks could be continued almost indefinitely under normal conditions without jeopardizing environmental safety provided the stored wastes are transferred periodically to new tanks before the existing tanks being to show even a minor leak. On the other hand, concentrating these wastes to less mobile residual salts was indicated to be less expensive by annual expenditures than continuing the practice of liquid storage in tanks because of the cost of new generations of storage tanks, including the transfer of liquids from one tank to another. Also, there were certain obvious problems involved in periodically transferring the waste, particularly with moving the sludges in the AEC's

40/ P. W. Smith and R. E. Tomlinson, Hanford High Level Waste Management Reevaluation Study, ISO-981 DEL, p. 22 (August 31, 1967). (Hereinafter Hanford HLW Reevaluation Study.) [The designation "DEL" indicates that material has been scissored out of the report. Originally, the report apparently contained "unclassified" pages and "secret" pages. On August 8, 1973, the entire report appears to have been classified "Confidential". Then on November 19, 1974, about the time NRDC requested a copy of it, the report classification was again changed to "Unclassified, Declassified With Deletions." The deletions include, for instance, identification of the radionuclides of concern and their amounts in the underground storage tanks. See, Table 4.1, p. 16. No explanation was provided how this information could be inimical to national security.]

41/ GAO 1968 Report, p. 12.

42/ Hanford HLW Reevaluation Study, p. 7. (emphasis added)

EXHIBIT 25 (Continued)

> alkaline wastes. Furthermore, there is no known way to predict when a waste tank is going to have small leaks and leakage of a single-shell tank invariably results in escape of some radioactivity."43/

Thus, to reduce the leaks and to maintain low annual (as opposed to cumulative) operating costs, the AEC chose to "solidify" through evaporation the in-tank wastes rather than build new tanks. Before the self-boiling (i.e., more concentrated) liquid wastes could be evaporated to salt cake, however, the primary heat-generating radionuclides cesium-137 and strontium-90 had to be removed to a substantial extent44/ from the in-tank supernatants and sludges, respectively, whenever possible.45/

The fractionization of the heat-generating radionuclides has resutled in the accumulation of as high as 50 million curies46/ of these relatively long-lived,hazardous wastes in liquid form in the B Plant or, increasingly, in solid form in the Waste Encapsulation and Storage Facility. The lack of adequate advanced planning is clearly demonstrated by the absence of a plan for storing these highly concentrated forms of cesium and strontium during the many hundreds of years that they will remain hazardous.

In sum, a poor choice in terms of long-term management was made when the wastes were initially stored. The long-term storage problem was greatly complicated when the waste management facilities were expanded without adequate forethought about the ultimate disposal of the long-lived wastes. Today what was initially viewed and repeatedly proclaimed as only an interim storage means -- high-level wastes in near-surface storage tanks -- is becoming -- by default -- the long-term storage program.

2. No Detailed Criteria Or Standards Have Been Established To Judge The Adequacy Of The Current High-Level Waste Management Program

The in-tank wastes, either liquid or salt cake, and the strontium and cesium wastes in B Plant constitute basically two categories of high-level radioactive wastes at Hanford.47/ Detailed plans for the safe storage of these wastes until they decay

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43/ Lennemann, op. cit., p. 6.

44/ The efficiencies of removal of these two radionuclides from the supernatants and sludges is not considered in the draft statement. In terms of Current Acid Waste the draft simply states that a "majority" is removed. (p. II.1-61.) We note, however, that it is reported elsewhere that 70 to 90% of the cesium and strontium are removed during the fractionization of the high-heat wastes. (C.M. Unruh, A Preliminary Safety Analysis of Near Surface Storage of Radioactive Waste As Salt Cakes, BNWL-1194, p. 2 (January 1970).)

45/ Evidently the sludge from the 15 SX tanks cannot be removed hydraulically due to their leaky and weak condition. (p. II.1-70.) The draft statement is unclear about whether or not a similar situation arises with regard to other tanks. For instance, how many of the 14 tanks that are no longer in use because of suspected loss of integrity are in the SX Tank Farm? (p. II.1-78.)

46/ Hanford HLW Reevaluation Study (Appendix) p. 26.

47/ A question arises about whether or not to categorize existing Hanford stock piles of purified neptunium (p. II.1-20), americium (p. II.1-30), and even the plutonium as high-level wastes. The current status and potential future use of these highly toxic actinides should be thoroughly discussed. Since the commercial nuclear industry could be generating huge quantities of these materials in the future, it is unclear whether or not the Hanford stock piles will ever be used.

to innocuous levels are not presented in the draft statement. Furthermore, meaningful criteria by which to judge future plans are not even presented.

The draft states that the required studies and necessary development of technology to determine whether or not storing high-level salt cake/sludge in shallow earth burial is acceptable will be completed by fiscal year 1981. This investigation will have to provide conclusive information that the waste materials will not pose potentially serious environmental or health hazards during the toxic lives of the wastes. In tanks that only contain significant amounts of fission products (e.g., strontium and cesium) the wastes will have to be securely contained on the order of one thousand years. However, in the case of tanks, such as the SX tanks, that contain significant quantities of the very long-lived actinides, safe storage must be assured for about one million years.[48/]

Making a judgment about the possible safety of these wastes over such long periods of time wll not be easy and certainly should not be made solely by a few scientists and government officials at Hanford. In order to assure that a decision to leave the high-level salt cake/sludge in the tanks permanently is safe and generally acceptable to society, the criteria that

48/ The average concentration of just plutonium-239 in the sludge at the bottoms of the SX tanks is about 8,000 nanocuries per gram. (P.W. Smith in Forsman and Schmidt, op. cit., p. 46.) This is a concentration 800 times greater than the maximum concentration of transuranic nuclides permitted by AEC regulations in solid wastes -- a less mobile waste form than sludge -- which are buried in the earth either irretrievably or for longer than 20 years. (p. II.1-97.)

will be used to make that decision should be formulated in detail now and subjected to general review and criticism before events have overtaken the planning process once again at Hanford. Establishing the specific criteria is especially important now because it appears that, in fact, the near-surface at Hanford does not meet the general geological, hydrological and other siting cirteria that are recognized for the storage of commercially-generated high-level radioactive wastes.

Scientists at the AEC's Oak Ridge National Laboratory have stressed, in their analysis of the safety criteria for high-level waste disposal sites, the importance of using deep geologic formations for wastes that contain the relatively large amounts of transuranic nuclides existing in some of the underground tanks at Hanford:

> "[t]he presence . . . of long-lived transuranics, especially ^{239}Pu (half-life, 24,413 years), ^{240}Pu (half-life, 6580 years), and ^{243}Am (half-life, 7340 years) requires assurance of waste containment for a time period of the order of several hundreds of thousands of years. For such long time periods only deep geologic formations offer the stability required for preserving the necessary degree of containment."[49/] (emphasis added)

Thus, an ultimate disposal scheme that would permanently leave the transuranium-contaminated wastes in the ground at Hanford violates the most fundamental requirement envisioned by some of the AEC's own scientists.

49/ F. Gera and D. G. Jacobs, Considerations In The Long-Term Management Of High-Level Radioactive Wastes, ORNL-4762, p. 128 (February 1972).

EXHIBIT 25 (Continued)

A team of USGS scientists in a 1974 preliminary report for the AEC concerning the geological and hydrological criteria that are pertinent to high-level waste disposal expressed concern about a potentailly serious effect resulting from the shallow burial of radioactive wastes in the Columbia Plateau region (which encompasses the Hanford Reservation):

> ". . . fresh water could occur quite deep in parts of the Columbia Plateau and . . . even shallow disposal or storage of waste could contaminate a valuable source of water at great depth if the potential for ground water to move downward is substantiated." 50/

The USGS scientists also expressed the preliminary opinion that the Columbia Plateau region is tectonically active now and that the tectonic activity in the Northwest may increase during the time the transuranic wastes will remain hazardous:

> "Continued microseismic activity in the Hanford area of the Pasco Basin, together with the historic occurrence of major earthquakes on the plateau, indicates that the area is still tectonically active."
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> * * *
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> "This motion and the possibility that the coasts of Oregon and Washington are being underthrust by the ocean floor indicate that the lack of major earthquakes in that locality may not be a permanent condition. The development of tight folds in the Columbia Plateau and the indication of continuing crustal unrest in that region may be related directly or indirectly to the interaction

50/ E. B. Ekren, et al., "Geologic And Hydrologic Considerations For Various Concepts Of High-Level Radioactive Waste Disposal In Coterminous United States," Open File Report 74-158, p. 73 (1974).

> of the oceanic and continental plates, and the next 1 m.y. may see an increase in tectonic activity in the northwestern part of the United States." 51/

This possible lack of tectonic stability violates one of the principal ultimate disposal criteria for high-level wastes developed by the Oak Ridge Scientists.52/

While the Oak Ridge and USGS reports are recent, the AEC was informed by a National Academy of Science's advisory committee eighteen years ago that the vadose zone at Hanford was unsuitable for permanent waste disposal. In the committee's last report, before it was disbanded by the AEC, the committee stated that,

> "All proposals for surface or near-surface storage of calcined high-level waste products in semi-arid regions where 'dry soil' above the water table is assumed to be a safe container, should be examined carefully in the light of possible events of future centuries. Even storage of these products in surface tanks or bins as a permanent disposal appears to be risky."53/

51/ Id. at pp. 70, 173. (References omitted.)

52/ Gera and Jacobs, op. cit., p. 131. (Another criterion that is not met by the Hanford Reservation that the ultimate disposal site not be in an area affected by any of the Pleistocene glaciations. Id. at 93. The Hanford area, in fact, was inundated by a massive flood resulting from the breaking of a glacier dam only about 12,000 years ago. p. II.3-B-27. Although not discussed in the appendix on meteorology (II.3-E) the glaciers must have had a substantial effect on the climate at Hanford.)

53/ Committee on Geologic Aspects of Radioactive Waste Disposal, Division of Earth Sciences, National Academy of Sciences -- National Research Council, Report to the Division of Reactor Development and Technology, United States Atomic Energy Commission, pp. 70-71 (May 1966).

Therefore, at the least the Commission must immediately prepare a set of detailed environmental and safety criteria which are to be met by any proposed long-term storage means at Hanford. This should be the starting point. The approach currently in use at Hanford of hoping that in some unspecified way the near-surface at Hanford will prove to be safe is unacceptable. As the Oak Ridge scientists pointed out in their report,

> "[t]he only correct approach to the selection of the disposal formation is to check the proposed geologic environments against the very stringent safety standards required by the magnitude of the potential hazard. Only after an alternative type of formation has been found acceptable from the point of view of safety should elements such as convenience of operation and cost play their part in the selection."54/

To do less, as the Commission has in the past and continues to do, violates the environmental and safety standards under the National Environmental Policy Act and the Atomic Energy Act.

54/ Id. at p. 100.

C. The Draft Environmental Statement Fails To Assess Fully The Cumulative And Potential Future Environmental Effects Of The High-Level Waste Management Program

One fundamental deficiency of the draft statement is its failure to consider the potential cumulative adverse environmental effects of high-level wastes released to the environment during the entire time that the long-lived radionuclides pose a hazard. In particular, the possible impacts of radioactive wastes should have been evaluated over a period of time approximating twenty half-lives of the critical radionuclides in the wastes. The draft statement does not do this. In this regard, the draft statement does not meet the NEPA requirement to assess fully the long-term environmental effects of waste management operations at Hanford.

1. The Potential Extent And Full Effects Of The Environmental Contamination From The In-Tank Wastes Are Not Fully Analyzed

The draft statement contains a number of undocumented assertions about the lack of deleterious environmental or health effects due to the routine or accidental release of radionuclides into the environment at Hanford. These opinions should always be labeled as such to avoid their confusion with facts. Unfortunately, some of these judgments are not only not identified

as opinions; they also appear to be ill-founded. For instance, in regard to the largest (115,000 gallon) tank leak at Hanford, there is the following unreferenced conclusion:

> "Based on results of the [106-T tank leak] study . . . and the basic knowledge of liquid movement in the Hanford sediments, further movement of the radioactivity from its present location will be negligible." (p. III.2-4)

The draft statement does not describe, in detail, as it should, the "basic knowledge" that purportedly substantiates the Commission's opinion that the radionuclides will not move significantly far away from their existing location near the tank. Such an explication is needed because several mechanisms, physical and biological, could, in our opinion, lead to the dispersal of a significant fraction of the radioactivity during the hundreds of years that the radionuclides will be hazardous. For instance, soil moisture may be transported back and forth across the contaminated soil zone as different transport mechanisms alternately dominate.[55/] This movement of soil moisture may cause the radionuclides to migrate toward the surface and/or the water table at different times. Also, if vegetation is not prevented from growing on top of the tank farm area[56/] or if burrowing animals are not kept away from the soil contamination,[57/] these biological vectors could bring significant amounts of radioactivity to the surface, from whence it could disperse widely. (p. III.1-38.) In our opinion, other means, singly or in combination, by which the radionuclides could be moved include a rising water table due to increased recharge from agricultural irrigation (p. II.3-D-67),[58/] the ponding of cooling water from nuclear reactors, increased rainfall from cloud seeding for agricultrual reasons,[59/] the construction of the proposed Ben Franklin Dam.[60/] Furthermore, perched water could invade the contaminated soil and cause the radionuclides to migrate toward the River or the surface without the necessity of first migrating through the entire soil column above the water table. (p. II.3-D-26.)

In sum, a number of possible mechanisms could cause a significant fraction of the radionuclides in the soil near the 106-T tank to move away from their current position. The draft statement should have addressed this issue forthrightly and discussed these possible mechanisms in detail.

55/ See. R.E. Isaacson, et al., "Soil Moisture Transport In Arid Site Vadose Zones," ARH-SA-169, p. 8 (January 1974).

56/ See, K.R. Price, "Tumbleweed and Cheatgrass Uptake of Transuranium Elements Applied To Soil As Organic Acid Complexes," BNWL-1755, May 1973.

57/ See, T.P. O'Farrell, R.E. Fitzner and R.O. Gilbert, "Distribution of Radioactive Jackrabbit Pellets in the Vicinity of the B-C Cribs, 200 East Area, U.S.A.E.C. Hanford Reservation," BNWL-1794, September 1973.

58/ Hanford HLW Reevaluation Study, p. 26.

59/ Id. at 25.

60/ W.A. Haney, Editor, Final Report on the Effects of Ben Franklin Dam on Hanford, BNWL-412, p. 2 (May 1967).

In order to assess the potential environmental effects of radionuclides in the soil due to leaks in tanks, the possible mechanisms for release should have been analyzed separately for each tank due to the great heterogeneity in the composition of the soil in the waste storage areas. (p. II.3-D-34.)

Already a total of about 230,000 curies of cesium-137 alone has leaked out from the underground tanks. (p. II.1-C-134.) For comparative purposes, the maximum permissible body burden (MPBB) for occupational exposure is only 30 microcuries.[61] Thus, there is the equivalent of roughly 8 billion MPBB's of cesium-137 in the soil around the underground tanks which have leaked.[62]

The potential gravity of the hazard posed by the leaked waste materials is indicated in the following statement concerning the continuation of the high-level waste solidification program:

> " . . . the hazard to the surface of the Hanford plateau by the radioisotopes in the salt cakes is small relative to the hazard posed by the isotopes on the soil outside the tanks. . . ."[63]

Thus, the draft statement's failure to address thoroughly the long-term hazards posed by the leaked radionuclides, according the this analysis, is a greater omission than not considering the safety of storing salt cake in the underground tanks.

Although the evaporation of most of the water from the high-level wastes reduces their mobility, the fact that there will be substantial (30%) amounts of interstitial and residual liquids remaining (p. II.1-86) means that high-level liquid wastes will leak out as the tanks become more corroded.[64] Within the next few years it seems likely to us that many more tanks will have lost their integrity[65] so that the salt cake/sludge cannot be sluiced out. Thus, the draft statement additionally should have considered the possibility that even in the relatively near future the high-level wastes which are now at least partially protected by the tanks will be vulnerable to the same types of dispersal mechanisms as the leached wastes.

The firm conclusion of a detailed 1967 internal analysis of alternatives to the fractionization and solidification program was

> ". . . that the basic plan of the current Hanford Waste Management Program is sound and should be followed. Most of the long-lived heat-emitting isotopes . . . should

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61/ International Commission on Radiological Protection, Report of Committee II on Permissible Dose for Internal Radiation, p. 63 (1959).

62/ Unfortunately, the draft statement does not list either the types or the amounts of the other important radionuclides which also leaked into the soil. (p. II.1-C-134.)

63/ Hanford HLW Reevaluation Study, p. 12.

64/ ". . . the integrity of the tank liner and shell cannot be assumed for long periods." (p. II.1-86.) The draft statement should have explained how long, in fact, it is estimated that the integrity of the tank liner and shell would be maintained under these conditions.

65/ Pitting of steel tanks containing neutralized Purex wastes has been measured to occur at rates up to 2 mils/month. (W. E. Berry, Corrosion in Nuclear Applications, p. 65 (1971)) At that rate one-quarter or three-eighths inch steel would last roughly 10 or 20 years, respectively.

be isolated for high integrity storage . . . . The low heat wastes should be evaporated to salt cakes in the existing underground tanks. The tanks should be pressure filled with sand and grout capped with a weather-proof mat, isolated from surface waters, and marked for continued exclusions of the public . . . . The salt cakes and contaminated tanks . . . could be left in place indefinitely or transported to a better place when a consensus is reached on the governing criteria."66/

Seven years later the AEC is continuing this program evidently still without adopting the general criteria or standards by which to judge whether or not leaving the salt cake/sludge materials in the underground tanks permanently is compatible (1) with procedures for the management of commercially-generated high-level radioactive wastes, or (2) with the safe permanent storage of the wastes.67/ Thus, the draft statement outlines a series of major areas that remain to be investigated before a well-founded decision can be made on the long-term safety of storing the salt cake/sludge in the underground tanks:

> "The required investigation includes waste characterization, tank failure effects, waste-sediment reactions, radionuclide transport, radionuclide resuspension, potential water pathways, seismic effects, potential biological pathways, acts of man, and waste retrievability." (p. V-21.)

66/ Hanford HLW Reevaluation Study, pp. 8-9.

67/ The lack of established national criteria by which to judge the acceptability of a permanent storage means is repeated frequently in official analyses of waste management at Hanford. For instance, the "[l]ack of long-term [storage] acceptability consensus" was listed as one of the bases of the Hanford Waste Management Program in 1969. (P.W. Smith, "The Nature, Present Handling, and Storage of Chemical Processing Wastes, " in Harvey, op. cit.)

It is disappointing, to say the least, that after 17 years of the adoption of the current program, so much work apparently remains to be done. Only a year and a half ago, the AEC stated that the "[e]valuation of long-term storage of salt cake in existing tanks [would be] completed" by fiscal year 1974, i.e., before July 1, 1974.68/ Now in the draft statement it is stated that the "required investigation" will continue until fiscal year 1981, another seven years. (p. V-21) The draft statement should contain a full explanation of the need for this substantial delay that the draft claims has become required within the past few months. The continuing delay in making this important decision from a sound informational bases is evidence enough of the need for a detailed, comprehensive review of the waste management program at Hanford by an outside, independent group.

By delaying a decision for such a long period the AEC is, in fact, probably choosing to leave the wastes in the underground tanks, because the opportunity to retrieve them by safe, known means is being lost rapidly. Already the sludge in the 15 SX tanks cannot be retrieved by sluicing. (p. II.1-70.) Undoubtedly, several other tanks are too weak or have lost their integrity to such an extent that there would be substantial quantities of radioactivity lost during sluicing operations. Thus, it appears that through poor advanced planning and inaction from an unwillingness to spend the needed sums for safe management of these high-level wastes over their toxic period of at

68/ WASH-1202(73), op. cit., p. 38.

least 1,000 years, and, perhaps, orders of magnitude longer, depending on the kind and amounts of radionuclides in the tanks. More importantly, the draft statement should consider fully how leaving the salt cake/sludge wastes in the soil permanently would be compatible with any acceptable set of national criteria.

2. The Potential Seriousness Of Accidents Is Not Adequately Considered

The discussion of possible major accidents is flawed in at least three ways. First, the judgmental term "credible" is used without an explanation of its meaning in the context of accident analysis.[69] This is necessary because whether or not the chance of a particular accident occuring is "credible" will undoubtedly vary from scientist to scientist. Of course, the best way to avoid the inherent ambiguity in the use of the word "credible" is to cite the probability with which the accident may occur. In the absence of such quantification of the probability, there should be at least a description of the process by which particular accidents were judged to be "credible" or "incredible."

Second, although the discussion implies that for each type of accident the "worst case" was analyzed, other, more severe accidents seem to have been mentioned in other AEC documents and, furthermore, the "worst" conditions were not assumed for the accidents considered. For instance, in regard to the high-heat wastes concern has been expressed in the past that,

> "[i]f cooling action were discontinued, as by salt crystallation or by loss of liquid cover, the sludges [in the SX, A and AX tank farms containing 120 million curies of strontium-90 and 150 kilograms of plutonium] would self-heat to temperatures that could calcine the salts, destroy the tank structure and volatilize some of the fission products."[70]

The draft statement did not discuss whether or not this type of accident could still occur and, if so, what the long-term consequences would be. In particular, the draft statement should have analyzed such an accident for the one tank in the A-AX-AY-AZ tank farm complex generating sufficient decay heat to sustain boiling (p. III.2-14) and all of the SX tanks, in which the sludges still contain heat-generating strontium. (p. II.1-70.) Although cooling is evidently provided by fans for some tanks (pp. II.1-70; III.2-14), the possibility that the fans, and their back-up fans, become inoperative during the approximately 50 years that they will be needed for cooling [71] should be fully considered. Simultaneous failure of the cooling fan and its back-up does not seem incredible to us. A "common mode" failure for these cooling fans could possibly arise, for instance, as the result of accidental or purposeful human intervention. An example that the "worst case" conditions, in fact, are not assumed is the analysis of a major tank failure. Initially, the possible

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69/ There is no definition of "credible" in the Glossary.

70/ Hanford HLW Reevaluation Study, p. 41.

71/ Id. at 21.

concentrations of radionuclides do not seem to have been maximized. For instance, the assumed concentration of plutonium-239 is listed as 0.14 μCi/gal. However, the concentration of plutonium-239 in the high-level liquid waste that leaked from the 106T tank had a plutonium concentration of 34 μCi/gal, or about 250 times higher than assumed.[72/] Furthermore, the worst possible soil conditions, which are known to be very heterogeneous (p. II.3-D-54), are not assumed. Apparently, a "typical" amount of silt, which controls the percolation rate, was used in the calculation. How would the calculation have changed if the lowest known amount of silt in the storage areas had been used? Or, what if during the next several hundred years during which the wastes remain toxic, the hydrological conditions changed substantially from those assumed?

Third, the potential consequences of the assumed accidents are considered only for the very short-term. For instance, in the case of a tank-dome failure, could substantial radioactivity be released slowly as precipitation and soil moisture entered the exposed wastes or as the whole range of possible physical and biological dispersal mechanisms operated over time. Also, if remedial action were taken following a tank-dome collapse what would be the risk to workers?

[72/] AEC, Report On The Investigation Of The 106 T Tank Leak At The Hanford Reservation, Richland, Washington, p. 43 (July 1973).

3. The Possibilities For Sabotage, Terrorist Or Military Attack, Or The Theft Of Special Nuclear Material Are Not Discussed

The draft statement at the beginning of the chapter on accidents says that ". . . the accidents analyzed also [represent] potential consequences of sophisticated sabotage directed at waste management operations." (p. III.2-1) While this statement may be true, it does not address the fundamental issue of what could be the consequences of a determined terrorist or military attack. In our opinion, the consequences could be much more severe following such an attack than were the effects in the assumed accidents. For instance, the results following detonation of a 3 megaton nuclear weapon over the tank farm areas has already been analyzed for the AEC. One possible control action following the explosion would be to confiscate crops over a 20,000 square mile area.[73/] The draft statement should have been more candid about the potentially catastrophic nature of events such as this.

[73/] C.M. Unruh, op. cit., p. 39.

D. The Draft Statement Does Not Consider In Detail All Reasonable Alternatives To The Separable Parts Of The High-Level Waste Management Program

The discussion of alternatives -- which should be the heart of an adequate environmental statement -- is wholly inadequate. There are three principal deficiencies. First, the advantages and disadvantages of each alternative are not considered over the entire time that the wastes must be securely protected. Second, the discussion of alternatives does not fully consider the possibility that selection of one option now, e.g., long-term storage of moist salt cake or sludge in single-walled carbon tanks, may, in practice, eliminate an opportunity to choose a safer alternative, e.g., solidification into a low-leachable solid and disposal in a deep geological formation, in the future. And, third, the wrong standard -- immediate reduction of current population radiation exposures under existing conditions -- is used to discriminate between choices. Because the first two points are discussed at length elsewhere in these comments, they will not be discussed further in this section.

All recognized radiation protection criteria include the caveat that radiation exposures should be kept as low as practicable. This standard is adopted because it is assumed that all exposures to radiation, no matter how small, may cause damage. The AEC has adopted this philosophy in regard to both its own operations and its regulations for the commercial nuclear power industry. Unfortunately, the AEC has not yet promulgated general criteria for deciding what is "as low as practicable".

However, common sense dictates the use of parameters that can meaningfully distinguish between proposed alternatives. That is, the quantity used to measure the effectiveness of proposed options to decrease releases of radioactivity must change according to the option selected. The draft statement does not use such parameters, however.

In previous AEC documents which pertained to the effluent reduction program, the number of curies of radioactivity eliminated from effluents into the environment per dollar cost was used to assess the comparative value of alternatives.[74/] Another parameter that may be particularly useful in assessing the long-term advantages of alternatives is the acreage of land, on and off the Reservation, on which activities must be controlled in order to preclude the possible release of radionuclides stored in the soil.

Unless the AEC adopts parameters such as these for use in the selection of alternatives, there will be no sound basis for implementing the as low as practicable standard or for presenting an adequate discussion of alternatives in the draft statement.

74/ See, AEC, Richland Office, "Effluent Reduction Program, Status Report," March 1972.

III

THE DISCUSSION OF SOIL DISPOSAL AT HANFORD IS INCOMPLETE, MISLEADING AND DOES NOT ADEQUATELY CONSIDER THE CUMULATIVE, LONG-TERM ENVIRONMENTAL EFFECTS OF THE PRESENT PROGRAM AND REASONABLE ALTERNATIVES

The practice of using the ground as a radioactive waste dump has been criticized several times in the past. One water resources expert, citing a 1949 AEC report, stated that

> "[t]he Atomic Energy Commission is on record that the practices [of discharging intermediate-level radioactive wastes to the ground] at these places [including Hanford] may not be satisfactory for permanent use and that they require continued surveillance [U.S. Atomic Energy Commission, Handling of Radioactive Wastes in the Atomic Energy Program, 17 (1949]."75/

A former standing committee of the National Academy of Sciences (NAS)-National Roserach Council (NRC) had a long history of objecting to the disposal of highly radioactive wastes to the ground at Hanford:

> "Throughout the fabric of the10-year history of the Committee's deliberations run some continuing threads of purpose and conviction. Prominent among them is the realization that none of the major sites [including the Hanford Reservation] at which radioactive wastes are being stored or disposed of is geologically suited for safe disposal of any manner of radioactive wastes other than very dilute, very low-level liquids. . . ."76/ (emphasis added)

The NAS-NRC committee went on to discuss in detail its reasoning for rejecting ground disposal of radioactive wastes as practiced at Hanford and elsewhere.77/ Among the many statements outlining the hazards associated with disposal into the soil is the following:

> "At all sites where continuous disposal of low-level wastes or frequent unscheduled releases to the earth materials underlying the site occur, there is always the danger of a build-up of concentrations in the soil and underlying rocks. An equilibrium may be established by balancing the rate of disposals with the rate of decay of radioactivity; continuous disposals beyond this rate could lead eventually to hazardous excesses of concentration, at which point the earth materials would no longer be a suitable disposal medium.
>
> Future changes in the ground-water regimen through intensive agricultural irrigation or nearby construction of dams or other water-regulatory works may easily affect earth materials containing adsorbed radionuclides. Especially reactive will be the unconsumed irrigation water containing dissolved fertilizer components and biological refuse from plants and soils. Since, ion-exchanged nuclides of earth materials are subject to reversible equilibria, under leaching conditions that may be superimposed by radically different water introduced into the system, there may easily be induced a removal rate that is much

75/ R.L. Nace, Associate Chief, Water Resources Division, U.S. Geological Survey, in testimony before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Eighty-Sixth Congress, First Session, Volume 4, p. 2603. (February 3, 1959).

76/ Committee on Geologic Aspects of Radioactive Waste Disposal, Division of Earth Sciences, National Academy of Sciences-National Research Council, Report to the Division of Reactor Development and Technology, U.S. Atomic Energy Commission, p. 11 (May 1966). [hereinafter cited as NAS-NRC Report.]

77/ The Committee was especially concerned because "[s]uch methods represent a concept of easy disposal that has had and will continue to have great appeal to operators, but we fear that continuation of the practices eventually will create hazards that will be extremely difficult and expensive to eliminate." Id. at 70.

EXHIBIT 25 (Continued)

> faster than the sorption rate. The future chemical condition of the soil and applied water is not always predictable, as man's requirements from his environment are likely to change in future years of land use in the United States." 78/

Recently, the risk involved in ground disposal of radioactivity has been admitted by the AEC:

> "Soil columns and holding ponds and basins retain radionuclides. Radionuclides with longer half-lives can build-up faster than they decay, which might result in unforeseen hazardous radioactive contamination. . ."79/

Slowly, as more liquids flow through the soil, radionuclides are being carried to the groundwater and thence to the Columbia River. While apparently only small quantities have reached the river to date, ". . . in the course of a century or two [long-lived radionuclides] may be carried to the water table by catastrophic 'once-a-century' deluges."80/ Or, the same result may occur over a longer period of time due to a more subtle mechanism, such as a substantial change in groundwater movement. The groundwater quality and movement could be radically changed by a combination of man's activities near Hanford, such as dam building, irrigation, and discharge of industrial effluents. Construction of the proposed Ben Franklin Dam, for instance, would bring the "low level disposal sites in the 200 East Area . . . near the predicted ground water stagnation

78/ NAS-NRC Report at 32.

79/ Lennemann, op. cit. p. 21.

80/ NAS-NRC Report at 67.

point."81/ A rise in the water table beneath the waste disposal sites would bring additional radionuclides in contact with groundwater and would eventually increase the level of radioactivity in the Columbia River."82/ Future earthquakes in the Pasco basin and adjacent areas may cause "moderately strong ground shaking" at Hanford.83/ Large scale irrigation may be causing ". . . stresses above and beyond those naturally imposed." (p. II.3-C-19) The resulting earthquakes, in turn, could trigger landslides at The White Bluffs, which are weakened by ". . . the discharge of large quantities of irrigation water

81/ Unruh, op. cit. p. 33.

82/ "Significant increases in the groundwater level under the 200 Areas [waste disposal areas] would tend to inundate the dry sediments progressively, thereby reducing the distance between the confined radionuclides and the water table. . ." Brown and Warren, Land Requirements and Waste-Management Policy At Hanford, in International Atomic Energy Agency, Management of Low- and Intermediate-Level Radioactive Wastes, 533 (1970). The fact that the steady-state water table elevation may be increased by 40 feet in the intermediate- and high-level waste disposal areas following construction of the Ben Franklin Dam led to the decision not to construct proposed cooling ponds for the Hanford Number Two commercial nuclear power plant at Hanford because they would have raised the water table another 30 feet, substantially inundating radioactive waste-bearing soil. [Hanford Number Two Environmental Report, Washington Public Power Supply System, subsection 2.5.4, page 13 (January 14, 1972)].

83/ Unruh, op. cit., p. 30.

> "Earthquakes of sufficient intensity to create damage are unlikely in any one year, but their occurrence is probable within any one century. . . . The geologic youthfulness of many lines of bedrock deformation suggest that an earthquake potential is present."

Newcomb, Strand & Frank, Geology and Ground-Water Characteristics of the Hanford Reservation of the United States Atomic Energy Commission, Geological Survey Professional Paper 717, 48 (1972).

to [the] ground atop the bluffs. . . ." (p. II.3-C-16) Radioactive wastes which have been discharged to the ground in the 100 Areas could then be swept away by the flooding caused by the landslides (p. II.3-C-16) to the Columbia River.

The draft statement fails to consider adequately the likelihood and potential effects of such slow or catastrophic releases of radionuclides that are contained in the soil and that continue to be discharged to the soil. By not fully analyzing these possible events the draft statement does not meet the NEPA standards for full disclosure and careful consideration of alternatives that may reduce environmental harm.

A. The Draft Statement Fails To Discuss Thoroughly The Uncertainties In Current Knowledge About The Hydrological And Geological Conditions At Hanford Pertaining To The Fate Of Radionuclides In The Soil

Predicting the potential environmental effects of radionuclides in the soil at Hanford depends crucially on having (1) an adequate data base for the geohydrological properties of the Reservation and (2) valid simulation techniques. According to the reports of Dr. Raul A. Deju, who recently conducted a "comprehensive review of the groundwater management and environmental monitoring programs at the Hanford Reservation . . ."(p. II. 3-D-77), neither the data base nor the simulation (computer) techniques in use at Hanford is adequate.

1. Mathematical Models

In his report on mathematical models (p. II.3-D-83, ¶ 65), he described, as follows, ". . . the nature of the processes to be modeled and the hydrologic characteristics of the Hanford Reservation" (Deju, April 1974, p. 3):

> "Low and intermediate level wastes can seep through the unsaturated zone and may eventually reach the water table. Rainfall may filter through disposal sites and pick up radiocontaminants in solution.
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> * * *
>
> Flow in the unsaturated zone in an arid environment such as prevails at Hanford is difficult to model because of the many controlling factors. Combined water, air, vapor, and temperature induced flow components must be considered. Once the contaminants reach the water table they will flow horizontally in solution generally toward the Columbia River. This flow is described by standard hydrologic equations. Models to describe the flow patterns in the Hanford sediments must account for the occurrence of anisotropies, hydrologic barriers, recharge and discharge areas. In addition, they must account for the interactions between microcontaminants, between macrocomponents, and between microcontaminants and macrocomponents." (Id.)

Deju also described one of the characteristics of the geohydrology at Hanford that potentially could result in the substantially more rapid movement of water:

> "When the water table is raised from the Ringold conglomerate to the glaciofluviatile and fluviatile deposits as a result of plant discharges, leakages or any form of recharge, the much lower gradient required for percolation of comparable quantities of water through the glacio-

fluviatile materials frees over 90% of the water for accelerated migration downgradient. Travel times in the glacio-fluviatile sediments will be 100 times (or more) smaller than those observed in the Ringold." (Id. at 9.)

He went on to compare the complexities of the hydrogeological regime at Hanford with the adequacy of the data and the mathematical models. Below, for each of the models he reviewed are the "Problem Areas and Work Needed":

FLOW IN THE VADOSE ZONE

"The project is still at a very early stage and much work needs to be done. following areas are of immediate concern:

* Prior to attempting a numerical solution to the theoretical model, the relative importance of the various flow mechanisms acting on the system must be experimentally assessed.

* Work in this model should hopefully lead to the numerical solution of the flow problem in the vadose zone. The method of characteristics or variational calculus must be used. An expert on these techniques must be retained to aid with the numerical algority. The method of finite differences must be avoided.

* The concept of thermodynamic pressure needs clarification and its physical significance needs to be properly analyzed.

* The conditions under which the isothermal assumption does not hold must be clearly defined.

* The constitutive equations assume perfect loss of memory, i.e., "the stress depends only on the current strains, it remembers nothing of the strain history." This perfect

memory loss may not be a valid assumption. . . .

* The model being developed appears aimed at performing the functions that the present Partially Saturated Flow Model (PST) was designed for but is only inadequately capable of performing. More close cooperation between Mr. Nelson [co-authored of model] and the Battelle staff responsible for PST could lead to more efficient model programs.

* The experimental (field) program needs to be expanded so that the relative importance of the various factors affecting flow in the vadose zone is properly assessed. Close cooperation between Mr. Nelson and the personnel responsible for the experimental work is needed. The following specific experimental determinations must be made:

  (a) value of water potential vs. depth and time in the lysimeters,

  (b) value of barometric pressure vs. depth and time in the lysimeters,

  (c) extent of moisture removal by barometric pressure pumping,

  (d) hydrologic inventory at the lysimeter site,

  (e) correlation of extent of precipitation and infiltration, and

  (f) effect of temperature and pressure changes on water potential and water transport." (Id. at 18-20)

THE PERCOL MODEL

"The Percol model is not presently capable of modeling the chemical changes occurring if a tank ruptures or a very acid discharge of fluid occurs because in such cases an equilibrium condition will not be met at every point in the flow path. It is important that a model be designed to study the chemical interaction between a

moving fluid containing radiocontaminants and a porous medium when the velocity of the fluid is so great that equilibrium at every point is not achieved.

The effect of soil moisture content changes on sorption also be examined.

It appears to me that the use of the PERCOL model could be increased if the above work is done by allowing direct use of the model to predict the chemical consequences of a tank leak under simplified assumptions. Such results are important if we want to establish an adequate contingency plan." (Id. at 28)(emphasis in original)

PARTIALLY SATURATED

FLOW MODEL

"* The computer program appears extremely efficient and time consuming and could use additional improvement.

* When this model is applied to a tank rupture situation two problems can easily arise:

(a) The boundary conditions at the tank botton will probably result in large potential changes and thus lead to numerical instabilities, and,

(b) the high background moisture content is an artificial condition imposed by the basic equation used to fit the moisture content-capillary pressure relationship and can lead to erroneous results.

* No cross cooperation presently exists between Nelson who is conducting the vadose model at CSC (see a preceding section) and the Battelle staff responsible for PST.

* The assumptions used in developing PST are not clearly stated in the reports available. They must be clarified and their applicability to the Hanford environment could stand verification.

* The accuracy of the model needs verification using field data from an actual leakage." (Id. at 30-32.)

TRANSMISSIVITY ITERATIVE ROUTINE

"The transmissivity iterative routine is heavily dependent on the availability of good pumping test data. Such data are presently very inadequate. As discussed in a separate report (Deju, 1974) a field program involving geologic, geophysical and hydrologic work needs to be implemented to determine accurately:

* The position of the bottom surface of the unconfined aquifer,

* The amount of infiltration and location of infiltration sites, and

* The value of transmissivity and storage coefficient at various points in the reservation.

Specifically regarding the model several areas require improvement:

* The computer program should be made more efficient and less time consuming.

* A storage coefficient calculation to be performed similtaneously with the transmissivity calculation should be added to the model. The initial assumption of a constant storage coefficient appears rather inaccurate.

* It is not clear how, if at all, the model is capable of accounting for transient boundary conditions or flow rate variations.

* It is important that improvements be made in the model in the transmissivity determinations:

near the mounds underlying the waste disposal sites,

in areas where small radii of curvature in the streamtube occur, and

near impermeable boundaries.

* Error analysis shows that the values of transmissivity resulting from the model as applied to these areas may be quite erroneous.

* The results obtained from the model have apparently not been checked using known hydrologic field practices to verify their possible accuracy, especially in critical areas." (Id. at 38-39.)

VARIABLE THICKNESS TRANSIENT

(VTT) FLOW MODEL

** The adequacy of the VTT model to stimulate actual hydrologic conditions needs to be properly and accurately tested.

* The model is likely to suffer from artificial dispersion. Such smearing is a result of the numerical algorithm and not of poor data. For large values of the flow velocity the basic equation being solved probably behaves more like a hyperbolic than a parabolic differential equation.

* The model does not account for any possible flow through the aquifer bottom.

* The [14 simplifying] assumptions . . . [for VTT model] must be carefully examined and those that are deemed inapplicable to the Hanford Reservation must be removed and the model changed accordingly.

* Results of the model must be compared to observed field water table measurements and where disagreement is noted a careful scrutiny must be made to establish the reasons for the discrepancy." (Id. at 44-45.)

TRANSPORT MODEL

"The data base for this model need to be improved. Additional transmissivity and storage data from pumpint tests are needed. Also, an attempt should be made to expand our knowledge of dispersion components and the Sr sorption coefficient in the Hanford Reservation. Data improvements will hopefully allow a closer correlation between actual contamination patterns observed in the field and model-calculated results.

In addition to the improvements noted above, there is a need for streamlining the entire computer algorithm. The algorithm is very slow, thus restricting its usefulness. A careful analysis of numerical dispersion should be conducted and documented.

The tank leak situation requires a great deal of additional work and testing to verify the model's confidence limits. The applicability of the model to this problem needs to be clearly established." (Id. at 54 & 59.)

DATA BANK

"One of the serious drawbacks presently holding progress with the Hanford water management effort is the lack of a rational data storage/retrieval system where all the hydrologic data are stored and easily accessible to the user in any desirable format.

"It is imperative that a contractor with expertise in water management and data handling be made responsible for establishing a data bank where all the Hanford hydrologic data would be stored and from which the data can be easily retrieved in a variety of formats.

"Such a data bank should be geared to the Batelle computer and the Batelle library. The work to be done must include:

(A) a comprehensive annotated literature survey of Hanford hydrogeologic publications and related matters;

(B) a comprehensive data system covering all wells in the basin, their identifying data, positioning, drilling data, testing, chemical quality, etc;

(C) a comprehensive information cataloguing system;

(D) a comprehensive core-storage handling system; and

(E) development of the necessary software to handle the storage of data and their easy retrievability in a variety of desirable formats." (Id. at 60, 61.)

2. Field Testing Program

After thoroughly reviewing the data elements, specifically, aquifer thickness and aquifer properties, for the mathematical models discussed above, Dr. Deju concluded as follows:

> " * Most of the data obtained from pumping tests that have been conducted at Hanford are of extremely poor quality and do not cover most of the reservation.
>
> * There is wide discrepancy between various geologists at Hanford as to the position of the bottom of the unconfined aquifer.
>
> * The extensiveness of glacial outwash channels in the area needs to be properly clarified." (Deju, May 1974, p. 36.)

3. Regional Hydrology

In the Introduction to his report on the regional hydrogeology at Hanford, Dr. Deju rem: that "[i]n spite of all these years of concerted effort, the interaction between the radionuclides and groundwater continues to be a cause for concern." (Deju, June 1974, p. 1.) In the Abstract to this report, Dr. Deju summarizes his findings as follows:

> "The monitoring programs to measure water-levels and extent of radionuclide contamination resulting from the synthetic systems noted above suffer from a variety of weaknesses. Problems in the water-level monitoring program include: (1) use for monitoring of piezometers or wells open over long vertical intervals, (2) inconsistencies and lack of measurement continuity, and (3) use of wells open at the water table. Three aspects of the radionuclide monitoring program are subject to criticism: (1) the sampling procedure, (2) the representativeness of the samples, and (3) the capacity of the program to describe the actual radionuclide concentration in the ground water.
>
> "From an overall programmatic standpoint it appears that the hydrologic program at Hanford needs additional supervision and periodic auditing." (Id. at p. ii.)

These strong criticisms in Dr. Deju's reports concerning the existing hydrogeological data, computer models, and hydrological testing and monitoring, are not fully reflected in the draft statement. In order to have met the full disclosure requirements of NEPA, they should have been thoroughly evaluated and considered.

B. The Draft Statement Does Not Adequately Consider Alternatives To The Ongoing Practice Of Discharging Highly Radioactive Liquid Wastes To The Soil At Hanford

The conclusion in the draft statement (p. IX-8) not to reduce further the amounts of radionuclides in intermediate-level effluents discharged to the ground at Hanford is based on short-term economic savings and not on a full evaluation of the potential long-term costs and environmental effects of this continuing practice. First, as in the analysis of better containment means for the high-level wastes, an insensitive parameter -- short-term annual radiation dose -- is used so that there is no apparent advantage of an alternative that, in fact, reduces the extent of radioactive contamination in the environment.

The importance of fully considering possible long-term effects of waste disposal practices, instead of just the next two or three years in the draft statement, was revealed in an earlier study. At the end of 1967 it was estimated that for only a $22 million capital investment and an incremental operating cost of $5 million per year, ". . .aqueous discharges to the environment at concentrations exceeding drinking water limits. . ." would be discontinued. One advantage of adopting such a program would have been that the cost of returning contaminated areas to unrestricted use would have cost $1 to 2 billion less by 1980 than if the aqueous discharges had continued with no reduction.[84/]

Second, there should have been a full consideration of the possibility -- in our view, the almost certainty -- that the N Reactor and Purex Plant will operate far past 1977. By restricting the time frame to the date that the existing contract expires is misleading in light of the past extensions for operating the N Reactor and the great political and social pressure which has been and will continue to be applied to extend the operating life of the N Reactor.

Under the alternative which assumes that the N Reactor will operate into the 1980's, the draft statement should have considered fully the need for N Reactor plutonium for nuclear weapons and specifically evaluated not reprocessing the N Reactor spent fuel in the near future. It is our understanding that the very low quality of N Reactor plutonium has resulted in it not being used in any event. Furthermore, it is our understanding that there are ample stockpiles of N Reactor and other plutonium for the foreseeable research and development needs. If this is correct, there would seem to be no valid reason to reprocess N Reactor spent fuel until such time as a better waste management system is adopted at Hanford. In any event, this issue should have been considered in detail in the draft statement.

84/ R. J. Sloat, compiler, Hanford Low Level Waste Management Reevaluation Study, ARH-231 DEL, p. 11 et seq. (December 29, 1967).

IV

THE PRESENTATION OF DATA AND OTHER INFORMATION IS AT TIMES CONFUSING, INCONSISTENT, MISLEADING AND INACCURATE

The draft environmental statement must serve two important functions. First, it must be a full disclosure document. Relevant information and analyses, including responsible critical points of view cannot be omitted. Further, the information must be presented in an intelligent and understandable way for both the concerned citizen and the expert.

Second, the draft statement must be primarily a decision-making document, highlighting the choices to be made and providing sufficient information and analyses of reasonable alternatives to allow intelligent choices. This requirement places additional obligations on the authors regarding the statement's format and organization. Important material cannot be buried obscurely in appendixes and not referenced in the more introductory or general parts of the statement. All significant uncertainties and controversies must be made accessible to decision-makers who may not have the opportunity to review, in detail, all portions of the statement. Naturally, the information and analyses in the draft must be made as accurate and well-founded as possible in order to preclude the selection of options on the basis of inaccurate data or faulty reasoning.

Unfortunately, this draft statement does not meet NEPA's high standards for the adequacy of environmental statements in this regard.[85/]

A. The Draft Statement Misrepresents The Accuracy Of Some Data And Does Not Reveal The Reliability Of Other Data

The presentation of data is frequently very imprecise, confusing and misleading. Virtually no estimates of accuracy or reliability of data or calculated values are given. In order for the values listed in the draft statement to have been meaningful, the best estimate of error in measurements should have been presented and there should have been descriptions of simplifying or other assumptions that were made in deriving various results. For instance, if radioactivity is measured by taking a "grab sample" -- a procedure that can give fallacious data -- the controls and checks that are performed to ensure that the sample is representative of the actual condition should have been discussed. Such checks might include repeated sampling in one day or on successive days, the use of standard samples to check methodology, and cross-checking analyses from different laboratories.

Also, the accuracy of numerical values should have been reflected in the way in which numbers are written, as is standard

85/ The Guidelines of the President's Council on Environmental Quality (40 C.F.R. Part 1500) require (Appendix I) that draft environmental impact statements be accompanied by a Summary that reveals specific information. One of the informational requirements for the Summary is the listing of the "[n]ame, address, and telephone number of [the] individual at the [responsible] agency who can be contacted for additional information about the proposed action or the statement." The Summary in this draft statement does not list such an individual and does not contain other information that is required.

in scientific writing. For instance, the amount of plutonium in the bottom of the Z-9 crib is listed in Table III.2-26 (p. III. 2-51) as 38.0 kilograms, as if the last place were significant, i.e., as written the standard meaning is that the amount of plutonium is precisely 38.0 kilograms and not either 37.9 or 38.1 kilograms. However, a footnote indicates that the true value is unknown, but it is believed to be between 25 kilograms and 70 kilograms.[86]

Furthermore, the data presentation is frequently inconsistent in the use of units. For instance, in one section (II.1.1.4) which summarizes inventories of radioactive wastes, the amount of plutonium-239 in solid wastes buried in the ground at the 200 Areas is listed in grams, or units of mass. (p. II.1-126) On the other hand, the amount of plutonium-239 estimated to be in underground tanks by 1980 in the 200 Areas is given in curies, or units of radioactivity. (p. II.1-127) For the expert who knows that there are about 16 grams per curie of plutonium-239, it is possible to make the conversion from curies to grams for comparative purposes. However, the draft statement does not present this conversion factor, nor does it provide any other assistance in this draft statement to assist the concerned citizen.

[86] The final report on the investigation of the Z-9 trench states that "[t]he best estimate is that the plutonium content in the top 30 centimeters is about 40 kilograms. It is unclear why the draft uses the value 38 kilograms. Nuclear Reactivity Evaluations of 216-Z-9 Enclosed Trench, ARH-2915, p. 4 (December 1973).

B. The Discussion Of Simple Factual Matters Is Sometimes Confusing

Of a somewhat different nature is the reporting of the same factual material differently in different sections. For instance, even with regard to such a simple question as the number of underground tanks at Hanford, the draft statement is confusing. At page I-1, the draft lists 152 tanks existing and 4 more under construction, for a total of 156 tanks.[87] But, Table II.1-4 (p. II.1-72) mentions 151 existing tanks with two new tanks under construction, for a total of only 153 tanks. A few pages later on, the draft states that there are five new tanks under construction (p. II.1-78). In the next chapter it is stated that there are 153 underground tanks existing (p. III.2-2). While at page V-16, we are told that at present there are 152 tanks. Thus, depending on the section of the draft statement, there are from 151 to 153 existing tanks and from 2 to 5 tanks under construction.

C. The Quality Of The Draft Statement Is Reduced By Unexplained Differences In Data Presentation

Significantly more serious than the draft's inability to keep track of the number of underground tanks, are the inconsistencies in assessing the environmental impact of the effluent from

[87] Essentially the same information is conveyed on page II.1-33, if the following absurd sentence is interpreted as meaning one of the five tanks has been completed: "Five additional tanks of this latter design are under construction, one of which was completed in October 1973."

the N Reactor to the 1301-N crib, which is discussed in several places. The first discussion of the crib occurs in the second chapter. The discharge of radioactive seepage from the crib to the Columbia River is described as follows:

> "Some flow from the crib and trench forms a surface seepage at the river bank referred to as the N Area Riverbank Springs. Over half the discharged water reaches the river in 4 to 10 days." (p. II.1-57)

Two specific points need to be made about the draft statement's analysis of the magnitude of this radioactive discharge to the River. First, the data concerning the time of travel of the discharge and radioactivity from the crib to the River is not adequately interpreted. And, second, the amount of radioactivity discharged to the River via the crib appears to be underestimated when it suits the purpose of the Commission.

1. At page II.1-57 the draft states that more than 50% of the discharge to the crib reaches the River in 4 to 10 days. In the next chapter, the draft changes to an assertion that the minimum travel time for radionuclides between crib and River is 3 to 5 days (p. III.1-5). Yet a third formulation appears in the Appendix, where the draft estimates that about 20% of the discharge takes 2 to 4 days to reach the River. (p. II.3-D-51)

These estimated periods for travel time between the crib and the River are, however, much shorter than the average flow time calculated on the basis of other information in the draft statement. By using 10.8 feet per day as the average flow rate of the groundwater (p. II.3-D-44), and 800 feet as the distance from the crib to the River (p. II.3-D-51), the average flow time should be about 74 days. Thus, the expected average flow time exceeds by a large amount the actual flow time for at least a major portion of the discharge.

In light of this seemingly contradictory information in the draft statement and information in previous studies which measured the travel time of tritium in the discharge to be 79 days,[88] a full explanation is needed of how such a large fraction of the discharge and some of the radionuclides released to the crib can now arrive at the River so fast, compared to average groundwater flow rates. The draft statement should openly admit, if it is true, that severe channeling has taken place beneath the 1301-N crib and that 20% to 50% or more of the discharge flows fairly directly into the River, instead of moving through the soil in such a way as to retard significantly the migration of radionuclides. If, in fact, there is substantial channeling, then even under the most narrow interpretation of the AEC's regulations the discharge to the 1301-N crib is to an unrestricted area. The draft statement should have explained, in this case, why the discharges to the 1301-N crib do not meet the criteria for releases to controlled areas contained in AEC Manual Chapter 0524.

2. In 1972, about 7000 curies of H-3 and about ten curies of mixed radionuclides were released via seepage from the 1301-N

88/ J.R. Eliason, "Field Evaluation of Ground Disposal of Reactor Effluent - 1301-N Crib," BNWL-CC-1032, p. 4 (February 8, 1967).

crib into the Columbia River. Additionally, in 1972, the large discharge pipe for the N Reactor's cooling water carried about 1400 curies of mixed radionuclides to the River. (p. II.1-B-30) In 1973, according to the draft, about 480 curies of H-3 and five curies of mixed radionuclides seeped from the crib to the River (p. II.3-D-52) For 1973, the draft also provides figures for the total number of curies actually released to the 1301-N crib itself, indicating that more than 5500 curies of mixed radionuclides (including about 480 curies of H-3) were discharged into the 1301-N crib from the Reactor. Assuming similar behavior of the radionuclides in traveling from the crib to the River each year, thousands of curies of mixed radionuclides must have been discharged to the crib in 1972 as well as in 1973.[89]

Yet in assessing the potential reduction in radioactivity released to the crib and to the River if the N Reactor did not operate, the draft apparently assumes that the N Reactor is currently discharging and would discharge in the future (a) only 200 curies of presumably mixed radionuclides (not including H-3) to the crib, (b) less than 500 curies of H-3 to the groundwater (presumably meaning less than 500 curies of H-3 to the 1301-N crib), and (c) less than ten curies of presumably mixed radionuclides to the River. (p. V-11) In other words, although the N Reactor has apparently been releasing thousands of curies of radioactivity in recent years to the crib and to the River, the draft assumes, without explanation, that a similarly large amount would not be released in any future year to either the crib or to the River if the N Reactor is operational. While this may be a convenient assumption for the Commission's argument that not much would be gained in terms of reducing radioactive releases if the N Reactor were shut down, we could find no justification of this assumption in the draft statement. For instance, there is no listing of an effluent control project for the N Reactor during Fy 1973 to Fy 1975 which would accomplish this reduction, although $42 million of waste management projects are described, including some for the N Reactor. (p. V-25)

The only other reverence we could find to any reduction in radioactive effluent is the simple assertion in a footnote to Table III.1-2 that, "The [total] annual discharges [from the N Reactor to the Columbia River] have been reduced to < 500 Ci/yr tritium and < 10 Ci/yr of all other radionuclides after CY-1973." (p. III.1-7) To achieve this result thousands of curies of radioactivity would have to be removed from the cooling water discharged to the River and the bleed water to the crib.

At the least, there should have been an explanation of how this dramatic reduction in radioactive effluents by thousands of curies was accomplished. However, it seems to us that the favorable numbers are simply in error. On February 2, 1974, the Richland Operations Office, in answering one of our interrogatories,[90]

[89] To some extent these data are inconsistent. The fact that 7000 curies of H-3 appeared in crib seepage during 1972 implies that about 7000 curies were discharged to the crib. Yet in 1973 it is claimed that only 480 curies of H-3 were discharged to the crib, which then evidently seeped to the River. There is no explanation of this apparent difference in the apparent amount of tritium released to the crib from year to year in the draft statement.

[90] Supplement to Defendants' Answers to Plaintiffs' Interrogatories dated February 22, 1974, at p. 3, Natural Resources Defense Council, Inc., et al. v. Ray, et al., Civil Action No. 3924, E.D. Wash. (filed Aug. 1, 1973).

stated that the current schedule called for 340 curies of mixed radionuclides with half-lives over 1 year and 200 curies of H-3 to be discharged to the 1301-N crib during the years 1974, 1975, 1976, and 1977.

D. Some Purportedly Factual Statements Are Misleading

An example of a seriously misleading assertion in the draft statement is the unreferenced claim in the Summary that

> "[s]tudies show that the effluents from up to nine plutonium-production reactors have had no harmful effects on the migration or spawning of salmon or produced any biotic downgrading of the aquatic ecosystem in almost 30 years of plant operation and concurrent scientific observation." (p. I-6)

The purportedly supporting evidence is in the next sentence:

> "An annual survey in the Hanford reach of the river shows a fairly constant increase in Chinook salmon nesting from the late 1940's up through the fall of 1973."

However, what the draft statement fails to point out is that this "marked increase of spawners. . . is most likely related to displacement of fish due to inundation of previously productive areas."[91/]

Thus, the conclusion that the thermal effluents were not deleterious, based solely on the observation that the spawning fish population increased, is unwarranted. Indeed, additional information presented within the body of the draft statement indicates that the thermal effluents can be detrimental to juvenile salmonids. (p. III.1-61.)[92/]

91/ AEC, draft environmental statement, Washington Public Power Supply System, Projects 1 and 4, Docket Nos. 50-460 and 50-513, p. 2-23 (December 1974).

92/ See, also, Comments of the U.S Department of the Interior on the draft environmental statement, Waste Management Operations, Hanford Reservation, Richland, Washington, p. 13 (December 13, 1974): ". . . Hanford area research . . . has demonstrated that the potential clearly exists under periodic conditions of river flow and temperature for lethal exposure of migrating juvenile salmonids to heated discharges."

V

CONCLUSIONS AND RECOMMENDATIONS

The draft environmental statement on the waste management program at Hanford was written only after NRDC and four co-plaintiffs brought a lawsuit to compel the AEC to meet its obligations under NEPA. For the reasons set forth above, we believe that this draft statement falls far short of the strict standards that have been established by the Council on Environmental Quality, the Environmental Protection Agency and the courts under NEPA. The draft statement does not even remotely approach achieving the primary objectives for which it should have been written. If the draft statement is to satisfy the provisions of NEPA, as the court order requires, it must be completely rewritten.

The draft has performed, however, one valuable service: it has publicly demonstrated that no coherent plan exists for the safe management of radioactive waste at Hanford until they decay to innocuous levels. Immediate action is, therefore, required on two levels. First, the major failures of the draft statement must be corrected to provide a full assessment of the present situation and to formulate a comprehensive program for safely managing the radioactive wastes at Hanford. Second, on the basis of information already available, certain actions must be taken as soon as possible.

A. Independent Review is Required

Based upon our analysis of the draft, the review of numerous other documents and discussions with scientists who are familiar with the situation at Hanford, we believe it would not serve a useful purpose to have the AEC (or its successor, ERDA) prepare either a new draft or a final environmental impact statement on waste management operations at Hanford. If the present draft statement is any guide, it appears highly unlikely to us that the AEC personnel who have been responsible for waste management operations can fruitfully be asked to investigate themselves.

Moreover, decisions concerning waste management at Hanford are currently being made without the needed assessment of alternatives, in some cases possibly foreclosing the adoption of more environmentally sound policies. The current situation cannot be allowed to continue indefinitely on the hope that the personnel at Hanford may accept their responsibilities under NEPA. Traditional legal remedies to enforce NEPA compliance require time which we do not have.

We do not say that the required programmatic statement under NEPA should not be prepared at all. On the contrary, we believe that it is crucial for a comprehensive, detailed statement to be written and circulated for public agency comment. Extraordinary measures, however, are needed to achieve this goal and to achieve it quickly.

We believe that only an outside independent review holds a serious hope of producing safer management of Hanford's vast quantities of radioactive wastes. The two investigations of the General Accounting Office demonstrate the utility of outside

EXHIBIT 25 (Continued)

reviews in obtaining better practices at Hanford. In recent years, the GAO's findings and recommendations stand alone as reports which have resulted in significantly enhanced protection to the environment and public health at Hanford. We also note that in their public statements, AEC officials have themselves supported the value of outside review by independent groups.[93/]

We therefore urge the Administrator of ERDA to convene as soon as possible an independent task force with a strong mandate to assess the current status of Hanford. It should publicly report its findings, and recommend changes in policies and procedures, where necessary, to increase the margin of safety and waste management operations at Hanford. Such a course of action is clearly authorized by NEPA.[94/]

The composition of the task force should reflect fully the large number of diverse issues that need to be addressed. For instance, the Department of Defense should be represented in order to consider the need for continued production of plutonium-239 in the N Reactor and to assess the risks posed by relatively vulnerable near-surface storage facilities to military attack. Appropriate federal security officials should be represented in order to evaluate security precautions to prevent theft of purified plutonium-239 and to prevent possible sabotage of waste storage facilities. Principally, however, competent geologists, hydrologists, nuclear scientists, radiation health physicists, marine and radiation biologists, economists, computer experts and policy experts from the Department of the Interior and the Environmental Protection Agency should sit on the task force.

Additionally, representatives from the States of Oregon and Washington, universities and other institutions, as well as from the public should be on the task force, in order to develop public acceptability of the final report and to ensure that a broad range of viewpoints is adequately represented. If the task force is to be effective, it will have to have adequate funding for staff and consultants and it will have to receive substantial administrative support from ERDA.

We firmly believe such an independent investigation is required to assure a full and fair appraisal of the risks currently posed by radioactive wastes at Hanford; this appraisal in turn represents the indispensable basis for analyzing available alternatives for safe ultimate disposal.

Moreover, it is both appropriate and important to have a broadly based group evaluate acceptable long-term radioactive

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93/ In discussing the advisability of periodic reviews of the AEC's radioactive waste management practices, William Lennemann, then the Chief of the Chemical Processing Branch, Division of Production and Materials Management of the AEC, wrote in 1972:

> "Periodic audits and appraisals by both management and independent groups provide valuable assistance and guidance in upgrading waste management operations, practices and controls." W. Lennemann, op. cit., supra note 17 , at 21.

94/ See National Environmental Policy Act of 1969, §§ 101(a) 102(A), 102(C), 42 U.S.C. 4331(a), 4332(A), 4332(C).

waste management policy, because the level of safety that is desirable involves value judgments which should be broadly based. Once the comparative risks and choices have been described, these decisions should not be consigned either to scientists or to agency officials. The answer to the question, "How safe is safe enough?" must be answered by consensus and not by a few with a vested interest in a particular answer.

B. ERDA Must Immediately Construct New High-Level Waste Tanks, End Further Purex Reprocessing and Stop Deliberate Releases Of Significantly Radioactive Liquids To The Soil

Based on the information -- or lack of it -- in the draft and in other AEC materials, we think certain preliminary conclusions can be drawn regarding the subject of primary concern at Hanford -- the high-level wastes:

(1) Storing the highly leachable, moist-salt cake/sludge in the near-surface tanks which either have already lost their integrity or will soon lose it does not represent an acceptable plan for long-term disposal. Near-surface, in-tank disposal would violate the standards the AEC has suggested for managing its own radioactive wastes and for managing the wastes generated by the commercial sector.

(2) As the tanks in which the high-level wastes are now stored continue to disintegrate, retrieval of the material will become either impossible or extremely expensive and hazardous.

(3) No plan presently exists for ultimate disposal of these wastes. Given the need for extensive research and development to develop such a plan, it is unrealistic to expect that ultimate disposal facilities, most probably in a geologic formation, could be constructed before several decades have elapsed.

Based on these premises, we believe ERDA must immediately undertake a construction program to replace single wall tanks which are about to fail or which can be expected to fail in the future in order to assure that the existing wastes can be retrieved at the time when an ultimate disposal plan is finally implemented. Unless the present tanks that have not yet failed are replaced before they do, many options for the safe, responsible disposal of the wastes will be foreclosed.

In addition, no further reprocessing should be undertaken at the Purex Plant until ERDA has developed a plan for ultimate disposal of the high-level liquid waste which would be generated and until sufficient storage capacity has been built to replace single wall tanks before they fail. As we pointed out in our comments on WASH-1539 on wastes generated by commercial nuclear power plants, no justification exists for producing additional high-level liquid waste in advance of an assured means of permanently containing it. Since the plutonium generated in the N Reactor is not suitable for nuclear weapons and the Defense Department needs no additional plutonium at the present time, no reason exists for operating the Purex Plant in any event. Moreover, any capacity in new tanks or older, structurally sound tanks should be used on a priority basis for waste in

tanks whose deterioration may soon preclude retrieval. It should not be used for new waste generated by further Purex operations.

In addition to these two minimum requirements for responsibly dealing with the high-level wastes, ERDA should commit itself to a similarly responsible course in treating intermediate-level liquid wastes. The present practice of disposing of this waste directly to the soil has been continuously criticized for two decades. Existing regulations forbid this practice, and the AEC has acknowledged that it is technically feasible to stop it. Since lead time for planning and construction is substantial, ERDA must commit itself immediately to funding effluent reduction programs for the N Reactor and the Purex Plant if either operates beyond their presently planned shutdown in 1977

In our opinion, these three steps -- a high-level waste tank construction program, an end to further reprocessing, and an end to the deliberate release of significantly radioactive liquid waste to the soil -- must be taken immediately. They would at least preserve ERDA's capability to manage safely the high-level wastes and would end at last the deliberate and routine release of significantly radioactive material to the environment. Further major decisions may then be deferred until the complete investigation of Hanford's waste management practices required under NEPA has been completed.

After 30 years of inaction, the time available within which to make decisions has grown short. The immediate actions which we have recommended will mitigate some of the more severe long-term hazards posed by further delay. But ERDA must stop making decisions based on the need to avert immediate crises and begin a process of responsible and rational decision-making. The independent review and interim actions discussed above represent the necessary first steps in this process. They also represent, in our judgment, the minimum action required if ERDA is to fulfill its responsibilities under NEPA and under the Atomic Energy Act.

EXHIBIT 26

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
412 Mohawk Building
222 S. W. Morrison St.
Portland, Oregon 97204

January 20, 1975

IN REPLY REFER TO
10ED.3

Dr. J. L. Liverman, Assistant General Manager
for Biomedical and Environmental Research
and Safety Programs
U. S. Atomic Energy Commission
Washington, D. C. 20545

Dear Mr. Liverman:

The U. S. Department of Transportation has completed its review of your draft environmental statement for Hanford Reservation Waste Management Operations. This review was coordinated with Region X U. S. DOT agencies, including the U. S. Coast Guard, Federal Railroad Administration, Federal Highway Administration and National Highway Traffic Safety Administration.

The attached comment report was prepared by Deputy Regional Federal Highway Administrator M. Eldon Green and represents the coordinated response of all the above DOT agencies and this office.. Please advise if we can be of any further assistance in your efforts regarding this proposal.

We appreciate the opportunity to review this statement.

Very truly yours,

M. Eldon Green

M. Eldon Green, Deputy
Regional Administrator

for: Don Samuelson, Regional Representative
of the Secretary of Transportation

Attachment

EXHIBIT 26 (Continued)

U. S. Department of Transportation
Region X Comment Report
on
Atomic Energy Commission
Draft Environmental Statement

"Waste Management Operations -
Hanford Reservation, Richland, Washington"

prepared by

Deputy Regional Federal Highway Administrator
M. Eldon Green

for

Don Samuelson
Regional Representative of the Secretary of Transportation

January 17, 1975

Analysis and Recommendations: If the Atomic Energy Commission continues the existing Hanford Reservation waste management operations as proposed in this draft environmental impact statement, then the U. S. Department of Transportation would have no further interest in this proposal. Current AEC policies, criteria and standards for management of high-level liquid radioactive wastes do not allow transportation offsite.

However, if Hanford Reservation authorities are faced with a shut-down of the N Reactor and the Purex Chemical Processing Plant and nuclear fuel is shipped offsite for processing, then close coordination between AEC and the U. S. Department of Transportation would be required regarding transportation and handling of hazardous materials. This should be so indicated in the final environmental statement.

We presume shipment would be by rail. The final environmental statement should indicate the method of shipment, how and what precautions would be observed in the transport of the irradiated fuel. The Federal Railroad Administration advises that the transportation of radioactive materials by rail is considered to be a safe method if all of the present federal regulations are complied with. This must be accomplished not only by the carrier involved but also the material must be properly prepared for shipment by the consignor.

Leakage from an overfilled railroad tank car should not or could not occur if such shipment were supervised by knowledgeable personnel acquainted with the physical characteristics of the material. There are

definite standards to provide proper outage to avoid such spills or leakage through the various outlets, whereas the internal pressure is increased by rising atmospheric changes. This can also be controlled by providing insulated tank cars for such shipments.

There is, of course, the ever-present potential hazard due to the possibility of a derailment, accident or fire which could cause the tank to rupture. The AEC and other agencies are equipped to handle such situations if properly notified. Thus, it is the Federal Railroad Administration's viewpoint that rail affiliated incidents are infinitesimal other than as noted above.

If Hanford Reservation authorities are faced with the ultimate disposal of high-level wastes, packaging and shipment to an offsite repository (alternative #4, p. V-22), then we recommend the final environmental statement indicate that any AEC investigations for such packaging and transport of wastes would be coordinated with the U. S. Department of Transportation. The draft environmental statement appears to indicate the transport mode cannot be determined at this time by AEC without completion of extensive research and development activities.

The summary to the draft environmental statement, pages I-1 through I-12, did not contain a list of those agencies, groups and individuals to whom the statement was furnished for review and comment. We suggest this be shown in the final environmental statement pursuant to Council on Environmental Quality guidelines (p. 20557 of the August 1, 1973 Federal Register - Vol. 38, no. 147 - "Appendix I - Summary to Accompany Draft and Final Statements"). This would show AEC's coordination effort with those agencies having jurisdiction and special expertise on the transportation and handling of hazardous materials (p. 20558 of F.R. Vol. 38, No. 147 dated August 1, 1973).

EXHIBIT 27

Natural Resources Defense Council, Inc.
664 HAMILTON AVENUE
PALO ALTO, CALIF. 94301
415 327-1080

Washington Office
917 15TH STREET, N.W.
WASHINGTON, D.C. 20005
202 737-5000

New York Office
15 WEST 44TH STREET
NEW YORK, N.Y. 10036
212 869-0150

January 21, 1975

Dr. James L. Liverman
Assistant General Manager for
Biomedical and Environmental
Research and Safety Programs
U. S. Atomic Energy Commission
Washington, D.C. 20545

Dear Dr. Liverman:

Pursuant to 40 F.R. 1116, I submit the enclosed comments on the Draft Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington, on behalf of Lieutenant Colonel Arthur S. Kubo.

Sincerely yours,

Terry R. Lash, Ph.D
Staff Scientist

TRL:kc

Enclosure

cc: Lieutenant Colonel Arthur S. Kubo

DEPARTMENT OF THE ARMY
UNITED STATES MILITARY ACADEMY
WEST POINT, NEW YORK 10996

RECEIVED
JAN 17 1975
NRDC - CALIF.

MADN-F

15 January 1975

Dr. Terry R. Lash
Staff Scientist
Natural Resources Defense Council, Inc
664 Hamilton Avenue
Palo Alto, CA 94301

RE: Draft Environmental Statement, Waste Management Operations, Hanford Reservation, Richland, Washington

Dear Dr. Lash:

I appreciate this opportunity to comment on the Draft Environmental Impact Statement (EIS) concerning radioactive waste management operations at the Hanford Reservation. Exigencies cause these too brief comments to be narrowly focused on the on-going and proposed high-level waste management program.

Concisely, the Hanford high-level waste management program works towards immobilizing the highly toxic liquid wastes for the near-term, while developing a long-term disposal strategem. Whether the long-term can be achieved and the propriety of ultimate tank storage are my major concerns.

1. I find that the near-term, salt cake solidification goal perhaps sub-optimal, and suggest the following for consideration:

a. The EIS makes reference to the deteriorated condition of the waste tank liners; the short steel liner life; the interstitial, highly caustic residuum; and the difficulty of recovering solidified wastes from deteriorated tanks. These factors invite speculation on the unprobable though possible breach of containment and the sequence of actions that follow. Although alluded to (III.2.4 Salt Cake Storage Tank Dome Failure), no statement of definitive contingency planning is made in the EIS as to how the salt cake will be retrieved nor where such a large volume of highly toxic, friable and water soluble material will be stored. (See 2.c.)

EXHIBIT 27 (Continued)

b. The proposal to continue reprocessing of spent N Reactor fuel should be reconsidered (V.2.1 and V.2.3.2.2). To be sure the incremental savings in storage requirements if reprocessing is discontinued is small, forgoing immediate reprocessing would preclude the production of the more difficult to manage neutralized wastes. Although requiring resolution of a few engineering obstacles, this course assists the overall scheme; it will (a) reduce the volume and storage requirement of diluted neutralized high-level wastes*, (b) preclude strontium and cesium removal because of the longer pre-processing storage period, (c) leave open the option of transhipping the spent fuel to a commercial reprocessor, and (d) permit on-site reprocessing and direct solidification if the high temperature melt formation processes (V.2.4.3) are eventually utilized at Hanford.

c. Of most serious concern is the unaddressed question, "Does this present solidification program permit the ultimate disposal alternatives 3 and 4 (V.2.5)?" (See 2.b. below.)

2. The ultimate waste disposal alternatives suggested for the Hanford Facility are unfortunate.

a. The taxonomy of alternatives appears based on an escalatory philosophy of decision making, one of minimizing the current cost subject to public acceptance. This view does not clearly address the totality of safety issues today and in the long-term future, long-term surveillance and monitoring requirements, and the anticipated total cost of each alternative that accounts for not only the large initial capital costs but properly reflects annual operating and maintenance costs plus capital replacement costs in perpetuity. This narrowing accentuates the fact that if waste management is not funded on a current basis (with on-going programs), after-the-fact costs distort the decision making process. This aspect has a close analogy in the commercial high-level waste management program, and I greatly fear that an acrimonious public debate on the utilization of interim storage facilities (as they were originally designated) as final disposal respositories will make current ERDA (AEC) argument on the creation of federally administered interim storage facilities less credible and even moribund. Much as the Lyons Repostory had flaws, the idea of ultimate disposal in near surface storage tanks is egregious, technically, socially, and environmentally. In this matter I feel that ERDA would do well if it directly pursued alternative #3 (V.2.5) as a minimum rather than the more circuitous course of action proposed.

*/ Footnote: A gross initial savings of 15 to 20 million dollars. From this must be subtracted the cost of interim storage and the incremental handling costs not realized if the current program continues.

b. The difficulties of altering the management scheme from in-tank solidification (alternatives 1 and 2) to out of tank solidification, packaging, and disposal (alternatives 3 and 4) have not been addressed. Ancillary to the waste recovery issue cited in 1.a. above, is the operational difficulty of removing the salt cake and decommissioning the storage tanks. The anticipated conditions of the carbon-steel tank liners cause standard sluicing and decontamination techniques to appear infeasible. A more complete analysis of this difficult transition is necessary prior to assuming that alternatives 3 and 4 are possible if current solidification practices continue.

In conclusion, I find that for all that was written, the discussion of the ultimate disposal alternatives and how present operations enhance ultimate safety of the Hanford facility await better resolution.

Thank you very much for this opportunity to assist in this important matter. Do not hesitate to contact me if I can be of further assistance.

Most sincerely,

ARTHUR S. KUBO
LTC, EN
Assistant Professor of
Nuclear Engineering

EXHIBIT 28

DOCKET NUMBER
PROPOSED RULE PR - Misc Notice (39 FR 32929) WASH 1538
Waste Management - DES & Hearing (GM) #28

STATE OF WASHINGTON 23 [illegible] 11:41
OFFICE OF THE GOVERNOR
OLYMPIA [illegible]

DANIEL J. EVANS
GOVERNOR

January 18, 1975

Mr. Paul Bender, Secretary
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dear Mr. Bender:

We have received the draft environmental impact statement "Wastes Management Operations, Hanford Reservation, Richland, Washington" (WASH-1538). This draft statement has been reviewed and the state of Washington has no comment to make at this time.

Notice has been received of hearings concerning this statement to be conducted in Richland, Washington on January 21, and Portland, Oregon on January 23. The state of Washington will be represented by Fred Adair, but the state does not plan to present a statement.

Sincerely,

Daniel J. Evans

Daniel J. Evans
Governor

DJE:blr

DOCKETED
USNRC
JAN 23 1975
Office of the Secretary
Public Proceedings
Staff

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GLOSSARY OF TERMS

The explanation of terms used in the Hanford Environmental Impact Statement is prepared according to the general usages developed during operations on the Hanford site. Where possible, the explanations are developed also in accordance with established standards.

The information is arranged alphabetically, including terms which are constructed by joining several words. For example, "salt cake" is listed under s and "low-level waste" under l.

A

abiotic - caused by non-living entities

activation - the induction of radioactivity in material by irradiation with neutron radioactive material, a radiation generating machine, or a nuclear reactor

activity - a measure of the rate at which a material is emitting nuclear radiations; usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time, the standard unit of activity is the curie (Ci)

adiabatic lapse rate - the rate of decrease of temperature with height of dry air lifted with no external heat losses or gains through an atmosphere in hydrostatic equilibrium

alpha radiation - an emission of particles (helium nuclei) from a material undergoing nuclear transformation; the particles have a nuclear mass number of four and a charge of plus two

alpha waste - waste material which is contaminated by radionuclides which emit alpha particles, particularly transuranic elements

anastomosing channels - branching or interlacing channels forming an interconnecting system

anticline - an uparched fold in which the rock strata dip away fron the fold's axis; the opposite of syncline

antithetic - as applied to faults, indicates faults with dips in the opposite direction from the dip of the enclosing rocks

aquifer - a subsurface formation containing sufficient saturated permeable material to yield significant quantities of water

atomic number - the number of protons in the nucleus of each chemical element

alluvial fan - rock deposit laid down by streams flowing from mountains into lowland regions

B

background radiation - the level of radioactivity in an area, which is produced by sources other than the one of specific interest; in the Hanford region, the background radiation is produced by naturally occurring radioactive materials in the crust of the earth, cosmic radiations, and the fallout from nuclear weapons tests

base case - the activities as presently planned; in environmental impact considerations and cost/benefit analyses, the detailed plan of actions for which impact is assessed and to which reasonable alternatives will be compared

benthic organisms (benthos) - those organisms dwelling on the bottoms of bodies of water

beta radiation - essentially weightless charged particles (electrons and positrons) emitted from the nucleus of atoms undergoing nuclear transformation

bioconcentration (bioaccumulation) - the process whereby an organic system selectively removes an element from its environment and accumulates that element in a higher concentration

biological oxygen demand (BOD) - a measure of the organic pollution of water, determined by the extent to which bacteria and other contained organisms in a water sample will use dissolved oxygen in a given period of time; therefore, a measure of the residual oxygen in the water for use by other organisms such as fish

biomass - the total mass of living and dead organisms present in an area, volume, or ecological system

biota - the plant and animal life of a region

biotic - caused by living organisms

body burden - the amount of a specified radioactive material or the summation of the amounts of various radioactive materials present in an animal or human body at the time of interest

boiling waste - high-level liquid radioactive waste containing radionuclides (principally ^{90}Sr and ^{137}Cs) which provide sufficient decay heat to be near the liquid's boiling point; such liquid usually requires some supplemental means of cooling

bottoms (tank) - the more concentrated material remaining in Hanford high-level liquid radioactive waste tanks after the bulk of the contents have been pumped out for solidification or transfer to other storage tanks; also refers to specific tanks used to collect such bottoms waste from several other tanks

breccia - rock composed of angular fragments cemented together

burial ground - an area specifically designated for the subsurface disposal of solid waste or excess materials; at Hanford such sites are used to temporarily isolate the material from the environment

byproduct material - radioactive material produced in a nuclear reactor, ancillary to the reactors main purpose of producing power or fissile materials; fission products are usually considered to be byproduct material

C

caisson - a vertically oriented cylindrical structure used for the subsurface disposal or storage of materials

caliche - an accumulation of calcareous material formed in soil or sediments in arid regions

cask - a container designed for the transporting of radioactive materials, the design usually includes special shielding, handling, and sealing features to provide positive containment of the materials and to minimize exposure of personnel

chemical oxygen demand (COD) - a measure of the extent to which all chemicals contained in a water sample use dissolved oxygen in a given period of time; therefore, a measure of residual dissolved oxygen in the water available for use by organisms such as fish

chemical processing - chemical treatment of materials to separate specific usable constituents; at Hanford, the separation by chemical means of plutonium from uranium and fission products resulting from irradiation of the uranium in a nuclear reactor

coliform (count, number) - a measure of the bacterial content of water; a high coliform count indicates potential contamination of a water supply by human waste.

concentration guide - the average concentration of a radionuclide in air or water to which a worker or member of the general population may be continuously exposed without exceeding appropriate radiation dose standards (see maximum permissible concentration)

9 1 1 3 9 1 0 9 9 4

confined aquifer - a subsurface water bearing region having defined relatively impermeable upper and lower boundaries and whose pressure is significantly greater than atmospheric throughout

contamination (contaminated material) - the deposition, solvation, or infiltration of radionuclides on or into an object, material, or area whereupon the area, material, or object is considered "contaminated"

controlled area - any specific region of the Hanford Reservation into which entry by personnel is regulated by physical barrier or procedure

counts per minute (cpm) - the number of events per unit time recorded by an instrument designed to detect radioactive particles; especially used to indicate the relative amount of radioactive contamination

crib - a linear excavation of about 15 ft in depth along the bottom of which is laid a perforated pipe, after which the ditch is backfilled with broken rock or other loose material and then covered by soil and a membrane which is impermeable to liquids; the pipe is then used to distribute intermediate-level liquid wastes along the crib

critical - the condition in which a material is undergoing nuclear fission at a self-sustaining rate; the critical mass of a material is that amount which will self-sustain nuclear fission when placed in an optimum arrangement in its present form; the minimum critical mass is the amount of a fissile isotope that will self-sustain nuclear fission when placed in optimum conditions

criticality safety - those procedures and understandings necessary to the handling of fissile materials in a manner that will prevent them from reaching a critical condition

curie (Ci) - a unit of radioactivity defined as the amount of a radioactive material that has an activity of 3.7×10^{10} disintegrations per second (d/s); millicurie (mCi) = 10^{-3} curie; microcurie (μCi) = 10^{-6} curie; nanocurie (nCi) = 10^{-9} curie; picocurie (pCi) = 10^{-12} curie; femtocurie (fCi) = 10^{-15} curie

D

daughter products - the nuclides formed by the radioactive disintegration of a first nuclide (parent)

deactivated - the condition of a facility or disposal site where steps have been taken to preclude further operation or the further addition of waste materials

decay chain - the sequence of radioactive disintegrations in succession from one nuclide to another until a stable daughter is reached

decay heat - the thermal energy produced in a material by its own radioactive disintegrations

decontamination - the selective removal of radioactive material from a surface or from within another material

decommissioning - the process of removing a facility or area from operation and decontaminating and/or disposing of it or placing it in a condition of standby with appropriate controls and safeguards

diastrophism - the process by which the crust of the earth is deformed producing mountains, faults, etc.

diethermal region - that portion of a body of water whose temperature varies with the daily fluctuating light cycles

dip-slip fault - a fault in which one wall has moved up or down the face of the fault relative to the other; contrasts to strike-slip fault

disintegrations per minute (dpm) - the number of radioactive decay events occurring per unit time in a given amount of material

disposal - the planned release or placement of waste in a manner that precludes recovery

ditch - a linearly oriented excavation; often used for the temporary diversion or disposal of process waste streams

dome - a roughly symmetrical upfold (anticlinal uplift) with beds dipping radially outward with roughly equal amounts from a given point; with the development of an axis, a dome becomes an anticline

dose - a general term indicating the amount of energy absorbed from incident radiation by a specified mass

dose commitment - the integrated dose which results from an intake of radioactive material when the dose is evaluated from the beginning of intake to a later time (usually 50 years); also used for the long term integrated dose to which people are considered committed because radioactive material has been released to the environment

drum - a metal or composition cylindrical container used for the transportation, storage, and disposal of waste materials

dry well - a bore hole that does not sink deep enough to reach goundwater; used to monitor the movement of liquid waste released near the surface and to check for possible leaks in underground waste storage tanks

dummy - a mock-up of a production reactor fuel element, which contains no uranium and is used only for spacing fuel

E

ecology - that branch of biological science which deals with the relationships between organisms and their environment

ecosystem - an assemblage of biota (community) and habitat

enterococci (count) - a measure of the number of a particular group of bacteria present in a water sample; these bacteria are associated with the fecal material of warm blooded animals, an indication (more specific than coliform count) of potential contamination of water by human wastes

environmental surveillance - a program to monitor the impact on the surrounding region of the discharges from industrial operations

evapotranspiration - the combined loss of water from soil by evaporation from the soil and from the surfaces of plant structures

excursion - a sudden rapid increase of power produced when a reactor or other system of fissile material undergoes a sudden increase in reactivity

exposure - the condition of being made subject to the action of radiation

F

fallout - those radioactive materials deposited on the earths' surface and in the atmosphere following the detonation of nuclear weapons

fanglomerate - a mxiture of heterogeneous sediments originally deposited in an alluvial fan, subsequently cemented into rock

fast flux (fast neutron) - a stream of neutrons having energies (velocities) near that imparted to them by a fission event; when applied to nuclear reactors, refers to those using high velocity neutrons to cause successive fission events

feral - existing in a natural state

fertile isotope - a nuclide which is particularly capable of being transmuted into another useful nuclide (especially ^{238}U which is transmuted in production reactors to plutonium)

fissile - material capable of undergoing fission by any process

fissionable - material capable of undergoing fission by slow neutrons

fission (nuclear) - the division of a nucleus into two nuclides of lower mass, usually accompanied by the expulsion of gamma rays and neutrons

fission products - the nuclides formed by the division of a heavier nucleus; most usually in a nuclear reactor

five hundred year storm - those weather conditions which are characteristic of the worst storm having occurred in an area at any time during the past 500 years; used to indicate the probability of recurrence

food-chain - a linear sequence of successive utilizations of nutrient energy by a series of species

food-web - the concept of nutrient energy transfers (including decomposition) between species in an ecosystem

fractionization - the process of removing specific constituents (such as strontium and cesium) from liquid waste

French drain - a rock filled encasement with an open bottom to allow seepage of liquid waste into the ground

fuel (nuclear, reactor) - fissionable material used as the source of power when placed in a critical arrangement in a nuclear reactor

fuel separation (fuel reprocessing) - processing of irradiated (spent) nuclear reactor fuel to recover useful materials as separate products, usually separation into plutonium, uranium, and fission products

G

gamma radiation - electromagnetic energy emitted in the process of a nuclear transition

gamma scan - process of measuring the energy spectrum of the gamma rays emitted by a material in order to determine its constituent nuclides

gastronitestinal dose (GI) - the dose to the stomach and lower tract of humans and animals via external exposure or via internal transport of radioactive material

GeigerMuller Tube - a gas-filled tube used to detect radiation events by the ionization pulse produced in the gas; used on a GM counter

glacio-fluviatile - pertaining to streams flowing from glaciers, or the deposits made from such streams

graben - a geological structure which is a generally linear block bounded by faults on each side, along which the block has dropped, relative to the sides

groundwater - water which exists or flows below the surface (within the zone of saturation)

H

habitat - the abiotic characteristics of the place where biota live (see community)

half-life - the time required for the activity of a radionuclide to decay to half its value; used as a measure of the persistence of radioactive materials, each radionuclide has a characteristic constant half-life

high efficiency particulate air filter (HEPA) - an air filter capable of removing at least 99.97% of the particulate material in an air stream

high-heat waste - liquid radioactive waste which generates sufficient fission product decay heat to cause self-boiling and self-concentration (see self-boiling waste)

high-level liquid waste - fluid materials, disposed of (by storage in underground tanks) from Hanford operations, which are contaminated by greater than 100 μCi/ml of mixed fission products or more than 2 μCi/ml of ^{137}Cs, ^{90}Sr, or long-lived alpha emitters

hood - a canopy and exhaust duct used to confine hazardous materials in order to reduce the exposure of industrial workers

hydraulic conductivity - the parameter relating the volumetric flux to the driving force in flow through a porous media (particularly water through soil); a function of both the porous medium and the properties of the fluid

hydraulic potential - a measure of the force present to cause groundwater flow; related to the height of the column of water above the point at which the potential is being measured and the elevation of the point relative to mean sea level

hydrostatic equilibrium - the state of a fluid where no relative motion occurs between fluid elements and the pressure at any point is equal to the weight of a unit cross-section of a column of fluid above that point.

hypothetical maximum individual (max man) - a postulated person who is assumed to receive the maximum credible radiological dose through each of the exposure pathways from the source being considered (such as swimming often in a body of water, eating large quantities of fish obtained from that water, and drinking a large amount of water from the same source)

I

inactive - the condition of a facility or disposal site which is not presently being operated or to which materials are not being added

intermediate-level liquid waste - fluid materials, disposed as a result of Hanford operations, which contain from 5×10^{-5} µCi/ml to 100 µCi/ml of mixed fission products, including less than 2 µCi/ml of ^{137}Cs, ^{90}Sr, or long-lived alpha emitters

inversion - a condition where temperature increases with height in the atmosphere

ion exchange - process for selectively removing a constituent from a waste stream by reversibly transferring ions between an insoluble solid and the waste stream; the exchange medium (usually a column of resin or soil) can then be washed to collect the waste or taken directly to disposal; for example, a hot water softener

irradiation - exposure to radiation by being placed near a radioactive source; usually in the case of fuel materials, being placed in an operating nuclear reactor

isokinetic - a line in a given surface connecting points with equal wind speed

isopleth - a line connecting all points of equal air concentration in plotting that air concentration at ground level as a function of direction and distance from a point of release

isotherm - a line joining points having the same temperature

isotope - nuclides with the same atomic number, (i.e., the same chemical element) but with different atomic masses; although chemical properties are the same, radioactive and nuclear properties may be quite different for each isotope of an element

K

K_{eff} (multiplication factor) - a measure of the degree of sequential change in the number of fission events in a system containing fissionable material; when the multiplication factor is one or greater, a self-sustaining chain reaction is possible; defined by the ratio of the average number of neutrons produced by fission in each generation to the total number of corresponding neutrons lost by absorption and leakage

knuckle - point where the side wall and the bottom curved surface of the tank meet

L

leaching trench - an excavation used for the disposal of liquids so that the soil will remove contaminants while allowing water and other solvents to pass through

lithologic - pertaining to the characteristics and study of rocks

loess - a homogeneous, nonstratified, unindurated sediment, largely silt, deposited primarily by the wind

9 6 6 0 1 6 8 1 1 6

long-lived isotope - a radioactive nuclide which decays at such a slow rate that a quantity of it will exist for an extended period; usually radionuclides whose half-life is greater than 3 years

low-heat waste - liquid radioactive waste which does not generate sufficient fission product decay heat to boil or self-concentrate

low-level liquid waste - fluid materials, disposed of at Hanford, which are contaminated by less than 5×10^{-5} μCi/ml of mixed fission products

M

macrophytes - the plant life of a body of water which is larger than microscopic

man-rem - used as a unit of population dose; often the average dose per individual expressed in rems times the population affected

maximum permissible concentration (MPC) - the average concentration of a radionuclide in air or water to which a worker or member of the general population may be continuously exposed without exceeding an established standard of radiation dose limitation

metasediments - sedimentary rocks, such as sandstones and shales, that were subjected to metamorphism sufficient to modify but not to obliterate evidence of their sedimentary origin

metavolcanics - volcanic rocks, such as tuffs and lavas, that were subjected to metamorphism sufficient to modify but not obliterate evidence of their volcanic origin

monocline - a downward flexure in otherwise horizontal strata without any corresponding upfold to form a syncline or anticline

N

neutron - a particle existing in or emitted from the atomic nucleus; it is electrically neutral and has a mass approximately equal to that of a stable hydrogen atom

neutron activation - the process of irradiating a material with neutrons so that the material itself is transformed into a radioactive nuclide

nitrogen oxides (NO_x) - a mixture of nitrogen-oxygen containing compounds formed as gaseous waste effluents during the combustion of most fossil fuels

nuclear fission - see fission

nuclear radiation - particles and electromagnetic energy given off by transformations occurring in the nucleus of an atom

nuclear reactor - a device constructed of fissionable material such that a chain of fission events can be maintained and controlled to meet a particular purpose

nuclide - a species of atom having a specific mass, atomic number and nuclear energy state

nucleus - the positively charged center of an atom

P

palagonite - a hydrated basaltic glass that, in the Pasco Basin, was commonly formed when molten basalt entered water; indicative of an aqueous environment, often associated with pillow lava

partitioning - the process of separating liquid waste into two or more fractional solutions

penetrating radiation - forms of radiant energy which are capable of passing through significant thicknesses of solid material; these usually include gamma rays, x rays and neutrons

periphyton - organisms that live attached to underwater surfaces

permissible dose - that dose of ionizing radiation which, in the light of present knowledge, carries negligible probability of causing severe somatic injury of genetic effect

pH - a measure of the relative acidity or alkalinity of solution; a neutral solution has a pH of 7 acids have pH's of 7 to 1, bases have pH's of 7 to 14

phytoplankton - microscopic plants that live drifting in a body of water

pillow lava - basaltic material congealed in rounded masses, indicative of submarine flows or eruptions

population dose (population exposure) - the summation of individual radiation doses received by all those exposed to the source or event being considered

power reactor - a nuclear reactor designed to produce heat for conversion to electrical energy or mechanical propulsion

present worth - the present worth for a series of expenditures related to a plan of action is the amount of money that would need to be invested on a certain date at a fixed rate of interest in order to provide the required funding to accomplish the action; at the end of the action, the balance of invested money has been reduced to zero and the amount of money invested plus the interest on that money equals the total expenditure to accomplish the action

production reactor - a nuclear reactor designed for transforming one nuclide into another; usually, a conversion of natural uranium into plutonium

Purex - the facility and process which uses steps of solvent extraction and ion exchange for the separation of plutonium and uranium from irradiated production fuels

R

rad - a special unit of measure for the absorved dose of radiation; one rad equals 100 ergs absorbed per gram of material

radiation (ionizing) - particles and electromagnetic energy emitted by nuclear transformations which are capable of producing ions when interacting with matter; gamma rays and alpha and beta particles are primary examples in Hanford waste

radiation survey - evaluation of an area or object with instruments in order to detect, identify and quantify radioactive materials and radiation fields present

radiation zone - area which contains radioactive materials in quantities significant enough to require control of personnel entry to the area

radioactive (decay) - property of undergoing spontaneous nuclear transformation in which nuclear particles or electromagnetic energy are emitted

radioiodines - isotopes of iodine which are radioactive

radionuclide - a nuclide which is radioactive

radiotoxicity - the property of a material of being able to adversely affect biological organisms through the mechanism of nuclear radiation

radwaste - waste materials which are radioactive

raptor - bird of prey

reactivity - a measure of the capability of a system to maintain criticality; systems with high reactivity are capable of undergoing rapid excursions of increasing power; systems with low reactivity will undergo slower excursions; systems with negative reactivity will not become critical

reactor - a nuclear reactor

redd - the spawning grounds or nests of salmon

Redox - a facility and the process for separating plutonium and uranium from irradiated reactor fuels by using successive steps of chemical Reduction Oxidation together with solvent extraction

regolith - rock "waste" or surface mantle of unconsolidated rock debris; in the Pasco Basin, the basin-fill sediments that are the parent materials of the local "soils"

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release limit (release guide) - a control number which regulates the concentration or amount of radioactive material released to the environment in an industrial situation; usually dose to persons in the environment derived from environmental behavior of the released material so that the dose is kept below a selected control value

rem - a unit of measure for the dose of ionizing radiation which gives the same biological effect as one roentgen of X rays; one rem approximately equals one rad for X, gamma, or beta radiation

reprocessing - chemical processing of irradiated nuclear reactor fuels to remove desired constituents

retention basin - an excavated and lined area used to hold contaminated fluids until radioactive decay reduces activities to levels permissible for release

retired facility - a facility which has been shut down with no intentions of restarting and which has had appropriate controls and safeguards placed on it

roentgen - a unit of measure of ionizing electromagnetic radiation (x and gamma); one roentgen corresponds to the release by ionization of 83.8 ergs of energy per gram of air

rupture - a breach of the metal cladding of a production reactor fuel element thereby releasing radioactive materials to reactor cooling streams

S

salt cake - the solid residue resulting from a concentration of high-level liquid waste in Hanford underground waste storage tanks

sanitary landfill - a burial operation for the purpose of disposing of sanitary sewage

sanitary sewage - human wastes and other nonradioactive material for disposal to preserve public health

scintillation (counter) - light flashes produced in crystalline material by ionizing radiation; measurement of the level of activity of the source

seepage pond - an artificial body of surface water formed by discharge from Hanford process operations

seismicity - the tendency for the occurrence of earthquakes

self-boiling waste - high-level liquid radioactive waste whose constituent radionuclides contribute sufficient decay heat to cause the solution to boil and/or self concentrate

shielding - bulkheads, walls, or other constructions used to absorb radiation in order to protect personnel or equipment

short-lived isotope - a radioactive nuclide which decays so rapidly that a given quantity is transformed into its daughter products within a short period (usually those with a half-life of days or less)

slug - a fuel element for one of the Hanford production reactors

smear - a means of measuring loose surface contamination on an object by wiping it with paper, gauze, etc., and then measuring the disintegrations per minute on the wipe with an instrument

solid wastes (radioactive) - either solid radioactive material or solid objects which contain radioactive material or bear radioactive surface contamination

sorptive capacity - the measure of a material's ability to sorb specific constituents from a liquid as it passes through the material

source material - uranium or thorium or any ores which contain at least 0.05% of uranium or thorium

source term - the quantity of radioactive material, released by an accident or operation, which subsequently causes exposure after some mechanism of transmission or deposition

special nuclear material (SNM) - plutonium, ^{233}U, ^{235}U, or uranium enriched to a higher percentage than normal of the 233 or 235 isotopes

special work procedure (SWP) - a formally written procedure for the conduct of work involving radioactive materials

stability (atmospheric) - a description of the atmospheric forces on a parcel of air following vertical displacement in an atmosphere otherwise in hydrostatic equilibrium; if the forces tend to return the parcel to its original level, the atmosphere is stable; if the forces tend to move the parcel further in the direction of displacement, the atmosphere is unstable; if the air parcel tends to remain at its new level, the atmosphere has neutral stability

standby - the condition where a facility or burial ground, etc., is placed in a non-operating condition but is maintained in readiness for subsequent operation

storage basin - a water-filled facility for holding irradiated reactor fuels with the water acting as a shield

strike-slip fault - a fault in which the movement (offset) has been parallel to the fault's strike; contrasts to dip-slip fault

sulfur oxides (SO_2, SO_3) - compounds formed as waste effluents during the burning of some fossil fuels

synclinal valleys - a structure formed by down warping in geological formations; in a syncline, the rock strata dip towards the fold's axis; the opposite of anticlines which, in central Washington, commonly form ridges

T

tank - a large metal container located underground for storage of liquid wastes

tank farm - an installation of interconnected underground containers (tanks) for storage of high-level waste

taxon (pl. taxa) - a unit of classification (usually biological) of any degree of specificity or generality; e.g., family, order or subspecies

tectonic - of pertaining to, or designating the rock structures resulting from deformation of the earth's crust

terminated - the condition of a waste disposal site in which its use is to be discontinued because its capacity has been reached (or for other reasons); specific conditions to be met upon terminating a site are established by ERDAM-0510

terrane - any rock formation or series of formations

tracer - a radionuclide(s) or chemical introduced in minute quantities to a system or process for the purpose of using radiation or chemical detection techniques to follow the behavior of the process or system

transmutation - the process whereby one nuclide changes (or is changed) into another; usually by the addition of nuclear particles

transuranium - nuclides having an atomic number greater than that of uranium (i.e., greater than 92)

transmissivity - a coefficient relating the volumetric flow through a unit width of groundwater to the driving force (hydraulic potential); a function of both the porous medium, fluid properties, and saturated thickness of the aquifer

trench - a ditch used for the disposal of solid radioactive waste or low-level liquid waste

trophic levels - pertains to groupings of organisms according to characteristics of their intake of nutrition

turbidity - a measure of the degree to which sediments and other foreign matter are suspended in water (cloudiness)

U

unconfined aquifer - an aquifer that has a water table or surface at atmospheric pressure

V

vadose zone - the unsaturated region of soil between the ground surface and the water table

V-trench - a concrete-lined, earth-covered excavation for storing drums containing transuranic bearing solid radioactive waste

W

water table - upper boundary of an unconfined aquifer surface below which saturated groundwater occurs; defined by the levels at which water stands in wells that barely penetrate the aquifer

wind rose - a diagram designed to show the distribution of prevailing wind directions at a given location; some variations include wind speed groupings by direction

Z

zooplankton - microscopic animals that live drifting in a body of water

LIST OF ELEMENTS

ELEMENT	SYMBOL	ATOMIC NUMBER	ELEMENT	SYMBOL	ATOMIC NUMBER
actinium	Ac	89	mercury	Hg	80
aluminum	Al	13	molybdenum	Mo	42
americium	Am	95	neodymium	Nd	60
antimony	Sb	51	neon	Ne	10
argon	Ar	18	neptunium	Np	93
arsenic	As	33	nickel	Ni	28
astatine	At	85	niobium	Nb	41
barium	Ba	56	nitrogen	N	7
berkelium	Bk	97	nobelium	No	102
beryllium	Be	4	osmium	Os	76
bismuth	Bi	83	oxygen	O	8
boron	B	5	palladium	Pd	46
bromine	Br	35	phosphorus	P	15
cadmium	Cd	48	platinum	Pt	78
calcium	Ca	20	plutonium	Pu	94
californium	Cf	98	polonium	Po	84
carbon	C	6	potassium	K	19
cerium	Ce	58	praseodymium	Pr	59
cesium	Cs	55	promethium	Pm	61
chlorine	Cl	17	protactinium	Pa	91
chromium	Cr	14	radium	Ra	88
cobalt	Co	27	radon	Rn	86
columbium	Nb	(see niobium)	rhenium	Re	75
copper	Cu	29	rhodium	Rh	45
curium	Cm	96	rubidium	Rb	37
dysprosium	Dy	16	ruthenium	Ru	44
einsteinium	Es	99	samarium	Sm	62
erbium	Er	68	scandium	Sc	21
europium	Eu	63	selenium	Se	34
fermium	Fm	100	silicon	Si	14
fluorine	F	9	silver	Ag	47
francium	Fr	87	sodium	Na	11
gadolinium	Gd	64	strontium	Sr	38
gallium	Ga	31	sulfur	S	16
germanium	Ge	32	tantalum	Ta	73
gold	Au	79	technetium	Tc	43
hafnium	Hf	72	tellurium	Te	52
helium	He	2	terbium	Tb	65
holmium	Ho	67	thallium	Tl	81
hydrogen	H	1	thorium	Th	90
indium	In	49	thulium	Tm	69
iodine	I	53	tin	Sn	50
iridium	Ir	77	titanium	Ti	22
iron	Fe	26	tungsten	W	74
krypton	Kr	36	uranium	U	92
lanthanum	La	57	vanadium	V	23
lawrencium	Lw	103	wolfram	W	(see tungsten)
lead	Pb	82	xenon	Xe	54
lithium	Li	3	ytterbium	Yb	70
lutetium	Lu	71	yttrium	Y	39
magnesium	Mg	12	zinc	Zn	30
manganese	Mn	25	zirconium	Zr	40
mendelevium	Md	101			

LIST OF ABBREVIATIONS

AEC	Atomic Energy Commission
AECM	Atomic Energy Commission Manual
ALATEP	"As low as technically and economically practicable"
ALE	Arid Lands Ecology, a reserve run for ERDA by Battelle, Pacific Northwest Laboratories
approx	approximately
ARHCO	Atlantic Richfield Hanford Company
ASATEP	"As soon as technically and economically practicable"
atm	atmosphere
BNW	The Pacific Northwest Laboratories of Battelle Memorial Institute, commonly referred to as Battelle-Northwest
Btu	British thermal unit
CAW	Current Acid Waste
cc	cubic centimeter
cm	centimeter
CF	Concentration Factor
cfs	cubic feet per second
m^3	cubic meter
Ci	curie
DEIS	Draft Environmental Impact Statement for Waste Management Operations issued September 1974
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERDAM	Energy Research and Development Administration Manual
erg	a centimeter-gram-second unit of energy
FFTF	Fast Flux Test Facility
F.P.	fission products
fpm	feet per minute
fps	feet per second
FSAR	Final Safety Analysis Report
ft^2	square feet, ft^3 = cubic feet
g	gram (Seismology, g = gravity)
g/day	grams per day
gal	gallon(s)
gpd	gallons per day
gpm	gallons per minute
gpy	gallons per year
HEDL	Hanford Engineering Development Laboratory (operated by Westinghouse)
HEHF	Hanford Environmental Health Foundation
HEPA	High Efficiency Particulate Air
HMS	Hanford Meteorological Station
ITS-1 and -2	In-Tank Solidification, Units 1 and 2
kV	kilovolt
kW	kilowatt
kW-hr	kilowatt-hour
ℓ	liter
max	maximum
mbs	millibars
MCi	megacurie
μCi	microcurie
mCi	millicurie
m^2	square meter, m^3 = cubic meter
MeV	million electron volts
mg	milligram
m/hr	1000 pounds steam per hour
min	minimum (Time, minute)
ml, ℓ	milliliter, liter
MPC	Maximum Permissible Concentrations
mph	miles per hour
mrad	millirad
mrem	millirem
mR/hr	milli-Roentgen per hour
MSL	Mean Sea Level
MT	metric ton
MW	megawatt
MWe	megawatts, electric units
MWt	megawatts, thermal units
No.	number
PAS	Purex Acidified Sludge
pCi	picocurie
PMF	Probable Maximum Flood
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
%	percent
PSAR	Preliminary Safety Analysis Report
PSS	Purex Sluicing Supernatants
PST	Pacific Standard Time
SS	stainless steel

tonnes	metric ton = ~2200 lb = 100 kg
Tri-Cities	area including cities of Richland, Pasco and Kennewick, Washington
UNH	uranyl nitrate hexahydrate
UNI	United Nuclear Industries, Inc.; a wholly-owned subsidiary of United Nuclear Corporation, formerly DUN
wk	week
WNP-2	Washington Nuclear Plant (Number 2)
WPPSS	Washington Public Power Supply System; The utilities company which operates WNP and the Hanford Generating Plant
wt	weight