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FINAL
ENVIRONMENTAL IMPACT STATEMENT

Long-Term Management of Defense High-Level Radioactive Wastes

(Research and Development Program for Immobilization)

Savannah River Plant
Aiken, South Carolina

November 1979

U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Nuclear Energy
Washington, DC 20845

FOREWORD

The purpose of this environmental impact statement (EIS) is to analyze the environmental implications of the proposed continuation of a large Federal research and development (R&D) program directed toward the immobilization of the high-level radioactive wastes resulting from chemical separations operations for defense radionuclides production at the DOE Savannah River Plant (SRP) near Aiken, South Carolina. This statement analyzes, in general, the environmental impacts which could result from subsequent implementation on the SRP high-level wastes, of the technology developed during the R&D phase. It does not address the impacts of alternative R&D programs for immobilization. Any specific proposals to actually implement the results of the R&D program will be covered in subsequent project-specific reviews.

A related document, *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste at the Savannah River Plant* (Report ERDA-77-42), issued in May 1977, included a description of the SRP high-level wastes and some 23 alternatives for managing these wastes. However, without an extensive R&D program, the only alternative actually available to DOE is continuation of the present SRP storage of wastes as a mixture of alkaline sludge, salt and liquid in large underground carbon steel tanks. The purpose of the R&D program, therefore, is to create additional options for the management of the SRP wastes, which may also be applicable to the high-level wastes at other DOE sites.

The proposed multi-year R&D program is aimed at developing the technology for removing the wastes from the tanks, concentrating them into a high activity fraction, and immobilizing the radioactive nuclides in a high integrity form for subsequent disposal. The proposed R&D program is sufficiently broad in its initial stages so that the immobilized waste could be made compatible with a variety of disposal techniques, such as in a mined geologic repository or surface engineered storage. Moreover, the R&D program could be modified in later stages, as appropriate, to yield a waste form specifically tailored to the exigencies of the disposal method ultimately selected. Sufficient time is allowed to implement any such changes and to consider system compatibility.

The alternatives to carrying out the proposed immobilization R&D program are to decide to (1) continue tank storage of the wastes, or (2) fund an R&D program for direct disposal of the wastes in bedrock under the Savannah River Plant. The consequences of these alternatives have been analyzed for comparison to the consequences of conducting and implementing the proposed immobilization R&D program.

Because of their advanced stage of development, borosilicate glass monoliths are utilized as the reference waste form in the analyses in this statement. However, these analyses do not imply a decision to actually use this waste form. Rather, since these analyses are carried out using glass properties and characteristics which are believed reasonably attainable with near-term technology, and since another waste form would not be chosen unless it had equal or better processing and product characteristics than assumed herein for borosilicate glass monoliths, the EIS calculations can be considered limiting for any advanced waste form in that they should represent the worst conditions expected. A large R&D program is being conducted on other advanced waste forms at a variety of national laboratories, universities, and industrial plants.

The *"Report to the President by the Interagency Review Group on Radioactive Waste Management"* (IRG) includes the following recommendations:

> The IRG recommends the DOE accelerate its R&D activities oriented toward improving immobilization and waste forms and review its current immobilization programs in the light of the latest views of the scientific and technical community. Since final processing of defense waste has been deferred for three decades the IRG also recommends that remedial action, including immobilization of the waste, should begin as soon as practicable.

Accordingly, the proposed R&D program is aimed at permitting a decision on an SRP immobilization plant in 1982, and the waste forms in 1984.

Comments and suggestions for use in the preparation of this EIS were solicited in a Federal Register Notice (42 FR 27281, May 27, 1977), which announced the intent to prepare this statement and the availability of ERDA-77-42. A draft version of this EIS was issued in July 1978 and comments on the draft were received through June 1979. The substantive points identified in the comments received are summarized in Appendix A and are addressed at the appropriate places in the text of the statement. In addition, each letter and the corresponding DOE response are given in Appendix B. Many of the comments on the draft centered around the programmatic versus project-specific nature of the document, and how it fits into the overall waste management decision process. An expanded discussion of these topics is included in the Summary and Description of Proposed Action sections. A Glossary of Terms and Abbreviations is included as Appendix C.

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1. SUMMARY

The Savannah River Plant (SRP) near Aiken, South Carolina, is a major installation of the Department of Energy for the production of nuclear materials for national defense. It began operations in the early 1950's and is currently the Nation's primary source of reactor-produced defense materials. The SRP operations also produce liquid high-level radioactive waste from the chemical processing of fuel and target materials after irradiation in the SRP nuclear reactors. The high-level waste has been and is continuing to be stored safely in underground tanks that are engineered to provide reliable storage of the waste isolated from the environment. No on-site or off-site radiation injuries have occurred from these operations, nor has there been any off-site contamination. However, some local leaks and spills have occurred, and the tanks have to be replaced at regular intervals (20-50 years). The impacts of present and relatively near-term management of this tank storage were developed in a previous environmental statement issued in final form in September 1977.*

The present statement explores the environmental implications of a large research and development (R&D) program aimed at developing the proposed continuation of technology for removing the wastes from the tanks and immobilizing the radionuclides in solid forms for subsequent disposal. Any later proposals to take action of potentially significant impact, such as the construction of a major waste treatment facility or the construction of a permanent waste repository, will be covered in subsequent project-specific environmental reviews.

The proposed R&D program is directed toward developing technology for converting the waste into two fractions: a durable waste form containing over 99% of the radioactivity, and decontaminated salt, with storage or disposal of the waste form, e.g., in an off-site geological repository, an on-site surface storage vault, or an on-site geological repository (bedrock cavern) and storage of the salt in: decontaminated waste tanks at SRP, an on-site surface vault, or an off-site geologic repository.

The following alternatives to the proposed immobilization R&D program are assessed for environmental impact:

- continue storing high-level waste in subsurface storage tanks, which is a continuation of the present management practice.
- slurry the high-level waste into bedrock caverns, an on-site geological repository. (This alternative has been designated as environmentally unacceptable by the U.S. Environmental Protection Agency (EPA)).

* Environmental Impact Statement, Waste Management Operations, Savannah River Plant. Report ERDA-1537, Energy Research and Development Administration (September 1977).

Throughout the document, storage will mean that the waste is retrievable with only moderate effort and should have some surveillance and maintenance by man. Storage may continue indefinitely, or may later be replaced by disposal. Disposal will mean that there is no intent that the waste would be retrieved. Some disposal options provide for retrievability for periods of years after emplacement of the waste.

The proposed R&D program allows for the development of a variety of waste forms. The reference waste form for Savannah River wastes is borosilicate glass monoliths, but programs at a variety of DOE sites are investigating concretes, calcines, high-silica glasses, clay ceramics, crystalline mineral analogues such as supercalcines, and SYNROC, glass ceramics, metal matrices, and multibarrier forms (see Section IV.D). The proposed engineering development effort on an immobilization plant design will be undertaken with sufficient flexibility so as not to foreclose any of the reasonable alternative forms under consideration prior to completion of a project specific environmental review.

The method for disposal subsequent to immobilization has not yet been chosen and alternative disposal options are not addressed in this EIS. This work falls under a separate DOE program and will be addressed in separate environmental reviews. Generic analyses of the impacts of geologic disposal of engineered surface storage subsequent to immobilization are presented in this statement. The waste form and container size could be made compatible with any geologic disposal option or any surface storage option. The outer container material may change depending upon the type of geologic formation, and engineered barriers may be used as a buffer between the waste form and the repository. The waste form technology development program will consider compatibility of the waste form with the host rock and with the outer container and engineered barrier materials. Cost differences among the off-site repository options also have little influence on the technology development program because they are small compared to total implementation costs of the alternative being developed. The variation in geologic cavern capital and operating costs shown in Section X between an off-site repository in salt ($200 million) and an off-site repository in rock ($390 million) is typical of the range to be expected. The difference of $190 million between these is about 5% of the total cost of the geologic disposal option.

Pertinent analyses of the geologic disposal option and other disposal options are included in the draft *EIS on Management of Commercially Generated Radioactive Waste*, DOE/EIS-0046-D, April 1979. These other options include chemical resynthesis, disposal in very deep holes, island disposal, sub-seabed geologic disposal, ice sheet disposal, reverse-well disposal, partitioning and transmutation, and space disposal.

Chemical resynthesis requires waste immobilization into synthetic minerals; the very deep hole, sub-seabed, ice-sheet, island and space disposal options require immobilization into a high-integrity form; and partitioning and transmutation requires separation of the wastes followed by immobilization of portions of the high-level fraction. The proposed R&D program is sufficiently broad in its initial stages so that it can be modified in later stages, as appropriate, to meet the needs of these options.

The remaining two options, disposal by rock melting or reverse-well disposal, involve direct disposal of liquid wastes in rock. These options are represented in this EIS by the alternative of liquid waste disposal in bedrock.

A summary of key quantifiable environmental impacts and costs of each alternative is given in Table I-1. The risk items shown in Table I-1 are discussed more fully in Section V, and the costs are covered in Section X.

There are no substantial environmental impacts arising from nuclear radiation for any of the three alternatives. Some of the individual doses in the SRP on-site cases are of concern; however, they could occur to only a limited number of people. The off-site population exposure risk from the alternative with highest risk (liquid waste stored in an SRP bedrock cavern) is more than one-thousandfold lower than natural radiation exposure to the same population. The factor of 200 cancer deaths per million man-rem recommended by the EPA can be used to convert the exposures from Table I-1 to possible health effects. This dose-effect relationship probably overestimates the actual radiation effects, as discussed in Section XII. Based on the EPA factor, the alternative with the highest off-site risk (slurry into bedrock) would result in 12 fatalities over a 300-year period, whereas the same population would experience about 46,000 fatalities over the 300-year period from natural radiation effects. Over a 10,000-year period, the risk would be 28 fatalities versus about 2,000,000 fatalities from natural radiation.

Nonnuclear fatalities to be expected from construction and operating activities related to each alternative are greater than those that would be expected from radiation effects, but are no larger than the risks voluntarily accepted by industrial workers.

The most significant quantifiable differences between the alternatives are the differences in budgetary costs. As shown in Section XI, none of the alternatives approaches the trade-off value of $1000 per man-rem for expenditures beyond the least expensive alternative (continued tank farm operation). (The value of $1000 per man-rem is somewhat arbitrary, and is used in this document as an example of how radiation risks might be evaluated and compared with monetary costs.)

Cost considerations and how they are balanced in a judgmental manner with the unquantifiable factors listed in Table I-2 are elements in deciding whether to proceed with the proposed program. Off-site radiation risks, occupational exposures, nonnuclear risks, and other environmental effects are small in absolute magnitude for all options analyzed.

Orientation of the proposed Savannah River technology development program toward conversion of the waste to a high-integrity form for subsequent disposal has been influenced by public opinion and perception of risks, as expressed through governmental bodies and special interest groups. For example, comment letters on the draft of this statement were received from the Governor of the State of Georgia indicating opposition to bedrock disposal of waste under the SRP site, and from the U.S. Environmental Protection Agency categorizing any bedrock disposal option at SRP as Environmentally Unsatisfactory.

II. DESCRIPTION OF THE PROPOSED ACTION

A. PURPOSE

This environmental impact statement (EIS) is issued to provide environmental guidance for the research and development program that is proposed to be carried out at the Savannah River Plant (SRP) and its subcontractors related to long-term management of the high-level radioactive waste generated at SRP as part of the Nation's nuclear defense program. Twenty-three alternatives for long-term management of the SRP waste had earlier been analyzed as to applicable technology, probable costs, and risks in *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste* (called the DWD). This programmatic statement is based in part on the technical information in the DWD[1] and in an earlier EIS on interim waste management at SRP.[2] It adds to this earlier material an assessment of the full range of environmental impacts associated with implementation of three of the alternative plans.

The research and development (R&D) is necessary for implementation of the alternatives outlined in Section I that involve processing the waste to an immobile form for storage onsite or offsite. One of the other alternative plans, continued tank farm operation, does not require the research and development work being a continuation into the future of present waste management practices at SRP. This alternative is the "No Action" case,* but will hereafter be referred to as "Continued Present Action." The remaining alternative plan, disposal of liquid waste in a bedrock cavern at SRP, would require extensive research and development, but this work is not currently proposed for funding.

The purpose of this environmental impact statement is to analyze the environmental implications of the proposed continuation of a large Federal R&D program to develop methods for immobilization of the SRP wastes. The EIS analyzes the environmental effects that would occur if the R&D program is followed by actual implementation of one of the alternative plans based on such research and development.

* "No Action" is terminology used in regulations issued by the Council on Environmental Quality.

B. POLICY AND OBJECTIVES

It is the policy of the Department of Energy to conduct research and development, testing, and design work with sufficient breadth and lead time to ensure that whichever of the most promising alternatives is selected for long-term management of defense waste, it can be implemented on a timely basis. This work is carried out with full public disclosure through public reports, information meetings, and environmental impact statements. The DOE policy is promulgated to achieve the following broad objectives:

- To supply the knowledge needed to isolate the waste from the environment for long enough or in a secure enough manner that it will pose negligible risk to human welfare.

- To encourage early public participation in the decision process, which must necessarily involve social and political consideration in addition to technical factors.

C. SHORT-TERM AND LONG-TERM BENEFITS EXPECTED FROM IMPLEMENTATION

The proposed research and development program will have the *short-term benefit of providing a more sound technical and* financial information base if the alternative of conversion of the waste to an immobile form is implemented. These efforts are focused on areas that require the greatest depth of new knowledge or that require long lead times for resolution.

D. RELATIONSHIP TO HANFORD AND IDAHO DEFENSE WASTE PROGRAMS, AND TO POSSIBLE FUTURE COMMERCIALLY GENERATED WASTE

Besides the SRP wastes, DOE also has high-level waste (HLW) management operations at both its Hanford site (near Richland, Washington) and its Idaho site (near Idaho Falls, Idaho). In addition, there is commercial high-level waste stored at the NFS plant near West Valley, New York and a possibility of additional commercial HLW generation if nuclear fuels reprocessing is ever resumed in the U.S. DOE has issued documents describing its current HLW management operations at Hanford[3] and Idaho,[4] the alternatives for long-term management of the high-level defense waste at the Hanford and Idaho sites,[5,6] and the alternatives for the long-term management of the high-level commercial wastes.[7,8] Close cooperation and information exchange on plans for management is maintained between SRP and the other HLW programs. Some of the proposed research and development activities for SRP wastes are applicable to the waste management alternatives at more than one site. However, many such activities are site-specific because of differences in chemical and physical forms of the existing wastes.

The most fundamental technical reason for pursuing separate programs at each of the waste sites is the fact that is not currently believed desirable to ship raw waste between sites for processing at another site. The waste at the different sites also has different properties. The Hanford, NFS, and SRP high-level wastes are the most similar, all being alkaline wastes, but they were generated from different fuels and by different separations processes. The Idaho and commercial wastes are intrinsically different acid wastes.

These differences in waste properties require development of processes tailored to each type of waste. Furthermore, a major part of the proposed Savannah River program is devoted to removal of the waste from tanks and processing to the point where a high-integrity form can be made. This part of the process is not applicable to commercial or Idaho waste, and it is only partially applicable to the Hanford waste because some of the Hanford tanks contain hardened sludge and/or may have potential leaks if slurrying liquids were introduced to the tanks. Information exchange is carried out among all the high-level waste programs, with the Savannah River Operations Office acting as a coordinating lead office. Duplication of research and development effort is avoided except where DOE management judgment indicates that duplication is desirable.

The Savannah River program is large enough on both economic and time scales to be a stand-alone project, and justifies optimization as such. The alternatives now in development would require about 14 years after startup to work off existing waste and become current with the ongoing waste generation rate. It will require a capital cost expenditure of about $3-4 billion (1980 dollars).

Environmental impact statements will also be issued for long-term waste management at the Idaho and Hanford sites at an early stage in their R&D and decision-making processes.

E. EXCLUSION OF SAVANNAH RIVER WASTES OTHER THAN HIGH LEVEL FROM THIS DOCUMENT

The low-level wastes (LLW) and transuranic wastes (TRU) at Savannah River are in different initial forms than the high-level waste, and are likely to be disposed of in different final forms. Therefore, separate programs must be developed to handle each type of waste. The possibility does exist, however, that incinerator ash from the LLW or TRU programs could be incorporated into the high-level waste forms. The volume and activity of any such material would be a small fraction of the material in the high-level program, and would therefore not influence the major decision process. Alternatives for long-term management of the TRU wastes at SRP are discussed in separate documents, currently under review by DOE.

F. SEQUENTIAL LONG-TERM HLW MANAGEMENT DECISIONS FOR SR, ID, AND RL

The research and development program proposed for continuation is aimed at having SRP to be the first U.S. site implementing a high-level nuclear waste immobilization program, with the other waste sites then following sequentially. The reasons for this decision are as follows.

- On a technical basis, the Idaho program for immobilization into a calcine acceptable for storage onsite is already well under way. There is no immediate technical or public acceptance reason for additional processing of this waste into glass or other advanced waste form at this time.

- The waste in tank storage at Savannah River is in a form that is easier to retrieve than the Hanford tank waste, and there is no danger of leaks to the environment from the addition of slurrying liquid to the Savannah River tanks during the removal process. Furthermore, the Savannah River R&D, design, and testing programs for both removal of the waste and subsequent processing are more advanced in time than those at Hanford.

- There will be some advantages from implementation experience that will accrue to the overall efficiency of the waste management program if the defense sites proceed sequentially in their immobilization programs.

An economic consideration is that funding for the total defense waste program will require several billion dollars. Spreading this expenditure over a longer time span by sequential implementation will provide Congress with a budget request having the least impact on other programs.

G. HISTORY OF REVIEWS OF THE LONG-RANGE WASTE MANAGEMENT PROGRAM AT SRP

The long-range waste management program at the Savannah River Plant (SRP) has had the benefit of reviews and recommendations by consultants and independent organizations. A short history of these reviews and the program decisions that were made based on them is presented here.

1. NAS (Through 1965)

From 1955 to 1965, the Committee on Geologic Aspects of Radioactive Waste Disposal of the National Academy of Sciences - National Research Council (NAS-NRC) served as advisor to the Division of Reactor Development and Technology of the U.S. Atomic Energy Commission. The Committee's responsibility to that Division was to observe and study critically the research and development activities of the Division with respect to radioactive waste disposals in the ground, and to provide counsel regarding the safety of the Division's current and proposed operations insofar as they are affected by geologic considerations.

Although its specific delegated responsibilities were the geologic aspects of the research and development program of the AEC's Division of Reactor Development and Technology, the Committee concerned itself with all phases of ground disposal of radioactive wastes and drew conclusions on overall waste management practices.

The Committee consisted of eight members who changed from time to time as earlier members were replaced by new ones. For the four meetings that concerned SRP, only one member was on the Committee continuously, and five were appointed just prior to the last meeting in 1965.

In September 1955, a conference was held at Princeton University at which 65 scientists representing many branches of earth sciences, biology and medicine, chemistry, physics, engineering, and other pertinent fields of knowledge considered various problems of radioactive waste disposal on land and offered suggestions toward their solution. The primary proposed disposal methods which developed from this meeting were disposal in salt, deep-well disposal in permeable formations, and conversion of liquid wastes to solids. Although this conference did not directly involve SRP, it set the stage for later conclusions by the Committee about proposed SRP waste storage programs.

In March 1960, the Committee met to consider a proposal to investigate the safety and feasibility of storing radioactive waste in facilities excavated in bedrock beneath the plant site. The Committee recommended that SRP proceed with test borings, and that the project then be reconsidered after the results of the tests were available. In addition, AEC asked the U.S. Geological Survey, the U.S. Bureau of Mines and the U.S. Army Corps of Engineers to assist in the design of the investigation in a consulting capacity.

In December 1961, after one test well was complete and three others started, the NAS-NRC Committee met at the Savannah River Plant to review the progress of the investigations and to make specific suggestions on the direction of the exploratory boring program.

The drilling and testing program for bedrock storage was finished in December 1962, and the results were included in an AEC report that was published in 1964 (Reference 9). The conclusion of this report was that storage of liquid radioactive wastes in excavated chambers was technically feasible. No further investigative program was outlined.

In June 1963, the NAS-NRC Committee met in Washington, D.C., to review bedrock storage. They concluded that for long-term safety, underground disposal at this locality is much better than storage in surface tanks, and that work be started on the next phase of the program. The Committee expressed concern that the hydrologic disturbance caused by the exploration drilling may have invalidated some of the hydrologic tests, and recommended that hydrologic observations should be continued until a state of equilibrium could be conclusively established. The Committee's review is given in Reference 10.

From 1964 through 1966, the U.S. Geological Survey carried on numerous hydrologic tests in the already existing bedrock exploration holes.

On April 12-13, 1965, the Committee with a different membership visited the Savannah River Plant to review the status of the bedrock waste storage project which had been carried on at a very low level during the intervening two years. This visit was one of an itinerary in which all of the major AEC production sites were visited to review their research and development programs on radioactive waste disposal to the ground.

The reviews and recommendations resulting from these visits are contained in a report to the Division of Reactor Development and Technology dated May 1966.[11] In regard to the bedrock waste storage exploration at the Savannah River Plant, a majority of the Committee recommended that the program be discontinued but a minority recommended that the program continue, outlining specific lines of investigation that should be pursued. Most of the Committee additionally recommended that high-level waste not be stored above freshwater aquifers. After much consideration of the recommendations as well as alternative programs for long-term containment of waste, the AEC decided to pursue the program outlined by the minority of the Committee. Comments on this report are contained in a letter from the Director of the Division of Reactor Development and Technology to the President of the National Academy of Sciences.[12] After the issuance of its report in May 1966, the Committee on Geologic Aspects of Radioactive Waste Disposal, NAS-NRC went out of existence.

2. GAO

In May 1968, the General Accounting Office reported on a review of high-level radioactive waste management. After reviewing conditions and programs at each site where high-level waste storage exists, GAO concluded that AEC needed to devote more vigorous attention to advancing the technology required to permit long-term storage at the Richland and Savannah River sites. This report is Reference 13. As a result of this report, SRP began a study of the Triassic bedrock nearer the Savannah River, and employed a consulting firm to independently review bedrock storage, and to develop concepts for the storage vault.

In January 1971, the General Accounting Office again reviewed the high-level radioactive waste management programs of AEC and concluded in its report:[14] "Although AEC has assigned a high priority to radioactive waste management problems, GAO believes that the level of effort given to these programs should be increased in view of their extraordinarily complex characteristics. The problems and delays being experienced are attributable primarily to a need for more definitive technology on such matters as the relative merits of alternative practices and proposals for interim and long-term storage."

In a June 1979 report, the General Accounting Office outlined the recommendations of an Interagency Review Group (IRG) to the President (March 1979) and concluded: "We believe the recent IRG effort is a good start toward establishing a viable Federal program for long-term nuclear waste management."[15]

3. S. C. Legislature

In May 1971, the South Carolina State Legislature adopted a resolution establishing a "committee to study the establishment of plants or facilities for the recovery of nuclear fuel and the storage of waste nuclear materials." A report on its findings was published in 1972.[16] One of the recommendations of the committee was "that South Carolina authorities oppose ultimate permanent storage of high-level radioactive waste in South Carolina because testimony given this committee up to this point in time indicates there are other more suitable locations for such storage."

4. Consultant Panel

In the fall of 1968, Du Pont convened a panel of six consultants in the fields of geology, hydrology, geochemistry, and civil engineering to review bedrock storage and all of the work to date, then to advise on the direction of the program. If the Panel recommended continuance, they were also expected to provide overall directions to the program. The Panel concluded in a May 1969 report:[17] "As a result of all these deliberations, the Panel is of the judgment that the bedrock storage proposal has sufficient promise of offering a permanent solution to a critical waste handling problem to warrant a major step forward in construction. At the same time, the explorations which have taken place over the past years make clear that a definitive assurance that bedrock storage would provide complete and permanent safety to the public can only be provided by the actual construction of the shaft and several of the tunnels. Such a procedure is essential to disclose the number and degree of fissures or fractures which will be encountered, in fact, at the depth under consideration. The Panel strongly recommends, therefore, the construction of the shaft and appropriate tunnels."

During the period 1969 to 1971, additional information became available on the Triassic rock, a low porosity sandstone-claystone, that was known to exist in the southeast one-third of the plant site. This rock is extremely impermeable and did not evidence any fractures, which were a source of concern in the crystalline metamorphic rock due to the difficulty of mapping them using test wells. The Du Pont consulting panel suggested that more exploration be done on the Triassic rock and reviewed the existing information in a progress report dated December 10, 1971.[18] After this information had been developed, the most suitable host rock would be selected for further exploration with a shaft and test tunnels.

5. NAS (Present Committee)

In March 1968, a Committee on Radioactive Waste Management was created by NAS-NRC to advise the Atomic Energy Commission, rather than only one division of AEC, on long-range radioactive waste management plans and programs. This committee sponsored a Panel on Bedrock Disposal to review that program specifically; the abstract of that Panel's report is as follows:

> The highly radioactive wastes aged in tanks at the Savannah River Plant (SRP) site must ultimately be transferred to some facility that offers effective retention for centuries. A solution under consideration is to store these wastes in vaults in the rocks deep beneath the site.
>
> For such long-term retention of radioactive wastes, an unprecedented degree of precise information is needed on the hydrologic systems in the bedrock, on the regional stress fields, on the structural integrity of mined openings, and on the chemical compatibility between the wastes and potential host rocks. It is also apparent that this needed degree of precision cannot be adequately obtained by exploration from the surface supplemented by a limited number of borings. This statement in no way diminishes the usefulness of the exploration from the surface, the chemical and physical tests, borings, and hydrologic calculations so far made. It reflects, rather, the fact that the metamorphic basement rocks, and the sedimentary rocks of Triassic age underlying the site, are neither uniform nor homogeneous and cannot be evaluated with precision from limited samples. The information acquired to date indicates a potential for a safe storage facility, but, in view of the intensity of the radioactivity of the material to be stored and the length of time required, the only prudent course is thorough exploration before final decision. The recently acquired data on the sedimentary rocks of Triassic age are encouraging and emphasize the need for complete exploration.
>
> Information from *in situ* exploration of the potential host rocks will be essential for development of an environmental-impact statement. Such *in situ* exploration is possible only by the construction of a shaft to the proposed depth and the excavation of tunnels.
>
> The proposed shaft and tunnels would serve several purposes. First, and most critical, such exploratory excavations would permit the examination and study of the host rock throughout the extent of the proposed vaults. Extrapolation of rock conditions from the walls of a small tunnel to a full-sized vault is reasonably certain, in contrast to the less certain extrapolation of rock conditions from borings hundreds of feet apart. Also, it will be possible to make chemical and physical analyses of the rock throughout the entire dimension of the proposed vaults. Further, before the final decision is made

to develop a full-scale storage facility, exploratory excavations will make possible observation of water movement in the host rock over a significant period. In addition, digging an exploratory shaft would identify the problems of engineering design and construction in penetrating the highly permeable water-bearing Tuscaloosa Formation that overlies the basement rocks. Because this is a primary regional aquifer, there must be assurance that a watertight shaft can be constructed through it and can be maintained.

The decision as to whether the exploratory shaft should be located in the metamorphic rocks or in the Triassic sedimentary rocks will depend on results of geological, geophysical, and geochemical investigations yet to be completed. Preliminary data suggest that the Triassic rocks are not extensively fractured, but the presence and spacing of joints and faults would be disclosed by the lateral tunnels. The physical, chemical, and engineering properties of the Triassic rocks are not adequately known, and exploratory excavations would facilitate their thorough study. If data from the exploratory shaft and tunnels do not clearly confirm that use of excavated vaults is safe for long-term isolation of SRP wastes from the biosphere, the concept as herein defined would become invalid.

The Committee on Radioactive Waste Management reviewed the report of the Panel on Bedrock Disposal and endorsed the following conclusions and recommendations:[19]

1. The Panel on Bedrock Disposal has reviewed the pertinent information on management of high-level radioactive wastes now stored in tanks at the Savannah River Plant site. It concludes that the current interim procedure of tank storage is acceptable for short-term containment but is not acceptable over the hazardous radioactive life of the wastes.

The Panel recommends that efforts toward development of permanent storage facilities be continued.

2. The Panel has reviewed alternative methods of radioactive waste processing and storage.

Whatever method is adopted, the Panel recommends that it be capable of protecting the biosphere from these wastes for not less than 1,000 years.

3. The Panel concludes that there is a reasonable prospect of achieving such protection by storing the wastes in vaults in rocks underlying the Tuscaloosa Formation beneath the Savannah River Plant site. This conclusion refers only to wastes that have been aged a minimum of 10 years. The underlying rocks include two major kinds, Triassic sedimentary rocks and older metamorphic rocks; safe storage may be possible in either one.

To guide underground exploration and permit a choice between the Triassic sedimentary rocks and the metamorphic rocks, the Panel recommends additional field and laboratory investigations. These investigations must produce definitive information as to the three-dimensional characteristics of the two rock units that underlie the prolific, water-bearing Tuscaloosa formation. Particularly important is information on (a) the fluid transmissivity of different parts of the two rock units, (b) the hydraulic gradients within the rocks of Triassic age, (c) the ion-exchange capacities of the two units, (d) the chemical reactions between the waste and the potential host rock, and (e) the regional stress fields in the two units.

4. The Panel concludes that no reasonable amount of exploration from the land surface can conclusively demonstrate the safety of waste storage in deep vaults. Essential for such a demonstration is *in situ* inspection and testing of the rocks in which vaults might be constructed.

Accordingly, the Panel further recommends that an exploratory shaft be sunk and exploratory tunnels be driven in the rock selected.

5. The recommended experimental program is intended to develop the information that would permit an orderly analysis of all factors relevant to safety and environmental considerations.

The Panel recommends that a systematic framework for accumulation of the required data be established in conjunction with the design of an exploratory shaft and tunnels.

6. Study of the recommended exploratory shaft and tunnels may indicate that the proposed deep vault storage at SRP would not be acceptable. Since some long-term alternative to tank storage is needed, concurrent research and development of alternative waste-management procedures are necessary.

The Panel recommends that the U.S. Atomic Energy Commission continue vigorously to investigate alternative methods of fixing and storing wastes.

7. Study of the recommended exploratory shaft and tunnels may indicate that the proposed deep vault storage at the SRP is acceptable.

In this case, the Panel recommends that a competent and impartial review be made of this additional information before the decision is made to charge the vault with waste.

6. Bedrock Explorations

Based on the recommendations of the Du Pont Consulting Panel, which were later concurred in by the NAS-NRC Panel, that the next step of exploration was the construction of an exploratory shaft and tunnel, a consultant architect-engineering firm was retained. Realizing that this storage facility, if constructed, would have requirements beyond that of ordinary rock tunnels the consulting architect-engineer was asked first to make a broad scope review of all of the information so far developed for an additional expert opinion on the feasibility and safety of the project.

This preliminary study of available data[20,21] concluded that the probability of the feasibility of the concept of storing radioactive wastes in bedrock tunnels is enough to warrant continuation of programmed and recommended studies of hydrology, rock mechanics, chemistry, and thermal considerations. It also concluded that "with data from 'above ground' studies only, it will not be possible to state conclusively that the overall project objective is feasible. The host rock must be penetrated with man-sized exploratory shafts in order to permit detailed inspection and *in situ* testing. Only after conducting, analyzing, and synthesizing the results of such *in situ* investigations will it be possible to reach a definitive conclusion."

Two other reports were produced by the consultant architect-engineering firm[22,23] on specific technical aspects of the program - deep shaft studies and the results of Triassic Exploration Drilling.

A draft environmental statement was prepared in January, 1972, to provide information on environmental impacts of a bedrock waste storage exploration program.[24] This statement covered impacts of sinking the exploratory shaft and tunnels and carrying out a data collection program. If the data were favorable for implementation of an actual waste disposal program in the bedrock, other environmental impact statements would have been written to cover the full-scale facility and the effects of disposal of radioactive wastes there.

In November 1972, active investigation of bedrock storage of radioactive waste was indefinitely postponed while major effort was turned toward alternative methods of waste storage such as temporary, near-surface storage in a solidified form. The AEC made this decision because of concerns about proving the integrity of bedrock for the period required for waste disposal as well as the advisability of disposing of high-level waste in an area with a large aquifer expressed by the States of Georgia and South Carolina. The press release on this decision is given in Reference 25, and a Federal Register notice announcing cancellation of the environmental statement is given in Reference 26.

H. REFERENCES FOR SECTION II

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21. *Supplement Number 1 to the Interim Preliminary Conceptual Analysis Report on the Bedrock Waste Storage Project.* Report by Parsons, Brinkerhoff, Quade, and Douglas, Inc. (November 1972).

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24. *Bedrock Waste Storage Exploration, Savannah River, S.C.* Draft Environmental Statement, WASH-1511 (January 1972).

25. *AEC Postpones Development of Bedrock Project at Savannah River Plant.* Press Release (November 17, 1972).

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III. CHARACTERIZATION OF THE EXISTING ENVIRONMENT

A. SITE LOCATION

The Savannah River Plant (SRP) occupies an approximately circular area of 300 square miles (192,000 acres) in South Carolina, 25 miles southeast of Augusta, Georgia (Figure III-1). The site borders the Savannah River for approximately 17 miles. The plantsite is closed to the public except for guided tours, controlled deer hunts, controlled through-traffic along South Carolina Highway 125 (SRP Road A) and along the Seaboard Coast Line Railroad, traffic on U.S. Highway 278 along the north edge of the site (Figure III-2), and authorized environmental studies.

The Savannah River Plant was constructed during the 1950s to produce the basic materials, primarily ^{239}Pu and tritium, used in the fabrication of nuclear weapons. The plant facilities (Figure III-2) consist of three operating nuclear production reactors (P, K, and C), two nuclear production reactors in standby condition (R and L), a small test reactor in standby condition (U), two separations areas (F and H) for processing irradiated materials, a heavy water extraction and recovery plant (D), a fuel and target fabrication facility (M), containing two test reactors, the Savannah River Laboratory (a process development laboratory to support production operations and containing three test reactors), and administrative facilities (A), and the many non-nuclear facilities necessary for plant operations.

The storage areas for high-level liquid waste are adjacent to the separations areas and consist of two tank farms linked to the separations areas and to each other by pipelines with secondary containment. In addition, a 195-acre burial ground area located between the F and H separations areas is used for controlled storage of solid radioactive wastes. The waste storage areas are at least six miles from the nearest Plant boundary.

Three major alternatives for long-term waste management at SRP are described in Section IV.B. Facilities needed for these management alternatives would be located as follows:

- New tanks for the alternative described in Section IV.B.1 would be built adjacent to the existing tank farms in F and H Areas (Figure III-2).

- The waste solidification facility and surface storage vault for the alternatives described in Section IV.B.2 would be built adjacent to and north of H Area (Figure III-2).

- Additional research and exploration would be necessary before a decision is made on the specific onsite location of the bedrock caverns for the alternatives described in Section IV.B.3.

B. SITE CHARACTERISTICS

1. Introduction

Characteristics of the SRP site that are pertinent to the long-term management of defense high-level radioactive waste include the geology, hydrology, meteorology, seismicity, biota, and background radiation. These characteristics are briefly reviewed below; a more detailed discussion may be found in DP-1323[1] and ERDA-1537.[2]

2. Geology

The plant is located in the Coastal Plain geologic province. This province is characterized by flat, mostly unconsolidated sediment of Cretaceous age or younger. About 20 miles northwest of the plantsite is the lower edge of the Piedmont Plateau (the other main geologic province in S.C.).

The soil layers of the plantsite affect the migration rates and directions of ground water and of any radioisotope present in the soils and ground water of the site. Geologic formations beneath the Savannah River Plant site are shown in Figure III-3, a cross section that bisects the plantsite. The formations are the Hawthorn, Barnwell, McBean, Congaree, Ellenton, Tuscaloosa, and bedrock (crystalline metamorphic rock and the Dunbarton Triassic Basin).[3] The sediments that constitute the formations above bedrock are either unconsolidated or semiconsolidated. The crystalline metamorphic rocks outcrop at the Fall Line and dip approximately 36 ft/mi to the southeast underneath the Coastal Plain sediments.

A large Triassic deposit in a basin of the crystalline rock underlies one-third of the plant area and is located in the southeastern section of the site. This deposit consists of sedimentary material formed into sandstones, siltstones, and mudstones.

The basement rock under the center of the plantsite is about 1000 ft below the surface. The geologic formations that immediately overlay the basement rock are called the Tuscaloosa and Ellenton formations; they are 500 to 600 ft thick below the plant. These formations consist of sand and clay and contain several prolific water-bearing beds, which supply over 1000 gal/min of water from each of several individual wells on the plantsite. Overlying the Tuscaloosa and

Ellenton formations are several formations of the Tertiary Period that range in age from about 10 million to about 50 million years. These formations have a combined thickness of about 350 ft in the central part of the plant. They consist predominantly of compact clayey sand and sandy clay with a few beds of sand and a few beds of hard clay. At depths ranging from about 100 to 180 ft, there is a zone in which the sandy deposits include calcareous cement, small lenses of limestone, and some shells. At scattered discontinuous localities, slowly moving ground water has dissolved this calcareous material and left these less consolidated than the sediments surrounding them. Some of these areas were filled with a concrete grout before major SRP facilities were constructed. At some places on the Savannah River Plant, the rocks of the Tertiary Period are overlain by more recent terrace deposits of alluvium. These deposits are usually thin in the upland areas, but are of significant thickness in the valleys of the Savannah River and some of its larger tributaries.

3. Hydrology

Surface waters provide a mechanism for transporting unavoidable releases of radioactive elements, stable elements, and heat offsite. These materials, if discharged to a plant stream, will move toward the Savannah River because almost all of the plantsite is drained by tributaries of the river (Figure III-2). Only one small stream (not shown on Figure III-2) in the northeastern sector of the site drains to the Salkehatchie River to the east, and this small stream has no operating facilities on it. Also, none of the facilities discussed in this statement will drain to this stream. Each of the tributaries is fed by smaller streams; therefore, no location on the site is very far from a continuously flowing stream. Knowledge of the flow in the streams is used to predict the offsite consequences of various routine and accidental releases.

In addition to the flowing streams, surface water is held in over 50 artificial impoundments covering a total of over 3000 acres. The largest of these, Par Pond, has an area of approximately 2700 acres. Water is held intermittently in marshes and over 200 natural basins, called Carolina Bays. A large swamp bordering the Savannah River receives the flow from several of the plant streams.

The source of most of the surface water on the plantsite is either natural rainfall or water pumped from the Savannah River to cool the nuclear reactors. The cooling water is discharged to the streams to flow back to the river or to Par Pond. Additional small amounts are discharged from other plant processes to the streams.

Two large reservoirs on the Savannah River upstream of the Savannah River Plant provide power, flood control, and recreational areas. Clark Hill Reservoir, completed in 1952, is 35 miles (70 river miles) upstream. Hartwell Reservoir, completed in 1961, is 90 miles (150 river miles) upstream. Operation of these reservoirs stabilized the river flow in the vicinity of the plant to a yearly average flow of 10,400 ±2900 cfs during 1961 to 1970. The minimum daily flow during this period was 6000 cfs. River water requires a minimum of 3 days to reach the coast from SRP, and the average flow times of 5 to 6 days probably better represents the travel time.

The monthly average temperature of the river water measured since July 1955, upstream from all SRP process water discharges, ranged from 6.8 to 26.8°C. The daily river temperature has reached 25.5°C or higher only during the months of June through September.

The Savannah River is used for fishing, both commercial and sport, and pleasure boating downstream of the plant, and also as a drinking water supply at Port Wentworth, Ga., for an effective consumer population of about 20,000, and at Hardeeville, S.C. (Beaufort-Jasper Water Treatment Plant), for a consumer population of approximately 50,000.

The five main streams on the plantsite are Savannah River tributaries. These are Upper Three Runs, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs (Figure III-2). They arise on the Aiken Plateau and descend 100 to 200 ft before discharging to the river. On the plateau, the streams are clear except during periods of high water. Rainfall soaks into the ground, and seepage from the sandy soil furnishes the streams with a rather constant supply of water throughout the year. In addition, four of the streams have received reactor cooling water discharges. These discharges, many times the natural stream flows, cause the streams to overflow their original banks along much of their length. For additional details on these streams see Reference 2.

The results of detailed studies[3] on the site reveal how the geology and hydrology of the plantsite affects ground water movement. Differences in the piezometric head (water pressure) measurements show the direction that ground water flow will take. Figure III-4 shows the vertical distribution of hydrostatic head in ground water near H Area, measured with six piezometers near the H-Area waste tank farm and four other piezometers outside H Area. Downward percolation of water from the water table is indicated by decline to minimum head in the Congaree formation. In the two piezometers (1E, 1D, Figure III-4) above the tan clay, the decline is probably fairly uniform with depth. Across the tan clay (1D to 1C), the decline is relatively abrupt (about 12 ft of head decline in 18 ft of depth). The tan clay, maximum 12 ft thick, is sufficiently impermeable to divert some of the water laterally to creeks, the nearest being several thousand feet away.

Within the fairly permeable sands of the McBean formation, the head declines only 2 ft in ∿50 ft of geologic material (1C to 1B). The green clay shown in Figure III-4 is one of the more significant hydrologic units in the region; it is only 6 to 10 ft thick in H Area (although somewhat thicker elsewhere), and its importance is easily missed if only drilling information is available. The 80-ft decline in piezometric head (1B to 3B, 1A) across the green clay indicates that the clay is continuous over a large area and has low permeability. Thus, the green clay also diverts water laterally to creeks that have eroded down into the McBean. These points of discharge are farther from H Area than the discharges from the Barnwell formation.

Ground water in the Congaree zone below the green clay also discharges into Upper Three Runs. This formation has the lowest hydrostatic head. The Ellenton formation has a head ∿7 ft higher than the Congaree, thus indicating the Ellenton is not receiving water from the Congaree formation.

Head is uniform in the three Tuscaloosa piezometers (P3C, P3B, P3A), lower than that in the Ellenton formation (DRB7WW), but higher than those in the Congaree. Both the recharge and discharge regions of the Tuscaloosa are principally off the plantsite, and they control its water level within the plantsite.

Piezometric contours for the Tuscaloosa formation (Figure III-5) indicate that the Tuscaloosa water flows from the Aiken Plateau in a curved path to the Savannah River valley. This lateral flow through the very permeable formation supports the Tuscaloosa water level on the plantsite. Recharge by vertical percolation from above probably does not occur at SRP. The Tuscaloosa aquifer underneath a portion of southeastern Georgia also flows toward and outcrops in the Savannah River valley as shown in Figure III-5.

4. Local Climate and Meteorology

The climate in the SRP area is tempered with mild winters and long summers. Augusta temperatures average 48°F in the winter, 85°F in summer, and 65°F annually. The average relative humidity is 70%. The average annual rainfall at SRP is 47 in. A detailed discussion of the methods for estimating environmental effects of radionuclides released from SRP to the atmosphere is presented in Appendix F of Reference 2.

The probability and magnitude of severe storms have been analyzed to determine their effects on SRP facilities. Two types of major storms, hurricanes and tornadoes, occur in South Carolina. Both types of storms are discussed in detail in Reference 2, including their frequency of occurrence.

The Savannah River Laboratory maintains its own meteorological station with an online computer to provide input from local weather conditions on the offsite dose effects of any SRP radionuclide releases.[4]

5. Seismicity

The Savannah River Plant is located in an area where moderate ground shaking might occur from earthquakes, based on earthquake risk predictions by the U. S. Coast and Geodetic Survey.[1,5,6] The only significant shaking in the SRP area during the last 3 centuries was from the 1886 Charleston, S. C. earthquake, centered 90 miles to the southeast. The maximum acceleration of that earthquake in the SRP area has been estimated at 0.05 g.[2] From geologic information as well as from seismic history of the east coast region a major earthquake near SRP is improbable.[2]

The Belair fault has had local interest in recent years. Based on a study of the Belair fault by the U.S. Geological Survey,[7] the Nuclear Regulatory Commission states:[8]

> The Belair fault zone is located about 16 km west of Augusta, Georgia. It is actually a number of faults, each 1.1 to 4.7 kilometers in length, which when taken together comprise a zone at least 21 kilometers long trending approximately north-northeast.
>
> The conclusion of the latest report by the U.S. Geological survey indicates that the age of the oldest unfaulted stratigraphic unit is thought to be between 2,000 and approximately 23,000 years old. The age of the youngest faulted unit is approximately 65 million years old. To date, no intermediate age strata have been found which would provide a more definitive date of last movement on the fault. Thus, although the study does not absolutely demonstrate lack of movement in the last 35,000 years, it does provide a high level of confidence that the last movement is not as recent as previously believed. With the absence of any correlation of macroseismicity with this fault zone, we have concluded that this fault is not capable within the meaning of Appendix A to 10 CFR Part 100, "Seismic and Geologic Siting Criteria for Nuclear Power Plants." We will continue to monitor research activities which could lead us to modify this finding.

The design basis earthquake for SRP incorporates an acceleration of 0.26 g, equivalent to an earthquake intensity of VII to VIII on the Modified Mercalli scale.[9]

Seismic monitors, which were installed in SRP reactor buildings between 1952 and 1955, are set to alarm at 0.002 g (intensity II) and have never indicated an earthquake shock of this intensity since their installation. In addition to the seismic monitors installed in the reactor buildings, a modern seismograph network, consisting of three short period vertical seismometer stations and a central recording station, was installed in 1976. This system was designed to provide a continuous record of any local seismic activity. Data on individual events collected by this network are provided to seismologists with the U.S. Geological Survey, the University of South Carolina, and Georgia Institute of Technology.

6. Biota

The Savannah River Plant site provides a wide variety of protected habitats; hence, the species' diversity and populations are both large. In general, the plantsite is a natural preserve for biota typical of the Southeastern Coastal Plain. The major effect of SRP on wildlife has resulted from changed habitat conditions since the government acquired the site. The production and support facilities occupy less than 5% of the plantsite. Radioactive releases are limited to low levels in limited areas and are shown by monitoring programs to result in only minor contributions to the ^{137}Cs content of deer and fish taken on or adjacent to the plantsite. For detailed discussion of the biota, see References 1 and 2.

7. Background Radiation

Natural background radiation includes both cosmic and terrestrial sources. These sources vary with location but are assumed constant with time within the recorded span of human history.[10] The calculated annual background radiation dose received by the average person living in the vicinity of the Savannah River Plant is approximately 120 mrem from natural sources; 35 mrem from cosmic radiation, 55 mrem from external terrestrial radiation and 27 mrem from internal radiation. For more details on natural background radiation in the vicinity of Savannah River Plant see Reference 2.

8. Environmental Park

The plant was designated as a National Environmental Research Park in June 1972. The various portions of the plantsite offer unusual opportunities for observing interactions between large industrial complexes and the environment. There are extensive areas of land protected from heavy traffic patterns, casual visitors, real estate development, and other disruptive influences. Because the land area is owned by the U.S. Government, long-term ecological research can be based at the Park with confidence in the continuation of the existing habitats. Several of the unusual opportunities offered are for observing and comparing the ecosystem changes brought about by heated water, flooding, atmospheric and aqueous emissions from fossil fuel power plants, uptake and retention of low levels of radioactive materials, forest management activities, and other stresses on the environment. Researchers from universities and government agencies are currently taking advantage of these opportunities for study.

9. Environmental Studies by Outside Contractors, Universities, and Researchers

Before the start of plant construction in 1951, the Limnology Department of the Academy of Natural Sciences of Philadelphia began a baseline study of the Savannah River in the vicinity of the Savannah River Plant. This study considered all the major groups of aquatic organisms (protozoa, lower invertebrates, insects, fish, and algae) together with the general chemical and physical characteristics of the river. The purpose of this study was to provide a comprehensive picture so that future changes that might occur in the Savannah River could be measured. Such changes might be due to the activities of the Savannah River Plant or to changes in upstream river conditions.

Since the baseline study, the Limnology Department has carried on a continuous program of detailed surveys of the river's biological, chemical, and physical condition.

The Savannah River Ecology Laboratory (SREL) of the University of Georgia was established in 1961 to study the ecology of the SRP site. It has conducted diversified studies of site characteristics to identify and follow natural changes since acquisition of the property in 1950 as well as to investigate the effects of SRP operations. Research is currently centered in three major programs: thermal ecology, mineral cycling, and radioecology of transuranic elements. Each of these programs is strengthened by the ongoing accumulation of knowledge of the basic ecology of the site. For further details of these studies see Reference 2.

10. Historic and National Landmarks

There are no known historic or national landmarks on the Savannah River plantsite. The site was set aside by the U.S. Government in 1950 as a controlled area for production of nuclear materials needed for national defense. It is not expected that the location for any of the facilities to be built on the Savannah River plantsite would have any historical or archeological interest; however, before any disturbance of a site is made, a site use permit will be processed through the Institute of Archeology and Anthropology, University of South Carolina.

C. SURROUNDING REGION

1. Demography

The location of the Savannah River Plant relative to population centers and geographic features within a 150-mile radius is shown in Figure III-1. The distribution of population within 150 km (about 95 miles) from the center of the plant is shown in Figure III-6. The projected population, within 80 km of the center of the plant, for the year 2000 is shown in Figure III-7.[11] According to the 1970 census, major population centers within about 25 miles of the center of the plant are:

City	*Distance, miles*	*Direction from Plant*	*1970 Population*
Augusta, GA	25	Northwest	59,864
N. Augusta, SC	25	Northwest	12,883
Aiken, SC	20	North	13,436
Williston, SC	15	Northeast	2,594
Barnwell, SC	15	East	4,439
Allendale, SC	26	Southeast	3,620
Waynesboro, GA	28	Southwest	5,530

2. Regional Land Use

In the counties surrounding the Savannah River Plant, approximately 65% of the land is forest[12] and approximately 30% is used for farming. The primary farm products are soybeans, corn and cotton.[13]

3. Nearby Nuclear Facilities

Three nuclear facilities are either planned, under construction, or in use adjacent to SRP (Figure III-2). Georgia Power Company plans to construct two power reactors at the Alvin W. Vogtle Nuclear Plant on the Savannah River at the southwest boundary. The Barnwell Nuclear Fuel Plant of Allied-General Nuclear Services is on the eastern boundary for chemical separations of commercial reactor fuels. A commercial facility for burying noxious chemicals and low-level radioactive wastes, Chem-Nuclear Services, is located adjacent to the Allied-General facility.

D. REFERENCES FOR SECTION III

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IV. BACKGROUND AND DESCRIPTION OF ALTERNATIVES

A. DESCRIPTION OF SRP HIGH-LEVEL LIQUID WASTE

1. Characteristics of Waste

Almost all (>99%) of the fission products generated in the fuel during reactor operations go into acidic aqueous waste streams during spent fuel processing. These wastes are made alkaline to a pH of 10 to 13 and transferred to large underground waste storage tanks. In the waste storage tanks, components insoluble in the highly alkaline solution precipitate and settle to form a layer of sludge on the tank bottom. The sludge contains oxides and/or hydroxides of manganese, iron, silicon, and aluminum, along with fission products, induced radioactive elements, uranium, transuranium elements, mercury, silver, and other nonradioactive elements. Most of the radionuclides are contained in the sludge; only the cesium remains predominantly in the liquid. Settled sludge volume is 6 to 10% of the total (unevaporated) waste volume, but 70 to 90% of this volume is interstitial liquid with a composition similar to the supernatant liquid. After the sludge settles to the bottom of a tank, the supernatant liquid is transferred to an evaporator for dewatering. The concentrate from the evaporator is transferred to a cooled waste tank where the supersaturated solution precipitates and forms salt crystals. The supernate is returned to the evaporator for further concentration. This process is repeated until essentially all of the supernate is converted to damp salt cake.

The waste in a single tank is made up of many waste streams from the spent fuel reprocessing plants, and its detailed composition varies from tank to tank. The chemical composition of the major components of the composite fresh waste is given in Table IV-1. Table IV-2 shows the concentrations of radionuclides in the fresh waste, with the assumption that the fuel has been cooled six months before being reprocessed. The radionuclide concentration in the salt is approximately three times the concentration in supernate with the same decay period.

TABLE IV-1

Average Chemical Composition of Fresh SRP High-Level Waste

Constituent	*Concentration*	
	Molar	*g/L*
$NaNO_3$	3.3	281
$NaNO_2$	<0.2	<14
$NaAl(OH)_4$	0.5	59
NaOH	1	40
Na_2CO_3	0.1	11
Na_2SO_4	0.3	43
$Fe(OH)_3$	0.07	7.5
MnO_2	0.02	1.7
$Hg(OH)_2$	0.002	0.5
Other Solids	0.13[a]	7.8

a. Assuming an average molecular weight of 60.

TABLE IV-2

Average Radionuclide Composition of Fresh[a] SRP High-Level Waste

Radionuclide	*Activity, Ci/gal*	*Radionuclide*	*Activity, Ci/gal*
^{95}Nb	105	^{241}Am	1×10^{-3}
$^{144}Ce-^{144}Pr$	68	^{99}Tc	5×10^{-4}
^{95}Zr	60	^{239}Pu	3×10^{-4}
^{91}Y	47	^{154}Eu	1×10^{-4}
^{89}Sr	36	^{93}Zr	1×10^{-4}
^{141}Ce	12	^{240}Pu	6×10^{-5}
^{147}Pm	12	^{135}Cs	4×10^{-5}
^{103}Ru	10	$^{126}Sn-^{126}Sb$	1×10^{-5}
$^{106}Ru-^{106}Rh$	4	^{79}Se	1×10^{-5}
^{90}Sr	3	^{233}U	2×10^{-6}
^{137}Cs	3	^{129}I	1×10^{-6}
^{129}Te	2	^{238}U	6×10^{-7}
^{127}Te	2	^{107}Pd	5×10^{-7}
^{134}Cs	1	^{237}Np	4×10^{-7}
^{151}Sm	8×10^{-2}	^{152}Eu	2×10^{-7}
^{238}Pu	1×10^{-2}	^{242}Pu	6×10^{-8}
^{241}Pu	2×10^{-3}	^{158}Tb	6×10^{-8}
^{244}Cm	1×10^{-3}	^{235}U	3×10^{-8}

a. After reprocessing fuel that has been cooled six months after discharge from reactor. See Table IV-6 for the average radionuclide concentration of reconstituted SRP high-level waste in 1985.

Both the chemical and radionuclide composition of the waste changes as the waste ages. The major changes are:

- Radiolytic decomposition of the waste. The major effect of this radiolytic decomposition is the slow reduction in the $NaNO_3$ concentration with an equivalent increase in $NaNO_2$ concentration. After 5 to 10 years, the $NaNO_2$ concentration approaches the residual $NaNO_3$ concentration.

- A slow reduction in the NaOH concentration due to reaction with CO_2 absorbed from air, forming Na_2CO_3.

- Decay of radionuclides. Figure IV-1 shows the decay of major radionuclides in this waste.

- Natural partitioning of the waste into sludge and supernate fractions. The sludge scavenges most of the radionuclides from the supernate as it settles to the bottom of the tank.

2. Characteristics of Reconstituted Waste for Long-Term Management

If waste removal from tanks is initiated in 1988, 25 waste tanks are expected to be in service. These tanks will contain approximately 12.7 million gallons (47 million liters) of damp crystallized salt, 3 million gallons (15 million liters) of sludge, and 6.2 million gallons (22 million liters) of liquid waste. Tables IV-3 and IV-4 show their radionuclide compositions with age.

Before solidification of the waste is started (or before transfer to an SRP bedrock cavern or replacement of waste storage tanks), the salt must be dissolved and the solution is used to slurry the sludge from the waste tanks. Dissolution of the total salt expected to be on hand in 1987 will require approximately 40 million gallons (150 million liters) of water. These operations will produce about 60 million gallons (227 million liters) of reconstituted waste which will be fed to the solidification facility or SRP bedrock cavern or returned to new waste storage tanks.

The reconstituted waste will be similar in chemical composition to the original neutralized fresh waste generated by the spent fuel reprocessing plants but will be less radioactive. The chemical composition of the reconstituted waste is shown in Table IV-5. Table IV-6 gives the activity of the significant radionuclides in reconstituted waste. Figures IV-2 and IV-3 show the radionuclide content of the waste from 0 to 1400 years and from 0 to 10^6 years after irradiation, respectively. The units are expressed as Ci/gal of reconstituted waste.

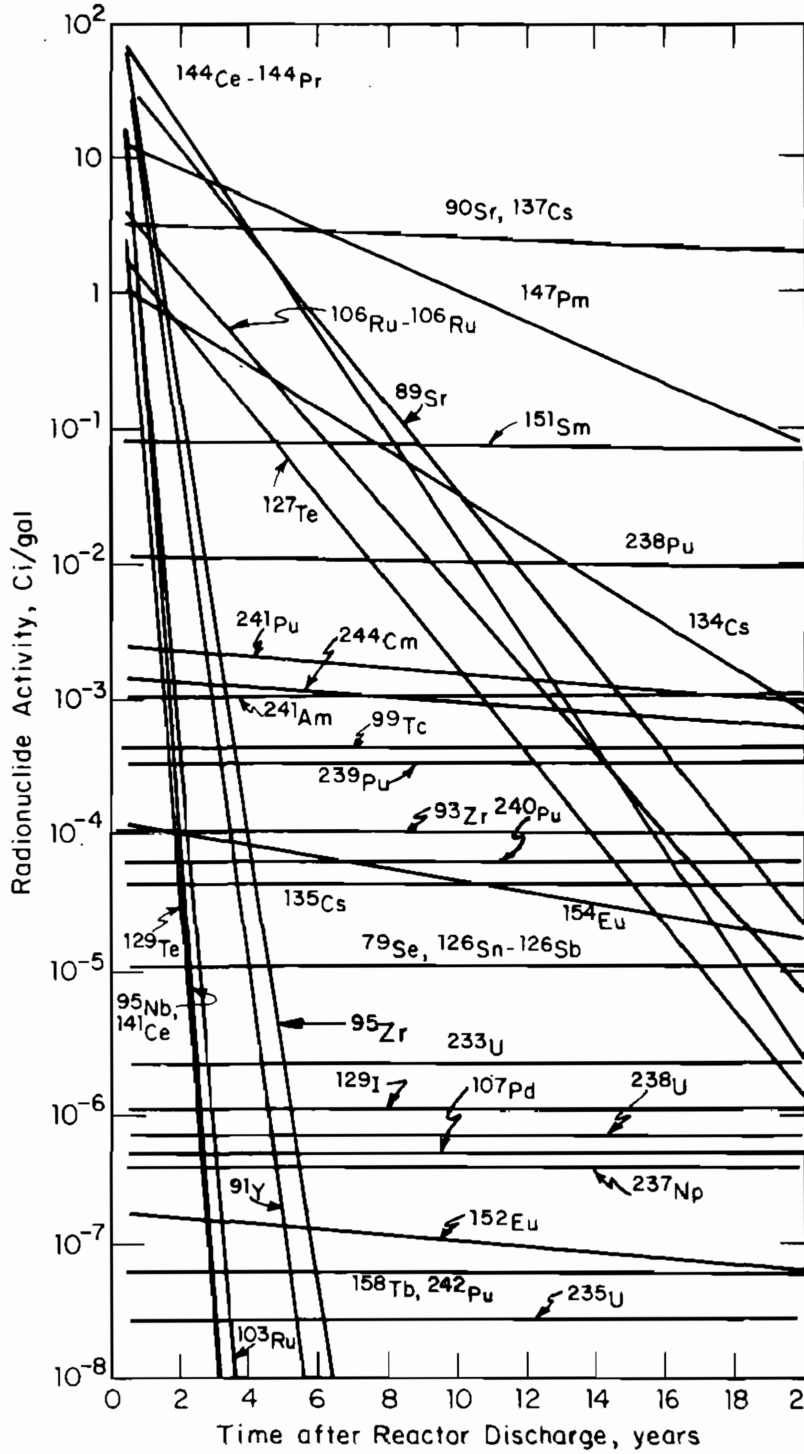

FIGURE IV-1. Radionuclide Composition of SRP Waste (0 to 20 years after irradiation)

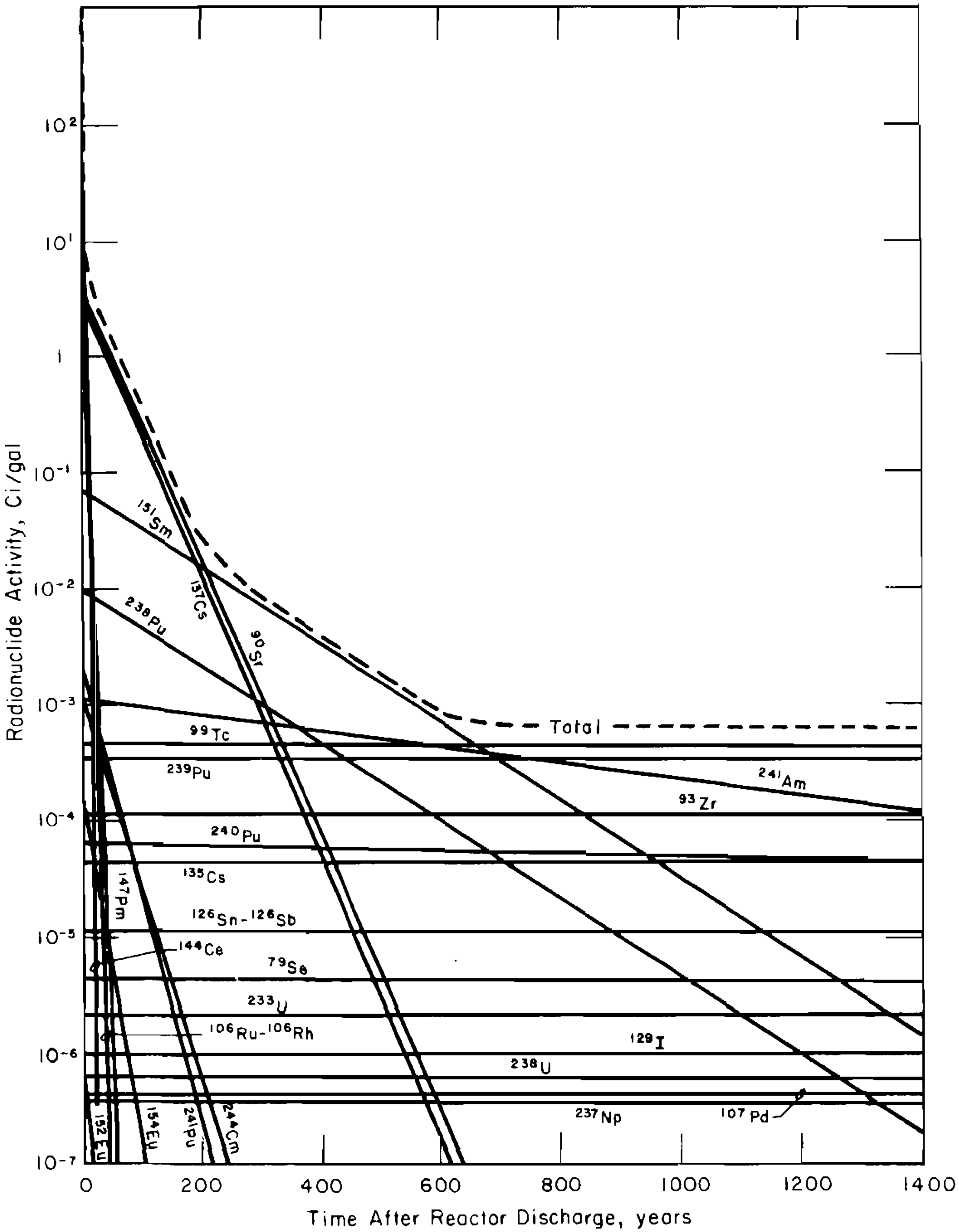

FIGURE IV-2. Radionuclide Composition of SRP Waste (0 to 1400 years after irradiation)

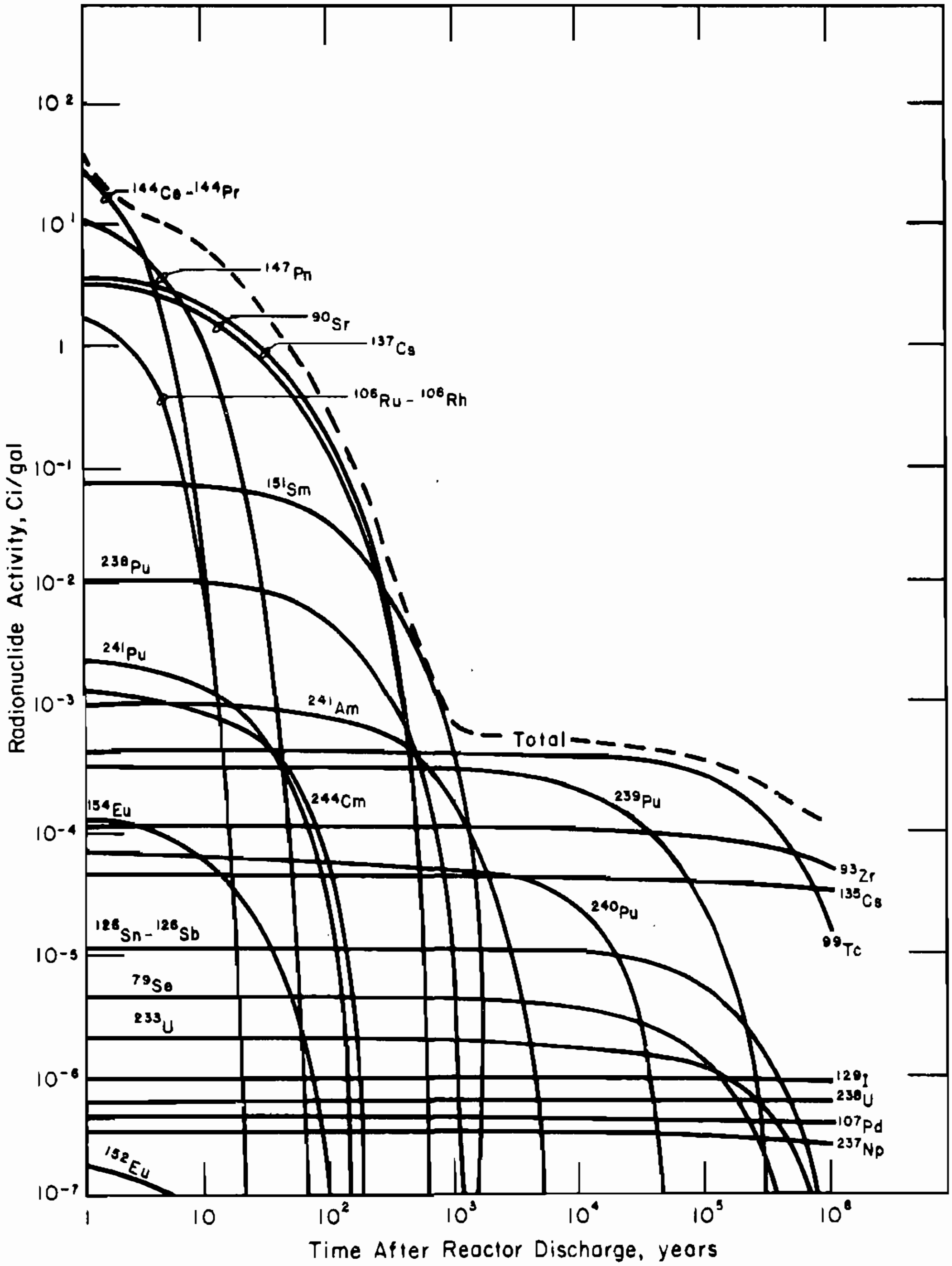

FIGURE IV-3. Radionuclide Composition of SRP Waste (1 to 10^6 years after irradiation)

TABLE IV-3

Average Radionuclide Composition of SRP High-Level Sludge

Time After Irradiation, years →	*Radionuclide Activity, Ci/gal* 1	5	10		*Radionuclide Activity, Ci/gal* 1	5	10
^{144}Ce-^{144}Pr	4.5×10^{2}	1.3×10^{1}	1.5×10^{-1}	^{241}Am	1.1×10^{-2}	1.1×10^{-2}	1.1×10^{-2}
^{95}Zr	9.6×10^{1}	1.8×10^{-5}	*a*	^{99}Tc	4.3×10^{-3}	4.3×10^{-3}	4.3×10^{-3}
^{94}Y	7.6×10^{1}	2.5×10^{-6}	*a*	^{239}Pu	3.5×10^{-3}	3.5×10^{-3}	3.5×10^{-3}
^{89}Sr	4.4×10^{1}	*a*	*a*	^{154}Eu	1.1×10^{-3}	8.3×10^{-4}	5.5×10^{-4}
^{95}Nb	6.0×10^{0}	*a*	*a*	^{93}Zr	8.6×10^{-4}	8.6×10^{-4}	8.6×10^{-4}
^{141}Ce	3.0×10^{0}	*a*	*a*	^{240}Pu	6.4×10^{-4}	6.4×10^{-4}	6.4×10^{-4}
^{147}Pm	1.0×10^{2}	3.6×10^{1}	9.7×10^{0}	^{135}Cs	2.2×10^{-5}	2.2×10^{-5}	2.2×10^{-5}
^{103}Ru	5.2×10^{0}	*a*	*a*	^{126}Sn-^{126}Sb	1.1×10^{-4}	1.1×10^{-4}	1.1×10^{-4}
^{106}Ru-^{105}Rh	2.4×10^{1}	1.6×10^{0}	5×10^{-2}	^{79}Se	1.0×10^{-4}	1.0×10^{-4}	1.0×10^{-4}
^{90}Sr	3.0×10^{1}	2.8×10^{1}	2.4×10^{1}	^{233}U	2.1×10^{-5}	2.1×10^{-5}	2.1×10^{-5}
^{137}Cs	1.6×10^{0}	1.5×10^{0}	1.3×10^{0}	^{129}I	9.4×10^{-6}	9.4×10^{-6}	9.4×10^{-6}
^{129}Te	9.4×10^{-1}	*a*	*a*	^{238}U	6.4×10^{-6}	6.4×10^{-6}	6.4×10^{-6}
^{127}Te	6.4×10^{0}	5.9×10^{-4}	*a*	^{107}Pd	4.4×10^{-6}	4.4×10^{-6}	4.4×10^{-6}
^{134}Cs	8.7×10^{0}	2.3×10^{0}	4.2×10^{-1}	^{237}Np	3.9×10^{-6}	3.9×10^{-6}	3.9×10^{-6}
^{151}Sm	7.5×10^{-1}	7.3×10^{-1}	7.0×10^{-1}	^{152}Eu	1.7×10^{-6}	1.3×10^{-6}	1.0×10^{-6}
^{238}Pu	1.1×10^{-1}	1.1×10^{-1}	1.1×10^{-1}	^{242}Pu	6.2×10^{-7}	6.2×10^{-7}	6.2×10^{-7}
^{241}Pu	2.4×10^{-2}	2.0×10^{-2}	1.6×10^{-2}	^{158}Tb	6.0×10^{-7}	6.0×10^{-7}	6.0×10^{-7}
^{244}Cm	1.3×10^{-2}	1.1×10^{-2}	9.5×10^{-2}	^{235}U	2.7×10^{-7}	2.7×10^{-7}	2.7×10^{-7}

a. Value <1 x 10^{-7}.

TABLE IV-4

Average Radionuclide Composition of SRP High-Level Supernate

Time After Irradiation, years →	*Radionuclide Activity, Ci/gal* 1	5	10		*Radionuclide Activity, Ci/gal* 1	5	10
^{144}Ce-^{144}Pr	2.6	7.4×10^{-2}	8.7×10^{-4}	^{241}Am	3.6×10^{-6}	3.6×10^{-6}	3.6×10^{-6}
^{95}Zr	2.7	5.0×10^{-7}	*a*	^{99}Tc	2.5×10^{-5}	2.5×10^{-5}	2.5×10^{-5}
^{91}Y	1.7×10^{-1}	5.7×10^{-9}	*a*	^{239}Pu	1.1×10^{-6}	1.1×10^{-6}	1.1×10^{-6}
^{89}Sr	1.0×10^{-1}	*a*	*a*	^{154}Eu	6.7×10^{-6}	4.8×10^{-6}	3.2×10^{-6}
^{98}Nb	1.7×10^{-1}	*a*	*a*	^{93}Zr	2.4×10^{-5}	2.4×10^{-5}	2.4×10^{-5}
^{141}Ce	1.7×10^{-1}	*a*	*a*	^{240}Pu	2.1×10^{-7}	2.1×10^{-7}	2.1×10^{-7}
^{147}Pm	6.1×10^{-1}	2.1×10^{-1}	5.7×10^{-2}	^{135}Cs	4.6×10^{-5}	4.6×10^{-5}	4.6×10^{-5}
^{103}Ru	1.4×10^{-1}	*a*	*a*	^{126}Sn-^{126}Sb	6.1×10^{-7}	6.1×10^{-7}	6.1×10^{-7}
^{106}Ru-^{106}Rh	6.7×10^{-1}	4.3×10^{-2}	1.4×10^{-3}	^{79}Se	6.0×10^{-7}	6.0×10^{-5}	6.0×10^{-7}
^{90}Sr	6.8×10^{-2}	6.2×10^{-2}	5.5×10^{-2}	^{233}U	7.1×10^{-9}	7.1×10^{-9}	7.1×10^{-9}
^{137}Cs	3.3	3.1	2.7	^{129}I	5.5×10^{-8}	5.5×10^{-8}	5.5×10^{-8}
^{129}Te	5.5×10^{-3}	*a*	*a*	^{238}U	2.1×10^{-9}	2.1×10^{-9}	2.1×10^{-9}
^{127}Te	3.8×10^{-2}	3.4×10^{-6}	*a*	^{107}Pd	2.6×10^{-8}	2.6×10^{-8}	2.6×10^{-8}
^{134}Cs	5.1×10^{-2}	1.3×10^{-2}	2.4×10^{-3}	^{237}Np	1.3×10^{-9}	1.3×10^{-9}	1.3×10^{-9}
^{151}Sm	4.4×10^{-3}	4.3×10^{-3}	4.1×10^{-3}	^{152}Eu	1.0×10^{-8}	7.8×10^{-9}	6.0×10^{-9}
^{238}Pu	3.8×10^{-5}	3.7×10^{-5}	3.5×10^{-5}	^{242}Pu	*a*	*a*	*a*
^{241}Pu	8.1×10^{-6}	6.7×10^{-6}	5.4×10^{-6}	^{158}Tb	*a*	*a*	*a*
^{244}Cm	4.5×10^{-6}	3.8×10^{-6}	3.2×10^{-6}	^{235}U	*a*	*a*	*a*

a. Value <1 x 10^{-9}.

TABLE IV-5

Chemical Composition of Reconstituted SRP High-Level Waste

Constituent	*Concentration*	
	Molar	*g/L*
$NaNO_3$	2.2	187
$NaNO_2$	1.1	76
$NaAl(OH)_4$	0.5	59
NaOH	0.75	30
Na_2CO_3	0.3	32
Na_2SO_4	0.3	43
$Fe(OH)_3$	0.07	7.5
MnO_2	0.02	1.7
$Hg(OH)_2$	0.002	0.5
Other Solids	0.13[a]	7.8

a. Assuming an average molecular weight of 60.

TABLE IV-6

Radionuclide Content of Reconstituted SRP High-Level Waste (1985)

Radionuclide	*Activity, Ci/gal*	*Total Activity, Ci*
^{90}Sr	2.1	1.3×10^8
^{137}Cs	2.2	1.3×10^8
^{147}Pm	0.77	4.6×10^7
^{144}Ce-^{144}Pr	0.19	1.1×10^7
^{151}Sm	0.07	4.2×10^6
^{106}Ru-^{106}Rh	0.03	1.8×10^6
^{238}Pu	0.01	6.0×10^5
^{241}Am	0.001	6.0×10^4
^{244}Cm	0.001	6.0×10^4
^{239}Pu	0.0004	2.4×10^4

3. Differences Between Savannah River, Hanford, Idaho, and Commercial Wastes

High-level radioactive wastes generated at Hanford are similar to those at the Savannah River Plant in chemical and radionuclide composition. Hanford wastes are also processed to excess alkalinity and transferred to large underground storage tanks. However, the high-heat wastes at Hanford are not cooled like those at SRP; therefore, sludge in the SRP tanks remains more flocculent. Radiocesium and radiostrontium are being removed from the Hanford waste and stored in double-wall canisters as cesium chloride and strontium fluoride. Cesium and strontium removal operations are expected to be completed in the early 1980s.[1] Idaho National Engineering Laboratory (INEL) high-level waste composition varies greatly depending on the type of fuel being processed, the irradiation history of the fuel, and the length of time the fuel is stored before processing.[2] Unlike Savannah River and Hanford, INEL high-level liquid waste is initially stored as an acid solution and contains high fluoride concentrations. After a suitable decay period, the acidic waste is converted to a granular solid in a fluidized-bed calciner. For further details on the composition of INEL waste, see the *Final Environmental Statement, Waste Management Operations, Idaho National Engineering Laboratory* (Report ERDA-1536).[3]

The commercial high-level nuclear wastes at the Nuclear Fuel Services Plant at West Valley, New York are quite similar to the SRP alkaline wastes. However, the NFS wastes also include a small quantity of acid Thorex waste.

If reprocessing of nuclear power reactor fuels is ever resumed, the waste from the reprocessing plants will be similar to INEL high-level waste before calcining, except that it will contain less aluminum, zirconium, and fluorides, and a higher concentration of radionuclides, which in turn will generate more heat per unit volume. Wastes from nuclear reprocessing plants for power reactor fuel are described in *Alternatives for Managing Waste from Reactors and Post-Fission Operations in the LWR Fuel Cycle* (Report ERDA-76-43).[2]

B. TECHNOLOGY OF THREE MAJOR ALTERNATIVES FOR LONG-TERM WASTE MANAGEMENT*

1. Alternative 1 — Continue Storage in Tanks

Description

This alternative is a continuation of present high-level waste management practices at SRP and is therefore the "No Action" alternative under CEQ designations. However, since a considerable amount of positive action is required over a long time period to carry out this alternative, it is herein referred to as "Continued Present Action."

For purposes of calculating waste volumes, the DWD and this EIS have assumed SRP reactor operation ceases in 1987.** Under this assumption, the backlog of high-level waste to be managed will be stored in 25 tanks. Each tank would contain less than 1 million gallons, and would have a capacity of 1.3 million gallons. They would be the double-wall Type III design now being built at SRP. Use of heat-treated steels and stress relief after construction is expected to result in a service lifetime of at least 50 years for these tanks.

New tanks would be built as required by the observed condition of the tanks in service. Salt or sludge would be reconstituted to liquid by dissolving or slurrying with water. This solution would be transferred to a new tank and evaporated to a damp salt cake or sludge as it was before transfer. The old tank would be cleaned and retired from service. The cycle of reconstitution to liquid, transfer to new tanks and evaporation, and retirement of old tanks would continue about every 50 years into the future. The process would cease when some future generation made a decision that some other disposal method would be more desirable, or that the radioactivity had decayed enough so that the tanks could be covered and abandoned.

The operations outlined above are described in detail in Reference 4.

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* Other alternatives and reasons for their exclusion from coverage in this document are discussed in Section IX.

** The normal design of a plant for the remote handling of large quantities of radioactive materials provides for safe operation over an extended period of years. A waste solidification plant would thus be operable beyond the time necessary to work off a backlog determined by a 1987 shutdown. If operations were extended past 1987, increases in impacts such as consumption of materials and pre-emption of repository space would be expected to be roughly in proportion.

Status of Technology

This alternative is a continuation of operations currently performed at SRP on a routine basis, backed by about 25 years of experience. The technology for all necessary phases is therefore demonstrated full scale and in-hand. The lifetime of new, Type III stress-relieved tanks has not been demonstrated, but is projected from experience with other tanks and laboratory studies to be least 50 years.

Research and Development Needed

No research and development effort is needed to implement this alternative at the current state-of-the-art level. However, improvements are being made in established methods of reconstituting waste, evaporation, level monitoring, tank surveillance, corrosion control, etc., as a result of small-scale, continuing research and development efforts. Current plans for these activities between now and the time that this alternative could be considered implemented (mid-1980) are discussed in detail in Reference 5.

2. Alternative 2, Subcase 1 — Immobilize* and Ship to a Federal Repository

The technology development program now under way and proposed for funding is oriented toward timely implementation of this alternative, which is illustrated in Figure IV-4.

Description

For all subcases of Alternative 2, salt solutions and slurried sludge are removed from the waste tanks in the two separations areas, F Area and H Area. These solutions are processed through a waste solidification plant which begins operation in 1988.

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* Glass is used as the reference form in the analysis of Alternative 2 (all subcases). As stated in the foreward, the decision on waste form has not yet been made since another waste form will not be chosen unless it had less impact than glass, the analyses presented are bounding.

In the solidification plant, the sludge is washed and centrifuged free of residual salt. The salt solution is likewise filtered free of residual sludge and then passed through ion exchange columns to remove cesium and strontium, re-evaporated, and handled as described in Section IV.C. The sludge and ion exchange product are combined with SiO_2, B_2O_3, and other glass-making materials to form a matrix containing about 35% waste (25% on a waste oxide basis). The glass product is sealed in steel containers and shipped for offsite geologic disposal. For current reference purposes, the geologic disposal formation is assumed to be salt beds, but other geologic formations are also being considered.

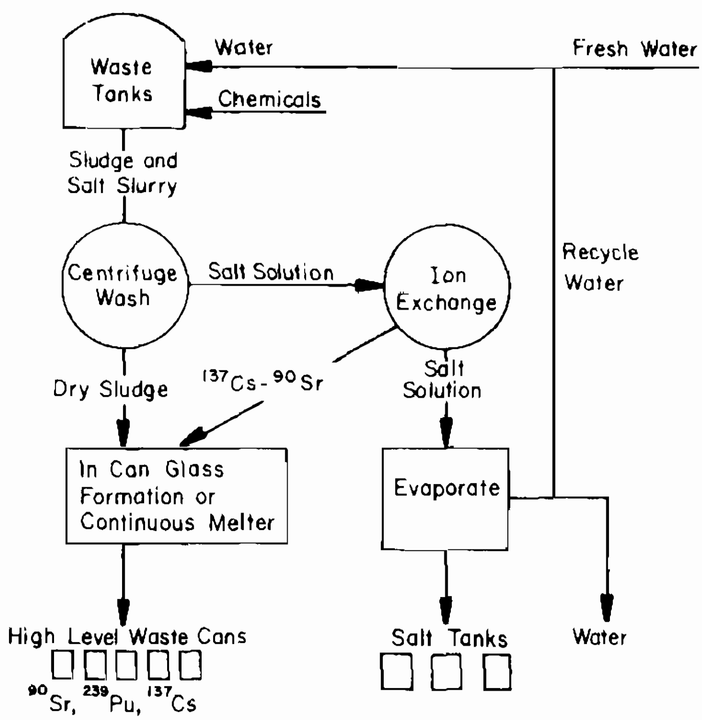


FIGURE IV-4. Conceptual Waste Solidification Process

A temporary storage facility is included to store up to two years of production of glass; the option of extended onsite storage is also open as discussed in Subcase 2.

Waste Removal and Tank Decontamination

Salt removal is accomplished by redissolving the salt in recirculated water and pumping the resultant solution from the tanks. Sludge removal is accomplished by slurrying the sludge with special pumps and pumping the slurry from the tanks. Residual sludge is then removed by chemical cleaning with oxalic acid solutions.

By 1988 when the waste solidification plant starts up, all waste will be stored in modern, double-wall, 1.3 million gallon tanks. H Area will have ten tanks containing salt and liquid, one tank containing sludge, and five tanks containing liquid and sludge. F Area will have five tanks containing salt and liquid, three tanks containing liquid and sludge, and one tank containing sludge. Twenty-five will be in service by 1985.

Waste tanks are each fitted with low-pressure pumps for slurrying and decontamination. Additionally, one mix tank in each area and the transfer tank in H Area are fitted with high-pressure pumps.

Waste transfer pumps (including installed spares) are required to move waste slurries from tank-to-tank and area-to-area. When possible, installed jets will be used to transfer salt solutions between tanks in the same area.

Additional equipment required for waste removal and tank decontamination includes:

- Slurrying and transfer pumps
- Water recycle tanks – F and H Areas
- Oxalic acid solution tanks and pumps – F and H Areas
- Interarea water recycle transfer line
- Equipment for relocating pumps including a shielded cask on a flatbed vehicle
- Piping, valves, spray jets, spray rings, and other minor auxiliaries.

Sludge removal and tank cleanout have been demonstrated, but improved technology is currently being developed. Removal of aged high-heat sludge from a waste tank retired in service, but still containing a sludge heel, was successfully demonstrated during FY 1979. Recirculated waste supernate was used as the slurrying medium.[6]

Salt Decontamination

The waste solidification plant for processing the dissolved-salt slurried-sludge mixture is under conceptual design with a new canyon-type building located just outside H Area. Present design calls for separate streams of salt solution and thick sludge to be transferred to the processing building. The salt concentrate must be further clarified of sludge fines before ion exchange processing. Sand filtration has been used in tests, and it, along with agglomeration and etched disk filtration, is being evaluated in further tests.

The principal radionuclide, ^{137}Cs, is removed from the dissolved salt by sorption on a phenolsulfonic ion exchange resin such as *Duolite** ARC-359. ^{106}Ru would not be removed, but with its 1-year half-life, will decay to innocuous levels in about 10 years. The small amount of ^{90}Sr (and some of the other lower concentration lanthanides and actinides) in the dissolved salt would be removed by an additional stage of ion exchange using a chelating resin. With this step added, principal residual activities in salt would be 1.5×10^3 nCi/g ^{137}Cs, 30 nCi/g ^{90}Sr, and <2 nCi/g Pu.

Equipment to perform these processes remotely at large scale is being developed and demonstrated in a semiworks mockup with nonradioactive synthetic wastes.

The heart of the waste solidification process is the incorporation of the radionuclides into a high-integrity, low-leachability matrix. Glass is being developed as the matrix in the SRP studies, but, as discussed in Section IV.D, a number of other matrices are being developed in companion programs at other sites. The options are still being preserved in the SRP design program to use any of the possible immobilization matrices. Current development of the glass process is based on the light water reactor (LWR) waste vitrification process being developed by Battelle-Pacific Northwest Laboratories (PNL). As the first step in incorporating the waste into glass, the washed sludge and ion exchange eluate are combined and converted to dry powder in a spray claciner. The powder flows by gravity with glass frit into a continuous, Joule-heated electric furnace. Molten glass is periodically poured into steel canisters. After cooling, lids are welded on the canisters, which are then

* Registered trademark of Diamond Shamrock Chemical Company.

tested, leak-checked and decontaminated. Each container holds 165 gallons of glass product with about 59 kilocuries of ^{90}Sr and ^{137}Cs. The heat output of each container is about 290 watts. Off-gases from both calciner and glass furnace are quenched, absorbed, and scrubbed before being released; scrub solutions are back-cycled to the waste feed.

The decontaminated salt solution is evaporated in two stages of bent tube evaporators as it is returned to existing waste tanks. The evaporator overheads are recycled for dissolution of more salt.

Status of Technology

Research and development to date have included a waste tank sampling program to provide the waste characteristics described previously in this section. Sludge and supernate have been separated on a small scale for both simulated waste and actual waste by centrifugation and filtration.[6] Testing of prototype wiped-film evaporators with synthetic waste began in FY-1977.[5] Several glass formulations have been prepared and evaluated in shielded cells using actual waste and the preferred formulation selected.[7] Compatibility of different container materials has been evaluated for the different waste forms.[8] Actual supernate has been used to demonstrate supernate decontamination at laboratory scale.[9] Engineering and cost studies have been performed for the complete process.[10] A research and development program in cooperation with Pacific Northwest Laboratories in Richland, Washington is continuing to evaluate the calcining and glass melting steps on a larger scale.

Research and Development Needed

Further research and development activities are planned in the areas of sludge removal, waste tank cleaning, calcining, deionization, glass melting, and others.

Still other research and development programs are devoted to alternatives to the reference processes. Besides those studies aimed at alternatives other than glass, alternative glass process studies are investigating in-can melting of glass, direct liquid fed melters, and a variety of other options.

The work on geologic repositories is being developed under a separate DOE program administered under the Office of Nuclear Waste Isolation (ONWI) and will be covered in a separate series of EISs. However, the SRP R&D program involves many interactions with the ONWI program. These interactions include determinations of waste form integrity under repository conditions, development of canisters and engineered barriers for the waste forms, and risk analyses of the different waste forms under repository conditions.

3. Alternative 2, Subcase 2 — Immobilize and Store in Surface Facility at SRP

Description

The processing steps of removal from tanks through vitrification are the same as those described for Subcase 1. Canned glass or other waste forms are stored in a reinforced concrete structure designed to withstand earthquakes, tornadoes, and missiles. This facility provides for natural-draft cooling of the individual containers, and is connected to the waste solidification facility by a tunnel. Shielded equipment places the cans in the storage position. Provision is made to recycle damaged or suspect containers to the canning facility. A possible alternative to the reinforced concrete structure is a water basin. Engineering and cost studies for these facilities were based on Reference 10.

Status of Technology

The status of technology is the same as that for Subcase 1, with the addition of the work that has been done on the air-cooled surface storage vault. Most of this work involves the conceptual design and is documented in Reference 10 for the SRP facility.

Research and Development Needed

Research and development needed by Alternative 2, Subcase 2 is the same as that for Subcase 1, except that the items related to an offsite geologic repository would not be needed. The air-cooled surface storage facility would be built using conventional materials and construction techniques, and would require comparatively little new research and development beyond the site selection activities.

4. Alternative 2, Subcase 3 — Immobilize and Dispose of in an SRP Bedrock Cavern

Description

The processing steps of waste removal from tanks through vitrification are the same as those for Subcase 1. The glass or other immobilized product is disposed of in a bedrock storage cavern below the Savannah River Plant site instead of in an offsite geologic storage facility. Previous studies[11] concluded that a cavern 1500 ft below the surface in the Triassic formation would be best. The head house and main access shaft for such a facility are tentatively located about eight miles from the separations area (H Area) in the southeastern one-third of the plantsite.

The waste forms are transferred in a cask to the head house where they are removed from the cask and lowered through the access shaft to tunnels in the Triassic rock. Specially designed machines transport the can to the storage position in the tunnel.

During the period of emplacement in the bedrock, cavern ventilation is provided and water inleakage is pumped out. After the tunnels are filled, the access and ventilation shafts are sealed and, in time, presumably would fill by seepage of water from the metamorphic rocks. After this filling, retrievability would depend on the integrity of the waste product and waste canisters and the ability to pump out the water. Retrievability could be extended beyond the cavern filling period if water pumping and surveillance were continued.

Status of Technology

The status of technology for Alternative 2, Subcase 3 is the same as that for Subcase 1 through the vitrification step. Conceptual design studies have been made for a bedrock cavern under the SRP site, and extensive drilling of test wells was done to establish the overall characteristics of the underlying rock. This preliminary work indicated a satisfactory site probably exists in a Triassic basin about 8 miles from the present separations areas, and about 1500 ft below the surface. An extensive description of the conceptual design and the geologic investigations carried out before work ceased on this concept in 1972 is given in Reference 11.

Research and Development Needed

The research and development needed for Alternative 2, Subcase 3 is the same as that for Subcase 1, except that the items related to an offsite geologic repository would not be needed. Instead, an extensive research and development effort would be required at SRP, with the objective of ensuring a high degree of confidence in the physical integrity of the bedrock cavern. This work would require more test drilling and construction of an exploratory shaft and tunnels. The same types of parameters would be measured as in Subcase 1. Particular emphasis would be placed on studying possible pathways to the Tuscaloosa aquifer, which lies above the potential bedrock cavern site. These requirements are discussed more fully in Reference 11, and would probably result in at least 10 years of increased time for implementation compared to other alternatives.

No development work oriented toward a bedrock cavern at SRP is under way, nor is any proposed for funding.

5. Alternative 3 – Dispose of Liquid Waste in an SRP Bedrock Cavern

Description

Present waste would be reconstituted to liquid as described for Alternative 2, Subcase 1, but with the salt and sludge streams combined. The waste slurry would be pumped about 8 miles through a heavily constructed double transfer line to a bedrock cavern. The cavern would be similar to that described for Alternative 2, Subcase 3, except that it would have a volume of about 17 million cubic feet to provide extra space for radiolytic gas, water inleakage, and rock creep (this is about 3 times the size of the cavern required for Alternative 2, Subcase 3).

Status of Technology

Reconstitution of present waste to liquid and transfer to the site of the bedrock cavern are similar to activities that are performed routinely in present waste management operations and would require no new technology development. Mining of the bedrock cavern is also within the capabilities of present-day routine mining.

Research and Development Needed

The research and development efforts for this alternative would be directed toward ensuring the integrity of the bedrock cavern, as described for Alternative 2 - Subcase 3, and in Reference 11.

This work is not now under way, and it is not currently proposed for funding. Furthermore, the U.S. Environmental Protection Agency in their comment letter on the draft of this EIS, has ruled this alternative to be Environmentally Unsatisfactory.

C. ALTERNATIVES FOR DECONTAMINATED SALT STORAGE

1. Description of Decontaminated Salt

The alternative that processes the high-level waste into an immobilization matrix also produces decontaminated salt. The dissolved salt removed from waste tanks is processed through a two-step ion exchange process, one to remove cesium and the other to remove strontium plus residual quantities of other lanthanides and actinides. The radionuclides eluted from the ion exchange columns are incorporated into the glass matrix.

Immediately after processing, the salt contains less than 1% of the radioactivity in the high-level waste. ^{106}Ru will be the predominant radionuclide in the salt. Its concentration depends on the age of the waste after the reactor irradiation producing the ^{106}Ru. After 10 years, this relatively short-lived radionuclide is reduced by a factor of one thousand, and after 20 years, by a factor of one million. The radioactivity in the salt after 10 years is shown in Table IV-7. In addition to the reference decontamination factors given in Table IV-7, the R&D program is also investigating the possibility of essentially complete decontamination of the waste after ^{106}Ru decay (^{106}Ru removal is also being investigated, but does not currently appear economically attractive). This extra decontamination might be performed in a second pass through the immobilization plant using different ion exchange resins if necessary, but the same equipment. It might also be accomplished with new, lightly shielded and relatively inexpensive equipment at the salt storage tanks.

After the dissolved salt solution is substantially decontaminated by ion exchange, it is evaporated in bent-tube and/or wiped-film evaporators and the concentrate is cooled to crystallized salt. The principal chemical composition of the salt, excluding any residual water, is shown in Table IV-8.[12]

TABLE IV-7

Radionuclide Content of Decontaminated Salt
(10-year-old waste)

Radionuclide	Concentration (nCi/g) *Chemically Measured*	*Computer-Calculated*
^{3}H	NA[c]	57
^{60}Co	NA[c]	390
^{90}Sr-Y[a]	2	9
^{99}Tc	125	220
^{106}Ru-Rh[b]	287,000	100,000
^{129}I	NA[c]	0.04
^{137}Cs-Ba[a]	100	480
^{144}Ce-Pr[b]	109[d]	220[d]
^{147}Pm[b]	100[d]	5200[d]
^{151}Sm	<10[d]	116[d]
^{154}Eu	71[d]	510[d]
^{238}Pu[a]	9	0.9
^{239}Pu[a]	0.3	0.02
^{240}Pu[a]	0.3	0.02
^{241}Pu[a]	2	3.5
^{241}Am[a]	0.5	0.03

a. With decontamination factors assumed Cs 10^4, Sr 10^3, actinides 10^2 (165 for computer-calculated concentrations).

b. Decay of short-lived radionuclide may contribute to differences in computer-calculated and chemically measured concentrations.

c. Not analyzed.

d. Concentrations of rare-earth fission products should be reduced by a factor of 10^2 (165) during decontamination operations.

TABLE IV-8

Chemical Composition of Decontaminated, Crystallized Salt

Component	*Weight Fraction*
$NaNO_3$	0.458
$NaNO_2$	0.186
NaOH	0.073
$NaAlO_2$	0.100
$NaCO_3$	0.078
Na_2SO_4	0.104

(Note that the nitrate fraction decreases and the nitrite fraction increases during the early years of storage.)

Research and development have not progressed to the extent that the concentration of mercury in the decontaminated salt can be determined precisely; however, the concentration is expected to be less than 4×10^{-4} grams of mercury per gram of salt. The total amount of Hg in the 16.3 million gallons (∿120,000 tons) of salt would then be less than 60 tons.

2. Alternative Storage Modes

Store in Tanks at SRP

The decontaminated salt solution is transferred to tanks outside the canyon-type solidification facility and processed through evaporators. The concentrate is transferred to decontaminated double-wall carbon steel waste tanks encased in reinforced concrete (this is the current design, or Type III, tank). The steel tanks have an expected life of 50 to 100 years, and the 2.5-ft-thick concrete encasements have an expected life of several hundred years. The concentrate is cooled to form crystallized salt. If all the solution does not crystallize when cooled, the supernate is recycled for further concentration until it does crystallize.

The tanks are monitored at the same level as the current practice for SRP waste tanks. After one hundred years when the residual ^{90}Sr and ^{137}Cs in the salt have been reduced by a factor of 10 due to radioactive decay, the access ports through the tank covers will be plugged and sealed. Other protective provisions include a confinement barrier over the tanks, such as reinforced concrete slab several feet thick with embedded durable warning signs, to prevent accidental intrusion and to obstruct malicious entry into the storage tanks. A 25-ft-thick earthen cover, faced with rock, is placed over the concrete slab to provide protection from surface conditions and to provide a landmark that will not be lost by weathering over the centuries. At the perimeter of the earthen mound, new monitoring wells are installed to allow continued surveillance if required.

Can and Store in an Onsite Surface Vault

The decontaminated salt solution is evaporated to form crystallized salt. Four cells in the canyon-type solidification facility are allotted to evaporate the salt solution and can the crystallized salt; two cells are allotted to evaporate the solution and can the salt; and two cells are allotted to decontaminate and inspect the canisters. The metal canisters are sealed by welding. After decontamination and inspection, the canisters are transferred to a surface storage vault. Because of the low radionuclide content of the salt, the canisters do not require forced cooling in the storage vault.

Can and Ship to an Offsite Federal Repository

The decontaminated salt solution is evaporated and placed in canisters identical to those proposed for use in a surface storage vault at SRP. The canisters are shipped to an offsite Federal repository for disposal.

Other Options After ^{106}Ru Decay

After ^{106}Ru decay, and particularly if a second stage of decontamination is used, the salt can be expected to be at a low enough activity that it can be treated essentially as a chemical, rather than a low-level radioactive waste. Possible options then available include shallow land burial in a dry location, sea disposal, and return of the material to commerce.

D. ALTERNATIVE WASTE IMMOBILIZATION FORMS

Disposal Alternative 2 calls for immobilizing SRP high-level waste in a high integrity form before placing it in a Federal Geologic Repository (Subcase 1), in a Surface Facility at SRP (Subcase 2), or in a Bedrock Cavern at SRP (Subcase 3). Borosilicate glass was selected in 1977 as the reference form for immobilization of SRP high-level waste, and a major effort is currently underway to develop the required technology. In addition DOE is investigating a number of alternative waste forms. A preliminary analysis of the waste forms will be completed in FY 1980. Forms that have potential superior product performance or process characteristics to those of glass will then be selected for more detailed review. Conceptual processes will be carefully defined for each selected waste form. These processes will be evaluated to provide improved assessments of performance attributes and will provide the basis for better quality cost estimates. Sufficient data is expected to be available in the form of regulatory criteria and from the waste form development and characterization program to provide a basis for a detailed systems assessment in FY 1983. The final waste form for immobilization of SRP high-level waste will be selected by the end of FY 1983 based on the results of the systems assessment. (See Figure IV-5 for overall evaluation schedule.)

1. Waste form Requirements

The high-level waste immobilization form must meet a number of different requirements at different stages of the waste disposal process; it is essential that it be considered in such a total system context rather than merely in terms of any single factor such as long-term leachability. These requirements include, by disposal stage:

a. Processing

- The waste form must be produced by a safe, practical process at acceptable cost.
- The waste form must be flexible enough to accept reasonable variations in waste composition and process conditions.

- The waste form must be certifiable in terms of process quality control and quality assurance testing.

- The waste form should desirably be amenable to second-generation improvements.

b. Interim Storage

- The waste form must be resistant to handling and short-term corrosion.

- The chance of radionuclide dispersal must be low on coolant loss or sabotage.

c. Transportation

- The waste form must be resistant to transportation accidents, including impact, short-term leaching, and hot fires.

- The waste form must be resistant to sabotage.

d. Repository Emplacement

- The waste form must meet repository handling requirements in regard to structural integrity, surface contamination, fire resistance, dimensions, weight, etc.

- The waste form must meet repository retrievability requirements. The requirements are not yet fixed but can be expected to be between 20 and 50 years.

e. Repository Storage

- The primary requirements are for low leachability under repository conditions assuming both static water (normal storage) and flowing water (accidents), and for good compatibility between the waste form and the host geologic medium.

- The secondary requirement is resistance to dispersal in accidental or deliberate intrusion.

The final arbitrator of these requirements is the projected health risk to man from exposure to radionuclides released by the waste form. On this basis, the waste form represents merely the final barrier in a multibarrier system to reduce the health risk. In no case is the waste form the primary barrier. Thus, for processing, the primary barrier is the processing building and the engineered containment of the processing equipment; for interim storage it is the storage basins and the waste canister; for transportation it is the waste canister and the shipping cask (already well developed for spent fuel handling); for repository emplacement, it is the canister, the repository, and the emplacement equipment; while for repository storage it is the canister, the repository itself, plus any engineered features such as overpacks. Despite the secondary nature of the barrier afforded by the waste form, the multibarrier concept still calls for the waste form to provide independent protection so as to maintain an acceptably small risk level even if any of the primary barriers should fail.

2. Borosilicate Glass Waste Forms

Borosilicate glass has to date been the waste form of most interest in the high-level waste disposal programs both in the U.S. and abroad.[13] It is now in commercial use in the European waste management programs. (See Table IV-9 for list of foreign HLW form programs.) One of the advantages of borosilicate glass is that it can accommodate a large variety of glass formers and waste compositions. The waste glass can thus be tailored to the particular waste composition and to the particular processing equipment and conditions. Table IV-10 gives a sample composition for one SRP borosilicate glass form.

The advantages of borosilicate glass for high-level waste immobilization include the following:

- Glass technology is well developed and uses simple, easily available materials.

- Extensive technology has been developed at Pacific Northwest Laboratories and elsewhere specifically for fabricating high-level waste forms.

- Borosilicate glass will accommodate essentially all the waste radionuclides except the noble gases, although a few of the more volatile like Cs, I, and Ru may have to be partially recycled from an off-gas system during glass formation. Borosilicate glass will also accommodate essentially all the nonradioactive elements in the SRP high-level waste sludge.

- The glass will accommodate relatively high waste loadings ($\sim$28 wt % total waste oxides) to produce a relatively high density product ($\sim$2.7 g/cm^3).

- Glass properties are not critically dependent on waste composition, glass former compositions, or processing conditions.

TABLE IV-9

International HLW Immobilization Status

Nation	*Process*	*Status/Major Milestone*
France	Borosilicate Glass - "AVM"	0.5 ton/day hot pilot plant startup 1978-1979 Production plant startup 1982-1983
Germany	Borosilicate Glass	"VERA" 0.5 ton/day cold pilot plant operation considering French "AVM" process for licensing
Eurochem	Borosilicate Glass Metal Matrix	French "AVM" selected for production plant VITRAMET - LOTES) Pilot Plant VITRAMET - PAMELA) 1981-1982
England	Borosilicate Glass	"FINGAL-HARVEST" production plant 1990 French "AVM" under consideration
Russia	Phosphate Glass	Cold pilot-plant work in progress
India	Borosilicate Glass	0.1 ton/day hot plant startup 1979-1980
Japan	Glass or Ceramic	Hot demonstration plant 1986
Sweden	Ceramic	Laboratory studies in progress

TABLE IV-10

Composition of Typical SRP Borosilicate Glass[a,b]

Calcine Composition		*Frit Composition*	
Fe_2O_3	42.0 wt %	SiO_2	52.5 wt %
Al_2O_3	8.5	B_2O_3	10.0
MnO_2	11.8	Na_2O	18.5
U_3O_8	3.9	Li_2O	4.0
NiO	5.2	CaO	4.0
SiO_2	3.8	TiO_2	10.0
Na_2O	4.7		
Zeolite	8.8		
$NaNO_3$	2.6		
$NaNO_2$	0.2		
$NaAlO_2$	0.2		
NaOH	3.9		
Na_2SO_4	1.3		

a. Glass will contain 28 wt % calcine.

b. Average density of glass will be 2.7 g/cm^3.

- The glass may be cast in large monoliths with a relatively small degree of cracking (based on present measurements, cracking approximately doubles the monolith surface area).

- The glass monoliths are compatible with relatively inexpensive and conventional stainless steel or carbon steel canisters.

- The canistered glass monoliths are structurally strong, have good impact resistance, and a high heat capacity. They require very large energy inputs to fracture them into airborne powder or to volatilize them.

- The glass has good resistance to radiation damage and to internal helium buildup (from radioactive alpha decay in the contained waste). Equivalent exposures of up to 10^6 years in radioactively spiked samples have shown essentially no radiation damage effects. Stored energy from the exposure was less than 35 cal/g.

- The glass is nonflammable and emits essentially no gases or volatile radionuclides at temperatures under 700°C. The canister may be kept contamination-free on the outside.

- The glass has good resistance to water leaching. At their expected surface temperature of ∿100°C (a maximum of 130°C if five-year-old waste is ever processed for immediate disposal), the SRP glass waste forms have measured leachabilities of about 10^{-6} to 10^{-7} $g/cm^2/day$.

- The glass has not been observed to devitrify at temperatures under 500-600°C, and even when it is devitrified, its leachability at expected repository conditions still remains in the 10^{-6} range.

The possible objections which have been raised against glass as a high-level waste immobilization form, have to do primarily with its behavior during high temperature leaching tests. At temperatures of 350°C and high pressures (well above the 100-130°C surface temperature expected for glass monoliths made from the SRP wastes), glass leaches relatively rapid (∿10^{-2} $g/cm^2/day$) in distilled water and shows extensive substitution and devitrification in brine. A possible interpretation of these tests is that they represent a form of accelerated testing which demonstrates inherent thermodynamic instability for glass as compared with some of the crystalline waste forms. Interpretation of any of the leaching experiments is complicated by the fact that glass leaching is a complex multistep process involving gel formation by water penetration, interstitial element diffusion, element replacement, devitrification, and glass structure dissolution. This complicated series of mechanisms in turn complicates the extrapolation from the relatively brief leaching tests to the long-term repository behavior.

3. Other Waste Immobilization Forms

Table IV-11 compares a number of possible high-level waste immobilization forms in terms of some processing and performance parameters. In many cases the judgments listed in the table are both qualitative and preliminary pending execution of the research programs to be described in the next section, but they do indicate the range of parameters to be expected.

The first three waste forms listed include calcine in which the waste is fired to a mixture of oxides at 300-700°C, rich clay in which the waste is solidified by mixing with clay to absorb water, and normal concrete in which the waste is set to a solid in cement. These forms are the primary choices for in-place immobilization of the wastes. They use available technology, they are marginal-to-good in leach resistance, but they offer little intrinsic resistance to transport accidents, thus putting almost all the reliance on the shipping cask.

The next forms listed include hot pressed concrete in which interconnected voids and excess water have been eliminated from the normal concrete, pelletized calcine in which the calcine has been agglomerated and some of its water solubility has been removed by firing the waste with various additives in the calcining process, glass in which advanced high temperature glasses might be considered in addition to the current waste glasses, and clay ceramics in which the waste-clay mixtures are fired to semiconventional ceramics. These forms are viewed as the current choices for the near-term waste immobilization plant at Savannah River. Current available evidence indicates glass to be the best of these forms.

The next three forms listed include supercalcine in which extensive additives are incorporated in the calcine mixture with the intention of producing an assemblage of highly stable, highly leach-resistant (mainly) silicate minerals after firing, SYNROC in which firing or hot pressing is used to produce a similar series of titanate minerals, glass ceramics in which a waste glass is deliberately partially devitrified under controlled conditions again with the intent of producing highly stable forms. Finally, the last three forms listed are representative of possible composite waste forms. They include metal matrices in which pellets of glass, supercalcine, or other waste forms are incorporated in a metal binder, multibarrier forms in which the individual waste particles are coated with carbon, Al_2O_3, or other impervious materials before metal encapsulations, and cermets in which very small waste particles are formed *in situ* in the metal matrix.

TABLE IV-11

High-Level Nuclear Waste Immobilization Forms — Properties Comparison

Waste Form	Devel. Status	Process Complexity	Process Flexibility	Waste Loading	Dispersion Impact Resis.	Long-Term Stability	Fire Resistance	Leachability 100°C	Leachability 350°C
Calcine	Available	Low	Excellent	High	Very Low	High	Poor	Poor	Poor
Rich Clay	Available	Low	Excellent	Low	Low	?	Poor	Medium	Poor
Normal Concrete	Available	Medium	Excellent	Medium	Medium	Medium	Poor	Medium	Poor
Hot, Pressed Concrete	5 years	High	Excellent	Medium	High	Medium	Medium	Good	Poor
Pelletized Calcine	5 years	High	Excellent	Medium	Medium	Medium	Medium	Good	Poor
Glass	Available	High	Excellent	Medium	High	High	Excellent	Excellent	Poor
Clay Ceramic	5 years	High	Poor	Medium	High	Medium	Medium	Good	Poor
Supercalcine	15 years	Very High	Poor	High	Very High	High ?	Best	Best	Poor
Synroc	15 years	High	Poor	Very Low	Very High	High ?	Best	Best	Good
Glass Ceramic	15 years	Very High	Poor	Medium	High	High	Excellent	Excellent	Poor
Pellet in Metal Matrix	5 years	Very High	Good	Low	Very High	High	Poor	Excellent	Poor
Coated Supercalcine in Metal Matrix	15 years	Highest	Poor	Medium	Very High	High ?	Excellent	Best	Poor
Cermet	10 years	Highest	Poor	Medium	High	High	Excellent	Excellent	Poor

Most Attractive | Intermediate | Least Attractive

These six forms (and other closely related forms) are the primary candidates for advanced waste form development. None of them, with the probable exception of glass marbles in a metal matrix, is available for use now or is even well characterized. Thus, the excellent properties listed for these forms in Table IV-11 are to some extent tautological in that the development simply aims at achieving these properties. However, the possibility of such an achievement is in most cases supported by limited experimental data.

4. Waste Form Development Program

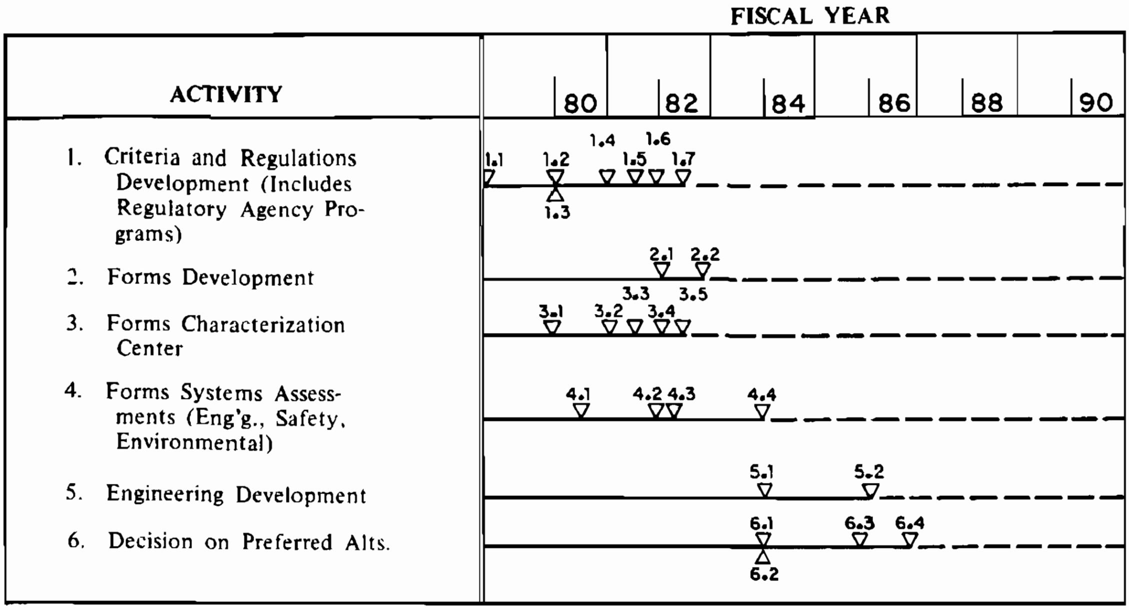
Essentially all the waste forms listed in Table IV-11 are under active development. The development programs are widely dispersed through the waste sites, the DOE national laboratories, industrial laboratories, and universities in order to secure the widest possible input. They are summarized in Table IV-12 and discussed briefly below for each of the major types of forms. Figure IV-5 shows the schedule and key milestones.

Calcine — Calcine waste form development is largely centered at the Idaho Chemical Processing Plant (ICPP),[14] where a long-term program has been pursued to calcine all the plant high-level waste for interim or permanent storage. Current ICPP studies on calcine waste forms are primarily concentrated on pelletizing the existing calcines either for direct disposal or for incorporation in a matrix system. Work on calcines is also under way in the super-calcine program and, as a calcine intermediate, on the borosilicate glass programs at PNL and SRL.

Rich Clay — Work on the rich clay and related clay solidification forms is largely being conducted at Hanford as a means for in-tank solidification of the Hanford wastes.

Polymers — Synthetic and natural (bitumin) polymers are in wide use for immobilizing low-level and transuranic wastes,[15] and Brookhaven National Laboratory (BNL) has done some work on polymers for high-level waste forms. However, the radiation and long-term stability of the HLW polymers is marginal. More important they are flammable, and in the case of the defense wastes which contain nitrate and permanganate as oxidizing agents, potentially explosive. Hence, no work is under way on polymer high-level waste forms.

Normal Concrete — A great deal of work has been performed on normal concrete high-level waste forms.[16,17,18] Major efforts have been carried out at Brookhaven National Laboratory, Oak Ridge National Laboratory, Penn State University, and Savannah River Laboratory. However, most current work on concrete waste



1.1 EPA Draft Gen. Criteria
1.2 Initiate NRC Staff Tech Position Papers
1.3 Preliminary ONWI Criteria
1.4 EPA Draft Tech Criteria
1.5 NRC Draft Regulations (10CFR-60)
1.6 Final ONWI Criteria
1.7 NRC Final Regulations

2.1 Glass Formulations Selected
2.2 Alternatives Selected

3.1 Established
3.2 Fully Operational
3.3 Testing Methods for Waste Forms Developed
3.4 Mat'ls Handbook Initiated
3.5 Methods for Barrier Mat'ls

4.1 Preliminary Glass
4.2 Preliminary Alts.
4.3 Final Glass
4.4 Final Alternatives

5.1 Glass Forms
5.2 Alternatives

6.1 DWPF Final Form
6.2 *Second Generation Forms*
6.3 Alts. for ICPP, Hanford
6.4 Form for Comm. Waste

FIGURE IV-5. National HLW Long-Term Management Program Waste Form Selection

TABLE IV-12

Alternate Waste Form Development

Current Programs	*Location*
Supercalcine, Coatings and Matrices	PNL
Sintered and Coated Calcine	ICPP
Glass Marble - Metal Matrices	ANL
Concrete (FUETAP)	ORNL
Cermet	ORNL
SYNROC	LLL
Sol-Gel	ORNL

forms is concentrated on in-place applications such as the ORNL shale hydrofracturing with grout, on the newer higher integrity concretes assumed below, or on low-level waste applications.

Hot-Pressed Concrete — Development of hot-pressed concrete waste forms is being pursued primarily at Oak Ridge National Laboratory under their FUETAP (Formed Under Elevated Temperature and Pressure) program.[19] Pennsylvania State University has also developed hot-pressed concrete forms.[20]

Pelletized Calcine — Pelletized calcines are being developed primarily in the ICPP calcine programs.[21]

Borosilicate Glass - Borosilicate glass is the most developed form. The U.S. effort is primarily focused at Pacific Northwest Laboratories (PNL) [22] and at Savannah River Laboratory (SRL).[6, 23] Work on adapting the borosilicate glass to their particular waste forms is also under way at each of the waste sites. In addition, as listed in Table IV-9, most other nations have borosilicate glass waste programs.

Phosphate Glass — Phosphate glass has received considerable attention as a waste form. U.S. studies have been concentrated at BNL and PNL; a number of studies have also been carried out in Russia and Western Europe, particularly Germany. However, these studies uncovered major problems in devitrification (low temperatures of crystallization with a major increase in leachability) and in incompatibility with container materials. Hence, no U.S. study is currently under way on these glasses.

High-Silica Glasses — High-silica natural glasses (obsidians and tektites) are known to have persisted for long periods in both terrestrial and lunar environments. However, these glasses work at about 1600°C, temperature high enough to drive off most of the ruthenium and cesium radionuclides from the waste. Investigation[24] is being made of several proprietary processes for low-temperature formation of high-silica glasses containing high-level wastes.

Clay Ceramics — Adding aluminum silicate clays such as keolin or bentonite to the waste typically produces an insoluble cancrinite-type material. This material can be fired to a nepheline-like ceramic. Some consideration is being given to these materials in the Hanford program. However, most of the attention is focused on the more-advanced ceramic analogues of long-lasting natural minerals in the supercalcine and SYNROC programs considered below.

Supercalcine — Pennsylvania State University,[25,26,27] working in cooperation with Pacific Northwest Laboratory, has added various silicate materials in the waste calcining process to produce synthetic analogues of natural silicate minerals which can be hot pressed or sintered to ceramic waste forms. Penn State is continuing this work in cooperation with PNL and the Rockwell International Company in one of the larger scale waste form development programs.

SYNROC — Prof. Ringwood at the Australian National University has developed[28] several assemblages of synthetic titanate minerals, which he calls SYNROC, as waste forms. As with the supercalcines, the SYNROC synthetic minerals are based on natural analogues that have persisted in nature for very long times and that can be sintered or hot-pressed to ceramic forms. Lawrence Livermore Laboratory is working with Prof. Ringwood on SYNROC development. In addition, SYNROC-type compositions are being looked at in a number of the other U.S. waste form programs on an exploratory basis.

Titanates, Niobates, Zirconates — Sandia Laboratories[29] have developed these materials as mineral ion exchangers and are pursuing a small program to determine the practicality of hot pressing or sintering them to waste forms. These materials are also being considered as engineered barriers around the waste forms.

Glass Ceramics — One form of glass ceramic can be made by sintering or hot pressing the mixture of waste and glass frit rather than melting it as in normal glass-making practice. The resulting lower temperature processes have some attraction in reducing radionuclide volatilization and chemical corrosion; they have received limited attention for the fluoride-containing wastes at ICPP.[30] The more common forms of glass ceramics are formed by controlled devitrification. PNL is pursuing a small program in this area in cooperation with a larger program at the Federal Republic of Germany.

Metal Matrices — Most of the waste forms discussed above such as calcines, concretes, glasses, ceramics, and artificial minerals can be formed in small sizes and dispersed in a metal matrix for better heat transfer, reduced frangibility, easier sampling, and additional leaching barriers. Low melting alloys such as Pb-Sb/Sn or Al-Si can be cast around the waste particles, while higher melting metals can be sintered around the particles at temperatures of about two-thirds their melting temperature. Metal matrix waste form work in the U.S. is primarily concentrated at Argonne National Laboratory[31] and Pacific Northwest Laboratory,[32,33] with smaller programs at the Idaho Chemical Processing Plant and elsewhere.

Multibarrier Forms — More complex matrix waste forms can be made by coating the waste particles with impervious materials such as carbon, alumina, or silicon carbide before placing them in the matrix. Such coatings provide additional barriers against waste leaching and also allow the use of higher temperature matrix-forming processes by reducing radionuclide volatilization. Concretes, sintered ceramics, and other materials can be used rather than metal as the matrix, if desired, when coated particles are used. The primary U.S. effort on multibarrier forms has been performed at Battelle Memorial Institute in their Pacific Northwest and Columbus Laboratories.[32,33] Consideration is also being given to applying to the multibarrier forms the coated particle technology developed by General Atomics for their high temperature gas cooled reactors (HTGRs).

Cermets — Cermet high-level waste forms are a particular matrix form in which very fine waste particles are dispersed in a metal matrix, usually by *in situ* precipitation. Oak Ridge National Laboratory[34,35] is developing a particular waste cermet in which the wastes (and additional metal formers) are dissolved in urea, and the metal formers are reduced from the solution to form a *Hastelloy**-like alloy containing finely dispersed nonmetal waste particles.

Fused Salt - This waste form is not currently under active development. The distinctive characteristic of the fused salt waste form is that no separation of salt and sludge is made, and the waste is not processed through ion exchange to a high activity fraction and a residual low activity fraction. Salt is dissolved from the tanks and sludge is suspended in salt solution. The solutions are blended and fed to a low temperature fusion plant. Water is removed in successive stages of evaporation and dehydration, using bent tube and wiped film evaporators and rotary melters. The water removed from the salt is recycled to the waste tanks for dissolution of additional salt.

Preliminary studies have shown that 1000-gallon containers can be used for fused salt without exceeding design centerline temperatures and transportation weight limits. Each container holds 1000 gallons of fused salt and contains 22.6 kilocuries of ^{90}Sr-^{137}Cs with a heat output of 130 watts.

Because the low temperature fusion process is simpler than partitioning waste and manufacturing glass or concrete, full-scale testing and implementation lead times would fall well within the schedules planned for previously described alternative plans.

Fused salt is a less expensive product than glass or concrete. Although the processing step of conversion to fused salt is about as expensive as vitrification or cementation, the salt decontamination step is eliminated completely. Somewhat higher container costs are incurred because of the larger volume of product, but the expense of returning decontaminated salt to tanks is eliminated.

Fused salt has risks similar to dry powder with regard to water intrusion. The risks from airborne particles is intermediate between dry powder and glass. Sabotage during processing carries a lower risk than that for other waste forms because there is no point in the processing operation where concentrated, fine particles are available.

Fused salt is not proposed for specific research and development activities because its costs and risks are intermediate between glass and the other major alternatives of continued tank farm operation or disposal of liquid waste in SRP bedrock. These product forms may not satisfy the desire of the general public regarding a high integrity waste product and the role the form would play in the multiple barrier concept. Most of the processes needed for a fused salt product would, however, be investigated in the course of an advanced form product development, so they are not precluded by the current program.

5. Canister and Engineered Barrier Programs

The waste forms are normally housed in a canister which provides a contamination-free handling surface, add mechanical strength, provides extra containment during shipping, handling, and interim storage, and also provides an additional barrier against repository waste leaching. This canister may in turn be surrounded by additional isolation materials, secondary canisters, and other engineered barriers. In many cases these engineered barriers are designed to provide radionuclide containment equivalent to that of the waste form itself. In the repositories they act to restrict and condition any flow of repository water to the waste form and similarly to restrict and condition any flow of leached radionuclides from the waste form to the repository.

Since the canisters and other engineered barriers form the interface between the waste form and the repository, they must be considered jointly by the waste form, transportation, and repository programs. In general, however, the waste forms program has primary responsibility for the initial canister and for any other engineered barriers added at the forms production plant; the transportation program has primary responsibility for engineered barriers in the shipping canisters; and the repository

* Trademark of Cabot Corporation.

program has primary responsibility for any engineered barriers added to the repository.

Each of the waste form programs includes a program for the primary canister to contain that form. More general canisterization and engineered barrier programs are also being conducted under the high-level waste management programs at Oak Ridge National Laboratory, Pacific Northwest Laboratory, and Savannah River Laboratory. Other types of engineered barrier studies are under way at Hanford and the ICPP for the options of in-tank immobilization of the wastes at these sites.

6. High-Level Waste Forms Characterization

High-level waste forms characterization serves two different purposes. First, it provides a basis for waste forms selection by comparison of the properties of the different waste forms with each other and with the waste form criteria and regulations. Second, once the waste form has been selected, it provides a means of quality assurance that the waste forms have been properly produced and that they meet the required standards. The first purpose is largely served by the properties tests of each form, and the second purpose is largely served by the quality assurance tests in each production program. However, a limited external characterization program is also necessary outside the direct development and production programs to make sure that all the candidate forms are evaluated on a uniform basis and that the quality assurance tests do indeed meet the regulatory requirements.

A waste characterization center is being established at Battelle Pacific Northwest Laboratory. (A DOE national laboratory is specified because of the need to handle large amounts of radioactivity in some of the tests.) The characterization center will develop required testing procedures and issue them for distribution, determine the relation between these procedures and any applicable regulations, issue reference data on each of the candidate waste forms, and verify data collected in the development and production programs.

In order to provide quality assurance on the characterization center data and to secure system-wide concurrence, the characterization center results will be issued through a materials review board composed of data users, independent experts, and a representative of a separate certification laboratory. The latter will be established in the separate waste repositories reporting chain and will provide independent quality assurance testing of the characterization center results.

The final components in the characterization program are the scientific laboratories. The purpose of these laboratories is to relate the observed properties of the waste forms to the fundamental processes underlying these properties. In most cases the properties measurements are made over a span of a few hours — at most a few years — and then extrapolated to hundreds or thousands of years for decision-making between waste forms. Since many of the waste form properties are nonlinear with time, such extrapolations can be made only in terms of the fundamental mechanisms underlying the measured properties.

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A. POTENTIAL EFFECTS OF CONSTRUCTION ACTIVITIES FOR EACH ALTERNATIVE

The potential effects of construction are covered in the following sections for activities that relate to the Savannah River site. The potential effects for geologic disposal are covered in DOE/EIS-0046-D.[1] Specific effects will be covered in separate site-specific EISs when and if actual facilities are proposed.

1. Land-Use Effects

The following components of the waste management alternatives would require commitment of land: 1) an immobilization facility at SRP, 2) a surface storage facility at SRP, 3) a bedrock cavern at SRP, 4) a continuing tank farm at SRP, and 5) an offsite geologic repository.

Any of the land requirements at SRP would be at or near existing chemical reprocessing areas, with the exception of a bedrock cavern, which would be within the site but might be several miles from the present processing areas. A processing facility and a surface facility would each require less than 50 acres. After operations cease, most of this land could be returned to unrestricted use. Any use of seepage basins would occur in areas currently used for that purpose, and the ultimate fate of such land would not depend on effects from long-term waste management activities. A continuing tank farm operation would require about 25 acres of additional land for building new tanks at intervals as often as every 50 years. This requirement would cease if a decision were later made to dismantle old tanks and reuse those sites for new tanks, or if a decision were made that containment of the material with high reliability was no longer necessary because the radioactivity in the waste had decayed to innocuous levels.

A bedrock cavern to dispose of liquid waste at SRP would probably require transfer lines from the location of the present tank farms to the location of the surface access to the cavern. A corridor of land about 100 feet wide and up to 8 miles long would be required. The transfer line would be a monitored, double line encased in a concrete culvert and would release no radioactive materials. The line could be dismantled, and the land could be returned to unrestricted use, if such a program were consistent with overall decommissioning policy for the SRP site.

Both a bedrock cavern at SRP and an offsite geologic cavern would require that the subsurface surroundings remain undisturbed by drilling or mining. The size of such an isolation area has not yet been determined and would depend on detailed physical characteristics to be measured for a specific site and future NRC regulations. Preliminary estimates indicate that exclusion of underground activities in an area about 4 miles in diameter centered over the repository would be adequate. Most of the surface area above the underground exclusion area could be used for normal activities. About 50 acres surrounding the access shafts would probably be controlled.

There are no sites of historical or archeological interest within the SRP boundaries that are being considered for location of waste management facilities. Any such sites that might exist where offsite repositories would be located would be identified in the environmental assessments specific to those facilities.

2. Impact on Animal and Plant Communities

Changes in the local ecology are expected during the disruptions accompanying the construction activities, with reversal of most changes and restoration to a new equilibrium after completion of these activities. Such changes would affect about 100 acres out of about 190,000 acres of land that is primarily pine forest for alternatives that involve new facilities at the SRP site. Clearing of wooded land will result in a loss of wildlife habitat. During such clearing and construction, animals will seek shelter in adjacent wooded areas; however, there may be increased mortality among displaced animals. Some foraging species may be benefited by this activity as new shrubs and low brush develop from natural regeneration.

The areas on the site that are not used for permanent facilities will be reclaimed by landscaping and reseeding. Such measures will minimize the long-term impact on terrestrial biota in the area.

The major potential for adverse impacts on aquatic ecosystems is associated with an increase of suspended solids and siltation in local surface waters resulting from runoff of eroded soil.

Turbid water, besides being aesthetically displeasing, will often be avoided by fish, although fingerlings and adults often are quite resistant to high concentrations of suspended solids for short periods. These effects would be mitigated by use of settling ponds and other measures described in Section V.A.3.

The Savannah River Plant (SRP) site has been designated as an Environmental Research Park. Local animal and plant communities are continuously studied by the Savannah River Ecology Laboratory (SREL) of the University of Georgia. Since the land disturbed by the waste management facilities would be less than one-tenth of one percent of the total SRP site acreage, the quality and continuity of the SREL program would be unaffected.

3. Impact on Air and Water Quality

The air pollution potential during construction would be significant only in the immediate vicinity of the construction activity, where disturbed surface soil would be sprayed to reduce dust to an acceptable level. Construction debris and other solid waste would be burned under carefully chosen weather conditions and would comply with the applicable State of South Carolina regulations. Because the distance to the nearest community is about 12 miles, the air quality at that point would remain almost unaffected.

Sanitary sewage would be treated according to applicable National Pollutant Discharge Elimination System (NPDES) permits. *For facilities at the SRP site, a new sewage treatment plant* would be built and spray irrigation would be used for the discharges, so that there would be no effluent water entering the streams.

Water use during construction would be from wells in the Tuscaloosa aquifer at a rate of a few hundred thousand gallons per day. Total withdrawal of water from the Tuscaloosa formation at SRP at an average rate of over six million gallons per day has had no discernible effect on water levels in the past 22 years. Use of well water or surface water for construction of offsite facilities, if an alternative plan incorporating offsite construction is chosen, would be covered in an environmental assessment for that site. Excavations for foundations of major structures often require extensive dewatering, in which ground water entering the excavation is pumped out to the surface water. Depending on the local ground water recharge, this dewatering may temporarily lower the water table in the vicinity, or it may affect flow gradients in the ground water in other ways and thus affect the quality of ground water. For facilities to be constructed on the SRP site, such effects would occur only in the immediate area and would not influence the offsite ground water because SRP wells would be in the large Tuscaloosa aquifer. Careful attention will be given to the condition of the water to be disposed of during the dewatering process. For example, settling ponds are frequently used for this purpose.

For all the land used in any of the waste management alternatives, erosion of exposed areas with the potential for siltation of adjacent aquatic systems will be minimized by adherence to Federal guides given in Reference 3 which suggest: 1) limiting vegetation removal to a minimum, especially along stream banks; 2) selecting proper sites for excavation-soil stockpiles; 3) limiting the steepness of inclines; 4) minimizing traffic on the construction site, particularly during wet periods; 5) early stabilizing and replanting of exposed soils; and 6) providing runoff channels and settling areas to collect and settle surface water runoff before releases to bodies of natural surface water.

Special precautions, such as building settling basins, would be taken for SRP construction areas that drain to Upper Three Runs Creek so that the quality and continuity of research conducted at the Savannah River Thermal Effects Laboratory, located downstream, would not be affected significantly.

4. Other Potential Impacts

The major construction projects under any of the alternatives would be processing and surface storage facilities at the SRP site, if an alternative including those operations is chosen. A much larger construction effort involving about 50,000 workers was involved in the early 1950s when the existing SRP facilities were built. Also a construction work force of 1000-3000 has been maintained at SRP almost continuously since plant startup. (It is currently about 1500.) A temporary peak construction force of about 5000 people for the waste facilities (less than 10% of the 1950s force) would need to be accommodated by local services representing a population base of about 300,000 (over three times as large as the early 1950s). Because of the small relative size of the construction force, it is anticipated that this accommodation could be made without disruptive social influences on the surrounding communities.

Construction of the major facilities will cause a significant increase in truck traffic around the plant site. Traffic control measures would be implemented, as required, to control truck traffic and ensure safe operations in the vicinity of communities, intersections in rural areas, and school bus pickup points. Construction workers will also increase the traffic in the area. Special efforts would be made to prevent an increased number of accidents during the period of peak construction.

Noise levels during construction of a surface facility will be of the same magnitude as those for any similar construction project, but the large distance from the construction area to the site boundary would reduce the offsite noise to an unnoticeable level. Construction areas would be monitored for compliance with all applicable regulations regarding occupational noise levels, and protective equipment would be used by workers as required.

The alternatives that involve major construction at SRP would require sewage treatment to serve as many as 5000 temporary construction workers. This function would be carried out using new and existing septic tanks and drain fields, sewage lagoons, and existing sewage treatment plants onsite. A new sewage treatment plant would also be built to serve the operating needs of a processing facility.

A positive benefit to the surrounding communities would result from extra revenues that would accompany the construction projects. Such revenues would be in the form of increased sales taxes and income taxes, if applicable, and purchase of materials and services from local vendors.

B. POTENTIAL EFFECTS FROM NORMAL OPERATIONS FOR EACH ALTERNATIVE

1. Occupational Radiation Exposures

The operations necessary to implement any of the alternative waste management plans will result in small amounts of radiation exposure to the operating personnel. The maximum exposures allowed by DOE radiation protection standards are 5 rems to the whole body each year and/or 3 rems each calendar quarter.[4] Extensive efforts are made to reduce worker exposure to amounts that are as low as reasonably achievable (ALARA) under these limits. These efforts include detailed planning of all work which involves radiation exposure potential to reduce exposure time, to provide adequate shielding, and to preclude radionuclide uptake. Such work is carried out under written procedures that are approved by health physics specialists. These procedures specify the time limits for the work and the protective clothing and equipment required. Depending on the radiation and contamination potential, the work may be continuously monitored by health physicists.

Experience with operation of the Savannah River Plant indicates that actual personnel exposures can be expected to be considerably less than the DOE standards as a result of the ALARA policy. A summary of SRP occupational doses for the period 1965 through 1975 is shown in Table V-1. The annual average dose per monitored employee ranged from 0.22 to 0.59 rem for the period. The maximum individual dose ranged from 2.7 to 3.7 rem, with the exception of a single apparent dose of 24.8 rem to an employee in 1971. This dose was not substantiated in followup investigations.

Work done in the irradiated fuel reprocessing areas at SRP is similar in many important aspects to work that would be done in conjunction with alternatives involving waste solidification. Table V-1A gives exposure experience for workers involved in the SRP reprocessing activities, excluding those whose jobs involve no potential occupational exposure. There is little difference in the exposure received by the average plant employee monitored and those involved specifically with processing operations. The radiation exposures of workers in new waste management facilities would be expected to be even lower than workers in present SRP processing buildings because of greater shielding and improved equipment for handling radioactive material which could be installed in new facilities.

Tables V-2 and V-3 give results of estimating the occupational exposures for each alternative by two different techniques: for Table V-2, individual doses were assumed to be the same as that for the average SRP experience for 1965-1975; and for Table V-3, individual doses were assumed to be equal to the DOE standards

TABLE V-1

SRP Whole Body Occupational Exposure Experience

Year	*Number of Employees Monitored*	*Total Exposure, rem*	*Average Exposure per Monitored Employee, rem*	*Maximum Individual Exposure, rem*
1965	4977	2340	0.47	2.9
1966	5032	2074	0.41	3.4
1967	5041	2604	0.52	3.0
1968	4875	2412	0.49	3.3
1969	4705	2758	0.59	3.2
1970	4626	2353	0.51	3.7
1971	4836	2401	0.50	3.3 (24.8)[a]
1972	5210	1711	0.33	3.4
1973	5005	1488	0.30	2.7
1974	5138	1367	0.27	3.1
1975	5263	1161	0.22	2.7
		Average over Period	0.42	

a. Higher value indicated by initial monitoring but not substantiated by subsequent investigation.

TABLE V-1A

SRP Reprocessing Area Whole Body Occupational Exposure Experience

Year	*Number of Employees Monitored*	*Total Exposure, rem*	*Average Exposure per Monitored Employee, rem*	*Maximum Individual Exposure, rem*
1965	1501	916	0.61	2.8
1966	1497	928	0.62	3.1
1967	1489	980	0.66	3.0
1968	1454	829	0.57	2.9
1969	1441	994	0.69	2.9
1970	1378	868	0.63	2.6
1971	1567	815	0.52	2.8
1972	1756	685	0.39	2.9
1973	1613	742	0.46	2.7
1974	1674	720	0.43	2.9
1975	1781	570	0.32	2.7
		Average over period	0.54	

TABLE V-2

Occupational Radiation Exposures Based on SRP Experience

	Operational Modules, rem/year in maximum year					
Alternative	*Removal from Tanks*	*Processing*	*Transportation*	*Storage*	*Total per Maximum Year, rem*	*Total for Campaign, rem*[a]
Alternative 1 - Continue storage in tanks	5.0[b]	Not applicable	Not applicable	7.6	1.26×10^{1}	3.56×10^{2}
Alternative 2, Subcase 1 - Process to glass; ship to offsite geologic disposal[c]	4.2	2.31×10^{2}	1.40×10^{2}	0	3.75×10^{2}	3.75×10^{3}
Alternative 2, Subcase 2 - Process to glass; surface storage at SRP[c]	4.2	2.31×10^{2}	Not applicable	6.7	2.42×10^{2}	2.64×10^{3}
Alternative 2, Subcase 3 - Process to glass; disposal in SRP bedrock cavern[c]	4.2	2.31×10^{2}	Not applicable	0	2.35×10^{2}	2.35×10^{3}
Alternative 3 - Slurry liquid waste into SRP bedrock cavern	4.2	Not applicable	Not applicable	0	4.2	4.2×10^{1}

a. See Tavle V-4 and text for campaign times.

b. This exposure occurs only when waste is reconstituted and transferred from an old tank to a new tank and during tank decontamination.

c. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

TABLE V-3

Occupational Radiation Exposures Based on DOE Standards

Alternative	*Operational Modules, rem/year*				*Total per Year, rem*	*Total for Campaign, rem*[a]
	Removal from Tanks	*Processing*	*Transportation*	*Storage*		
Alternative 1 - Continue storage in tanks	5.95×10^1[b]	Not applicable	Not applicable	9.04×10^1	1.50×10^2	4.24×10^3
Alternative 2, Subcase 1 - Process to glass; ship to offsite geologic disposal[c]	5.00×10^1	2.75×10^3	1.40×10^2	0	2.94×10^3	2.94×10^4
Alternative 2, Subcase 2 - Process to glass; surface storage at SRP[c]	5.00×10^1	2.75×10^3	Not applicable	7.97×10^1	2.88×10^3	3.14×10^4
Alternative 2, Subcase 3 - Process to glass; disposal in SRP bedrock cavern[c]	5.00×10^1	2.75×10^3	Not applicable	0	2.80×10^3	2.80×10^4
Alternative 3 - Slurry liquid waste into SRP bedrock cavern	5.00×10^1	Not applicable	Not applicable	0	5.00×10^1	5.00×10^2

a. See Table V-4 and text for campaign times.

b. This exposure occurs only when waste is reconstituted and transferred from an old tank to a new tank and during tank decontamination.

c. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

discussed above. The latter is a very conservative assumption because, even if the potential for such exposures existed, it would be impractical and undesirable to rotate and schedule all employees so that everyone received exposure up to the DOE limit. Other assumptions used to prepare Tables V-2 and V-3 are:

- The manpower requirements and time involved for each operation were estimated as shown in Table V-4. Most of the manpower estimates are based on experience with similar operations at SRP. It was assumed that surveillance and monitoring of a continued tank farm or an air-cooled surface vault would be done 24 hours per day. In contrast, a cavern disposal site would have less intense surveillance and would be monitored 24 hours per day by only one full-time person.

- Exposures to drivers and service personnel during offsite transportation are the same as those used in Reference 4 for 3000-mile truck shipments. Exposures reflect the limits specified in Nuclear Regulatory Commission regulations No. 10 CFR 71 (Reference 5) and No. 49 CFR 170-9 (Reference 6).

- For the alternative of continued tank farm operation, it was assumed that each tank would be replaced every 50 years. Radiation exposure would not be received from construction of a new tank, but would be received from the transfer operation between the old and the new tank and from decontamination of the old tank. Each of these operations is estimated to require six employees (including supervision) for six months. Assumed individual exposures were reduced each year to reflect the 30-year half-life of ^{90}Sr and ^{137}Cs, as discussed below.

- A time period of 300 years was used to estimate total exposures received from surveillance and monitoring. Assumed individual exposures were reduced each year to reflect the 30-year half-life of ^{90}Sr and ^{137}Cs, the primary contributors to penetrating radiation that would result in exposure from surveillance and monitoring. After a period of 300 years, individual exposures from these operations would be negligible fractions of natural background and are thus unimportant in the consideration of environmental impact.

- Surveillance and monitoring of a sealed geologic repository, either offsite or in SRP bedrock, would probably be done with a small observation force plus one person collecting and analyzing samples of water from several monitoring wells. These operations were all assumed to result in no exposure above background to the persons involved.

TABLE V-4

Manpower and Time Requirements for Operational Modules

Operation	*No. of Employees*[a]	*Time Required*
Tank farm surveillance and monitoring	21	300 years[b]
Reconstitute, transfer from old to new tank	20	6 months[c]
Decontaminate old tank	31	6 months[c]
Remove 60 million gallons from present tanks, transfer to new processing building	10	10 years
Process 60 million gallons to glass, 10-year time[e]	550	10 years
Transport glass offsite[e]	1100[d]	10 years
Air-cooled vault surveillance and monitoring	21	300 years[b]
Offsite salt cavern or SRP bedrock surveillance and monitoring	5	300 years

a. Include direct supervision but not indirect overhead.

b. Occupational exposures would be negligible after this time. See text.

c. These operations were assumed to be required once every 50 years for each tank for 300 years. See text.

d. This case represents truck shipment of the glass form over a distance of 3000 miles from SRP. Other cases are detailed in Reference 4.

e. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

- The manpower requirements and exposures for reconstituting the waste to a slurry and transferring it to a bedrock cavern at SRP would be the same as those for reconstituting the waste and transferring it to a glass processing building.

2. Non-Nuclear Occupational Risks

Each of the alternative plans carries some non-nuclear risk of minor injuries, major injuries, and death during construction of new facilities and during the operating campaign. (For minor injuries, only first aid is required and no days are lost from work; major injuries involve one or more lost workdays.) Experience with many construction activities at SRP and from 26 years of operations has shown that these risks can be low in magnitude and below those experienced in many other industrial activities. There is no reason to expect such risks associated with any alternative plan to be significantly different. Tables V-5 and V-6 give the results of estimating the number of occupational injuries during construction of new facilities and for the operating phases, respectively. The following assumptions were used to generate data for the tables:

- Construction of a new set of 24 tanks is required every 50 years during the 300-year campaign.

- Manpower and time requirements for construction of new facilities are estimated in Table V-7. For most facilities, the requirements were taken from venture guidance estimates for the actual facilities.[7] For construction of a bedrock cavern at SRP and for an offsite cavern in bedded salt, capital costs from the SRP Defense Waste Document[8] were used with estimates of the split between labor and materials to calculate labor requirements.

- Rates of occurrence of minor injuries, major injuries, and deaths are given in Tables V-7 and V-8 for construction and for routine operations, respectively.[9,10]

3. Offsite Radiation Exposures

All facilities in any of the waste management alternatives will be designed and operated such that radioactive releases from normal operations will be within nationally accepted standards for such releases. The current DOE standards for offsite radiation exposures are shown in Table V-9.[4]

TABLE V-5

Non-Nuclear Occupational Injuries During Construction of New Facilities[a]

Alternative	*Construction of Processing Facilities*	*Fabrication of Transportation Casks and Vehicles*	*Construction of Storage Facilities*	*Total for Campaign*
Alternative 1 -				
Continue storage in tanks	Not applicable	Not applicable	1600[b] 17	1600 17
Alternative 2, Subcase 1 -				
Process to glass; ship to offsite geologic disposal[c]	460 5	39 0.5	28 0.4	530 5.9
Alternative 2, Subcase 2 -				
Process to glass; surface storage at SRP[c]	460 5	Not applicable	130 1.4	590 6.4
Alternative 2, Subcase 3 -				
Process to glass; disposal in SRP bedrock cavern[c]	460 5	Not applicable	88 1.1	550 6.1
Alternative 3 -				
Slurry liquid waste into SRP bedrock cavern	Not applicable	Not applicable	180 2.2	180 2.2

a. Two annual numbers are given in each column for each alternative: top numbers are major injuries; bottom numbers are deaths.

b. These include construction of new tanks every 50 years during the 300-year period.

c. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

TABLE V-6

Non-Nuclear Occupational Injuries During the Operating Campaign[a]

Alternative	*Operational Modules* Removal from Tanks	Processing	Transportation	Storage	Total per Year	Total for Campaign[b]
Alternative 1 -						
Continue storage in tanks	5.5[c] 0.0047 0.00059	Not applicable	Not applicable	3.0 0.0027 0.00034	8.6 0.0074 0.00093	1160 1.03 0.13
Alternative 2, Subcase 1 -						
Process to glass; ship to offsite geologic disposal[e]	1.5 0.0013 0.00016	80.5 0.078 0.0089	*d* 1.6 0.052	0.58 0.00051 0.00006	83 1.7 0.061	990 16 0.63
Alternative 2, Subcase 2 -						
Process to glass; surface storage at SRP[e]	1.5 0.0013 0.00016	80.5 0.078 0.0089	Not applicable	2.3 0.0021 0.00026	84 0.081 0.0093	1500 1.3 0.17
Alternative 2, Subcase 3 -						
Process to glass; disposal in SRP bedrock cavern[e]	1.5 0.0013 0.00016	80.5 0.078 0.0089	Not applicable	0.58 0.00051 0.00006	83 0.080 0.0091	990 0.87 0.11
Alternative 3 -						
Slurry liquid waste into SRP bedrock cavern	1.5 0.0013 0.00016	Not applicable	Not applicable	0.58 0.00051 0.00006	2.1 0.0018 0.00022	190 0.16 0.021

a. Three annual numbers are given in each column for each alternative: top numbers are minor injuries; middle numbers are major injuries; bottom numbers are deaths.

b. See Table V-4 and text for campaign times.

c. These include reconstituting waste and transferring to new tanks every 50 years and decontamination of old tanks.

d. Transportation accident data were taken from Reference 8.

e. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

TABLE V-7

Injury Rates During Construction of New Facilities[9]

	Occurrences per Million Man-Hours	
	Major Injuries	*Deaths*
Mining Caverns	25	0.31
Casks and Vehicles	26	0.32
All Other Construction	16	0.17

Construction Time and Manpower Estimates

Construction Operation	*Man-Hours Required (millions)*	
Processing Facilities	29	
Transportation Casks and Vehicles	1.5	
Set of 24 New Tanks	17	One set every 50 years for 300 years
Air-Cooled Surface Storage Vault	8.1	
Mining Bedrock Cavern (Liquid)	7.2	
Mining Bedrock Cavern (Glass)	3.5	
Mining Offsite Salt Cavern	1.1	

TABLE V-8

Injury Rates During Routine Operations[a]

Occurrences per Million Man-Hours		
Minor Injuries	*Major Injuries*	*Deaths*
50	0.044	0.0055

a. Based on SRP operating experience over the ten-year period 1967-1976.[9]

TABLE V-9

DOE Radiation Exposure Limits to Offsite Individuals, mrem

Type of Exposure	*Maximum Individual Exposure*[a]	*Exposure to Average Individual*
Whole Body	500	170
Gonads	500	170
Bone Marrow	500	170
G. I. Tract	1500	500
Bone	1500	500
Thyroid	1500	500
Other Organs	1500	500

a. These individuals are assumed to be at the site boundary under conditions of maximum probable exposure.

The facilities must be operated to fall within the limits discussed above; they will also be operated so that exposures are kept as low as reasonably achievable. In all likelihood, this will result in extremely low, if not zero, exposures from the long-term storage or disposal facilities, with offsite exposures from the handling and processing operations that are comparable to those currently experienced from similar activities at SRP. In 1976, these exposures to a hypothetical individual receiving the maximum dose* were below 1 mrem from all SRP activities. These SRP exposures included contributions from the reactors and from isotopes such as ^{3}H, ^{85}Kr, ^{41}Ar, and $^{133,135}Xe$ that would not be released in significant quantities in the waste handling and processing operations. Routine exposures from SRP are discussed more fully in Reference 11.

Routine releases of radioactivity for an offsite geologic repository in salt have been analyzed by the Battelle Pacific Northwest Laboratories as part of their studies of geologic caverns for commercially generated waste.[1] They consist of only a few hundredths of a curie per year of ^{220}Rn and ^{222}Rn, which would be released as decay products from naturally occurring radium in the salt that must be mined during the years of emplacement. The radiation exposure that could result from this radon release is negligible to offsite individuals.

Emission Control Features of an Offsite Geologic Repository in Salt

All structures are maintained at a negative pressure relative to the atmosphere, and all entries into and from confinement areas are made through air locks. Contamination is controlled by directing air flow from areas of least contamination potential to areas of increasing contamination potential. Air discharged from confinement areas is exhausted through a prefilter and two high-efficiency particulate air (HEPA) filters. Ventilation systems are backed up by standby facilities to maintain confinement in the event of fan breakdown, filter failure, or normal power outage. Automatic monitoring of all potential sources of contaminated effluents is provided with remote readout and alarm at both the central control room in the mine operations building and the guardhouse.

All wastes arriving at the repository are fully contained in stainless steel canisters or steel drums. As a result, the only sources for airborne emissions from these waste containers are handling accidents that could damage and breach the canisters. Potential accidents are described in Section V.C.

* These individuals are assumed to be at the site boundary under conditions of maximum probable exposure.

Liquid wastes generated as a result of decontamination operations are processed onsite. Liquid radioactive waste systems include surge tanks, a waste evaporator, and a liquid waste solidification system. After evaporation and solidification, the wastes are transferred to below ground areas for disposal.

Solid wastes are processed through one of two onsite waste balers where they are sealed into drums. These wastes are then transferred to the mine for disposal.

Sanitary waste (nonradioactive) is collected in a sewer system which is connected to the local sewer trunk, if available, or given secondary treatment onsite and then disposed of in accordance with local and Federal regulations.

4. Nonradioactive Pollutants

No mechanisms have been identified for chemical releases under normal conditions for the storage or disposal modes; therefore, the following discussion is concentrated on processing operations.

If the waste is fixed in glass or other immobilization forms requiring high temperature processing, there will be releases from the processing operations to the atmosphere and to the onsite streams of chemicals such as Hg, NO_x, NH_3, CO_2, NaOH, $NaNO_3$, and heated water. These releases, when combined with those from other activities at SRP, must be within emission standards set by the states of South Carolina and Georgia and the Federal Government.[12,13] Some of the more important of these standards are shown in Table V-10. In addition to the limits imposed by the above standards, SRP operates under National Pollutant Discharge Elimination System (NPDES) permits that limit the discharge of pollutants to tributaries of the Savannah River.[14]

Waste management policy at SRP is to limit releases of potentially polluting chemicals to levels that are lower than those required by the standards and permits, to the extent that is reasonably achievable. This policy is implemented by operating controls and by engineering systems such as liquid-gas absorbers, catalytic converters, "cold-caps," wet scrubbers, absorbers, quench towers, sintered metal filters, iron-oxide mesh filters, venturi scrubbers, cyclone separators, condenser-absorber combinations, and HEPA filters. The extent to which these systems are needed and the releases to the environment that are to be expected

TABLE V-10

Typical State and Federal Air and Water Quality Standards[a,12,13]

Pollutant	*Limiting Concentration*	*Comment*
SO_2	80 $\mu g/m^3$	Ambient air, South Carolina
SO_2	43 $\mu g/m^3$	Ambient air, Georgia
SO_2	1300 $\mu g/m^3$	One-hour, air, South Carolina
SO_2	715 $\mu g/m^3$	One-hour, air, Georgia
SO_2	3.5 $lb/10^6$ Btu	Air emission, South Carolina
Particulates (Fly Ash)	0.6 $lb/10^6$ Btu	Air emission, South Carolina
NO_x	100 $\mu g/m^3$	Ambient air, South Carolina and Georgia
H_2S	10 ppm, 8 hr	Air, detectable effects
Non-Methane Hydrocarbons	130 $\mu g/m^3$	Three-hour, air, South Carolina
Sulfate	250 ppm	Drinking water standard, Federal
Chloride	250 ppm	Drinking water standard, Federal
Nitrate	10 ppm	Drinking water standard, Federal
Barium	1 ppm	Drinking water standard, Federal
Iron	0.3 ppm	Drinking water standard, Federal
Boron	1 ppm	Drinking water standard, Federal
Zinc	5 ppm	Drinking water standard, Federal
Chromium	0.05 ppm	Drinking water standard, Federal
Manganese	0.05 ppm	Drinking water standard, Federal
Arsenic	0.05 ppm	Drinking water standard, Federal
Mercury	0.002 ppm	Drinking water standard, Federal
Copper	1 ppm	Drinking water standard, Federal
Phenol	0.001 ppm	Drinking water standard, Federal

a. The above listing is not meant to imply that all the chemicals would be released from the waste management facilities.

will be determined as the research and development program proceeds and detailed design studies are made. Operation of similar processes and pollution-abatement devices at SRP is described in detail in Reference 11, where it is shown that SRP emissions to the atmosphere have been far below the standards shown in Table V-10, with the exception of particulates from some of the coal-burning power plants. Electrostatic precipitators have been installed on the largest power plants, and prototype improvements are being tested on other plants to ensure conformance with South Carolina emission standards for particulates.

Water that discharges from the SRP creeks to the Savannah River now meets Federal and State of South Carolina regulations. Currently the water discharged to the onsite creeks does not always meet these regulations. However, a project is under way with an expected April 1981 completion that would bring most discharges from individual operating sites into compliance with NPDES Permit No. SC 0000175 before those discharges enter the creeks.[14] Most of the water covered in the project is runoff from coal piles and ash basins, and is of low pH with high suspended solids.

In addition to the emissions to water and air described above, there will be low levels of occupational exposure to nonradioactive pollutants of some workers. Such exposures would occur during processing operations, but not during transportation, storage, or disposal. Reference 14 specifies limits and controls required for exposure to chemicals as legislated by the Occupational Health and Safety Act. Concentrations in air of chemicals to which the worker is exposed will normally be maintained by engineering controls such as ventilation at less than the action level values specified in Subpart Z of Reference 15. Potential exposure of the worker is limited because the chemicals are normally introduced into the process within ventilated enclosures designed to contain radioactivity. Exposures may occur in storage areas, during transport of chemicals from the storage areas, and during preparation of the chemicals for the processes. When concentrations are above an action level, routine monitoring is required rather than audit monitoring. When threshold limit values are exceeded, workers will wear personal protective equipment including respiratory protection as prescribed in Subpart I of Reference 15. Engineering controls would be added or modified to reduce transient high concentrations to less than threshold limit values. Records are required for each worker exposed to chemicals at concentrations greater than threshold limit values.

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* Project 78-SR-023 ($9.2 million).

5. Thermal Discharges

The amount of heat generated in any of the waste management operations is probably less than 10% of that from current SRP heat sources, such as nuclear reactors and coal-burning power plants. The total impact of SRP heat sources is within NPDES and State of South Carolina standards for the Savannah River (Table V-11). The following are sources of thermal discharges that would occur in the three alternative plans:

- Reconstituting the waste to liquid and evaporating it back to damp salt cake and sludge, as in transferring the waste from old tanks to new tanks if tank farm operation is continued.
- Processing reconstituted waste to an immobilization form.
- Storage of canned waste in an air-cooled surface vault.
- Additional power generation.
- Decay heat from disposal of waste in a geologic repository.

With regard to heated water discharges, most states are promulgating thermal standards under the state participatory provisions of the EPA's National Pollutant Discharge Elimination System (NPDES). These standards, which are subject to approval by the EPA, are used in writing NPDES discharge permits. A plant operator must obtain the required NPDES discharge permit from a state agency, or from the EPA if the operation is to be conducted by a Federal agency. The South Carolina standards that pertain to SRP operations and are part of the NPDES are as follows:

- The water temperature shall not exceed 90°F (32.2°C) as a result of heated liquids at any time after adequate mixing of heated and normal waters.
- After the water passes through an adequate zone for mixing, the temperature shall not be more than 5°F (2.8°C) greater than that of water unaffected by the heated discharge.
- The mixing zone shall be limited to not more than 25% of the cross-sectional area and/or volume of the flow of the stream and shall not include more than one-third of the surface area measured shore to shore.

As shown in Table V-11 and discussed more fully in Reference 10, current SRP operations satisfy all three of the water quality standards on temperature in the Savannah River. Present temperature increases in the river are almost completely due to operation of the production reactors, and any future waste management operations would cause an insignificant perturbation compared to this source. The largest potential warm water releases would be from the evaporators used in a continued tank farm operation or in processing the waste, but the condensate from these evaporators will be reused for slurrying other tanks, etc., rather than being released to the river.

As a further consideration regarding warm water releases to the river, the Limnology Department of the Academy of Natural Sciences of Philadelphia has carried on a continuing program of scientific investigation in the Savannah River, beginning with a baseline study in 1951. The baseline study considered all the major groups of aquatic organisms — the protozoa, lower invertebrates, insects, fish, and algae — together with the general and physical characteristics of the river. Since the baseline study, the program has consisted of spot checks four times yearly, detailed studies at 3- to 5-year intervals, and continuous diatometer studies. The 1951 to 1970 summary report of these studies[16] concludes that "there was no evidence in any of the areas studied of the effects of increases in temperature in the river caused by activities of the Savannah River Plant."

With regard to heated air discharges, the canned waste stored in an air-cooled vault would be cooled by natural convection and would generate about 2 megawatts of heat. This is a very small amount of heat dissipation compared to that of other facilities, such as the coal-burning power plants, which have been observed to cause no detectable environmental or noxious effects from heat.

TABLE V-11

Compliance by SRP with S. C. Standards for Temperature in the Savannah River

Criterion	*Standard*	*Maximum SRP Value*
Maximum temperature below SRP after mixing	32.2°C (90°F)	29.4°C[a]
Maximum temperature increase	2.8°C (5°F)	3.7°C[b]
Maximum mixing zone (% of cross-sectional area)	25%	<20%
% of surface area	33-1/3%	<25%

a. Maximum recorded below SRP.

b. Measured during May 1977 (one-time occurrence). Otherwise, the maximum increase has been 1.4°C, calculated using classified information for two reactors discharging to the river at minimum river flow.

C. POTENTIAL EFFECTS FROM ABNORMAL EVENTS FOR EACH ALTERNATIVE

Details of consequences and probabilities for a wide range of abnormal events will be published in Safety Analysis Reports dealing with all aspects of the waste management system that is finally selected. Such analyses must await detailed system designs based on results of the research and development program and the final alternative chosen for implementation. One of the primary purposes of the research and development program is to develop the design of the various parts of each alternative to ensure a high degree of confidence in acceptable safety regarding abnormal events, no matter which alternative is chosen.

Preliminary analyses have been reported in Reference 8 for risks from unusual events that might occur in all operations involved in any of the alternative plans. Events considered were major process incidents, natural events such as tornadoes and earthquakes, sabotage, airplane crash, and abandonment. When lack of detailed system design precluded the usual fault tree/event tree type of analysis, magnitudes of possible events were chosen using the judgment of technical persons familiar with 25 years of operations of similar facilities. The magnitudes were chosen to be upper bounds of credible occurrences. This approach provides a sound physical basis to obtain release fractions, to follow environmental pathways, and to calculate radiation exposures. Many of the probabilities used have a sound basis from either similar operating experience, analysis, or observation of natural events. However, some of the probabilities are only rough estimates, particularly those for sabotage or abandonment. The section on sensitivity analysis discusses the effects on overall risk that would result by varying the uncertain probabilities over wide ranges. Magnitudes of consequences for each event are also available in Reference 8 and can be used in combination with individual decision-maker's probabilities to calculate the resulting risks from these events, if desired. Detailed results from Reference 4 are reviewed in the discussion below. In general, they show that consequences alone, without regard for probabilities, do not pose any disaster potential for the offsite population because individual doses that could occur are comparable to background doses in most cases. When formal analyses are made of systems in a specific alternative, the results will probably show much lower risks than the generic studies.

Pathways from the waste to man that were considered are ingestion of airborne particles, land contamination from fallout of airborne particles, drinking water from the Savannah River, fish consumption from the Savannah River, and possible future use of local sections of the Tuscaloosa aquifer for drinking water. These pathways are discussed in detail in the DWD (Reference 8) and its references at the point that each event involving a specific pathway is covered. The pathways all represent pessimistic assumptions about meteorological conditions and water use, with no warnings or corrective actions. This method of considering pathways, along with the upper limit bounding of possible radioactive releases discussed above, should ensure that upper bounds of consequences from the important events have been covered.

Some of the important physical reasons why the hazards associated with the waste are limited include:

- Very large amounts of energy are required to create waste particles small enough to be widely distributed through the airborne pathway. This is true on a per curie basis for the salt cake and sludge currently stored in tanks as well as for the high-integrity forms like glass.

- There are no internal sources of high energy as part of normal operations in the waste management systems. Energy required to release radioactive particles would have to be introduced externally or in some abnormal manner.

- There are no radioactive noble gases or significant amounts of easily volatilized radioactive elements in the waste that could contribute to potential doses from the airborne pathway.

- High-integrity waste forms and the engineered surface or geologic storage facilities proposed for long-term waste storage can impose major barriers against waste migration.

- Liquid releases from SRP would be absorbed in the soil or diluted many orders of magnitude by the onsite creeks and swamps and by the Savannah River before reaching drinking water users. Even if diversion systems fail and no corrective actions are taken, no large individual doses can occur. None of the alternatives propose handling liquid wastes at any site other than the SRP site.

- The SRP waste facilities are within a large exclusion area.

An added level of accident protection to both workers and offsite population is provided by the design of waste management facilities. The construction methods and materials that meet routine radiation shielding requirements and that ensure adequate resistance to earthquakes and tornadoes also provide resistance and containment for other unlikely incidents.

1. Occupational Radiation Exposures

All the very low probability events that have some potential for releasing radioactive materials offsite also have the potential for exposing working personnel to high radiation levels. These events include major process incidents, tornadoes and earthquakes of incredible magnitude, sabotage, and airplane crashes. The distribution of radiation effects among the personnel at the site is impossible to predict because it would depend on precise details of location of the personnel and corrective actions relative to the chain of events underway. This is in contrast to the predictability of offsite effects (discussed in Sections V.C.3. and V.C.4. below), where the major determinants are amount of activity released and meteorology or water flow patterns. However, the radiation would probably be a small contributor to the worker injuries in these unlikely events; most of the injuries would be from explosive forces, falling buildings, tornado-driven missiles, fire, saboteur gunfire, etc.

Even though consequences mentioned above are possible, their occurrence is extremely unlikely. This fact is generally illustrated by formal safety analyses of existing and designed nuclear systems, and by the experience of the commercial and defense nuclear enterprises over the past thirty years. When this low probability of occurrence is considered, the resulting occupational risk (the product of consequence times probability) from radiation exposure is negligible for any alternative plan.

2. Non-Nuclear Occupational Risks

The non-nuclear risks to onsite workers from abnormal events are in the same category as the risks discussed above for radiation exposures, in the sense that injuries are possible but the likelihood of occurrence is so small that the risks are negligible. The number of injuries possible for each abnormal event is difficult or impossible to estimate because of the mitigating effects of forewarning, corrective action, etc. However, there has been no mechanism identified with the radioactive nature of the waste management alternatives that would increase the non-nuclear risks above those normally experienced in any large industrial operation. In practive, the unusually heavy construction of the waste management facilities would probably provide greater worker protection against abnormal events than that afforded by most other industrial facilities.

3. Offsite Radiation Exposures

Analyses have previously been reported[8] which estimate, using pessimistic values where assumptions are necessary, the offsite radiation exposures that might occur for a variety of abnormal events. The events considered were major process incidents; natural occurrence such as tornadoes, earthquakes, floods, and meteorite impact; sabotage; airplane crash; and abandonment. The analyses were performed for each of the three major alternatives, and within each alternative the analyses considered the four major modules: removal from tanks, processing, transportation, and storage. The results are given as consequences (measured by radiation dose commitment) to offsite individuals receiving the maximum dose and to the offsite population within 150 km. The consequences were then multiplied by an estimate of annual probability of occurrence to obtain annual risk. Finally, the annual risk was integrated over time, accounting for radioactive decay and population growth, to obtain total risk for the period. The detailed integrations are given in the Tables for a period of 300 years, the period of maximum risk before the ^{137}Cs and ^{99}Sr have decayed. (After 300 years of decay, individual doses that could occur from any of the events analyzed are negligible.) Population exposures integration to 10,000 years are also included and show the small additional impact of the long-lived isotopes. These data are given in Tables V-12 through V-16 for Alternatives 1-3. They show that there is no disaster potential to the offsite population from abnormal events for any of the alternatives. Although some of the maximum individual doses are of concern, they could occur to only a limited number of people and are calculated assuming no corrective actions are taken. Doses to average individuals in the nearby population would be thousands to tens of thousands of times lower, depending upon pathways, and therefore would be inconsequential compared to even the variation in natural background in the local area.

Regarding the vulnerability to sabotage or terrorism, there is no firm basis for estimating the probability of sabotage of waste processing or disposal facilities, and the probabilities used to complete the risk analysis are somewhat arbitrary. However, the consequences of credible sabotage events do have a sound physical basis. These consequences were found to be very small compared to levels that would possibly be attractive to terrorists, and indicate that the probability of sabotage being attempted is very low.

The exception to this situation is for liquid waste stored in a bedrock cavern. However, for this case, it is extremely unlikely that people would continue to drink well water from a location directly over a leak into the aquifer. Engineering design and safeguards aimed specifically at the problem of sabotage of the shaft or earthquake while filling would greatly reduce the risks below those pessimistically assumed for the analysis in this EIS. Examples of precautions that have been suggested in comment letters and elsewhere are: reinforced bulkheads sealed against backflow; small-diameter, double-walled piping; shock-proof mounting; and quick-acting shut-off valves at top and bottom. Furthermore, there are corrective actions that would be carried out if the shaft did fail because at the time the shaft would be open there would also be men, equipment, and technology readily available to either clear the shaft or re-seal it[8] (see Section XI).

Risks from storage or disposal in an offsite geologic repository are based on analyses prepared for the *EIS for Management of Commercially Generated Radioactive Waste*,[1] but modified to account for the differences in volume and radioactivity content between SRP waste and commercially generated waste. The base case of disposal in a geologic repository was chosen because more extensive research has been done on this disposal alternative than on others. The analyses in Reference 1 are based on the very conservative assumption of no radionuclide holdup by the geologic medium in the event of unforeseen release of radioactivity to the repository, and therefore the results are independent of whether the repository is located in salt, basalt, granite, or some other medium. Table V-17 gives the events that have been identified for abnormal releases, the estimated release of the major radioisotopes if SRP defense waste were in the repository, and the estimated frequency of occurrence of each event. When probability of occurrence is taken into account, the risk from all these events is negligible compared to the natural background exposure to the same individual. This is shown in Table V-17A, which is compiled from Reference 1 for commercial waste; the impacts from a repository containing defense waste would be even smaller. Other studies on the general subject of radiation risks from a geologic repository may be found in References 17 and 18. Environmental impact statements and safety analysis reports will be published for specific offsite repositories when decisions are made on their locations.

TABLE V-12

Summary of Exposure Risks for Alternative 1 - Storage of Waste as Sludge and Dump Salt Cake in Onsite Waste Tanks (Present SRP Waste Management Technique)

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks	Not applicable	Not applicable	Not applicable	Not applicable
Processing	Not applicable	Not applicable	Not applicable	Not applicable
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Routine Releases	Negligible	1.4	1.0	1.4
Spill during Transfer	2.2×10^{-2}	5.3×10^{2}	5.0×10^{-3}	2.6
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage by Dispersal	3.3	2.3×10^{4}	1.0×10^{-5}	2.3×10^{-1}
Sabotage by Explosion	4.1	9.8×10^{3}	1.0×10^{-5}	9.8×10^{-2}
Airplane Crash	4.1	1.1×10^{4}	1.0×10^{-5}	1.1×10^{-1}
Abandonment	3.9×10^{-1}	2.7×10^{4}	1.0×10^{-5}	2.7×10^{-1}

Time-Integrated Risk, 300 years, man-rem[a]	1.4×10^{3}
Time-Integrated Risk, 10,000 years, man-rem	2.3×10^{3}
Risk with Abandonment after 100 years[b]	2.4×10^{4}

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

b. Population risk integrated for 300 years, if tanks are assumed to be abandoned after 100 years, in accordance with proposed EPA criterion on duration of administrative control.

TABLE V-13

Summary of Exposure Risks for Alternative 2, Subcase 1 – Glass Stored in Offsite Geologic Storage

Event	*Maximum Individual Dose, rem*[a]	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing				
Routine Releases	2.2×10^{-5}	3.0	1.0	3.0
Process Incidents	$<1.0 \times 10^{-5}$	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	4.2×10^{1}	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation				
Routine Exposures	5.0×10^{-3}	6.3×10^{1}	1.0	6.3×10^{1}
Accidents	6.9×10^{-1}	1.2×10^{2}	1.3×10^{-4}	1.6×10^{-2}
Storage				
Expected Releases	Negligible	1.3×10^{2}	1.0	1.3×10^{2}

Time-Integrated Risk, 300 years man-rem[b] 6.5×10^{2}

Time-Integrated Risk, 10,000 years, man-rem 6.5×10^{2}

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a. Equivalent whole body dose, rem.

b. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-14

Summary of Exposure Risks for Alternative 2, Subcase 2 — Glass Stored in Onsite Surface Storage Facility

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing				
Routine Releases	2.2×10^{-5}	3.0	1.0	3.0
Process Incidents	$<1.0 \times 10^{-5}$	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	4.2×10^{1}	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Sabotage	1.9	3.8×10^{3}	1.0×10^{-5}	3.8×10^{-2}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Abandonment	Negligible	0	-	0
Time-Integrated Risk, 300 years man-rem[a]	2.2×10^{2}			
Time-Integrated Risk, 10,000 years, man-rem	3.4×10^{2}			

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-15

Summary of Exposure Risks for Alternative 2, Subcase 3 — Glass Stored in SRP Bedrock

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, /year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{-2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing.				
Routine Releases	2.2×10^{5}	3.0	1.0	3.0
Process Incidents	$<1.0 \times 10^{-5}$	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	4.2×10^{1}	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Expected Releases	Negligible	1.3×10^{2}	1.0	1.3×10^{2}
Time-Integrated Risk, 300 years man-rem[a]	3.4×10^{2}			
Time-Integrated Risk, 10,000 years, man-rem	3.4×10^{2}			

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-16

Summary of Exposure Risks for Alternative 3 — Unprocessed Waste Slurry Stored in SRP Bedrock

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing	Not applicable	Not applicable	Not applicable	Not applicable
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Expected Releases	Negligible	1.3×10^{2}	1.0	1.3×10^{2}
Earthquake with Shaft Open	7.6×10^{3}	3.8×10^{8}	3.3×10^{-5}	1.3×10^{4}
Earthquake after Sealing	$<1.7 \times 10^{2}$	8.3×10^{6}	3.3×10^{-6}	2.8×10^{1}
Sabotage before Sealing	3.0×10^{4}	1.5×10^{9}	1.0×10^{-5}	1.5×10^{4}
Sabotage after Sealing	2.8×10^{2}	1.4×10^{7}	3.3×10^{-10}	4.6×10^{-3}
Time-Integrated Risk, 300 years, man-rem[a]		6.2×10^{4}		
Time-Integrated Risk, 10,000 years, man-rem		1.4×10^{5}		

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-17

Moderate and Nondesign Basis Accidents Postulated for Repository in Salt

Accident Description	*Sequence of Events*	*Safety System*	*Release, Ci*	*Probability*
Canister drop in surface facility	Canister handling crane fails Canister breaches on impact	Positive latching grapple system and conservatively sized crane Building filter system	$3x10^{-4}$, ^{90}Sr; $3x10^{-4}$, ^{137}Cs; $1.5x10^{-6}$, ^{238}Pu; $6.0x10^{-8}$, ^{239}Pu; to building atmosphere	2×10^{-7}/yr
Canister drop down mine shaft	Canistered waste shaft hoist fails Canister breaches on impact	Failsafe wedge type braking system Mine exhaust filter system	$1.5x10^{4}$, ^{90}Sr; $1.5x10^{4}$, ^{137}Cs; $7.5x10^{1}$, ^{238}Pu; 2.9, ^{239}Pu; of small particles to mine atmosphere	1.3×10^{-8}/yr
Nuclear warfare	50-megaton nuclear weapon bursts on surface above repository Crater formed to 340 m with fracture zone to 500 m	Repository depth of 600 m	None	
Repository breach by meteor	Meteor with sufficient mass and velocity to form 2-km-dia crater impacts repository area 2-km-dia crater extends to waste horizon, dispersing 1% of waste to atmosphere	Repository depth of 600 m	$1.3x10^{6}$, ^{90}Sr; $1.3x10^{6}$, ^{137}Cs; $6x10^{3}$, ^{238}Pu; $2.4x10^{2}$, ^{239}Pu; half to stratosphere, half as local fallout	2×10^{-13}/yr
Repository breach by drilling	Societal changes lead to loss of repository records and location markers Drilling occurs 1000 yr after closure	Repository depth of 600 m Repository marked by monuments and records kept securely Site criteria - not desirable resources	$7x10^{-7}$, ^{90}Sr; $7x10^{-7}$, ^{137}Cs; $7x10^{-3}$, ^{238}Pu; 1.5, ^{239}Pu; distributed in drilling mud over 1.2 acres in the top 2 in. of soil	Not determined
Volcanism	Volcanic activity at repository carries wastes to surface	Site criteria - no history or potential for volcanic activity	Less than accident below	Not determined
Repository breach by faulting and groundwater transport	Fault intersects repository Access is created by pressure between aquifer, waste, and surface Aquifer carries waste to surface	Site criteria - low seismic risk zone Site criteria - minimal groundwater Repository depth of 600 m	$6x10^{-4}$, ^{90}Sr; $6x10^{-4}$, ^{137}Cs; 6, ^{238}Pu; $1.2x10^{3}$, ^{239}Pu; released to the groundwater 1000 yr after mine closure	2×10^{-13}/yr
Erosion	Repository overburden subject to high erosion	Site criteria - low erosion rates Repository depth of 600 m	Less than breach by a meteor	Not determined
Criticality	Criticality not feasible	—	—	—

TABLE V-17A

Possible Exposures and Risks from Geologic Repository

Accident Description	*Maximum Individual Exposure, rem (70-yr whole-body commitment)*	*Maximum Individual Risk, Probability Times Consequence, rem/year*
Canister drop down mine shaft	1.4×10^{-5}	1.8×10^{-13}
Repository breach by meteor	5.5×10^{6}	1.1×10^{-6}
Repository breach by faulting and flooding	7.4×10^{3}	3.0×10^{-11}
Repository breach by drilling	1.1×10^{4}	Probability Intermediate ($<5 \times 10^{-3}$)

4. Offsite Land Contamination

Levels of radionuclide deposition that would require evacuation of people and restrictions on farming and milk production are discussed in more detail in Reference 8 and are given below in Table V-18. The deposition limits were derived from the dose criteria given in Table V-19, which are also discussed in Reference 8.

TABLE V-18

Radionuclide Deposition Limits for Evacuation and Restrictions on Farming, Ci/m^2

	Evacuation		*Restrictions on Farming*	
Isotope	*Direct Radiation*	*Inhalation*	*First Year*	*Long Term*
^{90}Sr	-	2×10^{-4}	4×10^{-5}	2×10^{-4}
^{137}Cs	3×10^{-5}	1×10^{-3}	2×10^{-6}	8×10^{-5}
$^{238,239}Pu$	-	1×10^{-7}	-	-

TABLE V-19

Radiation Dose Criteria

Evacuation Limits	
External Irradiation	10 rem to whole body in 30 years
Inhalation	75 rem to critical organ in 50 years
Farming Restrictions (Short Term)	
^{90}Sr	5 rem to bone marrow in first year[a]
^{137}Cs	5 rem to whole body in first year[a]
Farming Restrictions (<1 year)	
^{90}Sr	(5 rem to bone marrow in 50 years)/year
^{137}Cs	(1 rem to whole body in 50 years)/year

a. The 50-year dose commitments due to these exposures in the first year are about 25 rem to the bone marrow from ^{90}Sr and 5 rem to the whole body from ^{137}Cs. (Almost all the dose from ^{137}Cs is received in the year in which it is ingested.)

Only two operational modules have potential for causing off-site land contamination for any of the abnormal events considered. These two are sabotage during removal of waste from tanks (common to all three alternative plans), and sabotage during processing waste to glass (unique to Alternative 2). The consequences, if each of these events did occur, are given in Tables V-20 and V-21, respectively, in terms of land contaminated and people evacuated.

TABLE V-20

Contamination Effects from Sabotage During Removal of Waste from Tanks

Distance from Release, km	*Acres Requiring Decontamination*	*People Moved*
15-20	8.5×10^3	2.2×10^3
20-25	1.1×10^4	3.2×10^2
25-30	1.3×10^4	0
30-35	1.6×10^4	0
35-40	1.8×10^4	0
40-45	2.1×10^4	0
45-50	2.3×10^4	0
50-55	2.5×10^4	0
55-60	0	0
Total Offsite	1.3×10^5	2.5×10^3

TABLE V-21

Contamination Effects from Sabotage During Waste Processing

Distance from Release, km	*Acres Requiring Decontamination*	*People Moved*
15-20	8.5×10^3	0
20-25	0	0
Total Offsite	8.5×10^3	0

5. Nonradioactive Pollutants

There will be no unusually large stores of chemicals required for implementing any of the alternative plans. Therefore, there is little potential for pollutant release to the environment for the abnormal events considered. Furthermore, mitigating features such as sand filters and liquid diversion systems would be expected to retain most accidental releases. Operations have been conducted over the past 27 years at SRP using large quantities of such chemicals as nitric acid and hydrogen sulfide with no adverse effect on the environment, as discussed in Reference 11. Similar experience for releases attributable to abnormal events is expected to apply to any future waste management operations.

If a high-activity fraction is separated from the waste and subsequently processed to a high integrity form such as Alternative Plan 2, there will remain about 16 million gallons of decontaminated salt cake. This salt could be stored in decontaminated waste tanks existing after processing, and would be subject to occurrence of the abnormal events discussed previously. The worst of these would be abandonment, with subsequent filling of the tanks with rain-water and runoff to the Savannah River. This scenario was analyzed in Reference 8, and the consequences are given in Section IV.C.3. of Reference 8. Not only is this event considered very unlikely, but also the river would not be polluted above drinking water standards even if no corrective actions were taken.

D. POTENTIAL EFFECTS FROM DECOMMISSIONING OPERATIONS FOR EACH ALTERNATIVE

1. Description of Decommissioning Technology

This section refers to the status of waste management facilities after decommissioning and the environmental impacts of decommissioning actions. Some decommissioning options would leave a residue of low-level radioactive waste, and this waste would be managed like the large volumes of low-level waste already in existence. Documents covering alternatives for long-term management of defense low-level waste are now in preparation by DOE.

SRP Waste Tanks

A program is now underway at SRP to retire waste tanks of the first three designs used at the plant. These tanks are being replaced with tanks incorporating design features (such as stress relief after construction) that are expected to increase useful lifetime and reduce maintenance costs. The technology developed for removing the waste from the retired tanks is applicable to decommissioning* all the tanks. A program of tank decommissioning would be implemented no matter which alternative plan is selected, because even continued tank farm operation will require tank replacement at intervals of about every 50 years. Decommissioning involves four major operations:

1. Removal of cake precipitated from solution during aqueous waste volume reduction is accomplished by dissolution with water heated to 90°C. The dissolution is enhanced by the use of movable agitation steam jets. The solvent water for these operations is recycled from evaporator overheads and other waste water, thereby minimizing the use of fresh water and discharges to the environment. To prevent airborne contamination from escaping through tank top apertures, a negative pressure in the tank is maintained.

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* Decommissioning is defined in ANSI Standard N300-1975 as the planned and orderly execution of a program devised for a nuclear facility to achieve a substantial and permanent improvement in the status of the shutdown facility. The program includes 1) decontamination of the structures, 2) removal of sources of radioactivity, 3) return of the site to a condition wherein it may safely be returned to unrestricted use, and 4) surveillance required for the protection of the public health and safety for a specified time if it is shown to be technically or economically infeasible to decontaminate the site to levels acceptable for unrestricted use.

2. Some of the tanks contain a sludge of waste particles that are insoluble in water. Removal of the sludge is accomplished by suspending it in a supernate solution from another tank and pumping to a settling tank or hold tank. Supernate is used as the sludge slurrying medium to avoid adding large volumes of new water into the waste tank system. This technique minimizes the amount of later evaporation required, and the number of hold tanks needed. The slurrying pumps are movable, and operation with a 1:1 ratio of supernate to sludge at a moderate pressure of about 100 psig gives an effective clearing radius of greater than 20 ft around each pump position.

3. After hydraulic sludge suspension of slurry removal, a sludge residue remains on the interior surface of a tank. Typically 4 wt % oxalic acid solution heated to 85°C is used through spray nozzles to dissolve this residue. The resulting solution is pumped to a hold tank, neutralized, and evaporated. The tank interior is finally washed with fresh water.

4. Salt deposits may have formed around any leak sites into the annulus between the primary container and the outer wall of the double-wall tanks. If so, hot water circulated by steam jets is used to dissolve these deposits in conjunction with the final sludge slurry transfer and with the water wash step of chemical cleaning in the tank interior. The annulus is then washed with fresh water.

Transfer of salt, supernate, and small amounts of sludge from retired tanks to new tanks has been demonstrated. Tests are now under way at SRP to transfer sludge and chemically clean retired Tank 16H. This will be a test of the process and equipment, rather than of the ultimate cleanliness attainable. Specific goals for the level of decontamination required for decommissioning of the SRP waste tanks are now being formulated through NRC-DOE-SRP discussions.

Processing Building

The technology and safety of decommissioning large processing facilities for radioactive materials have been studied recently and are detailed in Reference 18. The technology for decommissioning radioactive cells of the processing building is the same as that used presently for decontaminating hot cells. Caustic and/or acid washes are combined with the use of strippable paint to remove most contamination. Sandblasting or chipping of concrete can be used for especially resistant localized areas. Large pieces of equipment can be removed and cleaned by the above techniques and by electrolytic polishing. Present conceptual design for a processing building that would be used at SRP includes stainless steel liners on the cell floors and lower walls. The ability to remove these liners is expected to significantly decrease required decontamination efforts.

2. Decommissioning Options

Decommissioning alternatives range from leaving the tanks and processing building in place, with minimum removal of residual radioactivity and continuing surveillance and control, to dismantling and releasing the areas for unrestricted use. Each decommissioning mode requires a different degree of cleanliness. Although the alternatives can be identified, the criteria for cleanliness can only be provided on a tentative basis because of the lack of comprehensive regulatory guidance. Specific criteria for decommissioning within the framework of DOE and NRC guidelines is being developed as part of a research and development program that began in FY-1979.

The NRC guidelines on reactor decommissioning, particularly Regulatory Guide 1.86, and the extensive PNL document[19] on the decommissioning of a reprocessing plant give sufficient information to identify with considerable certainty the current decommissioning alternatives for SRP waste facilities. The objective of all of the alternatives is to ensure the continuing protection of the public. The resulting risk to the public must be acceptable, whichever of the following options is selected:

- Protective Storage (Mothballing). Most of the radioactivity would be removed from the facilities, but substantial quantities could remain. Openings in the facilities would be sealed, and other actions would be taken to place the tanks and buildings in a condition that requires a low-level effort of continuing surveillance, maintenance and security. Compared to other alternatives, this option requires a minimum of near-term effort and the lowest initial expenditure. The protective storage mode could be employed as a temporary action, a prelude for later extensive decommissioning.

- Entombment. In-place entombment consists of sealing all the residual radioactivity within a high-integrity durable structure. The structure should provide containment over the period of time that the residual radioactivity remains hazardous. This decommissioning effort would be much more extensive than for the protective storage mode. "Hardened" sealing would be used to isolate the remaining radioactivity from man. For example, the tanks and processing cells may be required to be filled with concrete or another suitable material.[19] Entombment may be found to be most suitable for a facility containing relatively short-lived radionuclides that decay to innocuous levels within a few centuries. At the end of that period, all restrictions on the use of the facility could be eliminated. A surveillance effort would continue during entombment, but to a lesser extent than for the protective storage mode.

- Unrestricted Release. For this alternative, all potentially hazardous amounts of radioactive materials would be removed from the tank farm areas and processing building. This could be done by extensive decontamination of the facilities that would result in a very low level of residual contamination or by dismantling and removing from the site all material that exceeds an acceptable contamination level. In either case, the remaining radioactivity would be innocuous and the site, either with or without the tanks and buildings, could be released for unrestricted use.

The unrestricted release mode may be deferred by first proceeding through the protective storage or entombment modes. However, unrestricted release after entombment would be far more difficult and costly than release after the protective storage mode. The entombment option was rejected for this reason in the PNL study.

Beyond the identification of decommissioning alternatives, regulatory guidelines are limited on other aspects of decommissioning, such as acceptable contamination levels. In recognition of the need for additional NRC regulations, the Advisory Committee on Reactor Safety has recently begun hearings with the aim of preparing recommendations to the Commission on the development of new rules for deactivation of nuclear facilities. Furthermore, NRC is funding a PNL study on the technology, safety, and costs of decommissioning a reprocessing plant. This study, which is based on the hypothetical retirement of the Barnwell Nuclear Fuel Plant, could establish a technical basis for specific decommissioning regulations and guidelines for reprocessing plants, including waste tanks. In addition, DOE is planning a comprehensive program to develop technology needed for decommissioning. The results of the NRC and DOE efforts will serve as the basis for the future decommissioning program for SRP waste management programs.

3. Occupational Radiation Exposure and Non-Nuclear Occupational Effects

All the basic operations involved in the decommissioning options have been carried out in the past. These include transfer of waste from tank to tank, decontamination of hot cells at SRP, and dismantlement or decontamination of other DOE facilities. There is nothing inherent about these decommissioning operations that would preclude their meeting the standards of occupational radiation exposure and safety discussed previously in Sections V.A., V.B., and V.C.

4. Offsite Effects

Offsite releases of radioactivity from decommissioning activities would be required to meet the same government regulatory standards discussed in Section V.A. (DOE Manual Chapter 0524) for releases from the waste management operations. However, the releases from decommissioning would have an inherent likelihood of being much lower because the total curies of activity processed would be many thousands of times lower. The operations involved in most decontamination steps, such as handling and evaporation of wash water and chemical cleaning solutions, are the same as those used in the primary waste management phase and introduce no new potential for radioactive release. It is concluded, therefore, that there will be no significant offsite radiation effects from any of the decommissioning options that might be implemented.

5. Impacts to Future Generations from Decommissioned Facilities and Land

All of the decommissioning options discussed in Section V.D.2. leave the facilities in such a condition that no radiation exposures could be incurred by any sizable portion of even the nearby population. The difference lies in the fact that a few individuals would be more protected from harm from their own actions than for others. For example, if waste tanks and reprocessing cells were dismantled and disposed of in a geologic repository along with the high-level waste, there would be no potential for anyone receiving radiation exposure at the site. In contrast, if those facilities were cleaned to a moderate degree and mothballed, and if surveillance and control were later lost, then some individuals could enter the tanks or cells (which would require considerable deliberate action) and receive undesirable radiation exposures.

Other differences in the way decommissioning options impact future generations are in the requirement for surveillance and control and in dedication of land. None of these differences is large, because in no case are more than a minimal surveillance effort and a few acres of land involved. The question of whether the reduced risk to some hypothetical future individuals committing unwise acts (such as deliberate intrusion or inadvertent use of contaminated land) and the availability of a few acres of land for unrestricted use are worth the extra monetary cost is a socio-political question that will best be answered at some time in the future by regulatory agencies. However, pertinent to the present decision-making process, there are no features of the research and development activities or of the three major waste management alternative plans that foreclose the availability of several reasonable decommissioning options for the future.

E. POTENTIAL EFFECTS FROM DECONTAMINATED SALT STORAGE

1. Storage in Waste Tanks at SRP

Various potential release mechanisms were evaluated for terminal storage of salt cake in tanks, and it was found that intense earthquakes pose the greatest risk. If an intense earthquake occurred immediately after the salt is stored, the tanks could be damaged and fill with rainwater. If they were then abandoned, they could overflow to the Savannah River during an extended period. *If no corrective actions were taken and if people* continued to drink the downstream river water and eat downstream fish, the consequences given in Table V-22 could be realized. Table V-22 also gives the annual risk from this event by multiplying the consequences by the probability of occurrence of the earthquake. The risk and cost of this storage mode are compared with those of the other storage alternatives in Table V-23.

2. Can and Store in an Onsite Surface Vault

Canisters containing the decontaminated salt are stored in a surface storage vault similar to the vault described in DPE-3410.[20] An evaluation of the various potential release mechanisms from the storage vault indicates that intense earthquakes present the greatest risk. The vault will be designed and constructed to withstand completely earthquakes of the intensity which might reasonably be expected to occur in the vicinity of SRP (see discussion of seismicity in Section III.) An earthquake of intensity MM IX would be expected to cause some cracking of the surface storage vault. An earthquake of greater intensity could cause extensive cracking of the concrete structure and could rupture some of the canisters stored in the vault. The probability of an earthquake of an intensity of MM X occurring at SRP is 2×10^{-5}/yr.

The canisters of salt are stored individually in storage wells located in the reinforced concrete slab floor of the vault. Each storage well will have a concrete closure plug. The closure plugs are assumed to remain in place with little lateral displacement after an earthquake. Therefore, rainwater dissolution of salt from damaged canisters with runoff to the river would occur much slower from this type facility than from waste storage tanks because the salt is not as accessible to rainwater.

If no corrective actions were taken following an earthquake of MM X and if people continued to drink the downstream river water and eat downstream fish, the consequences would be less than the exposures shown in Table V-22. When the exposures in Table V-22 are multiplied by the decreased probability of an earthquake of MM X (2×10^{-5}/yr versus 10^{-3}/yr for an MM IX earthquake), the risks become insignificant.

TABLE V-22

Dose to Individual Drinking River Water and/or Eating Fish after Runoff from Decontaminated Salt Tanks Damaged by an Earthquake[a]

Nitrate-Nitrite Concentrations	0.027% EPA drinking water limit
Mercury Concentrations	0.13% EPA drinking water limit
Individual Whole Body Dose, Drinking Water	0.17 mrem/yr
Individual Bone Dose, Drinking Water	0.08 mrem/yr
Individual Whole Body Dose, Eating Fish[b]	11 mrem/yr

Population Dose Risk over 105-Year Period[c]	7.2 man-rem

a. Assumes the amount of residual radioactivity in the tanks after decontamination is equal to or less than the radionuclide content of the salt and that 10% or less of the residual activity is transferred to the salt. Also assumes 25% of the tanks containing salt are damaged and 10% of the salt and radionuclides released from the tanks reach the river.

b. Assumes this individual eats 25 pounds of fish per year. The present commercial fishing industry could supply about 200 such people.

c. Based on a probability of 10^{-3}/yr for an earthquake of intensity of MM IX which is required to damage the tanks containing salt. Assumes 25% of the tanks are damaged. Estimates show that 100 years are required for rainwater entering the tanks to dissolve the salt and empty the tanks. Also assumes the population drinking water and eating fish caught commercially increases by a factor of 5 during the period.

TABLE V-23

Salt Storage Risk and Cost

	Tank Storage	*Onsite Surface Vault*	*Offsite Geological Storage*
Risk, man-rem[a]	7.2	0.14	1405[b]
Cost, millions 1978 dollars	57	1127	481

a. Exposure to offsite population, excludes occupational exposure.

b. Exposure for shipment by rail, including train crew. Exposure for shipment by truck would be 6770 man-rem which includes exposure to drivers.

3. Can and Store in an Offsite Federal Repository

The environmental effects of storage in an offsite Federal repository will be assessed in an environmental impact statement for the repository. However, since it has been shown that the environmental effects of the high activity fraction are negligible, the radiation effects of the decontaminated salt would also be negligible.

An evaluation of the radiological impact of transporting the salt indicates that exposure to radiation during transport presents the greatest risk. For the purpose of calculating the exposure, it was pessimistically assumed the radiation level 6 feet from the surface of the truck or train car is 10 mrem/hr, the upper limit permitted by Federal Regulations 10 CFR 71 and 49 CFR 170-9. Other assumptions are:

- A truck carries two drivers and averages 40 mph.
- A train car averages 10 mph.
- The population density beginning 100 ft on either side of the road or railway is 250 people per square mile.

For truck transport, estimated doses were based on assumptions that:

- Two drivers occupy the cab.
- The dose rate in the cab is 2 mrem/hr (as limited by 10 CFR 71).

- Two garagemen work on the truck each 1000 miles for 10 minutes in a 2 mrem/hr radiation field.
- 165 vehicles pass the truck each hour at a relative speed of 10 mph; each vehicle contains two people, and they are exposed at a distance of 6 ft from the side of the truck.
- Ten onlookers spend three minutes each, 3 ft from the side of vehicle, each 1000 miles of truck travel.

For train transport, extimated doses are based on assumptions that:

- Three crewmen spend half their time 300 ft from the cask.
- Ten brakemen spend 5 minutes each 6 ft from the side of the car carrying the cask each 1000 miles of travel.
- One passenger train carrying 300 passengers per day passes the cask at a relative speed of 30 mph; the passengers are at an average distance of 10 ft from the cask.
- Ten onlookers spend 3 minutes each 3 ft from the side of the train car each 1000 miles of car travel.

The radiation dose to transport workers and the public, under normal shipping conditions, calculated for shipping the salt a distance of 2000 miles, is shown in Table V-24. Shipment by rail would result in about 140 man-rem/year, while shipment by truck would result in about 675 man-rem/year (over the 10-year shipping period). Most of the difference is due to the doses to the truck drivers.

TABLE V-24

Radiation Doses for Salt Shipments Under Normal Conditions (For shipment 2000 miles from SRP)

	Total No. of Shipments in 10-Year Shipping Period	*Total Dose for All Shipments, man-rem*		
		To Transport Workers	*To Public*	*Total*
Truck	23,625	4,265	2,505	6,770
Rail	23,625	445	960	1,405

The greatest risk associated with shipping the decontaminated salt to an offsite Federal repository is from the physical injuries and deaths from transportation accidents. For transportation by truck, the probability[21] per vehicle mile for injuries is 9×10^{-7} and for fatalities is 5×10^{-8}. The probability[21] per car mile by rail for injuries is 4×10^{-7} and for fatalities is 3×10^{-8}. Assuming 23,625 canisters of salt are shipped 2000 miles to a Federal repository with one canister per rail car or truck, there would be approximately 38 injuries and 3 fatalities for rail shipments, and 85 injuries and 5 fatalities for truck shipments.

The canisters would be shipped in a cask that would provide thermal and shock protection for the canister of salt in the event of an accident. During transport, the probability/vehicle mile for releasing a small quantity of salt in an accident environment is about 1×10^{-10} for truck or 2×10^{-10} for rail car.[17] Assuming an accident occurs in which a damaged salt canister enters a stream with 100 cfs flow rate and all the salt is dissolved and released from the canister in 24 hours, an individual drinking water from the stream would receive a whole body dose of 0.08 mrem/yr and a bone dose of 0.04 mrem/yr. The consequences are nil even before multiplying by the extremely low probability.

F. SECONDARY (INDIRECT) ENVIRONMENTAL EFFECTS OF ALTERNATIVES

There have been no secondary environmental effects identified for any of the waste management alternatives that are not inside the usual range of environmental effects from operation of the Savannah River Plant. The possible exception is the increase in the construction force from 1000-3000 to about 5000. The following is a brief discussion of some of the items that have the potential for important secondary effects. In this context, secondary effects refer to changes in environmental, social and economic activities likely to be induced by implementation of an alternative waste management plan.

- The materials used in large quantity in any of the alternative plans are water, concrete, steel, glass formers, stainless steel, caustic, nitric acid, and oxalic acid. These are all common industrial products, and the SRP demand would be spread over several years with lead times such that external supplies and markets would not be affected. During certain phases of construction of any processing facilities and during the containerization steps if the glass waste form is chosen for surface storage, a relatively high number of stainless steel welders will be used. However, there will be enough lead time to train these personnel so that their skills are not considered to be a limiting item in implementation, and the use of skilled manpower will be mitigated somewhat by use of machine welding for containerization.

- If one of the geologic disposal alternatives is implemented, the materials disposed of will be irretrievable by future societies. Present day perceptions of utility are that such materials would be of no use in the future. If future perceptions of utility are different, then geologic disposal would have foreclosed an option for the future.

- Making a choice now for irretrievable disposal rather than for retrievable storage deprives future societies of the use of the technology and judgment that would accumulate over the storage period and it maximizes future regrets if it is later found that geologic disposal is not the most desired alternative. The extent that this might cause extra efforts by future societies is a secondary environmental effect of the present decision.

- It is concluded that the most important secondary effects are reflected in the large cost differences among the alternative plants. The difference of several billion dollars between the most expensive and least expensive alternatives represents, on the average, money diverted from the broad range of productive activities, goods, and services (including environmental improvements) included in the Gross National Product. As a limiting case for environmental effects, it might be considered that the full cost difference could be available to spend completely on other environmental improvement areas, and that implementation of the more expensive alternatives forecloses those improvements.

- Successful demonstration of long-term management of defense waste could have an important sociopolitical bearing on the acceptability of nuclear power generation by a significant portion of the public. If this increase in public acceptability resulted in greater utilization of nuclear power, there would be a net gain in the national economy and in resource conservation that would exceed the cost of the most expensive alternative for long-term management of SRP defense waste.

G. REFERENCES FOR SECTION V

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VI. UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Measures to mitigate potential environmental impacts include administrative controls as well as engineered systems. These measures will alleviate some of the adverse environmental effects caused by construction and operation of any facilities that may be built after research and development programs and design programs are complete. However, there are certain probable adverse effects on the environment that cannot be avoided regardless of which alternative is chosen (including continued present action). These unavoidable effects are discussed below. In evaluating possible adverse effects, it should be noted that construction and normal operations will be in compliance with applicable federal, state, and local laws and regulations.

A. RADIATION EXPOSURES

Unavoidable radiation exposures are assumed to be 1) occupational exposures based on SRP experience for removal of waste from tanks and processing and on federal standards for transportation, and 2) exposures to the general population on the same bases. Unavoidable exposures for all the geologic storage modes are assumed to be from very long-term transport of ^{129}I to a water supply after the waste is emplaced (130 man-rem). The occupational and public exposures are given in Table VI-1 and are discussed more fully in Section V. All the offsite exposures are very small compared to those from natural radiation, as discussed in Section XII.

B. NON-NUCLEAR EVENTS

Unavoidable non-nuclear events include occupational lost-workday injuries and fatalities during construction and operation of new facilities. These are summarized in Table VI-2 and are discussed in more detail in Section V. On a statistical basis, these events can be expected to occur; however, the trend of industrial accident rates has been downward, which indicates that safety programs will have the effect of causing some avoidance of expected casualties.

C. OTHER

Other unavoidable adverse environmental effects are the effects of construction, land-use requirements, water and power requirements, and chemical discharges. These are not expected to be large in terms of available resources or environmental impact, as shown in Sections V and VII.

TABLE VI-1

Unavoidable Radiation Exposures

Case	*Alternative Plan*	*Occupational Population Exposure, man-rem*[a]	*Offsite Population Exposure, man-rem*[a]
1	Continue Storage in Tanks	356	49
2.1	Process to Glass; Offsite Geologic Disposal[c]	3750[b]	750
2.2	Process to Glass; Surface Storage at SRP[c]	2640	67
2.3	Process to Glass; Disposal in SRP Bedrock Cavern	2350	200
3	Slurry Liquid Waste into SRP Bedrock Cavern	42	180

a. These are integrated over the time required for processing, transportation, and 300 years of storage, as discussed in Section V.

b. Includes occupational exposures during transportation to offsite repository.

c. Evaluated specifically for glass but expected to be similar for most high integrity waste forms.

TABLE VI-2

Expected Lost-Workday Injuries and Fatalities

Case	*Alternative Plan*	*Construction*[a] *Lost Workday Injuries*	*Fatalities*	*Operations*[b] *Lost Workday Injuries*	*Fatalities*
1	Continue Storage in Tanks[c]	1600	17	1.03	0.13
2.1	Process to Glass; Store in Offsite to Geologic Disposal[d]	530	5.9	16	0.63
2.2	Process to Glass; Surface Storage at SRP	590	6.4	1.3	0.17
2.3	Process to Glass; Disposal in SRP Bedrock Cavern[d]	550	6.1	0.87	0.11
3	Slurry Liquid Waste into SRP Bedrock Cavern	180	2.2	0.16	0.021

a. From U.S. average construction, industry, and mining experience.

b. Based on SRP operating experience.

c. Over a 300-year period.

d. Evaluated specifically for glass but expected to be the same for most high integrity waste forms.

VII. IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Numerous resources are used in constructing and operating major plant facilities. Some of the resource commitments are irreversible and irretrievable. Irreversible commitments are changes set in motion which, at some later time, could not be altered to restore the present order of environmental resources. Irretrievable commitments are the use or consumption of resources that are neither renewable or recoverable for subsequent utilization. Generally, resources which may be irreversibly or irretrievably committed by construction and operation of facilities for any of the alternative plans are: 1) biota destroyed in the vicinity, 2) construction materials that cannot be recovered and recycled, 3) materials that become contaminated with radionuclides and cannot be decontaminated for recycle, 4) materials consumed or reduced to unrecoverable forms of waste, and 5) land areas rendered unfit for their preconstruction uses and/or potential postconstruction uses.

Implementation of any of the alternative plans would involve construction activities on less than 0.5% of the land on the plant site. Although there would be an irretrievable loss of some individuals of the site biota during construction of facilities for any alternative, minimal adverse effects would be expected on the structure or stability of the plant and animal populations inhabiting the plant site. The primary resource commitments are shown in Table VII-1.

If one of the high integrity waste form alternatives is chosen, a waste solidification facility would be required. The facility would be constructed similarly to the two chemical separation facilities presently in use at SRP. At the end of the useful life of the waste solidification facility, it would have to be decommissioned. It is expected that decommissioning the waste solidification facility would require about the same degree of effort as decommissioning one of the chemical separation facilities. Surveillance of the facility would be required until it was dismantled and the area returned to unrestricted use.

If the alternative of placing the liquid waste directly in a bedrock cavern is chosen, some, if not all, of the waste would be irretrievably committed. It would not be possible, with current technology, to retrieve all of the liquid waste from a cavern. Therefore, the underground area of the caverns would be irreversibly committed. The surface area over the caverns could be used for any purpose with a restriction which would prohibit drilling, mining, or any other action that would breach the caverns.

If the alternative to continue storing high-level waste in tanks is chosen, approximately 50 acres of land will have to be committed every 50 to 100 years to build new tanks to replace the existing tanks. Presumably, however, when the tanks are emptied every 50 to 100 years, they could be decontaminated and dismantled so the site could be used for the next generation of tanks; if this can be accomplished, additional land will not have to be committed for waste tanks.

TABLE VII-1

Irreversible and Irretrievable Commitment of Resources[a]

	Continue	*Glass Form to a Federal Repository*			
	Tank Farm Storage	*Offsite Geological*	*Onsite Surface*	*Onsite Geological*	*Liquid to Bedrock*
Land, acres	80[b]	100[c]	125	100[d]	10[d]
Concrete, cubic yards × 10^3	375[e]	100	125	125	25
Carbon steel, tons × 10^3	70	20	25	25	5
Stainless steel, tons × 10^3	5	10	10	10	1
Electricity, MW-hr × 10^3	350[e]	900	900	900	40
Coal, tons × 10^3	150[e]	600	600	600	10
Cost, billions of 1980 dollars	0.510	3.60	3.75	3.61	0.755

a. Estimates based on experience with similar facilities; assumes 10 years of glass-forming operations.

b. Assumes old tanks are dismantled after they are emptied and new tanks are built in same area.

c. Glass-forming plant only; excludes land for offsite Federal repository.

d. Excludes surface restriction prohibiting drilling or mining.

e. Assumes replacing tanks five times in the first 300 years and maintaining surveillance for 300 years.

VIII. RELATIONSHIP BETWEEN ALTERNATIVES AND LAND-USE PLANS, POLICIES, AND CONTROLS

The purpose of this section is to evaluate how the implementation of any of the alternative plans for long-term management of SRP high-level waste conforms to or conflicts with Federal, state, and local land-use plans, policies, and controls.

The Savannah River Plant site was acquired and set aside by the U. S. Government in 1950 as a controlled area for the production of nuclear materials needed for national defense. The approximately 200,000-acre plant site is closed to the public except for guided tours, controlled deer hunts, controlled through-traffic along S. C. Highway 125 (SRP Road A), the Seaboard Coastline Railroad, and U. S. Highway 278 along the north edge of the site (see Figure III-2), and authorized environmental studies. The U. S. Forest Service has provided a program of forest management since 1951 and has reforested much of the site with productive stands of slash, loblolly, and longleaf pine.

In 1951, the University of South Carolina and the University of Georgia began studying changes in the site characteristics, and in 1961 the Savannah River Ecology Laboratory of the University of Georgia initiated studies of the effects of thermal and radioactive effluents on the site's ecology. In 1972, the SRP site was declared the Nation's first National Environmental Research Park; the site provides a large controlled area for environmental research by scientists from universities and other organizations.

The plant map (Figure III-2) shows the relatively small areas that would be required to construct facilities to implement alternative plans involving waste solidification or bedrock storage. This small increase in land use for waste management will have a commensurate minor effect, if any, on the use of the plant site for environmental research.

A South Carolina statute, that established a Nuclear Advisory Council to report to the Governor and General Assembly, states that the Council shall participate to the extent possible in the consideration of any decision concerning any proposed permanent storage of high-level waste in the State. The Department of Energy has stated its belief that it should, as a matter of policy, act in a manner consistent with the desires of the state in which waste facilities will be located. The Department also recognizes that the question of state participation in the waste facility siting process is a subject of pending Congressional approvals.

In summary, implementation of any alternatives is not expected to cause conflicts with land-use plans, policies, and controls pertaining to the Savannah River Plant site. The impact of an offsite Federal repository on national, state, and local land-use plans and programs would be addressed in the site-specific environmental statement for the repository.

IX. SHORT-TERM USES AND LONG-TERM PRODUCTIVITY

This section compares the short-term and long-term environmental gains and losses of implementing any of the alternative plans. For purposes of this discussion, short-term effects are those that occur during the period of construction and operation of the facilities. Long-term effects are those that extend past facility operations and into the indefinite future. Short-term effects are generally considered in terms of trade-offs in impact on the environment, land use, and cost. Long-term effects have to do with conservation of energy reserves, environmental effects, and land use.

The fundamental purpose of implementation of any of the alternative plans is to remove the SRP defense high-level waste from interim storage and place it in environmentally acceptable long-term storage or disposal.

A. SHORT-TERM EFFECTS

1. Gains

If one of the high integrity waste form alternatives is selected, the high-level waste will be placed in a solid, leach-resistant form which will enhance its isolation from man's environment, particularly during transportation and storage.

If the alternative to place liquid waste in bedrock underneath SRP is selected, the liquid waste would be isolated in a geological formation with a low probability of any of the radionuclides migrating into man's environment.

2. Losses

Implementation of any of the alternative plans will consume some depletable resources, such as water, cement, gravel, steel, and lumber; however, these are all common industrial products, and SRP consumption would not significantly affect their supply. Also, implementation of any of the alternative plans will require short-term dedication of land for construction of the facilities. However, each of the alternative plans will require less than 0.5% of the land on the Savannah River Plant site.

B. LONG-TERM EFFECTS

1. Gains

Even though the defense high-level waste is stored safely in waste tanks, if one of the other alternative plans is selected, the waste will be placed in a form and/or storage mode that would give greater assurance that it will remain isolated from man's environment.

2. Losses

If the SRP surface vault storage mode is selected for the high integrity waste form, approximately 20 acres of the 192,000-acre SRP site will be committed to a storage vault for many thousands of years or until a decision is made to store the waste form in another location.

If one of the bedrock cavern storage modes or the offsite geological storage mode is selected, the subsurface facility would be committed indefinitely; however, the surface area above the repository could be released with a restriction which prohibited drilling or mining in the area.

Placing the waste forms in a geological formation or a surface storage vault would reduce the surveillance that would be required for continued storage in tanks. However, all storage modes will require long-term continuing surveillance.

A summary of long-term and short-term costs and nuclear risks is given in Table IX-1. Short-term risks are the sum of occupational and offsite risks until the waste is placed in storage or disposal (about 10 years after start of removal from tanks). Long-term risks are the sum of occupational and offsite risks for 300 years after the waste is placed in storage or disposal.

A. GENERAL CONSIDERATIONS[1,2,3]

Costs for the three alternative plans in undiscounted 1976 dollars were developed previously[1] for the Defense Waste Document (DWD). The costs given here are updated from those in the DWD[2] and reflect the increasingly stringent criteria being applied to both the processing and storage of nuclear wastes. Costs include research and development, capital, and operations costs. For this document, the costs for certain alternatives are estimated from a designed and costed facility for the production of a glass product. Other alternatives have been estimated from public documents and cost studies.

The costs for Alternative 1, continued tank farm operation, include an amount equal to the cost in 1980 dollars of one set of new tanks. This should be more than enough money to provide a trust fund to build new tanks every fifty years, if required, and ensures that the costs for continued tank farm operation reflect the same degree of perpetuity as costs for the other storage or disposal modes. Creation of such a trust fund would require new legislation.

The accuracy of the cost numbers varies with the knowledge of the process evaluated. The cost of continued tank storage is very well established, and values shown in this report should be quite accurate. Solidification of waste of the SRP type is an undemonstrated process. Therefore, the cost of such a process is uncertain. The costs used for the solidification processes were based on venture guidance estimates; the processing rates attainable in the solidification steps are particularly uncertain because they depend on the successful operation of many undemonstrated processes.

The costs for bedrock and geologic disposal are based on an escalation of previous studies.[1] None of these disposal concepts has been demonstrated, and costs are subject to large changes depending on the criteria developed for the disposal concepts.

B. COST CENTERS

The purpose of this study is to allow a comparison of the alternative plans. Therefore, the accuracy of the cost estimates is not as important as having consistent, comparable estimates. To achieve this consistency, a series of cost centers were developed. Then the cost of each alternative plan could be determined by summing the cost of the applicable cost centers, which are defined as follows:

1. *Removal of Waste from Tanks.* The equipment and manpower requirements necessary to provide a uniform feed supply to the processing plant were estimated. In those plans where no processing occurs, this cost center value is reduced to reflect less piping and no mixing requirement.

2. *New and Replacement Tanks.* New and replacement tank needs were determined and these tanks were costed at $12 million each.

3. *Sludge Separation and Salt Decontamination.* A waste processing facility was designed, and a detailed cost estimate was made. That fraction of the total facility that applied to sludge separation and salt decontamination was determined, and appropriate capital costs were established. Similarly, that fraction of the estimated total facility operating costs that applied to this cost center was determined. Costs applicable to both salt and glass product, such as sludge separation, were distributed to these cost centers.

4. *Return of Decontaminated Salt to Old Tanks.* Capital costs for transfer lines and new evaporators were estimated. No capital cost for tanks was included.

5. *Vitrification.* As in Cost Center 3, that fraction of the total facility applicable to producing glass product was estimated, and that fraction of the total facility capital cost and of the total operating costs were determined.

6. *Transportation.* The capital and operating costs for transportation to a geologic site were estimated. Rail transport to a site about 1500 miles away was assumed. Capital costs consist of casks; operating costs represent the charge by the railroad.

7. *Temporary Storage.* In those plans requiring transportation, a facility is provided onsite to allow for storage of 2 year's production of glass product.

8. *Onsite Surface Storage Facility for Solidified Waste Product.* Onsite surface storage of all of the glass products is an expansion of the 2-year storage facility.

9. *Bedrock Cavern Storage at SRP.* The storage of SRP wastes in the bedrock under the Savannah River Plant site has been studied for over 20 years. The costs for bedrock storage of unseparated wastes were estimated in 1969. In this present analysis, the 1969 costs were adjusted upward to allow for additional transfer lines, larger tunnels, more monitoring, and escalation. The tunnel size requirements were estimated from a thermal analysis that established an acceptable storage matrix of contained waste. Tunnel size for liquid waste was determined by the quantity of liquid being stored.

10. *Offsite Geologic Storage.* Space requirements for storage of packaged waste in geologic formations were determined by a thermal analysis. Costs for providing the required storage space were obtained by extrapolation and escalation of previous studies[1] of geologic storage, and may be different than actually required when cavern performance criteria are established.

11. *Research and Development.* A considerable research and development effort would be required to implement any change in the present method of waste management of SRP. The various plans would generally require greater research and development efforts consistent with the degree of complexity of the plan. Estimates of the research and development costs for each plan are included in the cost tables.

C. RESULTS

Cost Table for Alternative Plan 1

(Storage of Waste as Sludge and Damp Salt Cake in Underground Waste Tanks — Present SRP Waste Management Technique)

	Number of Tanks
Tanks available end CY-1984	27
Tanks required for normal operation	30
New tanks required	3
Replacement tanks required (every 50 years)[a]	20

	Million 1980 Dollars
Capital Cost	
New tanks	35
Replacement tanks	240
Waste removal equipment	115
Total Capital	390
Operating Costs	
Tank replacement	95
Surveillance	25
Total Operating	120
Total Plan Costs	510

a. One tank replacement will provide for 100 years total storage; about the same storage time as provided by a surface storage facility. Replacement of either tanks or the surface storage facility after 100 years would require only a very small annuity that would not significantly affect the cost of these plans. Discounting would further reduce costs of this plan compared to the alternatives since replacement tank costs are delayed 50 years.

Cost Table for Alternative Plan 2 — Subcase 1

(Glass Product Disposed of in Offsite Geologic Storage and Decontaminated Salt Cake Stored in Onsite Underground Waste Tanks, million 1980 dollars)

	Capital Cost	*Campaign Operating Cost*	*Container Cost*	*Total Campaign Cost*
Removal of waste from tanks	145	95	-	240
Salt decontamination	1065	315	-	1380
Vitrification	820	325	-	1145
Return salt to tank	45	25	-	70
Waste tanks	75	-	-	75
Temporary storage - glass	80	30	-	110
Geologic storage	150	50	140	340
Transportation - glass	20	50	-	70
Research and development	20	150	-	170
Total	2420	1040	140	3600

Cost Table for Alternative Plan 2 — Subcase 2

(Glass Product Stored in Onsite Surface Storage Facility and Decontaminated Salt Cake Returned to Onsite Underground Waste Tanks, million 1980 dollars)

	Capital Cost	*Campaign Operating Cost*	*Container Cost*	*Total Campaign Cost*
Removal of waste from tanks	145	95	-	240
Salt decontamination	1065	315	-	1380
Vitrification	820	325	-	1145
Return salt to tanks	45	25	-	70
Waste tanks	75	-	-	75
Storage for glass	450	80	140	670
Research and development	20	150	-	170
Total	2620	990	140	3750

Cost Table for Alternative Plan 2 — Subcase 3

(Glass Product Disposed of in SRP Bedrock and Decontaminated Salt Cake Stored in Onsite Underground Waste Tanks, million 1980 dollars)

	Capital Cost	*Campaign Operating Cost*	*Container Cost*	*Total Campaign Cost*
Removal of waste from tanks	145	95	-	240
Salt decontamination	1065	315	-	1380
Vitrification	820	325	-	1145
Return salt to tanks	45	25	-	70
Waste tanks	75	-	-	75
Bedrock cavern - glass	290	100	140	530
Research and development	20	150	-	120
Total	2460	1010	140	3610

Cost Table for Alternative Plan 3

(Unprocessed Waste Slurry Disposed of in
SRP Bedrock, million 1980 dollars)

	Capital Cost	*Campaign Operating Cost*	*Container Cost*	*Total Campaign Cost*
Removal of waste from tanks	145	95	-	240
Bedrock cavern	380	60	-	440
Research and development	10	65	-	75
Total	535	220	-	755

D. REFERENCES FOR SECTION X.

1. *Alternative Plans for Storage of High Level Waste — Flowsheets and Cost*. Memorandum to J. M. Boswell, Internal Report DPST-76-95-17, Savannah River Laboratory, E. I. du Pont de Nemours and Co., Aiken, SC (May 5, 1976).

2. *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste, Savannah River Plant, Aiken, South Carolina*. Report ERDA-77-42/1, Energy Research and Development Administration (May 1977).

3. E. L. Graf. *Capital and Operating Costs for Defense Waste Processing Facility*. Internal Report DPSP-79-1020, Savannah River Plant, E. I. du Pont de Nemours and Co., Aiken, SC (March 1979).

A. METHODOLOGY

1. Monetary Valuation of Risks

Radiation Exposures

The Office of Management and Budget and the Nuclear Regulatory Commission (NRC) have requested that a value of $1000/man-rem be used to convert changes in radiation risks to dollars for use in cost-benefit analyses of reactor safety systems. The same value is suggested in NRC Regulatory Guide 1.110 for cost-benefit analyses for reactor radwaste systems (March 1976).[1] Even though the NRC value is recommended for changes in radiation risk, it is applied in this document to total radiation risk to illustrate a method of comparing budgetary cost of an alternative with one credible method of dollar-valued total risk of that alternative. An analysis has also been made of the incremental cost of risk reduction, using the least expensive alternative as a base. In each case, the analysis applies to implementation of a complete alternative, because implementation of only part of an alternative to achieve a partial risk reduction is not feasible.

The suggested value of $1000/man-rem is used in this assessment for analyzing the alternative plans on a total dollar cost basis. However, there are other methods of evaluating radiation risk that some decision makers may wish to use; for example, the risks to individuals are important to consider along with the overall population risks. Thus, it may be desired to use a lower value than $1000/man-rem for individual exposures about equal to or below those received from natural background and a higher value for exposures posing an immediate threat to the individual.

The validity of interpreting man-rem exposure to a population as actual risk is in doubt and may result in gross overestimates when exposure to the involved individuals is very low. The following excerpts on this subject are taken from Report No. 43 of the National Council on Radiation Protection (NCRP), January 15, 1975:

> "The indications of a significant dose rate influence on radiation effects would make completely inappropriate the summing of doses at all levels of dose and dose rate in the form of total person-rem for purposes of calculating risks to the population on the basis of extrapolation of risk estimates derived from data at high doses and dose rates."

"The NCRP wishes to caution governmental policy-making agencies of the unreasonableness of interpreting or assuming 'upper limit' estimates of carcinogenic risks at low radiation levels as actual risks, and of basing unduly restrictive policies on such an interpretation or assumption."

Land Contamination

Levels of radionuclide deposition that would require evacuation of people and restrictions on farming and milk production are given in Table XI-1. The deposition limits were determined by using methods described in Reference 2 and pathways parameters from References 3 and 4. The dose criteria in Table XI-2 were derived from those used in Reference 2 and from Protective Action Guides issued by the Federal Radiation Council, which sets guidelines for actions to be taken in the event of widespread contamination resulting from an unplanned occurrence.

The dollar valuation placed on deposition of radioactivity offsite depends on whether or not crop restrictions apply, on the fraction of land used for crops, and on whether people must be evacuated. These considerations are discussed in detail in Reference 2. Offsite land contamination occurs only to a limited extent and only for a few events considered in this document. Therefore, average values for the decontamination costs of the different types of land use (farm land and developed land) from Reference 2 were used, rather than specific values constructed for each event. These values and those from Reference 2 used for relocation and loss of income for affected people are the following:

1. All land within a radial sector above the milk and crop restriction limit was assumed to carry a cost of $230 per acre. This cost is a weighted average cost of deep plowing or scraping with replanting, a procedure that gives an overall decontamination factor of about 20.

2. A cost of $1700 per acre was used for the weighted average cost of decontaminating commercial and residential areas.

3. A cost of $2,900 per capita was used for moving expenses and loss of income.

Tables XI-3 and XI-4 give the number of people affected, the acreage, and the dollar valuation for the alternative plans and events for which a deposition limit is exceeded. The same atmospheric conditions were assumed for the radionuclide deposition calculations as for the dose estimates, i.e., 95th percentile pessimistic dispersion conditions with 1-cm/sec particle settling velocity and wind in the Jackson-Augusta direction. The site boundary is 15 km from the waste management area.

TABLE XI-1

Radionuclide Deposition Limits for Evacuation and Restrictions on Farming, Ci/m^2

	Evacuation		*Restrictions on Farming*	
Isotope	*Direct Radiation*	*Inhalation*	*First Year*	*Longer*
^{90}Sr	-	2×10^{-4}	4×10^{-5}	2×10^{-4}
^{137}Cs	3×10^{-5}	1×10^{-3}	2×10^{-6}	8×10^{-5}
$^{238,239}Pu$	-	1×10^{-7}	-	-

TABLE XI-2

Radiation Dose Criteria

Evacuation Limits	
External Irradiation	10 rem to whole body in 30 years
Inhalation	75 rem to critical organ in 50 years
Farming Restrictions (Short Term)	
^{90}Sr	5 rem to bone marrow in first year[a]
^{137}Cs	5 rem to whole body in first year[a]
Farming Restrictions (>1 year)	
^{90}Sr	(5 rem to bone marrow in 50 years)/year
^{137}Cs	(1 rem to whole body in 50 years)/year

a. The 50-year dose commitments due to these exposures in the first year are about 25 rem to the bone marrow from ^{90}Sr and 5 rem to the whole body from ^{137}Cs. (Almost all the dose from ^{137}Cs is received in the year in which it is ingested.)

TABLE XI-3

Contamination Effects from Sabotage During Removal of Waste from Tanks

Distance from Release, km	*Acres Decontaminated*	*People Moved*
15-20	8.5×10^3	2.2×10^3
20-25	1.1×10^4	3.2×10^2
25-30	1.3×10^4	0
30-35	1.6×10^4	0
35-40	1.8×10^4	0
40-45	2.1×10^4	0
45-50	2.3×10^4	0
50-55	2.5×10^4	0
55-60	0	0
Total Offsite	1.3×10^5	2.5×10^3
Cost	$\$3.0 \times 10^7$	$\$1.2 \times 10^7$

TABLE XI-4

Contamination Effects from Sabotage During Waste Processing

Distance from Release, km	*Acres Decontaminated*	*People Moved*
15-20	8.5×10^3	0
20-25	0	0
Total Offsite	8.5×10^3	0
Cost	$\$2.0 \times 10^6$	

2. Ranking According to Total Effective Cost

Tables XI-5 through XI-9 give the sum of capital and operating costs in 1980 dollars for each of the 3 alternative plans. They also show consequences of each important event for each of the four functional operations of removal from tanks, processing, transportation, and storage. The consequences are given as radiation dose commitment to the offsite population in the year of maximum consequence. A conversion factor of 1/6 was used to convert bone doses to equivalent whole body doses. The factor of 1/6 is the ratio of occupational limits for whole body and bone dose. Use of this factor is an attempt to account for the fact that health effects in bones would occur only at doses considerably higher than health effects induced by whole body doses.

The annual probability assumed for each event is shown, and the maximum annual risk in man-rem/year is given as probability times consequence. The time-integrated risks are shown for a 300-year period and a 10,000-year period, and are based on an assumed population growth in the local area of a factor of five between now and year 2140, then a level population. The integrated risks are evaluated at $1000 per man-rem and are added to the budgetary cost to obtain total dollar cost of the alternative.

The disposal risks from several candidate Federal geologic repository sites are now being studied by other groups as part of the waste management program for wastes from commercial reactors. As the studies are completed, their results will be factored into the analysis given in this document. It is presently assumed that an offsite Federal repository would be in bedded salt or other formations with no likely pathway to a water supply. The disposal risks are assumed to be the same as those for SRP bedrock with canned, high-integrity waste.

3. Incremental Cost-Risk

Another method of evaluating the trade-off between cost and risk was used to generate the incremental cost-risk results in Tables XI-5 through XI-9. Those results show the cost per man-rem for reducing risk by spending money beyond that required to implement the least expensive alternative (Alternative 1, continued tank farm operation). The integrated risk for Alternative 1 reflects the assumption that the tanks would be abandoned after 100 years with a probability of 1.0. This assumption is in compliance with a request by the U.S. Environmental Protection Agency during the comment period that their proposed criterion of reliance on administrative control for no longer than 100 years be recognized.

The calculations for each of the more-expensive alternatives were made by dividing the difference in budgetary costs between that alternative and Alternative 1 by the difference in risk between the two alternatives. The result, expressed as dollars per man-rem, is the cost for reducing risk below the risk attainable with the least expensive alternative. The negative result for Alternative 3 indicates that it has higher cost and higher risk than Alternative 1.

B. RESULTS

1. Total Effective Cost and Incremental Cost Risk

Results of the evaluation discussed in Section A are given in Tables XI-5 through XI-9 , along with maximum year consequences and probabilities that form part of the total risk. More detail on the basis of both the risks and costs is given in Reference 6.

2. Comparison of Risks with Natural Background and Standards

Radiation from naturally occurring radioisotopes and extra terrestrial sources (e.g., cosmic rays) is estimated to result in an average exposure of about 120 mrem/year to each individual living in the vicinity of the SRP site. Within 150 km (93 miles) of SRP, the background radiation level ranges from 60 to 450 mrem/year. In addition, about 100 mrem/year is received by the average individual in the general population from medical x-rays. For comparison, the present Federal standard that limits exposure to the average member of the population to acceptable levels is an additional 170 mrem/year from nuclear plant operations.

The population within 150 km of the center of the plantsite is about 1.7 million. In one year, the total exposure of this population to natural radiation is about 200,000 man-rem, and the total exposure from medical x-rays is about 180,000 man-rem. The total yearly exposure of this population, from natural radiation and medical x-rays, is thus about 380,000 man-rem/yr. Exposure risks to the surrounding population have been integrated over a 300-year period and a 10,000-year period, and in the latter case are compared with the average natural exposure to the same population. The risks over 10,000 years are not markedly different from those over 300 years, because most of the risk arises from short-lived isotopes. It has been hypothesized that health effects such as cancer might be caused in individuals exposed to low levels of radiation, and an average value of about 200 health effects per million man-rem has been calculated by extrapolating observations at high dose rates to low dose rates. This value has been used to calculate the possible health effects from waste management activities over 10,000 years, as well as those to be expected from natural background.

As detailed in other sections of this report, estimated exposures to the general population for the various alternative plans for long-term waste management are far below exposures from naturally occurring radioisotopes and from medical x-rays. The estimated exposures are very small in comparison with standards set by the Federal Government.

During the period in which the waste would be processed (if the waste is converted to a solid form), the radiation dose commitment* risk from processing operations is estimated to be about 3 man-rem/yr to the population within 150 km of the center of the plantsite, or 0.001 percent of the dose received from naturally occurring radioisotopes and medical x-rays. If solidified waste is shipped offsite, the dose commitment risk during this period due to transportation of the waste would be 60 to 160 man-rem/yr to the (much larger) general population along the transportation routes. Again, this is a very small fraction of the exposure to naturally occurring radioisotopes and medical x-rays.

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* Radiation dose commitment is the amount of radiation dose received from major pathways of exposure, internal and external, throughout the 70-year lifetime of an individual from direct first-pass exposure, assuming the exposure is received at age 20. Population dose commitment is the sum of radiation dose commitment of all individuals (total population in a given area) and is expressed in units of man-rem.

TABLE XI-5

Summary of Costs and Exposure Risks for Alternative 1:
Storage of Waste as Sludge and Damp Salt Cake in Onsite Waste Tanks
(Present SRP Waste Management Technique)

Event	*Population Dose for Maximum Year, man-rem*	*Probability, events/year*	*Maximum Risk, man-rem/year*
Removal From Tanks	Not applicable	Not applicable	Not applicable
Processing	Not applicable	Not applicable	Not applicable
Transportation	Not applicable	Not applicable	Not applicable
Storage			
Routine Releases	1.4	1.0	1.4
Spill During Transfer	5.3×10^2	5.0×10^{-3}	2.6
Explosion	3.0×10^4	1.0×10^{-4}	3.0
Sabotage by Dispersal	2.3×10^4	1.0×10^{-5}	2.3×10^{-1}
Sabotage by Explosion	9.8×10^3	1.0×10^{-5}	9.8×10^{-2}
Airplane Crash	1.1×10^4	1.0×10^{-5}	1.1×10^{-1}
Abandonment	2.7×10^4	1.0×10^{-5}	2.7×10^{-1}

Time-Integrated Risk, man-rem (300 years) (with abandonment)	2.4×10^4
Risk Value at $1000/man-rem, millions	$24
Budgetary Cost, millions	$510
Total Cost, millions	$534
Incremental Cost-Risk, dollars/man-rem	(Base Case)
Time-Integrated Risk, man-rem (10,000 years)	2.3×10^3
Natural Background Exposure, man-rem (10,000 years)	1.0×10^{10}
Possible Waste Management Health Effects	0.5
Health Effects from Natural Background	2,000,000

TABLE XI-6

Summary of Costs and Exposure Risks for Alternative 2-Subcase 1: Glass Stored in Offsite Geologic Storage and Decontaminated Salt Cake Stored in Onsite Underground Waste Tanks

Event	*Population Dose for Maximum Year, man-rem*	*Probability, events/year*	*Maximum Risk, man-rem/year*
Removal From Tanks			
Routine Releases	1.4	1.0	1.4
Sludge Spill	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.7×10^{5}	1.0×10^{-5}	1.7
Processing			
Routine Releases	3.0	1.0	3.0
Process Incidents	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation			
Routine Exposures	6.3×10^{1}	1.3×10^{-4}	6.3×10^{1}
Accidents	1.2×10^{2}	2.1×10^{-5}	1.6×10^{-2}
Storage			
Expected Releases	1.3×10^{2}	1.0	1.3×10^{2}

Time-Integrated Risk, man-rem (300 yr)	6.5×10^{2}
Risk Value at $1000/man-rem, millions	0.65
Budgetary Cost, millions	$3600
Total Cost, millions	$3600.7
Incremental Cost-Risk, dollars/man-rem	$132,000
Time-Integrated Risk, man-rem (10,000 yr)	6.5×10^{2}
Natural Background Exposure, man-rem (10,000 yr)	1.0×10^{10}
Possible Waste Management Health Effects	0.1
Health Effects from Natural Background	2,000,000

TABLE XI-7

Summary of Costs and Exposure Risks for Alternative 2-Subcase 2: Glass Stored in Onsite Surface Storage Facility and Decontaminated Salt Cake Returned to Onsite Waste Tanks

Event	*Population Dose for Maximum Year, man-rem*	*Probability, events/year*	*Maximum Risk, man-rem/year*
Removal From Tanks			
Routine Releases	1.4	1.0	1.4
Sludge Spill	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.7×10^{5}	1.0×10^{-5}	1.7
Processing			
Routine Releases	3.0	1.0	3.0
Process Incidents	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation	Not Applicable		
Storage			
Sabotage	3.8×10^{3}	1.0×10^{-5}	3.8×10^{-2}
Airplane Crash	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Abandonment	0	-	0

Time-Integrated Risk, man-rem (300 yr)	2.2×10^{2}
Risk Value at $1000/man-rem, millions	$0.22
Budgetary Cost, millions	$3750
Total Cost, millions	$3750.2
Incremental Cost-Risk, dollars/man-rem	$135,000
Time-Integrated Risk, man-rem (10,000 yr)	3.4×10^{2}
Natural Background Exposure, man-rem (10,000 yr)	1.0×10^{10}
Possible Waste Management Health Effects	0.07
Health Effects from Natural Background	2,000,000

TABLE XI-8

Summary of Costs and Exposure Risks for Alternative 2-Subcase 3: Glass Disposed of in SRP Bedrock and Decontaminated Salt Cake Stored in Onsite Underground Waste Tanks

Event	*Population Dose for Maximum Year, man-rem*	*Probability, events/year*	*Maximum Risk, man-rem/year*
Removal From Tanks			
Routine Releases	1.4	1.0	1.4
Sludge Spill	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.7×10^{5}	1.0 x 10-5	1.7
Processing			
Routine Releases	3.0	1.0	3.0
Process Incidents	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation		Not Applicable	
Storage			
Expected Releases	1.3×10^{2}	1.0	1.3×10^{2}

Time-Integrated Risk, man-rem (300 yr)	3.4×10^{2}
Risk Value of $1000/man-rem, millions	$0.34
Budgetary Cost, millions	$3610
Total Cost, millions	$3610.3
Incremental Cost-Risk, dollars/man-rem	$129,000
Time-Integrated Risk, man-rem (10,000 yr)	3.4×10^{2}
Natural Background Exposure, man-rem (10,000 yr)	1.0×10^{10}
Possible Waste Management Health Effects	0.07
Health Effects from Natural Background	2,000,000

TABLE XI-9

Summary of Costs and Exposure Risks for Alternative 3: Unprocessed Waste Slurry Disposed of in SRP Bedrock

Event	*Population Dose for Maximum Year, man-rem*	*Probability, events/year*	*Maximum Risk, man-rem/year*
Removal From Tanks			
Routine Releases	1.4	1.0	1.4
Sludge Spill	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.7×10^{5}	1.0×10^{-5}	1.7
Processing	Not Applicable		
Transportation	Not Applicable		
Storage			
Expected Releases	1.3×10^{2}	1.0	1.3×10^{2}
Earthquake With Shaft Open	3.8×10^{8}	3.3×10^{-5}	1.3×10^{4}
Earthquake After Sealing	8.3×10^{6}	3.3×10^{-6}	2.8×10^{1}
Sabotage Before Sealing	1.5×10^{9}	1.0×10^{-5}	1.5×10^{4}
Sabotage After Sealing	1.4×10^{7}	3.3×10^{-10}	4.6×10^{-3}

Time-Integrated Risk, man-rem (300 yr)	6.2×10^{4}
Risk Value at $1000/man-rem, millions	$62
Budgetary Cost, millions	$755
Total Cost, millions	$817
Incremental Cost-Risk	-$6500[a]
Time-Integrated Risk, man-rem (10,000 yr)	1.4×10^{5}
Natural Background Exposure, man-rem (10,000 yr)	1.0×10^{10}
Possible Waste Management Health Effects	28
Health Effects from Natural Background	2,000,000

a. The negative value indicates this alternative is more expensive and has higher risk than Alternative 1.

The estimated radiation dose commitment risk to the general public during storage of the waste is less than 10 man-rem/yr for most of the cases. This dose commitment is also very small compared to those from naturally occurring radioisotopes and x-rays.

If liquid is stored in a cavern, a severe earthquake or major sabotage during the one-year filling period could contaminate the Tuscaloosa aquifer. Large (probably lethal) individual radiation doses would result if people drank this contaminated water. Because of the possibility of these occurrences, the average radiation dose risk over a 300-year period for liquid waste storage in a bedrock cavern is about 180 man-rem/yr. These comparisons are summarized in Table XI-10.

C. SENSITIVITY ANALYSIS

This section is limited to highlighting the important elements of risk for the alternative plans. The cost estimates particularly those for geologic storage could change in magnitude for many different reasons, but the relative cost differences among the alternatives are expected to remain as given in this document.

TABLE XI-10

Comparison of Radiation Risks from Waste Management Operations with Other Sources

Source of Radiation	*Estimated Average Radiation Dose Risk, man-rem/year*[a]	*Time Factor, years*
Natural Sources	200,000	-
Medical x-rays	180,000	-
Liquid Waste in Bedrock Cavern	180	300
Canned Waste in Bedrock Cavern	30	300
Monitored Storage in Vaults	<10	300
Waste Processing Operations	22	5
Offsite Shipment of Canned Waste	60 to 160	5

a. Whole body equivalent.

The time-integrated risks arise almost completely from the storage operation. This is primarily because a time period of 300 or 10,000 years is considered for storage, but removal from tanks, processing, and transportation are all accomplished within about five years. Events with some of the largest consequences are also involved with storage.

Another aspect of the importance of the storage options is that removal from tanks is common to all the alternative plans except one, and processing is common to many. These two operations therefore cancel out of the comparison of many of the alternatives.

The events that have large consequences that strongly influence the relative risks of the alternatives are the following:

1. Sabotage for all the operations in each alternative has been assessed to be among the events with the largest consequences. Even so, the magnitudes of the consequences, particularly as measured by offsite individual doses and land contamination, are not very significant and are unlikely to be the kinds of results a terrorist group would find worthwhile. An exception is sabotage of liquid waste in a bedrock cavern at SRP. All the sabotage events were given a probability of success of 10^{-5} per year. If this were increased by two or more orders of magnitude, sabotage could have a dominating influence on the relative risks of the alternative plans.

2. Possible contamination of the Tuscaloosa aquifer if liquid waste is disposed of in an SRP bedrock cavern has the largest risk considered. This risk arises from possible earthquakes before or after shaft sealing and from sabotage before sealing. The consequences of these events are quite high, and although their probabilities are estimated to be low, the current state of knowledge does not allow them to be reduced enough further to result in a low risk. This alternative does, however, have promising possibilities for corrective action to almost eliminate the consequences if the events did occur. Consideration of using corrective action and of obtaining confidence in lower probabilities of contaminating the aquifer is important, because this alternative is relatively inexpensive.

3. Abandonment of a continued tank farm operation during the next century has a relatively large consequence that is reduced to a relatively small risk by using a probability of 10^{-5} per year. Raising this probability by an order of magnitude would make risk from abandonment comparable to the other tank farm risks. Even if the probability were assumed to be 100% that abandonment would occur early in the next century, the integrated population dose of 6.1×10^5 man-rem

valued at $\$6.1 \times 10^8$ would leave this alternative with the second lowest total cost (with liquid in SRP bedrock being slightly cheaper). Another consideration regarding abandonment is that the resulting individual doses would be low, and the event is amenable to corrective action.

An exception to the rule of low individual doses could occur from concentration of ^{137}Cs in fish in the Savannah River. If a societal situation could exist that could support a commercial fishing operation on the present scale and at the same time tolerate abandonment of the tanks, then about 200 people could get individual doses as great as 11 rem/yr if they continued to eat downstream fish.

In addition to the difficulty in estimating a probability for abandonment, there is also an uncertainty about the proper valuation of the consequences. In a society that had degenerated to the point that the tanks were abandoned, any adverse effects from the small amount of radiation exposure would be inconsequential compared with other hazards to life. The figure of $1000 per man-rem would probably overestimate the value the populace would place on possible radiation insults.

4. Consideration was given to the possible radiation doses that could occur over time periods of thousands of years. Time integrated doses given in previous sections of this document were evaluated for 300 years, and risks from ^{90}Sr and ^{137}Cs have ended by that time and risks from ^{238}Pu have almost ended. After about 1000 years, ^{239}Pu and ^{99}Tc are the main radioactive constituents of the waste. Because whole body and bone dose conversion factors for ^{99}Tc are factors of 500 and 6000, respectively, below those for ^{239}Pu, any radiological hazard would arise primarily from ^{239}Pu.

   Perspective on what such hazards might be can be obtained by considering the contribution to individual dose commitments from ^{239}Pu for the previously discussed abandonment of tanks. For that event, it was postulated that all waste would escape in about 135 years and that 10% would reach the Savannah River and influence the drinking water downstream. Such a rate of human consumption of ^{239}Pu would be much faster than the remaining 90% could leave the immediate tank area, move through the groundwater and surface streams, and ultimately undergo human consumption. Present indications from ion exchange mechanisms are that such movement, if it occurred at all, would take tens of thousands of years. However, for the tank abandonment case, individual bone dose commitments for the year of maximum uptake of ^{239}Pu were shown in the DWD[5] to be only 4.4×10^{-4} rem/person. Even if an individual added to that commitment by drinking such water for his lifetime, the result would still only be comparable to the lifetime dose commitment from ^{40}K (about 10^{-2} rem) that has always been a natural part of the bones of humans.

Thus, as shown in Tables V-12 through V-16 and Tables XI-5 through XI-9, individual doses that could be incurred from the risk scenarios covered in this document by extending the time scale beyond 300 years are so low that such a time extension is irrelevant to the process of choosing among waste management alternatives. Individual doses over time periods of a thousand years and longer would arise almost exclusively from ^{239}Pu, and, with the exception of a few maximum individuals near the scene of a hypothetical sabotage, would be tens to thousands of times lower than doses occurring naturally (which themselves vary by factors of three or four). This conclusion is supported by:

1. the low individual doses that would result from even a relatively rapid introduction of ^{239}Pu to the drinking water pathway (tank abandonment, over 135 years); and,

2. the much longer time span and greater dilution that would prevail for other pathways because of ion exchange holdup, slow movement of groundwater, dilution and holdup in the oceans, and radioactive decay.

D. CORRECTIVE ACTIONS

Radiation doses have been reported in this document with an emphasis on establishing a sound physical basis for upper limits on the amount of activity that could be released and on the most pessimistic pathways to man. Humans were assumed to receive the resulting radiation doses in a passive manner with no attempt at corrective action. However, corrective action could be taken if some responsible, organized society exists in the future. Because these corrective actions are relatively inexpensive and technically straightforward, the possibility of their implementation should be considered in weighing the pros and cons of each alternative. Likewise, the existence of these possibilities should further decrease the attractiveness of the waste storage facilities to saboteurs.

Table XI-11 gives examples of the corrective actions that could be applied to typical events, with an estimate of the cost. The corrective actions are described below.

1. Corrective Action A — Reduction of Atmospheric Exposure

Assume a rapid warning system has been set up for the area in which significant individual doses could be obtained from an airborne waste release. Analyses show that the required coverage would not have to be as great as even the SRP-to-Augusta distance. Given a wind velocity of 6 to 8 mph under the assumed 95th percentile bad weather conditions, at least an hour would be available to spread the alarm after an SRP release. The warning network might be any combination of in-place sirens, roving automobiles with loudspeakers, commercial radio and television announcements, C.B. radio, operators ringing telephones, and the civil defense warning system. The Savannah River Plant already has in operation a meteorological instrumentation and computer system to predict and monitor the path of any airborne release, so only people within the affected direction and distance would need to be contacted.

The appropriate action would require no special equipment or prior training. It would merely be for people to stay inside buildings or cars with the windows closed and any forced ventilation systems turned off. In addition, they might take simple air filtering action. The reason these actions are effective is that the hazard is from inhalation of the small radioactive particles, not from the negligible external dose from the radioactive plume passing over.

If the assumption is made that only 95% of the people in the affected area get the alarm and follow the procedure, then the population dose would be reduced by a factor of 14.

The risk of these airborne events is probably too low to justify any prior action, but for purposes of this study the cost is assumed to be $1 million for 100 sirens at $10,000 each, plus $1 million for an educational campaign, plus $1 million for operational expenses during an incident.

TABLE XI-11

Corrective Actions for Typical Events

	Type of Corrective Action	*Cost of Corrective Action, $*
Air-Cooled Vault with Glass		
Sabotage with conventional explosives	A	3×10^6
Airplane crash	A	3×10^6
Tank Farm		
Abandonment	B	2×10^6
Sabotage by spraying	A & B	5×10^6
Sabotage with conventional explosives	A &.B	5×10^6
Airplane crash	A & B	5×10^6
Triassic Cavern		
Expected releases	None required	---
Explosion in cavern	None required	---
Earthquake with open shaft	D	2.0×10^7
Earthquake after sealing	C	2.5×10^7
Sabotage with conventional explosives	D	2.0×10^7
Sabotage by drilling	None applicable	---

2. Corrective Action B — Reduction of River Water Exposure

A few days would pass before a liquid waste spill on the surface of the SRP site could flow through the creeks and swamp and to the river and then down the river to the drinking water users in the Savannah area. During this time a monitoring system would be set up downriver, and water system intake pumps would be shut down as the pulse of activity passed. This action should not cause an intolerable inconvenience because the pulses from the events studied would last at most a day or two. The available lead time could also be used to fill reservoir capacity before the arrival of activity. Another factor that mitigates the inconvenience is that industrial and household use of contaminated water could continue if adequate reservoir capacity were not available for storage during the entire length of the pulse. Drinking water accounts for less than 0.1% of a typical city's consumption, and adequate supplies could be stored in each household, etc., before arrival of the contaminated water.

With the above considerations, it is reasonable to expect the population dose would be reduced by a factor of at least 100. The maximum individual dose will be assumed to remain unchanged.

The cost is assumed to be $1 million for the monitoring system and flushout and $1 million for the spread of information and operations during an incident. Because SRP already has the required monitoring instrumentation and personnel, none of this money has to be spent in advance.

3. Corrective Action C — Reduction of Tuscaloosa Aquifer Exposure

The population doses given from use of contaminated Tuscaloosa aquifer water are based upon the assumption that the 50,000 users taking a certain fraction of the flow also take that same fraction of the activity released to the aquifer. This means the activity is assumed to be mixed uniformly, but in reality it will enter in a small area and then will diffuse outward. It will also be transported as a diffused plume in the direction of flow.

The corrective action would be to drill test wells to determine the boundaries of acceptable dilution created by the combination of diffusion and plume formation. The assumed 10% of the aquifer flow to be used by the 50,000 people is then taken from regions with negligible activity. Since the Sr and Cs is expected to remain within the aquifer under the plantsite for thousands of years, it will decay before reaching the river. The population doses are therefore assumed to be zero, except for the dose that might arise over very long periods from the long-lived isotopes such as ^{129}I, ^{135}Cs, and ^{239}Pu (if Pu migrates). The latter doses have been included in the consequence calculations, even though the resulting individual doses would be spread over thousands of years and would be a very small fraction of natural background.

All the water needed for ordinary use by people and probably all the industrial uses could be obtained from the McBean-Congaree aquifer, which lies above the Tuscaloosa aquifer and is unconnected to it. The projected use of the water under the plantsite by 50,000 people was based on 200 gal/day per person and use of 10% of the Tuscaloosa flow,[6] to give 10 million gal/day withdrawal. This is equivalent to 6900 gal/min. Wells in the McBean-Congaree aquifer now routinely supply 300 gal/min, so 23 such wells over the area of the plantsite could meet the requirement. Jackson and New Ellenton now each have a well capable of over 1 million gal/day withdrawal from that source.

Another approach is to consider that, of the 200 gal/day per capita consumption, only perhaps 50 gal/day need be distributed through an ordinary city system. This water and that used by small rural wells could be taken from the McBean-Congaree, as it is now. The remaining 150 gal/day allocation to industrial users could be taken from the Tuscaloosa. Any small amount of activity in the reject water flowing to the river would be sufficiently diluted in the river that negligible downstream dose would result.

The cost of this action is assumed to be $20 million for the mapping wells and monitoring plus $5 million for user wells not required otherwise. An initial system of monitoring wells would be part of any bedrock storage project, so that again none of this expense would have to be incurred in advance of an actual contamination incident.

4. Corrective Action D — Repair of Shaft Breakage to Re-isolate SRP Bedrock Storage from the Tuscaloosa Aquifer

One of the largest consequence accidents considered in the risk section is from a breaching in the open shaft of an SRP bedrock cavern; this breach could admit the waste from the cavern to the overlaying Tuscaloosa aquifer. However, such an accident can occur only when the shaft is actively manned because, once the waste is emplaced, the shaft will be sealed. During this active period, it is highly probable any shaft breach could be cleared out and resealed before significant activity were transferred to the Tuscaloosa aquifer.

The assumption is made that the shaft could be cleared and resealed for double the $10 million cost of construction the shaft initially. It is further assumed that this action prevents any activity from reaching the aquifer.

E. REFERENCES FOR SECTION XI

1. "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors." *Nuclear Regulation Guide No. 1.110*, Nuclear Regulatory Commission (1976).

2. *Reactor Safety Study - An Assessment of Accident Risks in U. S. Commercial Nuclear Power Plants.* WASH 1400, Appendix VI, Section 12.4, NUREG-75-014.

3. R. S. Russell (ed.). *Radioactivity and Human Diet*, Pergamon Press, Oxford, England (1966).

4. B. Aberg and F. P. Hungate (eds.). *Radioecological Concentration Processes - Proceedings of an International Symposium Held in Stockholm, 25-29 April, 1966*, Pergamon Press, Oxford, England (1967).

5. *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste.* Report ERDA-77-42-1, Energy Research and Development Administration (May 1977).

6. R. F. Bradley and J. C. Corey. *Technical Assessment of Bedrock Waste Storage at the Savannah River Plant.* ERDA Report DP-1438, Savannah River Laboratory, E. I. du Pont de Nemours and Co., Aiken, SC (1976).

XII. ENVIRONMENTAL TRADE-OFFS AMONG ALTERNATIVES

A summary of the quantifiable environmental impacts of each alternative is given in Table XII-1. The risk items shown in Table XII-1 are discussed more fully in Section V, and the costs are covered in Section X. Table XII-1 also shows the lifetime radiation dose commitment that the affected offsite population will receive from natural background.

Table XII-1 shows that there are no substantial environmental impacts arising from nuclear radiation for any of the three alternatives. The offsite population exposure risk from the alternative with highest risk (liquid waste stored in an SRP bedrock cavern) is about one-thousandfold lower than natural radiation exposure to the same population. It should be noted that there are large populated areas in this region that receive at least twice the average natural exposure and the public makes no attempt whatsoever to avoid these areas, indicating that there is no extensive public concern with exposures of this magnitude. The factor of 200 cancer deaths per million man-rem recommended by the EPA can be used to convert the exposures from Table XII-1 to possible health effects. This may overestimate the radiation effect, as explained in Reference 1. Based on the EPA factor, the difference between the alternatives with highest and lowest offsite risk amounts to 12 fatalities over a 300-year period, whereas under the same assumptions, the same population would experience about 46,000 fatalities over the 300-year period from natural radiation effects.

Non-nuclear fatalities to be expected from construction and operating activities related to each alternative are greater than those that would be expected from radiation effects, but are no larger than the risks voluntarily accepted by industrial workers.

The significant quantifiable differences between the alternatives are the differences in budgetary costs. The cost differences of as much as $3.2 billion among the alternatives are related to environmental trade-offs to the extent that environmental improvements are foregone in other areas by the expenditure of monies on radioactive waste management. Costs also influence the benefits left to future generations. Money spent now on radioactive waste management does not create productive assets that accrue to the benefit of the future, since such money must be taken from the mainstream of activities represented by the gross national product (GNP). The GNP includes many items that represent present day consumption of goods and services, but it also includes capital investment aimed at future productivity. Past experience has shown that the GNP includes enough investment in future productivity to grow at a rate of about 4% per year (corrected for inflation). This growth in productivity would be denied future generations for the money spent now on extra levels of risk reduction in the waste management area.

The difficult-to-quantify factors related to each alternative are shown with qualitative rankings in Table XII-2, and are a summary of discussions given in Sections V, VI, VII, VIII, and IX.

Cost considerations and how they are balanced in a judgmental manner with the unquantifiable factors listed in Table XII-2 are key elements in a decision process regarding which alternative should be implemented. Offsite radiation risks, occupational exposures, non-nuclear risks, and other environmental effects are relatively insignificant factors, because they are small in both absolute magnitude and when their monetary evaluation is compared with budgetary costs (see Section XI on cost-risk-benefit analysis).

A summary of long-term and short-term costs and nuclear risks is given in Table XII-3 Short-term risks are the sum of occupational and offsite risks until the waste is placed in storage or disposal (about 10 years after start of removal from tanks). Long-term risks are the sum of occupational and offsite risks for 300 years after the waste is placed in storage or disposal.

TABLE XII-1

Quantifiable Environmental Impacts

	Alternative 1	*Alternative 2*			*Alternative 3*
	Continued Tank Farm Operation	*Subcase 1* *Glass Shipped to Offsite Repository*	*Subcase 2* *Glass in SRP Surface Storage*	*Subcase 3* *Glass in SRP Bedrock*	*Liquid in SRP Bedrock*
Occupational Radiation Exposures Based on SRP Experience, man-rem[a]	360	3,800	2,700	2,400	42
Occupational Radiation Exposures Based on DOE Standards, man-rem[a]	4,300	30,000	32,000	28,000	500
Offsite Population Dose Risk, man-rem[b] (300 yr)	1,400	650	220	340	62,000
Offsite Population Dose Risk, man-rem[b] (10,000 yr)	2,300	650	340	340	140,000
Offsite Population Dose, man-rem (300 years)	230,000,000	230,000,000[d]	230,000,000	230,000,000	230,000,000
From Natural Radiation, man-rem (10,000 years)[c]	7,700,000,000	7,700,000,000	7,700,000,000	7,700,000,000	7,700,000,000
Potential for Accidental Offsite Land Contamination (from Sabotage), acres	130,000	139,000	139,000	139,000	130,000
Non-Nuclear Accidental Fatalities from Construction and Operations	17.1	6.5	6.6	6.2	2.2
Budgetary Cost, millions of 1980 dollars	510	3,600	3,750	3,610	755

a. Campaign totals for all workers.

b. Consequences times probabilities, summed over all events and integrated for 300 years and 10,000 years.

c. For the same time period and population as above.

d. The natural radiation calculations assume the population distribution around the offsite repository would be the same as around the SRP site. This is conservative, because the offsite repository would probably be located in a sparsely populated region.

TABLE XII-2

Summary of Unquantifiable Factors

	Alternative 1	*Alternative 2*			*Alternative 3*
	Continued Tank Farm Operation	*Subcase 1* *Glass Shipped to Offsite Repository*	*Subcase 2* *Glass in SRP Surface Storage*	*Subcase 3* *Glass in SRP Bedrock*	*Liquid in SRP Bedrock*
Relative Degree of Action Required by Future Generations	High	Low	Moderate	Low	Low
Relative Compliance with Public Expectations[a]	Low	High	Moderate	High	Moderate
Conformance with Policies of SC and GA State Governments	Low	High	Moderate	Low	Low
Conformance with NRC Regulations for Commercially-Generated Waste	Low	High	Moderate	High	Low
Potential for Regrets if Future Economics or Technology Indicates a Better Method[b]	Low	High	Moderately High	High	High
Likelihood of Successful Attainment of Required Implementation Technology	Highest	High	Higher	Moderate	Moderate
Effect on Implementation Date Relative to Alternative 2 — Subcase 1	Shortens	-	None	Lengthens	Lengthens
Requires Additional Management of Decontaminated Salt	No	Yes	Yes	Yes	No

a. Based on pre-draft comments and proceedings of DOE and EPA meetings on public policy issues. Also documented in Reference 2.

b. This factor involves both the ease of retrievability from the storage or disposal site and the ease of separating the radioactive constituents from the waste form.

TABLE XII-3

Summary of Long-Term and Short-Term Costs and Nuclear Risks

		Alternative 2			
	Alternative 1 Continued Tank Farm Operation	*Subcase 1* Glass Shipped to Offsite Repository	*Subcase 2* Glass in SRP Surface Storage	*Subcase 3* Glass in SRP Bedrock	*Alternative 3* Liquid in SRP Bedrock
Short-Term Risks,[a] man-rem	0[a]	4.60×10^3	2.57×10^3	2.57×10^3	2.19×10^2
Long-Term Risks,[b] man-rem	1.76×10^3 2.66×10^3	1.30×10^2 1.30×10^2	2.91 1.20×10^2	1.30×10^2 1.30×10^2	6.2×10^4 1.4×10^5
Short-Term Costs,[c] millions of 1980 dollars	0[a]	3600	3750	3610	755
Long-Term Costs,[b,c] millions of 1980 dollars	510[d] 3060[e] 102,000	175	175	175	175

a. Short-term risks are defined to be those that are incurred from activities additional to preparing the waste as salt cake and sludge in modern tanks, because such activities are common to all alternatives. Short-term costs are treated similarly.

b. Long-term risks and costs are integrated for 300 years and for 10,000 years.

c. All costs are in undiscounted 1980 dollars. Discounting of long-term costs would reduce their magnitudes to negligible fractions of short-term costs for any alternative.

d. This is enough for one cycle of tank replacement, and is more than enough to establish a trust fund for perpetual tank replacement.

e. This is enough to replace tanks every 50 years during the 300-year period or the 10,000-year period, undiscounted.

REFERENCES FOR SECTION XII

1. *Environmental Radiation Dose Commitment: An Application to the Nuclear Power Industry*. Report EPA-520/4-73-002, U. S. Environmental Protection Agency (1974).

2. B. D. Melber, S. M. Nealey, J. Hammersla, and W. L. Rankin, *Nuclear Power and the Public: Analysis of Collected Survey Research*. Battelle HARC Report, PNL-2430 (November 1977).

APPENDIX A

SUMMARY OF SUBSTANTIVE ISSUES COVERED IN COMMENT LETTERS

On May 27, 1977, ERDA issued a Federal Register notice (42 FR 27281) announcing the publication of *Alternatives for Long-Term Management of Defense High-Level Radioactive Waste — Savannah River Plant* (ERDA 77-42, also known as the Defense Waste Document, or DWD). Announcement was also made at that time of the intent to issue a programmatic EIS, and the public was invited to use the DWD as reference material to comment upon areas that should be covered in the programmatic EIS. In addition, a draft version of this programmatic EIS was given wide distribution and comments were solicited. Thirty comment letters were received on the DWD, and seventeen were received on the draft of this EIS. The substantive issues that were covered in these letters are summarized below, and are discussed at appropriate points in the main text. Major comments and specific DOE responses are given in Appendix B.

Several respondents indicated they felt that disposal of the waste in a bedrock cavern under the SRP site is an unacceptable alternative because the overlying Tuscaloosa aquifer might become contaminated. Others indicated a preference for the SRP bedrock disposal concept because of the large cost savings and lack of need for transporting the waste long distances inherent in that alternative. Bedrock disposal is retained among the alternatives discussed in this programmatic EIS so that the full range of cost and risk differences among the feasible alternatives may be presented. To eliminate the bedrock disposal concept from full public review at an early stage of decision-making would be to prematurely foreclose an option with important economic and sociological characteristics. It is noted, however, that no research and development work is under way or proposed related to an SRP bedrock cavern.

Suggestions have been made that the alternatives chosen for treatment and disposal of the defense wastes at the Savannah River, Hanford, and Idaho sites be similar, with as little duplication of research and development effort as possible, and with as much application toward commercially generated waste as possible. There is close interaction among the DOE sites, with research and development efforts differing as required by the different forms of waste at each site. If a decision is later made to reprocess commercially generated fuel, some of the work done for defense waste may be applicable to treating commercial waste. There are, however, major differences between the waste types because commercial waste bears a greater radionuclide and heat load. The difference stems from higher burnup of the commercial fuels and a more concentrated waste stream in the commercial plant designs. Also, waste at SRP is generated in an alkaline form by the addition of caustic while commercial reprocessing plants would produce acid waste.

Interest was shown in the analysis of vulnerability to sabotage or terrorism, and in the estimates of probability of successful sabotage. There is no firm basis for estimating the probability of sabotage of waste processing or disposal facilities, and the probabilities used to complete the risk analysis are somewhat arbitrary. However, the consequences of credible sabotage events do have a sound physical basis. These consequences were found to be very small compared to levels that would possibly be attractive to terrorists, and indicate that the probability of sabotage being attempted is very low. Possible sabotage should not weigh heavily in the decision process of choosing an alternative.

Several respondents indicated they felt that cost and cost differences should not be important considerations in choosing among the alternatives, while others thought cost is an important decision factor. Cost estimates are given in this EIS for perspective, but without judgment as to how they should be weighed by decisionmakers.

A period of 300 years was used to calculate time-integrated population exposure risks, and some comments reflected a concern that the time used should be from tens to hundreds of thousands of years. The basis for using 300 years is that enough radioactive decay has occurred by then that exposure to individuals if any of the unlikely events did occur would, in most cases, be small fractions of the natural background radiation individuals always receive. Longer time integration therefore has little meaning for decisionmaking among alternatives or for assessment of environmental impacts that may result from implementation of the alternative presently in the research and development stage. Integrated exposure risks for a period of 10,000 years have been added, however, to illustrate the fact that most of the risk occurs during the early years.

Opinions were given that the risk analyses should use fault-tree methods or some similar system of very detailed and systematic investigation. Such an approach is desirable once an alternative is chosen and engineering designs have been made. Until then, all the important components of the system and their failure probabilities and interactions cannot be defined. Instead, overall events that might have significant offsite exposure consequences were identified using 25 years of operating experience from similar facilities and technical judgment. A sound physical basis was established for upper bounds of the consequences from these events. Many of the overall probabilities of occurrence also have a sound basis from experience, but some are rough estimates (particularly the probability of successful sabotage). This method gives confidence that upper bounds of risks from the important consequences have been discovered, and should be adequate for decision-making among the alternatives. The fact that the resulting maximum risks for any of the alternatives are small also indicates that risk differences among alternatives will not be major decision factors.

A variety of comments and suggestions were received regarding placing a dollar value on population exposure risks as an aid to the decision-making process. The information in both the DWD and in this programmatic EIS is presented in such a way that each decision-maker or other individual can apply his own monetary valuation, or none at all, to the risks.

APPENDIX B

MAJOR COMMENTS AND DOE RESPONSES

Seventeen letters were received commenting on the draft version of the EIS. These comment letters and DOE responses to the comments are given in this appendix. In many cases, revisions were also made in the text of the EIS.

The following letters were received.

Letter Designation	Individual or Organization	Date Rec'd
A	Department of Health, Education, and Welfare	9/12/78
B	Abel Wolman (Johns Hopkins University)	10/2/78
C	Rustum Roy (Pennsylvania State University)	10/6/78
D	National Science Foundation	10/23/78
E	Duke Power Company	10/18/78
F	W. P. Bebbington	10/24/78
G	U.S. Nuclear Regulatory Commission	11/1/78
H	Environmentalists, Inc., Columbia, SC	10/30/78
I	Ruth S. Thomas	10/30/78
J	Ohio Environmental Protection Agency	11/1/78
K	Georgia Conservancy	11/1/78
L	U.S. Environmental Protection Agency	11/16/78
M	W. A. Lochstet (Pennsylvania State University)	11/13/78
N	Congressman Leo J. Ryan	10/12/78
O	U.S. Department of the Interior	10/20/78
P	Office of the Governor of Georgia	1/8/79
Q	Bennie Ricardo Brown, III (Simon's Rock Early College)	6/3/79

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
FOOD AND DRUG ADMINISTRATION
ROCKVILLE, MARYLAND 20857

SEP 12 1978

Mr. W. H. Pennington, Director
Division of Program Review
and Coordination
Office of NEPA Affairs, EV
Department of Energy
Washington, D.C. 20545

RESPONSES

Dear Mr. Pennington:

A-1 The Department of Health, Education, and Welfare has reviewed the health aspects of the Draft Environmental Impact Statement, DOE/EIS-0023-D, Long-Term Management of Defense High-Level Radioactive Waste, Savannah River Plant, Aiken, South Carolina, and have the following comments to offer.

Response: The requested reference has been added to Table 10.

Chapert V. The discussion of potential environmental effects has adequately addressed the issues that impact on public health and safety. It is noted that the occupational exposure of workers and the offsite population exposures are within the current radiation protection guidelines. However, in Table 10 "Typical State and Federal Air and Water Quality Standards," it cites the PHS, Drinking Water Standard, U.S. Department of Health, Education, and Welfare, 1962 as the Federal Drinking Water Standard. The proper reference should be the EPA's National Interim-Drinking Water Regulations, EPS-570/9-76-003. In the preference it states that these regulations will replace the PHS Drinking Water Standards of 1962.

A-2 Chapter XII. The discussions of cost/risk benefit is most helpful in assessing the future environmental and public health impacts from the Savannah River Plant Operations. Moreoever, the recognition of the need to adequately plan for corrective actions that can be taken to reduce population dose in the event of an unplanned release is significant.

Response: No response required.

Continued normal operations at the SRP can be expected to result in minimal environmental impact and to provide adequate protection of the public health and safety.

Sincerely yours,

Charles L. Weaver
Consultant
Bureau of Radiological Health

ABEL WOLMAN
THE JOHNS HOPKINS UNIVERSITY
BALTIMORE, MARYLAND 21218

2 OCTOBER 1978

Mr. W. H. Pennington, Director
Division of Program Review and Coordination
Office of NEPA Affairs, EV
Department of Energy
Washington, D.C. 20545

My dear Mr. Pennington:

B-1 Your letter and enclosure of August 3, 1978, have been received. The Report covers an Environmental Impact Statement on high level radioactive wastes at the Savannah River Plant, at Aiken, South Carolina.

The document impressed me as an excellent review of the long term history of examination of this provocative problem. Some reference should be made, as well, to the fact that AEC laboratories began work on containment of these wastes more than 20 years ago. This would round out the complete record of attention over at least a quarter of a century.

Reference to previous work on long-term waste management has been added in Section II-G, History of Review of the Long-Range Waste Management Program at SRP.

B-2 The alternatives considered and quantified appear reasonable, even though many of the attributes are essentially qualitatively assessed.

No response required.

B-3 One must inevitably be concerned about the fact that nearly ten years have passed since recommendations for critical exploration of bed-rock possibilities had been generally agreed upon by competent students of the problem. The abrupt closure by AEC in 1972 of these proposals should be clarified to the extent that the decision was non-technical and more a reflection of political threats by South Carolina representatives.

In any event, the present document, it is hoped, will move the exploration off of dead center.

The concluding paragraph of Section II has been modified to respond to this comment.

Very truly yours,

Abel Wolman
AW:eh

THE PENNSYLVANIA STATE UNIVERSITY
UNIVERSITY PARK, PENNSYLVANIA 16802
Telephone (814) 865-3421
October 6, 1978

W. H. Pennington
Mail Station E-201
GTN
Department of Energy
Washington, D.C. 20545

Dear Mr. Pennington:

Enclosed herewith some comments on the SRP EIS as requested in your letter.

Sincerely,

Rustum Roy
Director, Materials Research Laboratory
and
Chairman, Science, Technology and Society Program

COMMENTS ON DRAFT EIS
Savannah River Plant

General Comments

C-1 The document is a well-reasoned presentation of the probable environmental impact of the three waste disposal scenarios. I believe that a convincing case has been made that solidification itself would not be a highly impacting step.

A very fine part of the statement is the well-written summary which allows a reader to get a good perspective of the whole operation.

Response: This comment requires no response.

C-2 General Critique

1. Although it is alleged that these main scenarios have been treated as alternatives, in fact the entire document is focused on the glass alternative, and the three sub-cases thereof. This is not so serious a defect for the purpose of the EIS, however, it clearly leaves completely open the most important choice which DOE will have to make: which system?

Response: The purpose of the document is to explore the environmental implications of proceeding with an R&D program and the environmental impacts of alternatives thereto. Any later proposals to take action of potentially significant impact, such as the construction of a major waste treatment facility on the construction of a permanent waste repository, will be covered in subsequent project-specific environmental reviews.

2. The document does not specify the choice sufficiently to be meaningful. i.e. Unless the total system is described, how can the risks and costs be quantified. e.g.:

a) Offsite shipment to where? Transportation accidents are function of distance.

Response: A detailed explanation of the assumptions used in the risk assessment are included in ERDA 77-42. For conservatism, shipment was assumed over 3000 miles (probably the maximum distance a repository would be from SRP).

b) What geological host rock? This will determine design of temperature of container, which in turn will determine concentration of waste in glass. At 35% (p.IV-12) what would be the temperature at the surface of the container? P.IV-12 states that once emplaced the integrity of glass and container no longer matter, i.e. the release of the radionuclides is expected. (Probably correct evaluation.) THIS MEANS THAT UNLESS THE ROCK FORMATION OR

HYDRO-GEOLOGY CAN BE GUARANTEED SOMEWHERE OFFSITE, THE OPTION IS NOT VIABLE. Until this part of the system is readied, can one proceed with this option.

The specific disposal method on host media has not been selected. The proposed R&D program is flexible enough that it does not foreclose any of the geologic disposal options now under consideration. The summary has been modified to reflect this. It is emphasized that the Savannah River wastes produce very little heat. Even if canisters of glass containing five-year-old waste were emplaced in a salt cavern and the cavern were immediately backfilled and sealed, and the waste canisters were assumed to immediately disappear, the interface temperature between glass and salt would be about 150°C. In actual practice, four canisters of five-year-old waste would be produced compared with the number of canisters containing the very much older waste now on hand. The five-year-old canisters would be widely spaced among the cool canisters, even if they were actually placed in the repository immediately after production. The repository would remain open, dry, and cooled many years after waste production at Savannah River closed. The outer canister containing the glass would be specially chosen to give a long lifetime in whatever host medium the waste were emplaced, and the vicinity near each container would be backfilled with material having desirable chemical properties relative to the container and desirable retention properties relative to any waste that could escape. Taking all these factors into account means that the glass would never experience an interface temperature greater than 80-100°C, and it would be surrounded by a compatible host medium. There is abundant experimental evidence that glass is a high integrity waste from under these conditions.

C-3 3. The document is most baffling in what it omits. Surely both Alternative 1 and 3 were straw-men and should have had subcases which are the REAL COMPETITORS FOR THE GLASS OFFSITE SCENARIO. For example, why were these not considered.

Thus Alternative 1b: Dewater and add carefully tailored additions and concrete to solidify in tanks. Entomb with reinforced concrete, and grout under tanks with tailored supergrout.

With regard to Alternative 1b, scoping estimates have been made in the past for various means of in-tank solidification. When safety, occupational exposure requirements, and assurance of product quality and uniformity are provided for, these options cost about the same as removal from tanks and conversion to a high integrity form, and they provide an inferior disposal system.

Alternative 3b: Instead of the ludicrous straw man of pumping raw liquid or slurry into bedrock, employ well established (and improved by "super-grouting") Oak Ridge technology to solidify wastes in absorptive concrete. In my view the most probably real choices will be between Alt. 1b and 3b mentioned above. The technology of 3b is FAR ADVANCED OVER ANY GLASS TECHNOLOGY, with over 10 years experience in the U.S. Why was it ignored?

Alternative 3b could be employed if a decision were made to dispose of the waste in a bedrock cavern at Savannah River. The Oak Ridge technology is not applicable at Savannah River, since Oak Ridge uses fractured shale in thin sheets for disposal, and no such geology is available at Savannah River. The reference document, ERDA-77-42, discussed several low-integrity waste forms emplaced in bedrock under Savannah River. As discussed in Section IV-D, hot-pressed concrete as an alternative waste form is being investigated at DOE laboratories and will be considered as a possibility for the SRP wastes.

C-4 4. Budgetary costs. These are so dependent on specific technical choices (such as density of loading in canisters, and canister transportation and emplacement) that it borders on the meaningless unless the TOTAL SYSTEM COST IS SPECIFIED.

Total system costs are discussed and estimated in Sections X and XI. A large portion of the cost of the waste management program for the Savannah River defense waste will be for construction of the large shielded building for carrying out operations on the waste, and for removal of the waste from existing tanks and processing the waste so that it is ready for incorporation into some high integrity form. Total system costs are therefore not very sensitive to credible variations in present estimates of loading density, transportation, or emplacement. ERDA 77-42, Section IX, contains the detailed assumptions for cost estimating purposes.

C-5 Specific Critiques

p.11-1 (Para. 2, end) It is implied that grouting into bedrock would require "extensive R&D." This implies that such R&D would be more extensive than for the glass option. *The exact opposite is true by one* to two orders of magnitude. So far the U.S. glass R&D has not resulted in firming up (a) Composition and (b) Melter design, leave alone any actual technical problems such as electrode compositions, lifetime tests of refractories, etc. Compare this with Oak Ridge grouting technology - 10 years in situ experience. Which needs more R&D??

The sentence referred to in the comment addresses liquid waste (Alternative 3), not concrete grout. Most of the R&D required would be for the bedrock cavern itself and determination of its likely integrity, not for the waste form. As stated in Response C-3, the Oak Ridge technology is not applicable to the rocks underlying the Savannah River site, and also the Oak Ridge system is used for intermediate level wastes rather than high-level waste.

C-6 p.II-9. The candid if incomplete reports of the NAS *Committee and GAO reports leave me with the puzzle* - WHY DIDN'T SRP do R&D on the alternatives?

As stated in the Atomic Energy Commission press release *November 17, 1972, on postponing development of the bedrock* project at the Savannah River Plant, the Commission will place priority on research and development on other disposal methods. Consistent with the recommendations of the Interagency Review Group on Nuclear Waste Management (TID-29442), the Department of Energy is proposing to continue national research and development program on immobilization of the radioactive high-level waste for subsequent disposal. This program is described in Section IV-D.

C-7 p.II-9. Contd 4.3). This single statement is cited over and over again, as though it were the last word from the State government. It is a mild statement. Since then optistic estimates of other sites have changed. MOREOVER I BELIEVE THAT THE E.I.S. TOTALLY UNREALISTIC IN ITS"SOCIO-POLITICAL E.I.S." SURELY THE STATE OF S. CAROLINA SHOULD BE PAID SUMS IN THE ORDER OF HUNDREDS OF MILLIONS OF DOLLARS AS PAID FOR FEDERALLY-IMPACTED AREA WHILE EMPLACEMENT PROCEEDS. I believe the S. C. Legislature would have a very different attitude with a reasonable offer like that.

Selection of radioactive waste repository sites will be in compliance with the applicable regulations/guidelines. Socioeconomic issues will be addressed in project-specific environmental reviews.

C-8 p.II-11 (Para. 1). Very muddled or deliberately misleading. Why did AEC really stop work on bedrock storage in 1972? What was the total $ investment in this study? What was the "technology already in hand?" Glass? If it is not in hand now, how come it was in hand then?

The concluding paragraph of Section II has been modified to respond to this comment. Approximately $3-5M was spent on bedrock disposal studies. The technology in hand was that of retrievable surface storage as opposed to geologic storage.

C-9 p.IV-18 (Para.). The entire tone of the document suggests some urgency to get on with it. Why? "10 year development" of bedrock storage technology (already a high estimate) is unacceptable, as though it was expected that WIPP, and a final storage facility will be in operation in 10 years. Does some one believe that? If no, why the hurry? Will the public be very impressed by some tanks of hot glass? They have had themn at Harwell for 15 years and it hasn't convinced the public.

The decision addressed by this EIS is whether or not DOE should continue an R&D program. Any decision on implementation of an alternative will be addressed in project-specific environmental reviews.

C-10 Final Comment

The urgent, polemic tone advocating a particular solution is distressing. There is so little understanding of the total national picture, the total RWM system, the explosion of new science and technologies. THERE ARE VASTLY BETTER PRODUCTS THAN THE PROPOSED GLASS. VIZ ARTIFICAL MINERALS. THERE ARE VASTLY BETTER PROCESSES - OAK RIDGE GROUTING. UNLESS THESE ARE COMPARED AND A REASON GIVEN FOR CHOOSING GLASS, THE EIS IS INCOMPLETE.

Section IV-D has been included to discuss alternative waste forms, the national and foreign programs for their development, and the reasons for choosing glass as the reference waste form for the research and development, design, and testing program covered in this Programmatic EIS for the Savannah River Waste. The selection of a waste form for implementation in a project will be addressed in a project-specific environmental review.

It is not the intent of the document to imply a sense of urgency. Rather, this document analyzes the impacts of an orderly program for R&D to permit immobilization of the defense waste on a timely schedule, as recommended by the President's Interagency Review Group for nuclear waste management. It should be noted that if the program discussed in this EIS is followed by authorization in 1981, startup would not begin until 1988, and waste processing would work down the old inventory and become current with waste production in about the year 2000. It is also pointed out that the impact of further delay in the program would be continued storage of wastes in tanks, requirements to build more new tanks, and increased costs.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

October 23, 1978

OFFICE OF THE ASSISTANT DIRECTOR
FOR ASTRONOMICAL, ATMOSPHERIC,
EARTH, AND OCEAN SCIENCES

Mr. W. H. Pennington, Director
Division of Program Review
and Coordination
Office of NEPA Affairs, EV
Department of Energy
Washington, DC 20545

Dear Mr. Pennington:

Your letter of 31 July 1978 transmitted to the National Science Foundation (NSF) for review the Department of Energy's draft Environmental Impact Statement, DOE/EIS-0023-D, Long Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant (SRP), Aiken, South Carolina.

The draft statement has been reviewed by appropriate NSF staff. The following comments are offered:

D-1 To date, the SRP has an excellent safety record. The local populace is accustomed to the close proximity of that facility. A significant portion of local employment is SRP derived or related. Given the continuation of current trends these factors are unlikely to change significantly.

This DEIS appears to be well prepared and quite complete, with one exception noted. The energy requirement, which will be a high cost factor for each alternative, should be evaluated and considered in the decision process.

Requirements for the principal sources of energy for each alternative are estimated in Table VII-1. Costs for this energy are included in cost estimates discussed in Section XI-C.

D-2 Considering the local geology and hydrology, the size of the reserve wastes, and shortcomings inherent in long distance transportation, alternative (2), subcase (c), seems preferable (process to glass, disposal in bedrock cavern at SRP).

The proposed waste form technology development program does not foreclose any of the repository options being considered. However, selection of the type of geologic formation and the specific sites for repositories will be addressed in separate EIS's.

D-3 The draft statement indicates that certain research and development efforts are yet to be undertaken. When the results of these efforts are known, decisions on the alternatives may be made more adequately. Since the DEIS presents planning data in terms of a 300 year period, alternative (1) could be favored over the other two (continued storage in tanks). This would allow time for more advanced methods of treatment and storage to be developed that may be superior to those of alternatives (2) and (3). Alternative (3) appears to be the least desirable in view of possible problems in the future involving inaccessibility of the wastes.

Sincerely yours,

Daniel Hunt
Deputy Assistant Director

The Report to the President by the Interagency Review Group on Nuclear Waste Management, March 1979 (TID-29442) recommends that immobilization of the waste should begin as soon as practicable. As stated in the Foreword and discussed further in Section IV-D, a large R&D program is being conducted on alternative waste forms. This is in parallel to the development of the reference waste form, borosilicate glass monoliths. The proposed R&D program is aimed at permitting a decision on an SRP immobilization plant in 1982, and on a waste form in 1984.

DUKE POWER COMPANY
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(704) 973-4226

E. B. HAGER
CHIEF ENGINEER
ENVIRONMENTAL DIVISION

October 18, 1978

Department of Energy
Washington, D. C. 20545

Attention: Mr. W. H. Pennington, Director
Division of Program Review
and Coordination
Office of NEPA Affairs, EV

Gentlemen:

Re: Long-Term Management of Defense
High-Level Radioactive Wastes,
Savannah River Plant, Aiken, S. C.
DOE/EIS-0023-D
File Nos. GS-N-9, GS-N-9.9, GS-S-64

E-1 We appreciate the opportunity to comment on the subject environmental impact statement. Radioactive waste disposal, whether it be from the national defense program or from the nuclear electric energy program, is a most important unanswered question. While we recognize that the wastes from nuclear electric generating facilities and those from potential reprocessing facilities are different from the wastes generated at the Savannah River Plant, we believe that much important technology can be gained from the permanent disposal of the Savannah River Plant wastes.

The results of the study presented in the subject report justify a permanent disposal option. The costs are presented for continuation of storage and deferment of permanent disposal are unacceptably high from an environmental standpoint. We urge the Department of Energy to take a lead in demonstrating and licensing permanent radioactive waste disposal. We believe that dealing with waste disposal now will save many dollars, resources, and population exposures, expecially since ultimate disposal must be dealt with.

Yours very truly,

S. B. Hager
SBH/DBB:sd

The Federal government recognizes its responsibility in the proper management and disposal of nuclear waste. On March 13, 1978, President Carter established the Interagency Review Group on Nuclear Waste Management (IRG) to formulate recommendations for establishment of an administration policy with respect to long-term management of nuclear wastes and supporting programs to implement this policy. The draft IRG report was published in October 1978 and received extensive public inputs. The final IRG report (TID-29442) was published in March 1979 and forms the basis for planning by Federal agencies. The Department of Energy proposes to continue its research and development program to immobilize and dispose of the radioactive waste.

W. P. BEBBINGTON
905 WHITNEY DRIVE
AIKEN, SOUTH CAROLINA 29801

October 24, 1978

W. H. Pennington, Director
Division of Program Review and Coordination
Office of NEPA Affairs, EV
Department of Energy
Washington, DC 20545

Dear Dr. Pennington,

Thank you for the opportunity to comment on DOE/EIS-0023-D, "Draft Environmental Statement - Long-Term Management of Defense High-Level Wastes - Savannah River Plant." The Statement presents the dilemma of having to choose among alternatives that entail extremely high costs to achieve extremely low calculated risks and those that entail moderate costs with very low associated risks, one of the latter being the "do nothing" option of continuing forever the present waste-management practices.

F-1 Although no conclusions are presented in the Statement, it is evident from the summaries of "Research and Development Needed" in Section IV that only Alternative 2, Subcase 1, "Process to Glass and Ship to a Federal Repository," is under active consideration. This alternative is estimated to cost $1.7 billion, six times as much as continuing operation of tank storage (Alternative 1), and would achieve only a 36 per cent reduction in risk. Both of these alternatives have, I believe, important "difficult-to-quantify" factors that are not evaluated in Table I-2.

It is correct that Alternative 2-1, "Immobilize and Ship to Federal Repository," is receiving the major attention in the R&D design and testing program. However, decisions regarding the specific waste form or the ultimate disposition of the waste form have yet to be made. The planned R&D programs will provide the technical bases for these decisions. The needed R&D programs are discussed in Section IV-B and Section IV-D, which was added to describe planned work on alternative waste forms. The choice between Alternative 1 and the various options of Alternative 2 must be made considering both cost and the perceived values of the added safety and avoidance of the need for future action.

F-2 Alternative 2, Subcase 1 is so very high in cost that there is a high risk that the funding of it will be indefinitely delayed, thus continuing Alternative 1 by default. Alternative 2-1 would also certainly rate very low in "Conformance with Policies of Governments of States other than S. C. and Ga." Since the citizens of the states where the Federal repository would be located and across which the wastes would be shipped would have derived no economic benefits from the oeprations at Savannah River that created the wastes, their governments would be understandably reluctant to accept responsibility for disposal.

Included in Alternative 2 are three options for the ultimate disposal of the wastes: (1) Disposal in a Federal Repository, (2) Storage in Surface Facility at SRP, and (3) Disposal in a Bedrock Cavern at SRP. Each of these has its own merits and faults which change depending on the viewpoint of the evaluation. Eventually, a consensus decision must be reached that balances both local and national considerations of risk and benefits, both past and present. This statement considers the environmental risks and benefits and demonstrates that the impact is small from any of the alternatives. Other factors, including cost, are evaluated to the extent possible.

F-3 Another "difficult-to-quantify" factor for Alternative 1 is the risk that neither adequate funds nor adequately competent staff will be provided for centuries. Although the estimated cost of this alternative includes the endowment of funds for the future, the actual expenditures will presumably have to be authorized in annual Federal budgets. Attracting high-grade technical staff to the dead storage of old wastes will certainly be difficult.

The requirements for indefinite tank storage are given in Sections IV-B and XI. DOE recognizes the uncertainties in projecting the behavior of cognizant officials in the distant future.

F-4 Alternative 3, "Liquid in SRP Bedrock," deserves further consideration since it holds the promise of being achievable at reasonable cost and in reasonable times. As presented in the Statement, its only "quantifiable" shortcoming is its relatively high calculated "Offsite Population Dose Risk." This risk, according to Table XII-10, would be less than 0.1 per cent of either the natural dose or the average medical dose to the pertinent population, but is high relative to those calculated for the other alternatives. Virtually all of the risk calculated for Alternative 3 is associated with the period of about a year during which the waste would be transferred to the bedrock cavern; the risk once the waste was in the cavern would be very low.

Comment noted; no response required.

F-5 The vulnerability during the period of transfer was envisioned as being to sabotage or earthquake damage. The assumptions upon which these risks were calculated are not given in the statement.

The assumptions upon which the earthquake risks are based are in ERDA 77-42, p. V-42. The scenario assumes that 25% of the wastes are in the cavern at the time of earthquake, the earthquake frequency which would result in a pathway from the cavern to the aquifer would be 3.3×10^{-5}/yr., 5000 gallons of waste would be transferred to the aquifer every year for three years, 50,000 people move onto the plant site and use the water under the site 100 years after the earthquake. ERDA 77-42 also explains that the detailed scenarios considered for sabotage are not given for reasons of security but are given in a classified appendix to the document.

F-6 The second full paragraph on page XII-12 states qualitatively some extreme risks of failure during transfer in a manner that is quite different from the quantitative assessments made elsewhere in the Statement. Most certainly people would not be permitted to drink water from the Tuscaloosa aquifer if it had been so contaminated that it would give them lethal radiation doses!

The referenced paragraph is a summary of the quantitative results presented in Section V. It is customary to state consequences of possible accidents without corrective actions in Environmental Impact Statements. It is probably true that few people would actually receive large exposures before consumption of the water would cease, even by an uninformed group of users. Corrective actions are discussed for this scenario in Section XII-D.

F-7 In view of the potentially great advantages of Alternative 3 over the others, the Final Statement should present much more detailed explanations and analyses of the risks of sabotage and earthquakes, including the measures assumed to forestall their effects. The costs of additional measures to reduce the current estimates of risk by factors of 10 and 100 should be estimated. During the period of waste transfer, sabotage could be deterred by redundant technical surveillance and security techniques supplemented by onsite military forces. The vulnerability of the fill line between ground surface and the tunnel bulkhead could be greatly reduced by application of the sorts of safeguards that are applied to nuclear reactors - basically these would be automatic closures, top and bottom, actuated by seismic sensors. Again, redundancy of systems should greatly decrease risk.

The tradeoff between cost and risk is treated in Section XI. Optimization of the design to reduce radiation risks is treated by applying the NRC and OMB cost-benefit relationship $1000/man-rem. The analysis in Section XI is intended to allow risk-benefit considerations to be treated on a consistent basis for all of the alternatives by presenting the incremental cost-risk relationship for each alternative.

F-8 Table V-4, page V-11, "Manpower and Time Requirements for Operational Modules," should include data for transfer of liquid waste to a bedrock cavern.

On page IV-19 it is stated "...research and development efforts for..alternative (3) would be directed toward ensuring the integrity of the bedrock..This work is not underway and is not currently proposed for funding." In view of the potential of Alternative 3 and of the findings of the review panels (pages II-6 through II-10), this position should be reconsidered.

The manpower and time required for removal of wastes from old tanks and transfer to either new tanks or to bedrock cavern were assumed to be the same.

Sincerely,

W. B. Bebbington

CC: N. Stetson, SRO

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555
Nov 1, 1978

Mr. W. H. Pennington, Director
Office of NEPA Coordination
U. S. Department of Energy
Washington, D. C. 20545

Dear Mr. Pennington:

Subject: Draft Environmental Impact Statement, Long-Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant, Aiken, South Carolina, DOE/EIS-0023-D

This office has reviewed the Draft Environmental Impact Statement for the Long-Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant, Aiken, South Carolina (DOE/EIS-0023-D) as requested in your letter of July 31, 1978. In consideration of this draft environmental impact statement, our comments on DOE/EIS-0023-D are enclosed for your use.

Sincerely,

Voss A. Moore, Assistant Director
for Environmental Projects
Division of Site Safety and
Environmental Analysis

Enclosure:
Comments on DOE/EIS-0023-D

cc: Mr. Thomas Sheckells (5)
Environmental Protection Agency
Room 537, West Tower
401 M Street, S. W.
Washington, D. C. 20460

NRC COMMENTS ON DRAFT EIS,
LONG-TERM MANAGEMENT OF DEFENSE HIGH-LEVEL RADIOACTIVE WASTES,
SAVANNAH RIVER PLANT, AIKEN, SOUTH CAROLINA

General Comments

G-1 1. The document assesses the environmental impacts associated with the three identified alternatives; however the comparison between the alternatives does not include a recommendation on the preferred option.

2. Since no detailed technical descriptions have been provided in the subject document for any of the proposed high level waste management alternatives, the NRC is unable to provide comments related to maintaining releases to the environment to "as low as is reasonably achievable" (ALARA) levels.

The preferred alternative for this programmatic EIS is the continuation of an R&D program aimed at immobilization of the SRP liquid high-level waste for disposal and is identified in the Foreword and Summary. Detailed technical descriptions will be included in subsequent project-specific environmental documents.

G-2 3. The SRP onsite and offsite radiological environmental monitoring program and the operational monitoring results should be referenced. The existing SRP radiological monitoring program should be generally described and any changes to the existing monitoring program needed for each of the different waste alternatives should be discussed.

The Savannah River Plant has had an extensive onsite and offsite environmental monitoring program since 1951 (before plant startup). The monitoring program measures direct radiation, breathing air, deposited radioactivity and radioactivity in consumed materials including water, milk, fruit, vegetables, grain, fish, fowl, etc. A description of the monitoring program and results are given in the major reference document, ERDA-1537, Appendix E, and the results are also published annually for public distribution (Environmental Monitoring in the Vicinity of the Savannah River Plant - Annual Report). Due to the programmatic nature of this EIS, a description of the environmental monitoring program has been omitted. The monitoring program, together with any changes necessitated by the implementation of the waste management alternative, will be presented in project-specific environmental documentation.

G-3 Specific Comments

Page	Comment
II-9	The design of the Activity Collection (confinement) System does not incorporate a means to control the humidity of the exhaust air in the event of an accident before the air is passed through the HEPA filter-charcoal adsorber system. An engineered safety feature (ESF) filter system should consist of heaters, demisters, prefilters, HEPA filters, charcoal adsorbers, and after filters.
II-11	Consideration should be given to replacing the portable demineralizers in the Fuel and Target Storage Basin cleanup system with a permanent system. Also, the handling of demineralizer regenerant solutions is not described. Systems should be provided to maintain discharges of regenerant wastes to ALARA levels.

These comments were submitted on the draft of ERDA-1537 and were responded to on pages K-25 through K-29 of the final document.

G-3 contd

Specific Comments

Page	Comment
II-16	The report states that leakage in the process heat exchangers represents approximately one-fourth of the total releases from the reactor area. However, no mention is made of measures taken to isolate the leaking heat exchanger or to otherwise control releases. The capability of the systems to maintain releases ALARA in the event of process heat exchanger leakage should be described in the DES.
II-18	In order to achieve optimum control of releases and to maintain releases of radioactive materials in liquid effluents ALARA, releases should be collected in monitor tanks and each batch sampled before discharge. Releases should be monitored continuously and if activity levels exceed predetermined limits, the capability should exist to further process these effluents.
II-28	In order to maintain releases of radioactive iodine as low as is reasonably achievable, consideration should be given to adding iodine absorbers after the sand filters used to process effluents from the canyon processing areas and process vessel vents.
II-120	There appears to be an inconsistency in the methods for handling of drummed solid waste (20 year retrievable storage) versus bulky solid waste and contaminated equipment (buried directly in earthen trenches). The latter method could lead to migration of activity into the groundwater with eventual release to the environment. The environmental statement does not provide the details necessary to show that radioactive materials contained in these wastes will not migrate.
III-82	In order to prevent overflow from tank risers and vents, level controllers and alarms that will automatically terminate transfer of waste into the tank should be installed in all tanks.

G-4	Page	Comment	
	V-7	The monitoring method used to determine doses given in Table V-1 and V-1A should be discussed. It is not clear whether the average employee exposure from Table V-1 or V-1A was used for Table V-2. The discussion on fuel reprocessing inferred occupational exposure would be similar to waste processing considered in Table V-2.	The monitoring methods used to determine the exposures given in Tables V-1 and V-1A are included in the reference ERDA-1537, Appendix E. Also see response to comment G-2. As stated in the text of Section V-B.1, average SRP experience for 1965-1975 (Table V-1) was used to construct Table V-2 because there would be many people involved that are not subjected to radiation potential as high as with current reprocessing operations only. However, as stated in the text, there is little difference in the average exposures of the two different groups of workers.
G-5	Page	Comment	
	V-11	There is no obvious correlation between this table and the use of its data in Tables V-2 and V-3 for verification of dose calculations. The campaign times for each alternative should be clarified.	The correlation between the basic exposure data and estimated manpower requirements to construct Tables V-2 and V-3 is itemized in Section V-B.1, including components of campaign times.
G-6	Page	Comment	
	V-12	The pathways, age group, and compass direction of the site boundary location used in calculating the maximum individual dose (based on normal operations) should be identified in this statement, as well as in the referenced statement (p. V-17). What are the controlling radionuclides for airborne and liquid releases, based on SRP normal waste handling and processing operations?	The analyses indicate that tritium will be the most important radionuclide released to the environment from normal operations. Immersion/inhalation of atmospheric tritium at the site boundary, the milk pathway offsite, and human consumption of Savannah River water downstream will be the critical pathways. Dose calculations are for 70-year dose commitments. Detailed descriptions of the dose calculation methodologies are given in Appendices F and G of ERDA-1537.
G-7	Page	Comment	
	V-27	Why is the probability for an airplane crash for Alternative 1 (1.0×10^{-5} events/year) different from the value presented for each subcase of Alternative 2 (7.0×10^{-8} events/year)?	Details of derivation of probabilities are given in the reference document ERDA-77-42, as stated in the introduction in Section V-C. In the specific case mentioned in the comment, the lower probability results from an overlay of the probability of the airplane crashing into the building with the probability of hitting one of several smaller areas within the building.
G-8	Page	Comment	
	V-28	The maximum individual dose given for a spill (2.0×10^{-2} rem) differs from the value listed in Tables V-14, 15, and 16 (2.9×10^{-2} rem). Please explain this discrepancy.	The value of 2.0×10^{-2} rem is a typographical error, and has been changed to 2.9×10^{-2} rem.

	Page	Comment	Response
G-9	V-28	Sabotage events should also be considered for transportation and storage in the exposure risk analysis of Alternative 2, Subcase 1.	Sabotage has been considered for this alternative. The analyses show sabotage to result in negligible impacts. Discussion of sabotage for this alternative can be found on page VI-15 of ERDA 77-42.
G-10	V-30	Sabotage events should also be considered for storage in the exposure risk analysis of Alternative 2, Subcase 3.	See the response to G-9.
G-11	V-34	Offsite land contamination may also result from sabotage during transportation for Alternative 2, Subcase 1, and during storage for all the alternatives.	Land contamination beyond the immediate vicinity is estimated to be negligible for the transportation activity, as discussed in the reference ERDA-77-42. Sabotage during storage is also explicitly covered in that reference. Assumes high integrity shipping cask and waste form which would not result in significant land contamination due to sabotage.
G-12	VI-2	It should be noted that Table VI-1 references Table VIII-1 which does not exist.	The table has been corrected.
G-13	IX-2	It is not clear why the long-term man-rem doses for Alternative 1 and 3 are greater than those for Alternative 2 in Table IX-1. The differences in tabulated man-rem between alternatives for both short-term and long-term operations should be discussed.	The detailed components of risk that make up the summary of Table IX-1 are given in Tables V-12 through V-16 and Table V-2, so that each reader can examine the different sources of risk. These components were used to construct Table IX-1 as explained in Section IX-B.2.
G-14	XII-6	The basis for using a lower population dose due to routine waste processing releases in Tables XII-6, 7 and 8 rather than the dose given on page XII-6 (22 man-rem/yr) for processing operations is not clear.	The dose given on page XII-6 is incorrect, and has been changed to be consistent with the tables.
G-15	XII-7 thru XII-11	The resolution of the comments on Tables V-12 thru 16 should be incorporated into the summaries of costs exposure risks presented in Tables XII-5 thru 9.	The tables are consistent with each other, and have been changed to include risk integration to 10,000 years and updated costs.

	Page	Comment	
G-16	XIII-2	The offsite population dose risks presented in Table XIII-1 do not correlate with the information given in Table XII-10 page XII-13, particularly for Alternative 2, Subcase 3. Please clarify.	Table XII-10 gives average dose risk on an annual basis (man-rem/year), whereas Table XIII-1 gives time-integrated risk (man-rem). The two differ by an integration over time, taking into account radionuclide decay and population growth.
G-17		The radiation exposures listed in Table VI-1, page VI-2, should be included as additional quantifiable environmental impacts.	The radiation exposures given in Table XIII-1, Quantifiable Environmental Impacts, already include the exposures given in Table VI-1.
G-18		The derivation of the offsite population dose from natural radiation is not presented in the text of the document, and it is not clear how the value of 2.3×10^8 man-rem is obtained.	The offsite population dose from natural radiation is calculated by integrating the individual dose over the population within 150 km of the SRP site, with an allowance for population growth as explained in the text, and over the time period of interest.
G-19		The amount of accidental offsite land contamination should be revised, as appropriate, after consideration of the various comments on the topic of sabotage.	See Responses G-9 and G-11.

ENVIRONMENTALISTS, INC.
Founded 1972

October 30, 1979

Mr. W. H. Pennington
Mail Station E-201, GTN
Department of Energy
Washington, D. C. 20545

Dear Mr. Pennington:

SUBJECT: "Draft Environmental Impact Statement Long-Term Management of Defense High-Level Radioactive Wastes

Savannah River Plant, Aiken, South Carolina

July 1978 DOE/EIS-0025D"

H-1 General Comments:

The EIS purportedly "provides environmental input for decisions on whether Savannah River high-level radioactive wastes should be processed and solidified" in accordance with our national goals, or whether the wastes should be kept in storage tanks until such time as our priorities, technology, and regulations permit disposal in bedrock beneath the SRP site. "(S)ome future generation may make a decision that some other disposal method would be more desirable."

The EIS supports those who allege that there is no federal committment to solving our high-level radioactive waste management problems.

Three critical issues are ignored in the EIS: the problem of accumulated high-level radioactive wastes (HLRW); the fact that this country is seriously contemplating the generation of similar commercial nuclear energy wastes; the fact that this country is seriously considering accepting foreign waste fuel on a large scale.

Although the EIS gives lip service to the goal of solidification of waste and subsequent storage at a federal repository, the goal is not supported in the report. Clearly and consistently, remarks and judgments are introduced which are biased in favor of tank storage for an indefinite period of time, perhaps culminating in bedrock storage.

The purpose of this EIS is to analyze the environmental implications of a large Federal research and development program to develop methods for long-term management of the high-level wastes at the Savannah River Plant. The EIS analyzes the environmental impacts which would result from adoption and implementation of the developed technology. The preferred alternative is to conduct an R&D program aimed at immobilization for subsequent disposal. The purpose and preferred alternative have been clarified in the Foreword.

H-1 contd This narrow-minded attitude in favor of no action is unfortunate because the SRP waste management program could provide important leadership to assist this country toward a solution of its commercial nuclear waste problem.

This lack of dedication is outrageous because - for reasons of health and safety and acceptable economics - commercially-generated HLRW must be treated in a far more responsible manner. I enclose the Code of Federal Regulation to remind us all that commercial HLRW cannot be stored for more than five years. After that period of time they must be converted to dry solids and placed in sealed containers for shipment to a federal repository. Military HLRW have characteristics which require that they be isolated for similar periods of time and in a similar manner.

It is stated in the Report to the President by the Interagency Review Group on Nuclear Waste Management, March 1979 (TID-29442) that "since final processing of defense waste has been deferred for three decades, remedial action, including immobilization of the wastes, should begin as soon as practicable." DOE intends to act in accordance with the IRG recommendations after appropriate NEPA review.

H-2 Specific Comments:

Page I-2 mentions storage "for several decades". This period of time is not justified in relationship to the consideration of surface tank storage for 100 years (pg XI-4 and elsewhere). Cavern storage protection is noted for 300 years (pages XII-12 and elsewhere). Each of these time frames is unjustified when compared to the NAS/NRC recommendation of isolation for 1000 years (page II-9).

This confusion regarding the appropriate period of isolation of wastes is particularly important because of the EIS interest in continuing the present inaction by storing the wastes in surface tanks for 100 more years. This allegedly cheap option would clearly not be cheap if the wastes must be maintained for 1000 years. Furthermore, this option is not cheap if "some future generation" is forced to take action because our generation lacked the leadership to take decisive action.

The purpose of this EIS is to assess the environmental implications of continuing an R&D program which could lead to removal of SRP high-level waste from tanks, concentrating them into a high-activity fraction, and immobilizing the radioactive nuclides in a high-integrity form for subsequent disposal. This is the preferred action. However, other alternatives were considered to provide a range for comparison of potential environmental impacts.

The EIS has been modified to add integration of risks to 10,000 years. These changes are included in Sections V-C.3, Tables XII-5 through XII-9, and in the Summary. The costs for alternative 1 are independent of the length of time the tank farm remains in operation since, as described on p. X-I, a trust fund would be established which is adequate to replace tanks every 50 years.

H-3 Pg XII-20 clearly states that the Tuscaloosa and McBean aquifers are not interconnected. To my knowledge, this issue is still debatable. In the event of earthquake, accidents, technical complications, or some other factual misunderstanding, this uncertainty could clearly expand the area of catastrophe associated with bedrock or cavern storage.

As shown in Figure III-4, the McBean-Congaree aquifer is separated from the base of the Tuscaloosa aquifer by about 600 feet. Within this section are several beds of clay that would impede any upward movement of contamination that had found its way into the base of the Tuscaloosa. In addition, there appear to be no vertical gradients within the Tuscaloosa formation that would cause upward water movement from its base to its upper boundary. The difference in hydraulic heads shown on Figure III-4 indicates that there is not a direct connection between the Ellenton and Congaree formations. These two formations are separated by a clay that appears to be continuous over a large part of the southeastern U.S.

H-4 Pg III-9 The alternative of tank surface storage ignores the close proximity of the water table.

Of the three potential release paths for radioactive liquid wastes at SRP (into the ground, over the surface of the ground, and into the atmosphere), the most significant paths from the point of view of safety are surface spills and atmospheric releases. For radionuclides released into the clayey soil around the waste tanks, the time to migrate to groundwater and thence to surface streams is so long that the radionuclides will almost completely decay before reaching the streams. The relative immobility of radionuclides released to the ground at SRP is discussed in Section V and Appendices A and B of the backup document, ERDA-77-42, and in Section III of ERDA-1537.

H-5 Pg III-11 A major earthquake is regarded as improbable, despite (1) the area is a Class III earthquake zone; (2) major cavern excavation and refilling is proposed; (3) past experience with the refilling of caverns has resulted in earthquakes.

(1) SRP is in Zone II but near the boundary of Zones II and III as shown on the risk map of the U.S. (Algermission 1969); however, this page-sized map of the entire U.S. is only a generalized guide to earthquake risk. Facility design is based on sesmic risk factors developed from more specific information than location on a generalized map.

(2) & (3) Earthquakes have been induced by filling surface reservoirs where a new hydraulic pressure is imposed in the area. Earthquakes have also been induced by high pressure injection of fluid into wells. However, no data is known to DOE that indicate that earthquakes have been induced where the new hydraulic pressure is less than the original hydrostatic pressure.

H-6 Pg IV-11 & 12, Tank storage of HLRW at SRP:
How many HLRW tanks are now being used which are leaking?
How many HLRW tanks are now being used which are not leaking?
How many HLRW tanks are now under construction?
How many HLRW tanks will be constructed within the next five years?
Which if any, of the above HLRW tanks are stainless steel?
If the above tanks are used for long-term storage, how many will be required and how long will it be until the tanks can be covered and abandoned?

Answers to the first two parts of this comment require clarification of the term "leaking" as applied to waste tanks. The SRP high-level waste tanks provide three distinct barriers between the stored waste and the surrounding ground: (a) the steel "primary" tank, (b) the steel "secondary" tank under and around the primary, and (c) the water-tight reinforced concrete vault completely surrounding the two steel vessels. Nine primary tanks have developed cracks which allowed small quantities to seep into the secondary tanks, where it has been completely contained in all cases but one. There is no evidence that any of the secondary tanks have leaked (i.e. through fissures or flows in the walls or bottom); however, the steel secondary vessels of the 16 oldest tanks are only five feet high, and there has been one incident, in 1960, in which sufficient waste leaked from the primary to exceed the height of the short secondary pan. Almost all of the excess was contained by the concrete outer tank, but a few tens of gallons of waste escaped (presumably through an imperfectly-sealed construction joint) into the surrounding ground, where its radioactive components have been absorbed and have remained close to the tank for the past 19 years. From an environmental impact standpoint, only

H-6
contd

this one SRP waste tank has leaked. This tank has been permanently retired from service; as of October 1979, all of the liquid waste and over 98% of the sludge have been removed from the tank, and further cleaning of the tank are in progress. Seven of the other eight tanks in which some waste has leaked into the secondary vessels are currently in dormant service holding aged waste, although most of the liquid has been removed from two of these waste. One of the eight is in active service, with the liquid level restricted to below the elevation of the single known crack. The eight will be emptied, cleaned, and retired within the next few years as new tanks are completed.

In addition to the above eight tanks, 16 other tanks with double steel vessels, are currently in service (including three essentially empty tanks designated as emergency spares). Seven of these are of older (Type I) design and are scheduled for removal of their waste by 1984. Also, eight uncooled waste tanks having a single steel vessel inside a concrete shell are in low-heat waste service; all but one of these will be emptied (including sludge and salt cake) by the middle of 1983. One uncooled (Type IV) tank will remain in service as a cesium removal column feed tank, receiving off-specification overheads from the 242-H evaporator and low radioactivity waste from the Resin Regeneration Facility (Bldgs. 244-H and 245-H). The remaining nine existing tanks are of the current (Type III) design with stress-relieved primary vessels and secondary steel vessels the full height of the primaries. Four Type III tanks have been completed recently and will be placed in service late in 1979 or early in 1980, and 14 others are in various stages of construction, with scheduled completion dates of April 1980 (4), August 1980 (6), and March 1981 (4). All of the above tanks are of carbon steel.

Quantitative answers to the last part of the question depend on several factors yet to be resolved. Current forecasts predict high-level waste production at SRP averaging 1,600,000 gallons per year over the next decade. After aging, this can be reduced to salt cake and sludge occupying 30 to 35% of the original volume, i.e., about 500,000 gal./year. Thus, an average of four new tanks per decade would be needed to maintain the present mode of operation indefinitely, not counting replacements for tanks reaching the end of their useful lifetimes.

Under current criteria, tanks containing aged high-level waste will never be "covered and abandoned". If tank storage were continued indefinitely; the tanks would be replaced periodically as they deteriorated with time, moving the waste to newly constructed tanks, and thoroughly decontaminating the old tanks before abandonment. The expected high-integrity lifetime of stress-relieved tanks of current design is conjectural, but should average at least 50 years; this would require an additional six tanks per decade beginning about 2020 and gradually increasing thereafter.

H-7 Pg IV-17 refers to a "previous" cavern study which "concluded that a cavern 1500 feet below the surface in Triassic formation would be best" for cavern storage. This was an Idaho study. The studies of bedrock storage at SRP have been inconclusive. The EIS conslusion appears to be unsound.

The reference given in the draft EIS is incorrect. The intended reference is Technical Assessment of Bedrock Wash Storage at the Savannah River Plant, ERDA Report DP-1438, (1976) as shown on page IV-18 of this document.

H-8 Leaching problems and potentials are not addressed in the EIS.

Leaching from glass monoliths in abandoned surface vaults and bedrock caverns is discussed in Section V of the backup document (ERDA 77-42) and is shown to result in no significant population exposure. For conservatism, leach rates from small samples were used in the analysis to account for possible cracking of the monolith and no credit was taken for protection by the canister.

H-9 Pg V-5 reference to the sales tax and income tax revenues associated with HLRW construction ignores the attendant social costs of schools, roads, police, etc.

The existence and importance of socioeconomic aspects of constructing and operating the waste management facilities are recognized and will be addressed in detail in the project-specific environmental impact statement.

H-10 Over a year ago the group I represent commented on the SRP DWD:

"The goal of the waste management plan to be adopted at SRP should be to comply with the five-year solidification regulation now imposed upon proposed similar commercial facilities. The Number One priority of the SRP waste management plan should be the construction of a solidification facility for defense wastes, so that high-level wastes can be removed from the SRP site. Further consideration of already-discarded waste management techniques should be regarded as not only an unnecessary duplication of effort, but also as a lack of committment to the finding of solutions to the difficult problems at hand.

"Years ago guarantees were given that South Carolina would not be used for permanent storage of high-level radioactive wastes, particularly because of the unsuitable seismology and hydrology of the area. Federally-commissioned studies indicate that safety questions exist in the use of SRP bedrock for the storage of high-level wastes. An NAS/NOR study[2] concluded that it is doubtful that safety could be established for the proposed bedrock storage system for high-level liquid or soluble wastes; it was suggested that the plan be abandoned......

"On the other hand, a prototype for reducing the wastes to a glass form has been operated.[4] We believe that with the committment on the part of the SRP staff, the technique could be made operational within the least time and with the least environmental effect."

The Interagency Review Group on Nuclear Waste Management (IRG) has recommended that DOE accelerate its R&D activities oriented toward improving immobilization and waste forms and review its current immobilization programs in the light of the latest views of the scientific and technical community. Since final processing of defense waste has been deferred for three decades, the IRG also recommends that remedial action, including immobilization of the waste, should begin as soon as practicable. The preferred alternative is consistent with the IRG recommendations.

For more than two years, while assigned with a responsibility for assessing the problems and seeking solutions, the responsible decision makers have fooled around with paper shuffling. Responsible regulations have been ignored. Health and safety is being compromised in the interest of expediency and buck-passing. The public is the victim of a monstrous shell game.

Sincerely,

Suzanne Rhodes
President of Environmentalists, Inc.

Enclosure: ORR

COMMENTS ON
DRAFT ENVIRONMENTAL IMPACT STATEMENT
LONG-TERM MANAGEMENT OF DEFENSE HIGH-LEVEL RADIOACTIVE WASTES
SAVANNAH RIVER PLANT, AIKEN, S. C. (DOE/EIS-0023-D)
July 1978 U. S. Department of Energy

Submitted by Ruth S. Thomas
1339 Sinkler Road
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tel. 803-782-3000

General Comments:

The Report ("Draft Environmental Impact Statement, Long-Term Management of Defense High-level Radioactive Wastes- Savannah River Plant, Aiken, South Carolina"), contains numerous examples of overlooking evidence and factual data related to potential and existing health hazards and environmental degradation. This, together with the Report's failure to give proper emphasis to previous studies, contributes to the false conclusion that:

"There are no substantial environmental impacts arising from nuclear radiation for any of the three alternatives"proposed for Savannah River Plant (SRP) wastes. (page 1-3 of the Report)

Specific Comments:

The Report has too many failures, omissions and misstatements to comment on all of them:

I-1 1. Failure to include accurate information, including such subjects as monitoring. These ommissions lead to the mistaken impression that the dangers associated with radioactive wastes are quite easily controlled.

The risk analyses do not take credit for the potential reduction of consequences which may be afforded by corrective actions.

According to the Department of Interior, "it must be remembered that the data obtained from the monitoring will not necessarily prove that radionuclides are not migrating from the site.[1]

In a review of the Barnwell Nuclear Fuel Plant site, geologists and hydrologists with the Department of the Interior warn that the consequences of undetected radionuclides moving into the environment can be so serious that taking effective corrective action may be impossible or impracticable.[1]

I-2 2. Failure to give proper emphasis to the data contained in previous studies, including all of the fourteen references I have listed, a majority of the Report's references and numerous other documents and studies.

This question is answered by virture of the response to the other related questions specific to the fourteen references.

I-3 3. Failure to give proper emphasis to the recommendations of advisory groups such as the Committee on Geologic Aspects of Radioactive Waste Disposal of the National Academy of Sciences (NAS) of 1966.[3]

In preparing this EIS, DOE has considered the 1966 NAS report as well as more recent studies.

I-4 4. Failure to provide data obtained from the tests and studies which the NAS-1966 Committee requested if the advice to halt investigation of bedrock cavern storage of SRP wastes was not followed.[3]

The current report is based primarily upon studies and data more recent than given in the 1966 study.

I-5 5. Ommission of evidence about the losses and damages which have occurred as a result of radioactive wastes at the SRP and at other sites.[8,9,12]

The radioactive waste storage experience at SRP is referred to in the summary and described in detail in ERDA-1537, a reference to this EIS.

I-6 6. Misleading statements made about radioactive wastes and effects of the SRP. The Report indicates that the withdrawal of over six million gallons of water per day from the Tuscaloosa formation "has had no discernible effect on the water levels in the past 22 years." (page V-3 of the Report-DOE/EIS-0023-D)

The statement is correct and not misleading. It has nothing to do with radioactive wastes.

I-7 7. Failure to include information about problems which have been experienced in the operations to remove radioactive wastes from tanks, although the records on such operations must have been kept by the SRP and the Hanford plant.

See response to comment K-18.

I-8 8. Failure to use the data, evidence and findings contained in the Report's references, or explain the contradictions between the report's views on SRP waste plans and the information in such references.

For example, on page IV-3 of "Alternatives for Long-Term Management of Defense High-Level Radioactive Wastes-SRP" this statement appears:

"If liquid is stored in a cavern, a severe earthquake or major sabotage during the one-year filling period could contaminate the Tuscaloosa aquifer. Large individual radiation does would result if people drank this contaminated water."[13]

Further on in this report (page X-39) the subject of contamination is discussed. The document states that the "detrimental outcomes of the Tuscaloosa acquifer becoming contaminated are significant, including residents and industries being required to use another water supply."[13]

Large individual radiation doses could result if people drank the contaminated water. However, the low probability of an earthquake or sabotage event occurring which could contaminate the aquifer result in low population exposures when integrated over time.

I-9 9. Failure to give proper emphasis to earthquake data, as well as a failure to recognize the significance of the SRP being in a high earthquake zone.

See response to comment H-5.

I-10 10. Failure to connect the text of the Report to the listed references. Quotations from references are not used and the material to support the text are not documented by particular reference and page number.

Where appropriate, summaries of the references have been incorporated in the text and in these comments.

I-11 11. The failure to properly identify support information and the use of some references which are difficult to obtain make the task of discovering the reasons for the choice of SRP waste plans in Report DOE/EIS-0023-D arduous.

In addition to the extensive information in the report, adequate support information is listed in the references, which are all publicly available.

I-12 12. Failure to stress that:

"Responsible authorities in the United States and abroad generally agree that the best management approach (for high-level radioactive wastes) involves converting the wastes to inert, refractory solids before storage."

" Waste Solidification Program Summary Report, Vol. 11 Evaluation of WSEP High Level Waste Solidification Process", Battelle Pacific Northwest laboratories July 1972, (page 1.1)

The DOE Report lacks information about solidification, its present stage of development, the work now being done on solidification, the size of the experiments being conducted and the amount of effort needed to apply the present solidification technology to the SRP wastes.

Developing technology for removing the wastes from the tanks and immobilizing the radionuclides in a solid form is the preferred alternative in the EIS. DOE has a large research and development program for immobilizing radioactive waste. A description of this program has been added as Section IV-D.

I-13 13. Lack of information regarding the plans for a federal repository.

As stated in the Foreword and Summary, the purpose of this document is to explore the environmental implications of a large research and development program aimed at providing the information required to replace interim tank storage of the wastes with immobilization for long-term management. The method for disposal subsequent to immobilization has not yet been chosen. Specific plans for a Federal repository for the wastes are beyond the scope of this document and will be addressed in subsequent environmental reviews.

I-14 14. Failure to use Nuclear Fuel Services' reports to the Nuclear Regulatory Commission on operating experience, abnormal occurrances and unusual events (Docket No. 50-201 and Docket No. 70-952) as a basis for making predictions about the likelihood of human errors, equipments failures, design miscalculations, etc. to cause accidents, health hazards, exposures of workers and the public and environmental degradation.

The twenty-five years of safe operating experience at the Savannah River Plant is more appropriate and therefore is used as a basis for predicting factors identified in the question and in preparing safety analyses of similar current operations.

I-15	15. Failure to give proper emphasis to the problem of sabotage and terrorism and the studies which have been done on these subjects.[13]	Sabotage has been analyzed in the technical backup document for the EIS, ERDA 77-42, and the potential environmental impacts of sabotage have been summarized and presented in Tables V-12 through V-16 and Section V.C.4 of this EIS.
I-16	16. Failure to use recently discovered data, including information which makes existing plans for decontamination and decommissioning out-of-date.[14]	Decontamination of reactors with neutron-activated trace elements within the structural steel requires different decontamination techniques than the surface contamination which would be present at waste management facilities.
I-17	17. Failure to give proper emphasis to studies which present data on the capabilities of radioactive materials to cause cancer, leukemia and birth defects, including studies of Hiroshima and Magasaki victims, studies of uranium miners, and those related to x-ray exposure of animals and human beings.	Comparative risks of hazards of low-level radiation are discussed in the responses for questions M-1 and M-3.
I-18	18. Designation of a 300 year period for estimating radiation exposures related to proposals for SRP wastes when these wastes contain radioactive materials which remain toxic for hundreds of thousands of years.	See response to comment L-10.
I-19	19. Overlooking the concerns of the authorities and officals of South Carolina and Georgia and the people they represent-farmers, residents, property owners and businessmen.[7,10]	The concerns of the States are noted in the Summary.
I-20	20. Failure to estimate the loss of such natural resources as the Tuscaloosa aquifer and failure to include such costs in making comparisions between different plans for SRP wastes.	The environmental impacts resulting from contamination of the Tuscaloosa aquifer are included in Table V-16.
I-21	21. Basing the selection of SRP waste proposals on economic informtion which is incomplete and therefore faulty.	The economic information is complete to the best of our knowledge.
I-22	22. Failure to consider that the people of the 3.1 area would be receiving no compensating benefit to offset the detrimental effects of having radioactive wastes kept in South Carolina.	The compensating benefits are addressed in ERDA-1537, p. IX-2, and include increased employment for the area.

I-23 23. Failure to use the scientific method in addressing the problem of having radioactive waste materials in an area where contamination of ground water and drinking water supplies is possible and where conditions related to the presence of radioavtive wastes are unfavorable.[1,2,3,4,5,6,8]

Ground water movement depends upon local conditions. The Savannah River Plant has an extensive program to determine ground water movement patterns and to formulate predictive models. Other ongoing studies are examining the potential for contamination of ground water by buried waste. Although these methods involve a certain amount of uncertainty, we are utilizing the best technology available.

I-24 24. Failure to comply with the DOE's stated policy- "to isolate the waste from the environment for long enough or in a secure enough manner that it will pose negligible risk to human welfare." (page II-2 of the Report - DOE/EIS-0023-D.

Preparation of this EIS is not inconsistent with DOE's policy.

I-25 25. Failure to comply with other stated goals for radioactive wastes.[8,13]

See response to I-24.

I-26 26. Failure to give proper emphasis to previous studies which support the conclusion that SRP wastes need to be removed from South Carolina.[1,3,6,7]

The Atomic Energy Commission postponed indefinitely the SRP bedrock exploration program at the Savannah River Plant in 1972. The bedrock alternative was considered in this EIS to provide a range of alternatives for comparing potential environmental impacts. The preferred alternative for the management of SRP high-level liquid radioactive waste is to continue R&D directed toward immobilization for disposal. The method for disposal has not been chosen but options would include disposal outside of South Carolina.

Conclusion:

The Report points out that -"Successful demonstration of long-term management of defense waste could have an imporatnt sociopolitical bearing on the acceptability of nuclear power generation by a significant portion of the public." (page V-47 of the report) I agree, as I'm sure, do many men and women throughout the nation and the world.

Of all the nuclear energy problems, the one of greatest concern is the question of what to do with radioactive wastes. For this reason, it is imperative that decisions on SRP wastes and on other radioactive waste materials be based on as complete and accurate a collection of factual data and evidence as possible. Instead, Report- DOE/EIS-0023-D uses incomplete, misleading and faulty information.

Promoting and developing radioactive waste plans which ignore facts, which ignore the advice of earth scientists and which ignore recommendations of authorities and officals of South Carolina and Georgia would further add to the existing distrust which many people have of nuclear proposals, including the building and operation of nuclear power plants.

Submitted by Ruth J. Thomas on October 30, 1978

REFERENCES

1. Safety Evaluation-Barnwell Nuclear Fuel Plant (Docket 50-332), Division of Materials Licensing, U.S. Atomic Energy Commission, Appendix B, Comments of the Department of Interior, page 113 -(September 18, 1970)

2. G. E. Siple, Geology and Ground Water at the Savannah River Plant and Vicinity of South Carolina, USGS Water Supply Paper 1841 (1967)

3. Report from Committee on Geologic Aspects of Radioactive Wastes Disposal, NAS- ( ) to Division of Water Development and Technology (May 1966)

4. Operations Concerning the Management of High-Level Radioactive Waste Material. Report from the Comptroller General to the Joint Congressional Committee on Atomic Energy (May 1968)

5. Proposals and Problems for Managing High-Level Radioactive Wastes. Report from the Comptroller General to the Joint Congressional Committee on Atomic Energy, (November 1970)

Conclusions: These are the writer's opinions and the response given previously to the 26 questions respond to the specific points upon which the conclusion is apparently based.

6. Frank T. Garuccio, An Appraisal of the Location of the Barnwell Fuel Reprocessing Plant from Hydro-Geologic Considerations, Report to the Committee to Study the Establishment of Plants or Facilities for the Recovery of Nuclear Fuel and the Storage of Waste Nuclear Materials, (1972)

7. Report of the Committee to Study the Establishment of Plants or Facilities for the Recovery of Nuclear Fuel and the Storage of Waste Nuclear Materials. Report from the Committee of the South Carolina General Assembly to the Governor and General Assemly (1972)

8. Draft Environmental Statement, Waste Management Operations Savannah River Plant, Aiken, South Carolina. Report ERDA-1537, Energy Research and Development Administration (October 1976)

9. Letter C. L. Wakamo to Mrs. James T. Mills, Answers to questions, which includes the answer that the EPA and officals of Georgia were told "that all effort had been abandoned and that it was not a part of the Waste Management Program EIS consideration." (March 5, 1975) -On Bedrock disposal of radioactive wastes-

10. Letter David Domick to Senator Ernest F. Hollings, Answers to Questions by EPA (Ocober 26, 1971)

11. Preliminary Safety Analysis Report of the Barnwell Nuclear Fuel Plant, Allied-Gulf Nuclear Services, December 1970, pages dated 3/21/69, III.3-2B

12. Preliminary Data on the Occurrence of transuranium Nuclides in the Environment at the Radioactive Waste Burial Site, Maxey Flats, Kentucky, G. Lewis Meyer presentation at / International Symposium on Transuranium Nuclides in Environment, San Fransisco, Cal. (November17-21, 1975)

13. Alternatives for Long-Term Management of Defense High-Level Radioactive Wastes (HLW), Erda 77-44 (May 1977)

14. John J. Stephens, Jr. and Robert O. Fohl, Trace Elements in Reactor Steels: Application for Decommissioning, Report #2882 (August 1977)

State of Ohio Environmental Protection Agency
Box 1049, 361 E. Broad St.,
Columbus, Ohio 43216 (614) 466-8565
James A. Rhodes, Governor
Ned E. Williams, P.E. Director

Re: Long-Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant, Aiken, South Carolina

W. H. Pennington
Office of NEPA Coordination
U.S. Dept. of Energy
Washington, D.C. 20545

November 1, 1978

Dear Mr. Pennington:

The Ohio Environmental Protection Agency, acting as lead agency and review coordinator for Federal Environmental Impact Statements has received a copy of the above referenced document. The Director of OEPA has transmitted the document to me for comments, which follow.

J-1 General

Inasmuch as the operations described in the subject document are out of the jurisdiction of the State of Ohio, we have no immediate concern with the subject EIS. However, since Ohio has a well-established ongoing interest in fuel cycle and radioactive wate disposal matters, we have examined the document with considerable interest and would like to make the following comments.

At present Ohio has an active commercial reactor building program; one unit is operational, three are under construction, one has been decommissioned, and four more are in the planning stage. If the spent fuel from these reactors must ultimately be stored at a Federal Repository, such a program would be more easily established if the management of defense wastes were fully in harmony with and supplemental to the commercial waste program.

It is also becoming increasingly apparent that the radioactive waste disposal is beset with a number of (non-technical) institutional, political and social barriers which are more evident in the case of commercial reactor spent fuel elements than for defense related wastes. The subject EIS does not apparently take these into account.

The existence of institutional, political, and social factors are recognized in this EIS and summarized in Section XII.

J-2 Concerning the specific alternatives which are presented there are several comments which we trust you will find pertinent.

1) Alternative 1 - Continue Storge in Tanks. While this "No Action" alternative might be cheapest, environmentally benign and backed by the greatest experience, it also has the disadvantages of contributing nothing new or progressive to the state of the art of radioactive waste management. It also might add to a public perception of DOEs inability or indecision to dispose successfully of defense wastes.

2) Alternative 2 - Process to Glass and Ship to a Federal Repository. We realize that this alternative may be the most difficult to implement inasmuch as it requires the timely existence of both a Federal Repository and a radioactive waste shipping network. Nevertheless both the shipping and repository facilities will ultimately be necessary for both the civilian and military nuclear program.

Alternative 2 - Subcase 2 - Process to Glass and Store in Surface Facility at SRP. The construction of a surface facility for storage of high-level, non-reprocessable waste appears to represent an unnecessary expense. It has the added disadvantage of providing an alternative to a Federal Repository. Such a "Temporary" facility might well deflect the program for a Federal Repository and thus run the danger of becoming de facto permanent.

Alternative 2 - Subcase 3 - Process to Glass and Dispose of in an SRP Bedrock Cavern. This would demonstrate a waste disposal procedure which possibly could be applicable to the handling of commercial waste and thus add importantly to our knowledge in this area.

3) Alternative 3 - Dispose of Liquid Waste in an SRP Bedrock Cavern. The construction of an eight mile double walled pipeline raises serious questions of risk and expense. Furthermore storage of liquid wastes is at odds with the multiple barrier concept embodied in corrosion resistant containers and glassification of the waste and thus would appear to be a step backward in the state of the art. Also this method of disposal is inapplicable to commercial waste.

The alternatives considered in this EIS were selected to provide a range for comparison of potential environmental impacts. The preferred alternative is to conduct a research and development program aimed at immobilization for subsequent disposal. These comments appear to support the preferred alternative.

J-3 The report is generally well organized and written and comparatively free of technical errors. In Fig. IV-1, p. IV-5 the decay line for 95 Zr is not identified. It appears to be the line immediately to the right of the 91 Y decay line.

We appreciate the opportunity to comment on this Draft EIS and hope that these remarks will be helpful.

Sincerely,

Harold W. Kohn
Power Siting Coordinator
Ohio Environmental Protection Agency

HWK/caj

The appropriate label for ^{95}Zr was added.

The Georgia Conservancy
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Atlanta, Georgia 38305
Telephone: 404/262-1957

November 1, 1978

Mr. W. H. Pennington
Mail Station E-201
GIN
Department of Energy
Washington, D.C. 20545

Re: Draft EIS
Long-Term Management of
Defense High-level Radioactive Wastes
Savannah River Plant
DOE/EIS-0023-D

Dear Mr. Pennington:

We have reviewed the referenced report, and we have specific concerns and questions for which we request response in the final Environmental Impact Statement. As expressed in previous letters, we consider this matter to be of great importance to the health and safety of Georgians and protection of our state's resources.

We would like to express our appreciation to the Department of Energy for the early announcement of this document, making it more convenient for review.

The report concludes that there are "no substantial environmental risks" associated with any of the alternatives listed. Such a conclusion is extremely premature in view of the serious environmental concerns which remain unanswered, some of which are addressed in our following comments:

The Summary has been modified to reflect the uncertainty in the environmental analyses.

K-1 1) We continue to oppose management alternatives for long-term storage or disposal of nuclear waste at the Savannah River Plant (SRP) site, either on the surface or subsurface.

Surface storage poses too great a threat to Georgians from accidental releases in various possible incidents, including earthquakes, tornadoes, sabotage, aircraft crashes, spills, and errors in emissions control. Subsurface storage poses similar threats as well as an increased possibility for groundwater contamination, particularly in the Tuscaloosa aquifer which lies beneath the site and extends into Georgia.

Item 2 on page XII-14 describes the consequences of aquifer contamination as "quite high", but then attempts to explain them away due to "promising possibilities" and because the alternative is "the least expensive". We are not reassured by such comments.

The alternatives considered in this EIS were selected to provide a range for comparison of potential environmental impacts. The preferred alternative is to conduct a research and development program aimed at immobilization for disposal. Decisions to immobilize in a specific waste form and the method for disposal subsequent to immobilization will be the subject of future environmental reviews.

K-2 2) Only one alternative was listed for storage off the SRP site; an off-site federal repository. However, since this alternative was not addressed on a site specific basis, we must conclude that an acceptable waste management plan has not yet been presented. We, therefore, await further information on off-site alternatives available. In this regard, we question any off-site use of bedrock or geologic storage which has potential for contact with groundwater or aquifers. Furthermore, any off-site subsurface storage studies should include test drilling and construction of exploratory shafts and tunnels to determine the characteristics of possible storage caverns and their surroundings.

Details of the environmental impacts of an offsite geologic repository would be covered in a site-specific EIS for that facility. However, bounding estimates can be made at the present time to determine whether shipment to such a repository is a feasible alternative for the SRP wastes, and such estimates are included in this Programmatic EIS.

K-3 3) We question whether the alternative of disposal off the SRP site is being given full consideration. It is our understanding that studies on a federal waste repository have been largely limited to applications to commercial nuclear waste. Please advise us further as to specific work underway toward development of a defense waste repository other than the SRP site. We feel this must receive priority in view of the unacceptability of the SRP site.

The site exploration, technology development, and repository engineering studies underway in the National Waste Terminal Storage (NWTS) program encompass the alternatives of spent reactor fuel and solidified waste from reprocessing. Solidified defense HLW will differ from possible commercial solidified HLW only in the lower heat density for defense waste resulting from different operating conditions for defense material production reactors). The lower heat density means that disposal of all defense HLW will require less than four percent of the repository space needed for either HLW or spent fuel from commercial nuclear energy through the year 2000. Therefore, the geologic repositories under the NWTS program are being designed to accept high-level wastes both from the commercial sector and from defense programs.

K-4 4) The question remains on the ultimate relationship between disposal of defense wastes and commercial wastes. This question was partially addressed in Appendix A, but joint disposal was not ruled out. Our specific concern is that if commercial waste is being considered for disposal at the SRP site, it must be addressed as an added environmental impact in this Environmental Impact Statement.

See response to comment K-3 above, "No work..."

K-5 5) We agree that exploratory tunnels would be an essential step in determining the characteristics of possible storage caverns below the SRP site. However, we do not advocate the development of a tunnelling project because the SRP site is already considered unacceptable on the basis of the problems listed in comment 2 above.

No work is proposed for tunneling related to an SRP bedrock repository.

K-6 6) We do not support the assumption that the radioactivity from the waste will be negligible after 300 years. There is much evidence that even very low levels of radiation can cause cancer and genetic defects. Furthermore, plutonium has a half-life of 24,000 years and can cause lung cancer from minute doses.

The health effects of exposure to low levels of radiation continue to be examined and are cause for some uncertainty. Also see response to comment M-3. Time integration of the risks over 10,000 years has been added to the data in this EIS to indicate the longer term risks.

K-7 7) The consequences of future unintentional human disturbance of the stored waste should be addressed in detail. Since the waste will remain harmful for thousands of years, it is very possible that it will out-live human institutions existing today, and the records on its location may not be available to future generations doing exploratory drilling or subsurface excavation.

The consequences of human disturbance of the stored waste are bounded by the pessimistic assumptions used in Section V regarding sabotage, abandonment, airplane crash, etc. Any smaller scale disturbance would have smaller consequences, and they would be limited to fewer individuals.

K-8 8) Please indicate the pages of the report which address the possible natural forces acting on the waste over future years and their possible consequences in releasing the waste materials to the biosphere. Section V.C. on abnormal events begins to address this, as does page XII-14, but both references are far from complete.

Details of the consequences of natural events, beyond those included in Sections V and XI, are included in the reference documents ERDA-1537 and ERDA 77-42. In ERDA-1537, see pages III-100 to III-120. In ERDA 77-42, see pages V-8 to V-10, V-25, and V-42 to V-44.

K-9 9) Clarification is needed on the physical condition of the waste at the time it would be encased in molton glass. What percent water would remain in the sludge and ion exchange product? Has the powder form been decided upon as that described on page IV-15? What will the waste particle size be? Will encasement preclude the dissolving of the waste particles in water in the event that cracks developed in the glass?

Determination of the detailed waste composition is part of the proposed ongoing research and development and testing program. These characteristics are used in an upper bounding manner for purposes of this EIS, and are given in the reference document ERDA-77-42. Encasement of the waste glass will undoubtedly provide extra time before the glass could be contacted by water and leaching could begin. The analyses given here, however, take no credit for protection by the canister. The leaching estimates assume the glass is in small pieces, and take no credit for the glass as a large monolith.

K-10 10) We question the statement of page v-24 that "no large individual doses <u>can</u> occur" from liquid releases. It appears that with a sufficiently large release, large individual doses would indeed occur. To deny that this is even <u>possible</u> requires further explanation.

Studies at the SRP have identified no mechanism for a large, short duration release directly to drinking water users. Liquid releases would be absorbed in the soil or diluted many orders of magnitude by the onsite creeks and swamps and the Savannah River before reaching drinking water users. This is explained further in Section V and in ERDA 77-42, p. VIII-7 through VIII-15.

K-11 11) Each alternative considered should account for the added danger that come with transport of the wastes from site to site. Adequate containment must be provided to avoid accidental releases during transport. As a minimum, the containment of this material should meet the same requirements as those set forth for the transport of spent fuel from commercial nuclear reactors.

Transport routes should avoid population centers as much as possible and provide maximum security against unauthorized access to the waste.

Transportation risks are included in the offsite radiation risks developed in Section V.

K-12	We agree with the decision that any selected management alternative will allow for future retrieval and monitoring of the waste rather than merely disposal and abandonment. Too many questions remain unanswered on the future state of the waste, and the only way to know that it is adequately managed is to be able to verify its containment on a periodic basis.	The immobilized waste form will be of a high-integrity nature and its disposal will be in compliance with all applicable regulatory requirements including retrievability.
K-13	13) The option of reducing the amount of defense radioactive waste being generated should be addressed. This should include the recycling of Plutonium from obsolete or phased out weapons to reduce the amount of new inventories produced with the resulting reduction of waste materials. If a certain amount of fresh Plutonium is needed due to decay of existing inventories, this should be explained.	Alternatives for reducing the amount of defense waste generated are beyond the scope of this EIS. However, process development to reduce the volume of the waste is a continuous activity to support the SRP operations. Utilizing such process modifications as additional evaporation, condensate recycle, chemistry refinements, etc., the volume of waste generated has been continually reduced at SRP.
K-14	14) Other means of reducing total waste volume should be addressed, such as processing methods that use less water and generally methods to reduce the total amount of wasted material.	See response on K-13.
K-15	The population doses for various scenarios in the report do not include certain radionuclide vectors which are present in the fresh waste. Among those excluded are 89Sr and 134Cs, which have a high level of activity in the first 20 years or more after production. All radioactive substances present should be included in the dose analysis regardless of ther dose contribution.	The risk estimates for this EIS were developed using only the radioisotopes that make a major contribution to the risk. Inclusion of all radioactive subtances present regardless of their dose contribution is judged to add nothing to the process of disclosing environmental impacts.
K-16	16) In consideration of storage tanks used prior to long-term storage, acid storage in tanks of stainless steel or with stainless steel lining should be further addressed. Stainless steel would appear to provide a long tank life with less chance of leakage. In addition, there are indications that the acid waste would be easier to convert to glass after cooling and involves less waste volume than alkaline waste.	Storage of high-level liquid waste as acid solutions in stainless steel tanks was considered in the "Final Environmental Report - Waste Management Operations, Savannah River Plant," (ERDA-1537), September 1977. This option was rejected because studies made on the conversion of SRP wastes to acid form showed that operation of a dual acid and alkaline storage system would be required and could not be economically justified (page V-10 and 11 of ERDA-1537).
K-17	17) The integrity of existing tanks should also be addressed further in considering storage of the fresh waste prior to long-term disposal. Existing waste should be transferreed to adequate containment as soon as possible in those cases where leakage is occurring of where stress corrosion cracking is evident.	Relocation of existing wastes from cracked tanks to tanks of unquestionable integrity is already in progress and will be continued over the next several years as new stress-relieved (Type III) tanks are completed. All liquid waste and over 98% of the sludge has already been removed from Tank 16 (the only SRP tank from which stored waste has leaked past all barriers and into the ground), and work to remove the remaining sludge and surface contamination is continuing currently (October 1979). Similar waste removal and decontamination are in progress on schedule for all of the older (non-stress-relieved) high-level waste tanks at SRP, with priority going to those tanks which have developed stress corrosion cracks. Currently, most of the liquid waste has been removed from

K-17 contd

two cracked tanks (in addition to Tank 16), and salt removal is in progress in two tanks. Salt and/or liquid are scheduled for removal from all non-stress-relieved tanks (except evaporator feed Tank 13) by the end of 1982, but sludge removal will not be completed until 1984 because more elaborate equipment is required.

K-18 18) We are concerned whether the waste can be effectively removed from the existing tanks without serious environmental risks. The EIS assumes that the waste will be in new tanks when solidification processes begin, but does not address the essential step in the long range planning of getting it there.

It appears that reliquifying the salt cake in order to remove it would result in significant leaks; on the other hand, physical mining of the waste from the tanks poses problems of worker exposure or remote control work. It appears that a containment structure over the tanks would be necessary for the latter method.

Transfer of liquid waste from one tank to another and to the tank farm evaporators has been routinely practiced at SRP for nearly 20 years, and safe and effective techniques are well established. Most of the sludge (80-95%) was removed from seven tanks in 1966-69 by hydraulic "mining" (i.e., slurrying) using once-through high pressure water as the slurrying medium. More thorough sludge removal was not attained because of limited capacity to store the added water. Subsequently, a technique has been developed using recirculated waste supernate pressurized by long-shaft pumps submerged in the tanks, which eliminates the restriction on operating time imposed by the fresh-water method. The recirculated supernate technique has already removed 98% of the sludge from Tank 16, and a scheduled repeat of the operation is expected to remove almost all of the remainder. Although Tank 16 has more cracks than all other SRP tanks combined, self-sealing of the cracks with salt and/or sludge is so effective that little or no liquid seeped through the cracks during sludge removal. If leakage through the cracks in the primary tank had occurred, the liquid would have been retained by the secondary pan and transferred by an installed steam jet back into the primary tank; the same precautions will be applied in all future sludge and/or salt removal operations in other tanks.

Removal of most of the salt cake from a concentrate tank by dissolving in water or unsaturated waste supernate has been demonstrated in one tank in 1971-72, and further demonstrations are currently in progress in two other tanks. The recirculation of liquid necessary to continuously bring unsaturated liquid into contact with the salt surface can be accomplished by density-driven convection and/or mechanical agitation; both techniques are under development.

No need is envisioned or work is planned at SRP to remove salt or sludge from waste tanks by physical or mechanical (i.e. non-hydraulic) mining methods.

K-19 Sabotage of the waste facilities is still assigned an extremely low probability. This can be compared to the surge in commercial aircraft hijacking in recent years. A few years ago, the calculated risk of such acts would have been very small, since few had occurred, whereas the risk today is quite significant.

It would seem more realistic to admit the uncertainty of this occurrence and consequently assume a high likelihood to assure adequate protection. Safeguards and security measures should be increased accordingly. However, we are concerned that civil liberties of citizens be protected at the same time.

This comment expresses an opinion and requires no response. However, the structure of the data used in the sabotage analysis is available in the EIS and its references, so that the reader can apply his own estimate of probabilities if he so desires. Also, sensitivity of the results is discussed in Section XII-C.

K-20 20) Corrective action for River Water Exposure (p. XII-19) assumes that a liquid waste spill would be discovered with adequate time to shut down the Savannah area drinking water intake. We are not confident that human error can be avoided completely in such a case. There is also the question of who decides on behalf of the Savannah area people if a certain leak is serious enough to shut down their water supply. Similar concerns are raised under Corrective Action for Atmospheric Exposure (p. XII-17) where 95% of the populace are expected to respond to an alarm sounded after discovery of a release all within as little as one hour.

Corrective actions are presented to demonstrate that were they taken, a reduction of the estimated impacts could result by the indicated amount. For the purpose of calculating impacts which would result from implementing an alternative, the effect of possible corrective actions was not included. Consequently, even if the assumptions are considered optimistic, it would not affect the results in the document.

K-21 21) The cost calculation for Alternative Plan I includes costs for tank replacement only once during the 300 year projected management period. In actuality, a total of 5 sets of replacement tanks would need to be built at 50 years intervals in the 300 year period.

The proposed trust fund to finance these funds assumes unsupportable trends in inflation and materials production costs. It would, therefore, be appropriate to include the total cost of all tanks in the original cost estimate.

More realistic surveillance costs should also be used for this alternative.

With the above modifications in the cost estimate, we see alternative Plant I being much more expensive than presented, and possibly higher than some other alternatives analyzed.

Table XIII-3 has been modified to include undiscounted costs in 1980 dollars for tank replacement over periods of both 300 years and 10,000 years.

K-22 Short-term cost should not be the deciding factor in comparing alternatives. The unavoidable high cost of managing this waste should be borne now to assure adequate safeguards rather than deferring the cost of future generations with unacceptable risks of environmental contamination in the meantime.

This comment expresses an opinion and requires no response.

K-23 23) We must object to the ommission of certain important issues from Appendix A, "Summary of Substantive Issues Covered in Comment letters." In our comment letter of August 1, 1977 we addressed the following issues, which we believe are very substantive and should have been included in the summary:

a) The need to address impacts of transportation from site to site in each of the alternatives considered. (Our August 1, comment No. 3).

Transportation risks are included for all alternatives that involve offsite transportation in Section V, and the basis of these estimates is discussed in the major supporting reference, ERDA-77-42.

K-24 b) The option of reducing the amount of defense radioactive waste being generated. (Our August 1, comment No. 6).

Response to this comment was given earlier (K-13 and K-14).

K-25 c) Concern about the integrity of existing waste tanks and the methods to be used for storage prior to long-term storage. (Our prior August 1, comments Nos. 9 and 10.

Integrity of the underground double-shell high-level liquid waste storage tanks at the Savannah River Plant was discussed in the following documents:

1. "Final Environmental Impact Statement - Waste Management Operations, Savannah River Plant," (ERDA-1537, September 1977).

2. "Environmental Statement - Additional High-Level Waste Facilities, Savannah River Plant," WASH-1530, August 1974.

3. "Environmental Statement - Future High-Level Waste Facilities, Savannah River Plant," WASH-1528, April 1973.

Currently, DOE is preparing a supplement to ERDA-1537 to address certain specific design and safety features of these tanks. Preparation of this supplemental EIS is directed by the United States Court of Appeals for the District of Columbia Court (NRDC vs. Administrator, ERDA/DOE).

K-26 In conclusion, we believe that many technological questions involved in management of this waste have yet to be answered. In addition, the social issues and public acceptance questions must be resolved before an acceptable waste management alternative can be selected. As a part of this process, we recommend that the public hearing by the National Academy of Sciences (NAS) be utilized in preparing the Final EIS. The results of the present NAS study should also be accounted for. In addition, public comment to the Interagency Review Group on Nuclear Waste Management should recieve full consideration.

The national nuclear waste management strategy is being developed based on the recommendations of the Interagency Review Group on Nuclear Waste Management (TID-29442). The IRG report, as well as the public comments included with it, has received full consideration in the preparation of this document. Socioeconomic as well as institutional issues will be addressed in greater detail in project-specific environmental reviews. Although unavailable for this document, the results of reviews by the National Academy of Sciences will be addressed in Savannah River waste management programs and will be considered in preparing future environmental documentation.

K-26 contd We appreciate the opportunity to comment, and we ask that our comments be given full consideration in preparation of the Final Environmenta Impact Statement.

Sincerely,

Bob Kerr
Executive Director

BK/ea

CC: President Jimmy Carter
Governor George Busbee
Mr. James Setzer, Georgia Environmental Protection Division

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF THE
ADMINISTRATOR

16 NOV 1978

Mr. W. H. Pennington, Director
Division of Review and Coordination
Office of NEPA Affairs
Department of Energy
Washington, D.C. 20545

Dear Mr. Pennington:

The Environmental Protection Agency (EPA) has reviewed the Department of Energy's draft Environmental Impact Statement (EIS) for "Long-Term Management of Defense High-Level Radioactive Wastes" for the Savannah River Plant, Aiken, South Carolina (DOE/EIS-0023-D). Our detailed comments are enclosed.

L-1 EPA is concerned over the absence of any clear statement by DOE identifying the action on which the draft EIS has been prepared. In one instance, DOE states that the EIS is to provide "environmental input for decisions on whether Savannah River high-level wastes should be processed and solidified" (See Foreword). However, DOE also states on page I-1 (Summary that the EIS is intended to "provide for appropriate consideration of environmental values in planning for either permanent disposal or for storage over a period that could extend to several decades." EPA believes the purpose of this EIS should be clearly identified early in the document.

The purpose of the EIS is to analyze the environmental implications of a large research and development program to develop methods for long-term management of the high-level wastes at the Savannah River Plant. The EIS analyzes the environmental impacts which would result from adoption and implementation of the developed technology. The Foreword and Summary have been modified to respond to this comment.

L-2 As a Presidential Interagency Review Group (IRG) is currently recommending radioactive waste management policy, we question why the Department of Energy (DOE) is proceeding with the unilateral policy planning evidenced in this draft EIS. Additionally, EPA is in the process of developing environmental criteria for radioactive waste management. These criteria will address the objectives of waste management and the procedures necessary to provide public health and environmental protection. EPA is also developing environmental standards for high-level radioactive waste management which will be applicable to any disposal option used for the Savannah River Plant's (SRP) high-level wastes. Until such time as EPA's criteria and standards and the IRG policies are issued in final form, it is premature in our opinion for DOE to make firm decisions regarding the final disposition of any high-level waste.

The DOE defense waste management program is consistent with the recommendations of the Interagency Review Group on Nuclear Waste Management (TID-29442):

> "The IRG recommends the DOE accelerate its R&D activities oriented toward improving immobilization and waste forms and review its current immobilization programs in the light of the latest views of the scientific and technical community. Since final processing of defense waste has been deferred for three decades the IRG also recommends that remedial action, including immobilization of the waste, should begin as soon as practicable."

Decisions on whether to immobilize and on ultimate disposal of the waste will be made based on subsequent environmental reviews. The proposed R&D program is sufficiently flexible so as not to foreclose any of the reasonable alternative waste forms under consideration prior to a project-specific environmental review. The proposed R&D effort will factor applicable Environmental Protection Agency criteria into consideration as they become available.

L-3 EPA also has significant concern over specific storage options being considered for SRP waste. We are concerned that alternatives, such as storage or disposal of waste (in bedrock) beneath the Savannah River Plant, are still considered possible options by DOE. We believe that such alternatives are environmentally unacceptable and have so stated in our past reviews of waste management options (both EIS and technology assessment) for the Savannah River Plant. As noted in this EIS, as well as in past Energy Research and Development Administration's reports, bedrock storage or disposal presents a high potential for contaminating the Tuscaloosa aquifer. EPA strongly recommends that other more environmentally satisfactory alternatives be pursued, unless detailed studies (water movement, geological movement) can be provided with information to the contrary.

In accordance with the Council on Environmental Quality guidelines, this EIS analyzes the range of reasonable alternatives to the proposed continuation of an R&D program directed at immobilization. Our analysis does not show a high potential of damaging the aquifer from any of the alternatives; however, EPA's opinion is noted in the body of the EIS.

L-4 In revising the draft EIS, the Department of Energy staff should focus on the different methods of processing high-level waste into other waste forms. Since the final recommendations of the Interagency Review Group will concern ultimate disposal, information on the types of waste forms may be more beneficial than the current limited analysis to a final decision on the Savannah River Plant. Most importantly, until the purpose of the EIS is clarified and coordinated with the recommendations of the IRG, the environmental impact of each SRP alternative cannot be fully discussed.

The purpose of the EIS has been clarified in the Foreword and Summary. A section on alternative waste forms has been added as Section IV-D.

L-5 On the basis of the above concerns we have rated the draft EIS 3 (Inadequate). Further, on the basis of information already available to EPA as well as that provided in the draft EIS, we have categorized any bedrock disposal option at the Savannah River Plant as EU (Environmentally Unsatisfactory). We urge DOE to modify the EIS for the Savannah River Plant to reflect these concerns.

Should you or your staff have any questions, or wish to discuss our comments, please contact Florence Munter of my staff (755-0770).

Sincerely yours,

William D. Dickerson
for
Peter L. Cook
Acting Director
Office of Federal Activities (A-104)

Enclosure

A meeting was held with EPA on January 15, 1979 to discuss the basis for rating the EIS inadequate. It was determined that EPA had considered the document as a Project-Specific EIS instead of a Programmatic EIS and that the analysis was adequate for a Programmatic EIS. The EIS has been revised to clarify that it is a Programmatic EIS. In addition, other EPA comments have been reviewed in detail and the EIS has been modified accordingly.

REVIEW COMMENTS PREPARED BY
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

ON

DRAFT
ENVIRONMENTAL IMPACT STATEMENT
LONG-TERM MANAGEMENT OF DEFENSE HIGH-LEVEL
RADIOACTIVE WASTES AT SAVANNAH RIVER PLANT
AIKEN, SOUTH CAROLINA (DOE/EIS-0023-D)

General Comments

L-6 It is not clear for what action the draft EIS has been prepared. In the Foreword, DOE states that the EIS provides environmental input for decisions on whether Savannah River Plant (SRP) high-level wastes should be processed and solidified. However, in the Summary (p. I-1), DOE indicates that "the statement is intended to provide for appropriate consideration of environmental values in planning for either the permanent disposal of the waste or, if needed, for storage over a period that could extend to several decades." There is a clear difference in these statements regarding the purpose of the draft EIS. The draft EIS was obviously written for the latter purpose. However, given the current status of the radioactive waste program for selecting repository sites and EPA's many previously recorded objections to the use of bedrock disposal at SRP, we believe the draft EIS should be substantially revised to address in a more effective manner the processing and solidification options for storage and eventual disposal of SRP high-level radioactive waste.

This comment has been addressed above. The Foreword and Summary have been clarified accordingly.

L-7 The alternatives or options for high-level waste processing into suitable forms for long term storage or disposal received inadequate consideration in the draft EIS. Only two waste forms were considered, glass and the existing slurry/sludge combination. This limitation falls far short of achieving the purpose of the draft EIS as expressed in the Foreword. The discussion of solidification options in Chapter X provides very limited information for options that are only modifications of the vitrification option. No discussion is included for any of the solidification options that potentially offer a more effective barrier to migration of the waste. These options include such methods as metallic matrices, ceramics and others.

Section IV-D has been added to discuss alternative waste immobilization forms.

L-8 More consideration should be given to combinations of alternatives, such as surface storage followed by disposal in a deep geologic repository. According to the IRG's report, mined repositories might not be available until the year 2000. (Site availability is dependent upon a number of technical criteria and research, much of which is not available at this time.) In this case, storage of waste at facilities such as Savannah is an integral part of the overall national waste management strategy.

Alternative 2, Subcase 2 (convert the waste to glass and store on the surface at SRP) is intended to give the environmental impact of leaving the waste at SRP for a long period in lieu of immediate shipment to an offsite repository. Costs and risks are given in modular form to enable the reader to construct reasonably accurate cases for variations that may be of interest.

L-9 We have identified several problems concerning the length of time during which institutional control can be relied upon and the length of time for assessing the environmental impact of waste storage. EPA currently believes that reliance on institutional controls should be limited to about 100 years. This institutional control limit would drastically alter the two alternatives which involve surface storage of the high-level waste (Alternative 1 and Alternative 2 - subcase 2). The revised draft should consider EPA's forthcoming proposed institutional control limit of 100 years. (Federal Radiation Guidance on Waste Management). The 100 year institutional control limit also raises serious questions concerning the adequacy of the risk analysis in Chapter V. For example, in Alternative 2 - subcase 1, Glass Stored in Offsite Geological Storage, the exposure risk from the storage event is listed as negligible. We believe an abandonment scenario should be included for this event or activity. Preliminary findings in EPA's waste disposal risk assessment indicate that the loss of institutional control (abandonment) at a repository leads to potentially significant risks. In fact, the expected risk (time-integrated risk) for the abandonment scenario at a repository is greater than that presented in Table V-13 for the total risk.

The risk analysis has been modified at the request of EPA to reflect abandonment of the tanks after 100 years for Alternative 1 - Continued Tank Farm Operation. As stated in the text and the backup reference ERDA-77-42, consequences of abandonment of the air-cooled vault in Alternative 2 - Subcase 2 are negligible. Any geologic disposal system implies eventual abandonment, but population exposures received from long-term migration of such isotopes as I-129 and Tc-99 to the biosphere are negligible compared to exposures from natural radiation. Tables V-17 and V-17A are included as estimates of the risks that might be incurred by individuals intruding into an abandoned generic repository.

L-10 Another major problem with the risk analysis in Chapter V is the arbitrary cutoff of the impact assessment at 300 years. The potential hazards of the waste beyond 300 years are much too great for such an arbitrary decision. Risk assessment for waste management and disposal should be carried out for a much longer period. In addition, the consequences of risk assessments should be presented in health effects, as is common practice with risk assessments, rather than population doses as presented in the draft EIS. EPA believes the risk analysis presented in the draft EIS is inadequate and should be significantly modified before issuance of a final EIS.

The integration of risks for 300 years is not arbitrary, but is based on the fact that after that time exposures that could be received by average individuals in the nearby population from any of the unusual events could be only small fractions of the exposures normally received by those individuals from natural background radiation. This topic is discussed in Sections V-C.3 and XI-B.2.

The EIS has been modified to add integration of risks through 10,000 years, and a discussion of possible health effects has been added. These changes are included in Sections V-C.3, XI-B.2, Tables XI-5 through XI-9 in Section XIII, and in the Summary.

L-11 *Given the limitations on information presented in this EIS,* EPA questions the usefulness of the cost comparisons provided. Inclusion of all costs and sensitivity analysis of assumptions could significantly change relative costs of the alternatives. Thus, to avoid misinterpretations of the calculated cost estimates, an explanation of the limitations of the EIS should be presented. There are three types of limitations on the cost information presented:

1. Only certain types of costs are considered: budgetary costs for the storage systems, radiation risk to *the public, and land contamination. Environmental costs,* social costs and monetary costs other than engineering costs, are not considered.

2. The costs that are presented are calculated only for certain assumptions, e.g. budgetary costs and radiation risk are calculated for a limited area, and for a limited time.

3. Methodology and assumptions used in calculating budgetary costs are not fully explained.

EPA submitted similar cost comments regarding ERDA 77-42, but there has been no improvement in the cost comparison methodology in this draft EIS.

Comment No. 1 is incorrect regarding budgetary costs. The EIS includes monetary costs not only for the storage systems but also for all other parts of the long-term waste management activities, starting with removal of waste from tanks through processing the waste, transportation, and finally through ultimate disposal, where applicable to the particular alternative. DOE is unaware of any methodology for placing a monetary value on what the comment refers to as "environmental costs" and "social costs." There is, in fact, considerable controversy over whether it is useful to attempt to place a monetary valuation on radiation population risk, as *one of the examples in this EIS does.*

The assumptions regarding cost calculations are the best that can be made at this time; however, they do include a broad enough area and time span that any additional coverage would be insignificant.

The comparisons in the document are given primarily as examples of how a decision process might take the different aspects of the alternatives into account. The basic data for each alternative are available in the document, so that any *reader who so desires can make his own evaluation. Sensi*tivity analysis of the important factors is covered in Section XI-C. The accuracy of different components of monetary cost is discussed in Section X-A.

L-12 <u>Geological Comments</u>

EPA strongly objects to the storage or disposal of radioactive waste in the bedrock beneath the Savannah River Plant. In EPA's opinion, the alternatives involving storage or *disposal beneath the SRP are not viable and we have opposed* alternatives that involve bedrock disposal beneath SRP since 1972. (See EPA's enclosed comments on "Final Environmental Impact Statement, Waste Management Operations, Savannah River Plant," (ERDA-1537) and "Alternatives for Long-Term Management of Defense High-Level Radioactive Waste - Savannah River Plant," (ERDA-77-42).

The rationale for including disposal of waste in the bedrock beneath SRP in the alternatives covered is discussed in Sections I, II-A, and Appendix A. It is noted in Section I, SUMMARY, that EPA has disapproved of this alternative disposal mode. No work is under way, and none is proposed, on the bedrock disposal concept at SRP.

L-13 The basement rock beneath the Savannah River Plant is described in the draft EIS as crystalline metamorphic rock *grading into Dunbarton Triassic Basin* rock to the southeast. A vertical geologic cross section to a 2,000 foot depth is depicted in Figure 1 and shows approximately 1000 feet of unconsolidated sedimentary rocks overlying older crystalline metamorphic and Triassic sedimentary basement rock. The contact between the older crystalline metamorphic rock and younger sedimentary Triassic basement rock is a normal fault and predates the Triassic deposition. The presence of

As stated, mylonites and cataclastic textures are common in the metamorphic rocks of the Piedmont province and are also indicated in the metamorphic rock beneath SRP. The origin of these features, however, is quite ancient and is probably related to the orogenies of the Paleozoic. There is no reason to believe these ancient features are related to the current fractures in the basement rock or to modern seismicity in the region.

L-13 mylonite zones in the crystalline metamorphic rock has been contd reported by Christl (1964) and Diment et al. (1965). In addition, this rock type is indicative of major fault zones which parallel the Appalachian system as described in graphic detail by Higgins (1971) and Hatcher (1972).

Diment, et al. (1965), reporting on the basement rock beneath the Savannah River Plant, states: "Mylonite occurs in localized, intensely sheared zones of the basement rock, and elsewhere flaser textures are widespread as a result of mechanical granulation." The major fault zones which parallel the southern Appalachian Mountains also contain mylonite and cataclastic rocks and are a result of intense faulting. Mylonite zones along these faults are commonly one half mile wide and these grade into cataclastic rock zones up to 3 miles wide (Higgins, 1971); these rock assemblages characterize the fault zone. The widespread occurrence of mylonite and cataclastic rock (flaser texture) in the basement rock beneath the Savannah River Plant, in addition to the multiple complex fracture systems warrants careful DOE consideration. These occurrences will affect the integrity of the crystalline rocks as a repository for high-level waste. While preliminary data suggest that the Triassic sedimentary rocks are not as extensively fractured, the proximity of the basement rock and local inter-mixing of water from the basement rock with the overlying aquifer are factors of important significance in any bedrock disposal plan.

L-14 The 500 foot thick Tuscaloosa aquifer overlying the basement rock is one of the most important aquifers in the southeastern United States (See Figure 1). A saprolite clay of an average of 70 feet in thickness separates the basement rock from the aquifer, but locally this clay is absent. The investigative report of the National Academy of Sciences (1972) assumes that water from the basement rock is being transmitted upward into the Tuscaloosa aquifer at a rate of 0.002 gpd/ft^2 where clay is present, but at 0.0035gpd/ft^2 wherever the clay may be absent. To date, no absolute hydraulic separation of the basement rock from the Tuscaloosa aquifer has been proven by the chemical evidence available and it may be presumed that movement of waters between the basement rock and the aquifer occurs in accord with existing permeabilities and hydraulic gradients. The possibility of aquifer and basement water mixing, involving potential high-level nuclear waste, presents a potential risk of contamination in the Tuscaloosa aquifer and the biosphere.

The gross separation of the waters of the coastal plain aquifers and those of the bedrock are shown by: (1) the abrupt discontinuity in their chemistries TDS $\simeq$ 30 mg/l at the base of the coastal plain aquifer and 6000 mg/l in the crystalline metamorphic rock; (2) pumping about 1500 gpm in each of two plant areas continuously for 27 years has not caused a decline in hydraulic pressure in the crystalline rock; (3) a year-long pumping test in the crystalline rock showed no indication of leakage through the safrolite; (4) a large amount of helium has accumulated in the waters of the crystalline rock which could not have accumulated if there were even minor leakage from the metamorphic rock. Therefore, although it has not been conclusively demonstrated, the water mixing potential is considered to be extremely low. Migration of radionuclides from the cavern was considered in the preparation of the EIS and the potential environmental impact was determined to be insignificant.

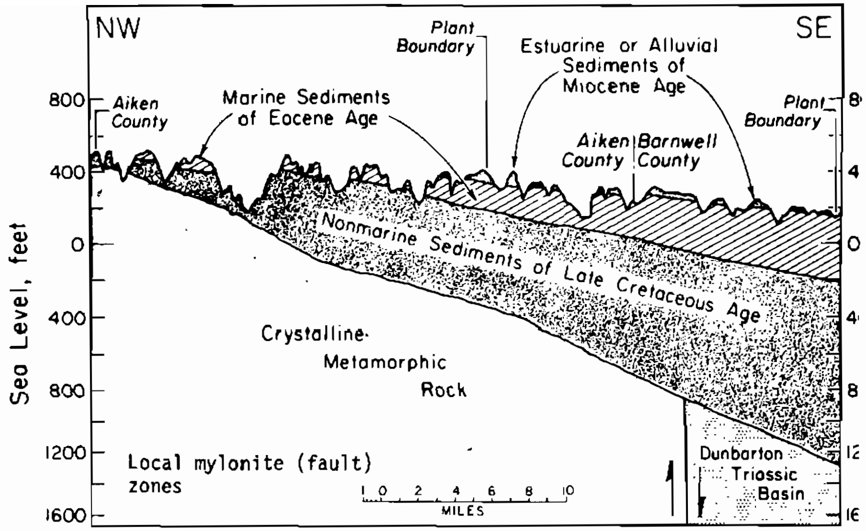

Figure 1: EPA has revised Figure III-3 (page III-5) from the source document to show the local mylonite zones and the fault between the Triassic sedimentary rock and the Metamorphic basement rock. The Tuscaloosa Aquifer is in the formation labeled as "Nonmarine Sediments of Late Cretaceous Age."

L-15 A map of earthquake hazard developed by Algermissen and Perkins, 1977, is depicted in Figure 2. Although the hazard in the East is lowered by the relative infrequency of large earthquakes, the total time in the last 250 years is actually greater than that in the West. As shown in Figure 2, the highest number in the East centers around Charleston, S.C., which in 1886 was the site of an earthquake of Intensity X on the Modified Mercalli Scale. While the cause of this severe earthquake is speculative as to origin, the earthquake epicenter lies but a few miles from the Savannah River Plant site.

The fact that the metamorphic bedrock is locally faulted and fractured makes bedrock disposal, even in the Triassic sedimentary rock, and unviable option at SRP. At a minimum, these geological problems should be discussed more adequately in the final EIS.

As stated on page III-11 of DOE-EIS-0023, the epicenter of the Charleston Earthquake of 1886 was about 90 miles from SRP. All investigations of known faults in the metamorphic bedrock have shown that they are noncapable faults. The options for storage of waste in bedrock assume that the cavern would be constructed in nonfaulted bedrock. Extensive field study would be required to determine whether disposal in a nonfaulted area is in fact feasible but studies to date do not preclude this possibility.

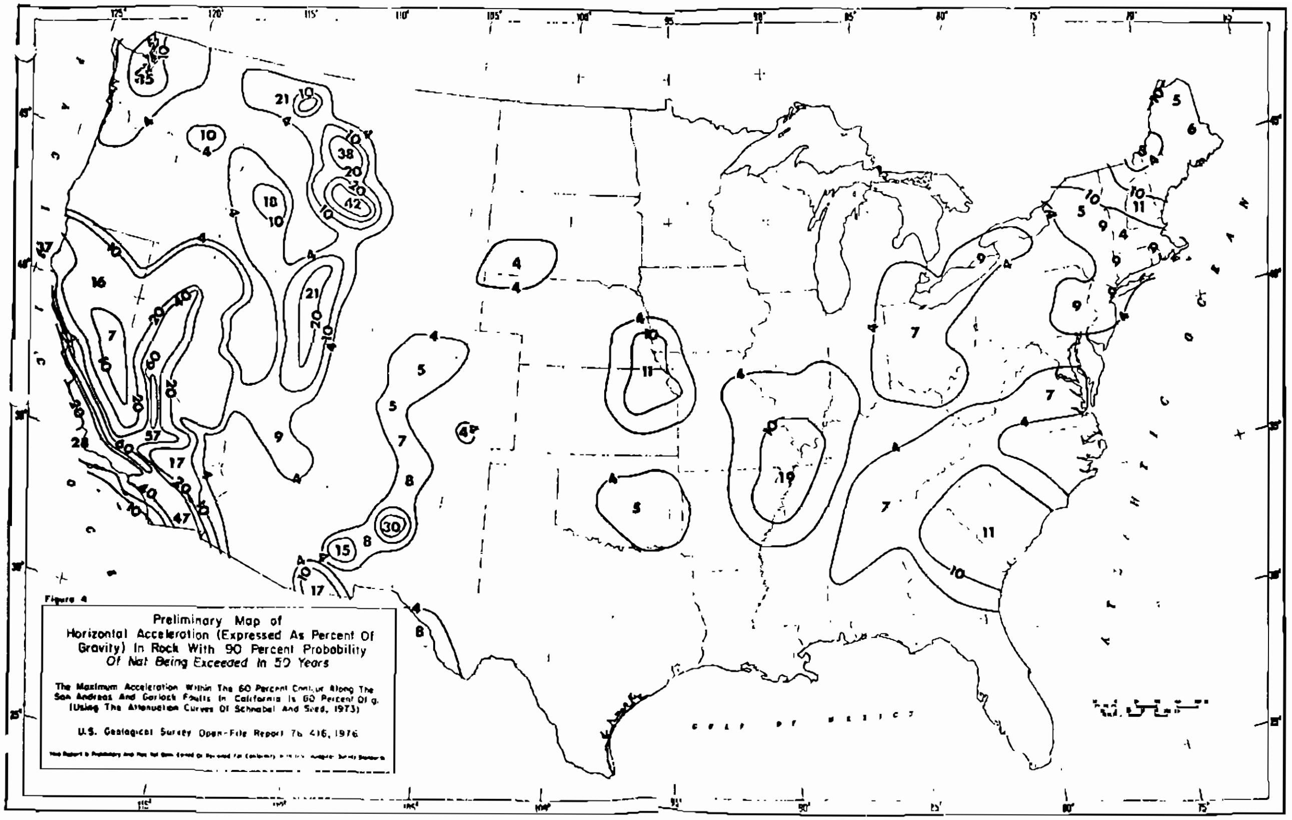

Figure 2: Earthquake Hazard Map of the United States developed by Algermissen and Perkins (1977). The numbered contours are the horizontal acceleration in hard rock as a percentage of g - the Earth's gravity. The numbers within each contour are the maximum expected accelerations at a constant-probability that the numbers will not be exceeded in 50 years. In other words there is a 10 percent probability that the acceleration values will be exceeded in 50 years. (From Algermissen and Perkins, 1977).

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Higgins, M. W., 1971, Cataclastic Rocks, Geological Survey Professional Paper 687.

National Academy of Sciences, 1972, An evaluation of the concept of storing radioactive wastes in bedrock below the Savannah River Plant site, Washington, D.C., 86p.

Specific Comments:

L-16 1) Page IV-5, Figure IV-1:

Two curves are labeled Eu-154. One of these labels is in error and should be corrected in the final EIS.

The figure has been corrected.

L-17 2) Page V-3, subsection 3, "Impact on Air and Water Quality", in the third paragraph: The use of settling ponds suggests that there will be some contamination present. What monitoring procedures will be provided and what radioisotopes and concentrations are expected? Also, what would prevent contamination of offsite groundwater?

If settling ponds are used in any alternative actually implemented, monitoring procedures and barriers against contamination of offsite groundwater would be similar to those used for present operations at SRP and would comply with all Federal and State regulations in effect at the time. Details of such facilities would be covered in later, project specific documents, when detailed system design is available.

L-18 3) Page V-16, Table V-9: The Radiation Exposure Limits in the drinking water regulations take precedence over DOE exposure limits. (See "National Interim Primary Drinking Water Regulations," EPA-570/9-76-003). Also what isotopes are included for this table and how are they released? A table such as this may also be needed in reference to the Clean Air Act.

Section V-B.4 and Reference V-13 have been modified to assure that any such releases will comply with all applicable Federal and State standards.

The limits apply to the radiation that could be received from a weighted sum of all isotopes released, as stated in the referenced text of the regulations.

L-19 4) *If the reconstituted waste is demineralized* and processed to glass, this would result in 5100 cannisters of glass (ERDA 77-42). There is no reference to this number of cannisters in this document, only a statement that the glass matrix would be 35 percent waste. Further details should be provided in the final EIS. There is a conflict between Table V-4, p. V-11, of this document and Table III-8 in ERDA 77-42 as to the time requirements for this option. In one case, it is 10 years; the other computes to 5 years. This discrepancy should be clarified and an explanation should be provided as to how the 5 years or 10 years was calculated. For example, if 23,625 salt cake cannisters were filled over a 10 year period, this works out to 45 per week, equaling an average process load of 45,000 gal/wk. This is an intensive operation which should not be neglected and discussed lightly. More explanation is needed in the final EIS.

The "reference case" duration for processing the SRP inventory has changed between the present time and the time of issuance of ERDA 77-42, but the total waste volume has not. This EIS estimated the potential environmental impacts based on total waste volume and individual canister characteristics rather than rate of processing. The actual rate of processing is likely to change further during this preliminary period of research and development, design, and testing, but more details of the final alternative to be implemented will be covered in the project-specific EIS for that alternative.

L-20 5) Page V-24: The discussion of hazards associated with nuclear waste is incomplete. Preliminary EPA studies of disposal of high-level radioactive waste in mine repositories indicate that there are pathways, particularly through water, that engineered barriers cannot be depended upon to prevent over long periods of time. The migration of some nuclides is not slowed to any great degree by geological barriers. The discussion of dilution on this page does not recognize that population dose is not significantly affected by dilution. In addition, the DOE staff implies that there will be permanent existence of the SRP exclusion area. As stated previously, EPA's forthcoming criteria states that reliance cannot be placed on institutional controls for periods beyond one hundred years.

The risk analyses for all the alternatives either include abandonment as part of disposal, or discuss the environmental consequences of abandonment of the long-term storage modes, thereby converting them to disposal.

It is beyond the scope of this Programmatic EIS to debate the usefulness of integration of very low individual exposures over long time periods to arrive at large population exposures. However, integration over 10,000 years has been added, along with a comparison with natural background.

The EPA limit of 100 years for reliance on administrative control has been included in the abandonment scenarios for continued tank farm operation and surface storage in an air-cooled vault at SRP.

L-21 6) Page V-26: The last paragraph on this page states that it is extremely unlikely that people will continue to drink well water from a location directly over a leak into the aquifer. In the long term, we believe knowledge that the waste repository exists and assumptions that water supplies will be monitored for radioactivity cannot be depended upon.

The analyses and conclusions given in the document do not depend upon future populations avoiding drinking any contaminated water - worst case results are given throughout the document, assuming no corrective actions are taken. However, DOE and other reviewers believe that it is important to point out mitigating measures that could be taken, and these are discussed in more detail in Section XII-D.

L-22 7) The summary of exposure risks in Tables V-12, V-13, V-14, V-15, and V-16 is inadequate in that the range of possible release events is very small. The time integrated risk is also artificially small because of the limitation of the integration period to three hundred years. More events should be considered, as well as a longer time period.

The tables have been modified to include risks integrated for 10,000 years, and to include abandonment of Alternative 1 after 100 years, as requested by EPA. As part of the bounding approach to this risk assessment, all the events that could contribute significantly to overall risk have already been included, and are described in more detail in the backup reference, ERDA-77-42.

L-23 8) Page V-27: Doses to a reasonable population should be calculated. Our criteria suggest that this be done for a much longer period than the 300 years given, since the waste is hazardous for longer than 300 years.

As stated in Section V, the population at risk was assumed to grow by a factor of 5 over a 150-year period. All populations that could incur individual exposures greater than a small fraction of background were included. The analysis was expanded to include integration of risks over 10,000 years.

L-24 9) Pages V-33 and V-34, subsection 4, "Offsite Land Contamination": This section should dicuss and reference the existing Protective Action Guides to ensure agreement with the Guides as well as the "Proposed Guidance on Dose Limits for Persons Exposed to Transuranium Elements in the General Environment," EPA Report #520/4-77-016.

Many details of the risk assessment are not included in this EIS but, as stated in the text, are included in the major reference documents in an effort to make this document more easily readable. As stated in the reference, ERDA-77-42, the Protective Action Guides were consulted in deriving the limits used for land contamination. The subject is still in a process of change regarding regulations and guides, and the latest available information will be used in documents related to any alternative proposed for actual implementation. The analysis presented is enough to show that land contamination possibilities from unlikely events would not be a major decision factor regarding the conduct of the research and development, design, and testing program covered in this Programmatic EIS.

L-25 10) According to the draft EIS, the status of present technology of glassification and vitrification is sufficient to have a waste storage facility operational by 1985. At that time, 60×10^6 gallons of reconstituted waste will be fed to a demineralizing facility (p. IV-4) from processing and solidification. If the waste is processed so that the high activity fraction is separated and solidified to glass, there would remain 24.5×10^6 gal of decontaminated salt cake (note on p. IV-22 a value of 16.3×10^6 gal is mentioned, an apparent conflict). If shipped offsite, it would involve approximately 23,625 canisters (p. V-45). This means that each cannister is capable of holding over 1000 gallons of salt cake. The draft EIS does not give an adequate explanation about this cannister requirement (though it is diagrammed in past reports-ERDA 77-42), nor does it provide the accident frequency data for vehicle loads exceeding 20,000 pounds. The salt cake alone weighs 19,500 pounds using salt density of 2.25 g/ml (ERDA 77-42). There is not enough information about this processing and shipping requirement; reference should be made in the final EIS to existing industrial experience with mass production of cannisters of high quality, glass formation processes, and demineralizer removal efficiences.

Radiation exposures and possible transportation accidents for alternatives that might involve shipment of decontaminated salt offsite are discussed in Section V-E.3. As noted in the comment, the canister is described in ERDA 77-42 and is incorporated in this EIS by reference. The injury frequency data given on p. VI-II of this EIS was taken from WASH-1238 which is based on actual accident frequency information during 1968 and 1969.

L-26 11) Page VII-2, table VII-1: Are the cost of salt cake disposal options included in Table VII-1, "Commitment of Resources?"

Yes, the cost of disposal of decontaminated salt cake in existing tanks at SRP is included, where applicable to the specific alternative, as pointed out in Section V-E, "Potential Effects from Decontaminated Salt Storage."

L-27 12) Page XII-3: See comments pertaining to pages V-33 and V-34.

See response to Comment L-24.

L-28 13) Page XII-1, 2nd paragraph: Is the $1000/person-rem based on a lower level of carcinogenesis? See ICRP-26. Furthermore, EPA does not believe the $1,000 per person-rem represents a valid measure of reducing risk.

It is not clear from the comment what a "lower level of carcinogenesis" means. The reasons for including an example cost-risk analysis involving a dollar value for radiation risk are discussed in Section XII-1.

L-29 14) In Table XII-7 on page XII-9 (Summary of Costs and Exposure Risks for Alternative 2 - Subcase 2: Glass Stored in Onsite Surface Storage Facility and Decontaminated Salt Cake Returned to Onsite Waste Tanks) the published value for the Incremental Cost-Risk in dollars/person-rem has been incorrectly calculated as $31,900. The value should have been $28,600.

The value given in the Draft EIS was calculated before round-off of the numbers to be presented in the table, thereby giving rise to the potential that the reader may calculate slightly different values. For this final version of the EIS, cost numbers and some risk numbers have been updated, and entries in the table have changed.

L-30 15) Section XII-B, pages X-II-6-XII-12. The Incremental Cost-Risk technique for comparing the various high-level waste management alternatives has several weaknesses. Ideally, a method of comparing alternative waste management techniques should use the present waste management techniques as the basis for the comparison. The order of the ranking (by a methodology) should be insensitive to choice of the base case. Unfortunately, the Incremental Cost-Risk methodology meets neither of these criteria. First, the Incremental Cost-Risk estimates incorrectly use the least expensive alternative (Alternative 3) as the base case. Since a change in the method of managing high-level wastes can only mean a change from the present waste management technique, the comparison with the least expensive alternative has little meaning, unless the present method is also the least expensive alternative. For example, if the present method of waste management (Alternative 1) is used as the base case, instead of the least expensive technique (Alternative 3), the order in which the three subcases of Alternative 2 are ranked changes. The final EIS should address these weaknesses in the Incremental Cost-Risk technique.

The order of the alternatives' ranking necessarily must depend upon the base case, because the waste is already in hand and is stored for an interim period in a method that can branch to either less expensive or more expensive alternatives, or remain the same.

As a coincidental matter, updated cost estimates between the draft EIS and this final EIS have resulted in Alternative 1 becoming the least expensive and, therefore, base case.

L-31 16) Page XII-12, Paragraphs 4, 5, and 6 pertaining to the quotations from NCRP 43: Again, ICRP-26 should be carefully studied and compared to NCRP 43 since ICRP-26 is the more recent reference.

Nothing is contained in ICRP-26 that negates the judgements expressed in NCRP-43, but NCRP-43 is the specific reference.

L-32 17) Page XII-13, Table XII-10: In the second column headed by "Estimated Average Radiation Dose Risk, person-rem/year." The 200,000 appears to be whole body exposure, and the 180,000 appears to be based on the mean effect on bone marrow: What is the basis for the remaining numbers? Are they total body numbers?

As stated in the footnote to Table XII-10, all the numbers in the first column are on the same basis and are whole body equivalent exposures.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 1 1977

Mr. W. H. Pennington
Director, Office of NEPA Coordination
U.S. Energy Research and Development
Administration
Washington, D.C. 20545

Dear Mr. Pennington:

L-33 The Environmental Protection Agency (EPA) has reviewed the Report on "Alternatives for Long Term Management of Defense High-Level Radioactive Waste at the Savannah River Plant, Aiken, South Carolina" (ERDA 77-42/1,2). The stated purpose of this site specific report is to describe the different alternatives along with their probable relative costs, risks, and uncertainties. A secondary purpose is to raise the issue of methodology for decision making in nuclear waste management. Subsequent to this report, before any long-range waste management plan is implemented, an environmental statement will be prepared to assess in detail the potential environmental impact of all of the preferred alternatives.

The comments in this letter are directed to the related "Alternatives" document (ERDA 77-42), which preceded the draft EIS, rather than the EIS itself. The "Alternatives" document was issued for public review, but was never formally revised. However, comments received on that report were considered by DOE in the preparation of this EIS. Specific answers to the EPA comments on the "Alternatives" document are provided here since they were appended to their EIS comments and since they address data and analyses upon which the EIS is based.

L-34 With regard to the alternatives examined in the report, it is noted that three of the eight considered in detail involve the disposal of high-level waste in bedrock below the SRP. EPA reviewed an EIS for this alternative in 1972, and concluded that serious uncertainties existed about the potential impact of this disposal method. To our knowledge little or no significant information has been developed to resolve these uncertainties during the past five years. While an attempt is made in the report to demonstrate that this alternative is the most cost-effective, the large uncertainties in the potential impact resulting from use of this method are sufficient cause for its rejection. Therefore, we continue to have grave concerns relative to the acceptability of this alternative and believe that the bedrock storage alternative should be totally eliminated as a permanent high-level waste disposal technique at the Savannah River Plant site. We would further state that the SRP site does not appear to be acceptable as a site for permanent disposal for high-level radioactive waste and that any of the storage alternatives for SRP, as stated in the report, would constitute temporary solutions requiring later remedial action.

The bedrock alternatives were included in the "Alternatives" document because, if these alternatives are indeed feasible, they represent the lowest cost solutions to the problem of disposing of the SRP high-level wastes. However, as emphasized in the text, major uncertainties do exist about the safety of the bedrock alternatives. These uncertainties can be resolved only by large-scale research programs, and no such large-scale research programs are currently underway or planned, in part because of the unsatisfactory ratings given to the bedrock alternatives by EPA. Disposal of the immobilized SRP waste would be at future Federal repository.

(contd)

L-35 Before a decision can be made regarding the ultimate disposition of the high-level waste at Savannah River Plant (SRP), presumably at an approved high-level waste disposal site, we believe a thorough examination of the objectives of waste disposal must be conducted. This is necessary in order to clearly define what is to be accomplished before implementation steps are taken.

In the period since EPA recommended a "thorough examination of the objectives of waste disposal," a major review of the nation's nuclear waste management program was undertaken by the Interagency Review Group (IRG) on Nuclear Waste Management, whose final report was published in March 1979. The IRG set forth planning objectives and broad technical and implementation objectives. Specific objectives, standards, and criteria need to be established by EPA and NRC through the regulatory process to complement the stated planning objectives. DOE has, and will continue to modify its technical objectives and implementation programs in response to emerging environmental protection criteria. These issues will be revisited in the course of subsequent site-specific environmental reviews.

L-36 EPA is in the process of developing environmental criteria for radioactive waste management. These criteria will address the objectives of waste management and will provide a basis for what must be accomplished in waste management activities to provide assurance of public health and environmental protection. EPA is also developing environmental standards for high-level radioactive waste management which will be applicable to any disposal option used for the SRP high-level wastes. Until such time as these criteria and standards are issued in final form, it is premature, in our opinion, to make firm decisions regarding the final disposition of any high-level waste.

Although the final waste management alternative chosen for disposing of the SRP high-level waste must meet all applicable EPA criteria and regulations, DOE must start its initial studies now so as to be ready to make firm decisions when the final criteria and standards are available. This is consistent with the recommendations of the Interagency Review Group on Nuclear Waste Management (TID-29442) in that immobilization of defense waste should begin as soon as practicable. It is also hoped that the results of the DOE waste management research and development programs will assist in the development of criteria and standards by the regulatory agencies. The proposed R&D program will be undertaken with sufficient flexibility so as not to foreclose any of the reasonable disposal methods under consideration prior to completion of a project-specific EIS.

L-37 While the SRP alternatives report is an important first step in exploring the disposal alternatives, we believe, in light of the above considerations, that no decision should be made for a particular alternative until clearly defined objectives are available. EPA expects to promulgate its proposed guidance for radioactive waste management in the next few months. We are in agreement with the need to find suitable disposal methods as soon as possible, but waiting a few months before committing significant resources and investments to specific alternatives seems prudent.

Neither the "Alternatives" document nor this EIS are aimed at arriving at final SRL high-level waste disposal methods. The purpose of this EIS is to obtain public inputs to orient the DOE research and development effort. Selection of the SRP high-level waste management alternative and the repository will be supported by future environmental documents.

If you or your staff have any questions or wish to discuss our comments in more detail, please call on us.

Sincerely yours,

(signature unreadable)
for
Rebecca W. Hanmer
Director
Office of Federal Activities (A-104)

Enclosure

A-ERD-A00131-SC
Review Comments Prepared by
United States
Environmental Protection Agency
on
Alternatives for Long Term Management
of Defense High-Level Waste
at the Savannah River Plant,
Aiken, South Carolina
ERDA Report No. (ERDA 77-42/1,2)

General Comments

L-38 We believe that the first step which must be taken is to define the problem which the proposed action is to solve. For example, certain of the alternatives presented would suffice for temporary storage as is now the practice. Other alternatives would more appropriately fit a category of long-term storage (say for 100 years) such as glassification and vault storage; while some alternatives may be more suitable for a permanent storage philosophy (in keeping with the long-lived isotopes involved) in glass encapsulated canisters buried in deep geological formations. Once the key time-related criteria have been determined and categorized, technical alternatives could be assessed for their applicability to well engineered systems in each time group. The objective would be to provide optimal environmental integrity in each time category.

Although the various alternatives considered do indeed leave the wastes in very different final states, all are carried to the same end point in the analysis by determining the long-range hazards from the different final forms; e.g., the hazards of abandoning the wastes in their existing tanks are compared with the hazards of leaving a glass waste form in a geological repository. The objective of the DOE waste management programs is to protect the human environment.

L-39 Given the limitations on the accuracy of the information presented in the report, the usefulness of the cost comparisons is also limited. Moreover, inclusion of all costs and a sensitivity analysis of assumption could significantly change relative costs of the alternatives. Thus, to avoid misinterpretations of the calculated cost estimates, an extensive explanation of the limitations of the report should have been presented, and the title of the tables should have indicated the limitations on the information that is presented. There are three types of limitations on the cost information presented in the report.

1. Only certain types of costs are considered: budgetary costs for the storage systems, radiation risk to the public, and land contamination. Environmental costs, social costs, on-site radiation risk, and monetary costs other than engineering costs, are not considered.

2. The costs that are presented are calculated only for certain assumptions, e.g., budgetary costs and radiation risk are calculated for a limited area, and for a limited time.

3. Methodology and assumptions used in calculating budgetary costs are not fully explained.

See response to L-11.

L-40 Other major inadequacies in the report are the failure to consider any impact beyond 300 years, and the assumption that the Savannah River Plant site will remain a controlled, low population, Federally owned area for at least the 300-year period. Restriction to 300 years implicitly considers that only the fission products, specifically, strontium-90 and cesium-137, are of concern. This is contradictiory to the description of the waste (page III-5) as containing plutonium-238 at a concentration of 1×10^{-2} Ci/gal (2,600 nCi/g) and plutonium-239 at a concentration of 3×10^{-4} Ci/gal (80 nCi/g), plus other actinides. Even after the 300-year period the plutonium-238 would still be present in a concentration of 230 nCi/g and the plutonium-239 decay would, of course, be negligible. Changes in population density cannot be ruled out (how many people lived in the present Phoenix, Ariz. city limits 300 years ago?) nor can governmental or societal changes. The discussions of abandonment, which presumably include loss of government ownership of the area, do not include population build-up or the intrusion into the area of curiosity seekers, archaeologists, or children.

See responses to L-9 and L-10.

Specific Comments

L-41 1. Bedrock Storage (Disposal) at Savannah River Plant

EPA has serious questions as to whether this is an appropriate method of disposal and more particularly whether the proposed site and scale of exploratory activity should be undertaken without a broader assessment of the generic issues of disposal.

See responses to L-3 and L-12.

L-42 More complete discussion and documentation of the results of previous investigations of hydrogeology would be necessary for an independent evaluation of the applicability at Savannah River Plant of the philosophy that the long-term storage of the ERDA's high-level wastes should rely only minimally on human surveillance and that the protection should be achieved primarily through isolation of the wastes within natural barriers. Our concerns with this philosophy of containment at Savannah River Plant arise from the fact, that deep testing to determine and interpret hydro-geologic parameters of the natural ground water regime is difficult under any circumstances, and is especially difficult in fractured aquifers such as the bedrock at Savannah River Plant. It is not possible to validate some of the physical assumptions of existing movements, and extrapolations for hundreds to thousands of years must be made with hydraulic coefficients derived from limited test data and relatively short testing periods. Furthermore, it is likely that future development and use of the Tuscaloosa aquifer above the bedrock will perturb the hydrologic regimes in both the Tuscaloosa and the bedrock in ways that are not entirely predictable at present. In the report, a section on Bedrock Disposal should specifically address the NAS report on geologic aspects of radioactive waste disposal, dated May 1966, and why ERDA is proceeding with a project of this magnitude contrary to NAS study conclusions.

See responses to L-13 and L-14.

The following comments on Bedrock Storage are more specific to the Report itself:

L-43 A. On page II-8 the Report discusses the third alternative, that of slurrying the existing wastes into a bedrock cavern dug in an impermeable Triassic mudstone under the Savannah River site. The advantages and disadvantages of this alternative are discussed at greater length in other sections with principal emphasis on possible events which could threaten the integrity of such a cavern after it has been filled (even partially filled) with the wastes. It would seem that the Report should give some attention to the prospect of the actual tunneling procedure creating cracks in the rock, disrupting the caverns integrity, and connecting the cavern to the aquifier above.

Previous analysis has indicated that tunneling in the triassic mudstone should be only a minor source of mudstone cracking. However, this analysis can be verified only by an actual program of exploratory mining; such a program is not now planned.

L-44 B. As an extension of the discussion on geologic disposal, the Report indicates on page II-9 that geologic disposal options would require large scale exploratory shafts for time-periods long enough to give a high level of confidence of the shaft's continued integrity after sealing. The obvious question that comes to mind in connection with this statement is "How long will the time-periods have to be to give that assurance?" Considering the scheduling needs and the decisions that will have to be made in the near future, it seems that thorough assurance of this disposal technique may not be available in the time frame required.

The actual time periods required to assess the integrity of the mudstone caverns cannot be determined until actual mining experience uncovers the actual geological conditions. However, if the high integrity rock is found, unless investigations which can be completed in a few years discover a potential problem, we would be assured of long-term integrity.

L-45 C. On page III-1 the statement is made that once the cavern is sealed it will require no maintenance or surveillance. Even though maintenance and surveillance may not need to be extensive, it hardly would seem prudent to abandon the site. Surely some inspection and monitoring would continue so as to provide an early warning of potential problems.

In actuality, a long-term surveillance program would almost certainly be maintained on the decommissioned repository. However, one of the design criteria for the repository would be to minimize the risk of abandoning the repository in accordance with the EPA policy guidance that limits the duration assumed for institutional control to 100 years.

L-46 D. On page III-22 Alternative 8 is discussed. The Report indicates that the bedrock cavern containing canned glass wastes is expected to eventually flood after sealing. It seems that if the cavern is expected to flood when it contains solidified wastes that it would similarly be infiltrated if the cavern contained liquid wastes. One could also conclude that if water can get in, the liquid wastes could use the same pathways to get out - possibly to the surrounding ground water. The Report should give more information on this projected flooding and what implications such flooding would have for the success of the bedrock options.

A cavern containing liquid waste would likely flood as readily as one containing solid waste. Such flooding is not expected to be of serious concern, however, because diffusion times from the cavern to the surface ground water are expected to be very long.

L-47 2. An appendix is needed to deal specifically with the dose modeling used throughout. For example, the use of a deposition velocity is frequently mentioned but it is not stated how this ground deposition is used in dose calculations, i.e., food pathway and/or external exposure. Appendix B has more than its proportionate share of errors and, as it stands, detracts from the overall effort. The proper evaluation and interpretation of actual environmental data as related to individual and population exposure, however, could be of real value in supporting the postulated results of accidents.

Dose modeling is covered in a general way in Section V of this EIS and in more detail in appendices F&G of the referenced ERDA-1537 (V-11). The primary influence of the deposition velocity is on the potential exposure from inhalation by an offsite individual because deposition reduces the airborne activity reaching an offsite location. Both the food pathway and external radiation exposure are minor compared to inhalation. Specific comments on Appendix B are addressed later in these responses.

L-48 3. Tables III-5 and III-7 should have a value of Ci/unit volume as a function of the various waste reduction techniques so that a better judgement can be made of the heat generated by the various solidification methods. The volumes also should be presented along with each alternative so that eventual volumes may be predicted for each storage or disposal technique.

Waste container volumes, curie contents, and heat generation rates for each of the solid waste forms for each alternative, as appropriate, are discussed in Section III of ERDA 77-42. More recent information on the glass waste form is contained in Section IV of this EIS (DOE/EIS-0023). Tables III-5 and III-7 of ERDA 77-42 present information on radionuclide content of the SRP wastes and are not concerned with waste techniques. Tables III-8 through III-12 include Ci/unit volume data for the feed and the product to illustrate waste volume reduction. These tables also include the total product volume.

L-49 4. Water and resource usage must be considered because some processes require more water than others. The disposal and/or reuse of these resources should be discussed.

Resource use for each alternative is discussed in Section VII of this EIS (DOE/EIS-0023). Disposal of these resources and associated waste after usage will be in conformance with applicable regulations and will be addressed in project-specific EIS's. Estimated water requirements associated with the alternatives covered in this EIS are not considered to be significant; some water is recycled to permit smaller process equipment and to minimize water requirements.

L-50 5. page III-3 - It is not clear how the population dose commitment was calculated over the 300-year period. This should be further addressed in this section.

The basis for a population dose integrated over 300 years is discussed in Section V.C.3 of this EIS and response to comment L-10.

L-51 6. page II-F - Table II-1. 3rd column, 3rd row should be 0.24 not 0.18.

Entry at 3rd column, 3rd row of Table II-1 is 0.24.

L-52 7. page II-4 - The NCRP has cast doubt on the use of the linear hypothesis model, but has suggested no alternative basis for action.

This subject is discussed in detail in the response to comment M-3.

L-53 8. page II-5 - The possibility of vaporizing cesium is ignored.

Significant cesium vaporization does not occur in any of the alternative processes presented in ERDA 77-42 and, therefore, does not present a significant hazard.

L-54 9. page II-5 - The reliance on the large exclusion area and low population density may refer to a temporary condition.

The large exclusion area and low surrounding population density are reasons why the present hazards of the waste are limited and does not necessarily apply for the future.

L-55 10. page III-5 - The cesium-137 content is 3 Ci/gal (800 uCi/ml). Even after the 300-year period considered, this is still 800 nCi/ml, a significant concentration.

Agree

L-56 11. page III-6 - Figure III-2. ^{94}Tc should be ^{99}Tc.

^{99}Tc is correct. This is a typographical error which does not affect the analysis.

L-57 12. page III-8 - The sludge contains 30 Ci/gal of strontium-90 (8 mCi/ml). After the 300-year period, there is still 8 uCi/ml. Similarly, the plutonium-239 content of the sludge is 3.5 x 10^{-3} Ci/gal (900 nCi/ml), well above the proposed TRU limit of 10 nCi/g.

These observations are correct.

L-58 13. page III-8 - Exponent error in ^{238}Pu concentration after 10 years. 3.5 x 10^{-3} should be 3.5 x 10^{-5}.

3.5x10^{-5} is correct. This is a typographical error which does not affect the analysis.

L-59 14. page IV-2 - The radioactive materials left after decommissioning will be a small fraction of the material in storage, as stated. However, these materials may be in a much more available form to the environment.

One of the objectives of decommissioning would be to minimize the likelihood that these remaining nuclides could migrate to the biosphere before decay to harmless levels.

L-60 15. page IV-2 - The use of natural levels (and medical levels) to indicate the comparative harmlessness of the wastes is improper. The radiation from the waste is an additional exposure and must be judged on its own merits. For example, the expected exposure from contamination of the Tuscaloosa aquifer is given as 180 man-rem per year. Over a 300-year period, this would be 54,000 man-rem which would justify an appreciable additional expenditure to eliminate the dose.

Radiation exposures resulting from natural and medical sources are presented to put the predicted exposures from disposing of the wastes in perspective. Table X-6 compares the alternatives on a cost-risk basis by adding justified additional expenditures to budgetary costs as suggested.

L-61 16. page V-1 - It is not clear whether there is any possibility that the cooling duct intakes or exhausts could be clogged, with consequent loss of cooling.

As stated on p. V-17, "the cooling inlets and outlets extend the entire length of the building, and it is unlikely that they could become plugged with dust or debris over very long time periods."

L-62 17. page V-8 - The canisters in the air-cooled vault "are expected to maintain their integrity for the indefinite future if they are kept dry." How long is indefinite? How will they be kept dry?

This comment refers to the discussion of routine releases. In this context, the canisters would be kept dry by the protection afforded by the storage vault until a nonroutine event could compromise the vault's integrity.

L-63 18. page V-8 - Refers to Reg. Guide 1.72 in text by 1.74 in the reference.

U.S. Nuclear Regulatory Commission Reg. Guide 1.76 (Design Basic Tornado for Nuclear Power Plants) is the correct reference.

L-64 19. page V-11 - Table V-1. The time-frame is uncertain. Is the food pathway considered or just immersion and inhalation? Is the dose from other nuclides listed in Table III-3 considered insignificant as compared to these four? Last isotope listed should be ^{238}Pu not ^{239}Pu. What is the assumed fraction of the total vault inventory to be released?

Table V-1 gives consequences of a sabotage event if it occurred before significant radionuclide decay (about 1990). The exposures are lifetime dose commitments from the airborne pathway through inhalation ingestion and immersion. Due to small amount of most radionuclides and half-life considerations (Table III-3 and Table III-7 of ERDA 77-42), exposures would arise primarily from the four isotopes listed. The typographical error for the ^{238}Pu has been noted. The derived release fractions are discussed in the text preceding Table V-1, and in the reference covering sabotage. The total release fraction is not given because of classification sensitivity.

L-65 20. page V-11 - Is the figure of 1.1×10^{-3} g of particles per gram of glass or per canister?

The figure 1.1×10^{-3} applies to gram of particles of diameter 16 mm and smaller per 1.87 cal/gram energy input. The energy input was assessed to be applied to a release small enough that the experimental results would apply.

L-66 21. To what particle size is the settling velocity of 1 cm/sec appropriate? How sensitive is the calculation to this parameter?

The settling velocity of 1 cm/sec applies to particles of 10 μm in diameter, but was applied to all particles 16 μm in diameter and smaller. It is believed this is a conservative approach, lacking fine structure in the experimental data on particle size distribution below 16 μm. The offsite exposures are sensitive to settling velocity, but this point was not investigated in detail because the potential offsite exposures are so small.

L-67 22. page V-12 - Table V-2. Last isotope should be ^{238}Pu.

The last isotope listed in Tables V-1 and V-2 of ERDA 77-42 is incorrectly given and should be "^{238}Pu." This change does not alter the results of the analysis.

L-68 23. page V-17 - The possibility of increased leach rates because of radiation damage to the glass has not been considered.

A large research and development program is being conducted on alternate waste forms as discussed in Section IV.D of this EIS (DOE/EIS-0023). Results of radiolysis studies to date indicate that leachability of borosilicate glass containing typical SRP high-level waste is unaffected by exposures equivalent to storage for up to 1 million years.

L-69 24. page V-18 - Same as above.

See response to the above comment (L-68).

L-70 25. page V-22 - Table V-8

a. What were the source terms used? *Table VIII-2?*

b. A footnote should be used to give population size considered.

c. Rates of bone to whole-body dose for $^{238,239}Pu$ is 4 for river water pathway but 40 for airborne pathway. These values should be the same.

d. Title columns in Table V-8B same as in A. Dose to man, man-rem/year.

e. Was lung dose intentionally omitted?

Table VIII-2 of ERDA 77-42 gives the source terms (1975 release guides) for radiation dose calculation. The population of the sector used (most populous sector which includes Augusta, 6A) was 203,000 out to a distance of 150 km. The ratio should be about 40 for both pathways. The bone dose from $^{238,239}Pu$ in Table V-8a should be changed from 0.028 man-rem to 0.28 man-rem; this was a typographical error and does not alter the analyses. Table V-8 is adequately titled, since this is a single table. Radionuclide release was assumed to be soluble which results in the highest dose to the critical organ. In this case, lung dose was more than an order of magnitude less than bone dose.

L-71 26. page V-23 - Table V-9A, B. Rates of bone to whole body dose for ^{238}Pu and ^{239}Pu are not consistent in Tables A and B. There is, most likely, an exponent error. Footnote population size.

The whole body dose for the maximum individual in Part B of Table V-9 was a typographical error. The whole body dose should be 1.8×10^{-4} mrem instead of 1.8×10^{-8} mrem. Population of the sector used was 203,000 out to a distance of 150 km.

L-72 27. page V-26 - Table V-12A, B and Table V-13A, B. Several exponent errors. Ratios between the two tables are not consistent.

The data in these tables are correct.

L-73 28. page V-27 - Same comments as above in page 26. Bone dose from ^{90}Sr should be included in Table V-14B.

The data in these tables are correct with the exception of the population dose -- air pathway (V-14A) in which the bone dose for ^{90}Sr is 1.4×10^{4} man-rem (shown incorrectly in the table as bone dose for ^{137}Cs.

L-74 29. page V-45 - Table V-33. What population size was assumed? What fraction was assumed released to the Tuscaloosa Aquifer? To the atmosphere?

The population size is stated in the text immediately preceding the table as 50,000 potential future onsite users. As stated in the text, release fraction and other details are not presented due to classification.

L-75 30. page V-46 - The concept of a maximum individual dose should be applicable. The stated average individual doses of 150 rem seem to be clearly acceptable.

The concept of maximum individual exposure is not applicable to this sabotage event because of the time scale involved and the population distribution/water use scenario. Whether or not a consequence of 150 rem to some individuals is acceptable depends upon the probability of occurrence and the number of individuals. The document makes no judgments regarding acceptability.

L-76 31. page V-46 - The probability that a terrorist could be able to sabotage the facility in the absence of security is given as 10. This seems very low. Also the possibility that a terrorist group ("smaller than a small army") could overcome the security is apparently considered negligible. These assumptions need further explanation.

The probability of sabotage cannot be determined; however, it is assumed to be low. The probability that a terrorist group could perform a successful sabotage in the presence of security is given on page V-45 as 10^{-5}. The probability that a terrorist group could perform a successful sabotage in the absence of security and radiation monitoring is given on page V-46 as 10^{-3}. A 10^{2} attenuation is attributed to the security force.

L-77 32. page VI-1 - Possible degradation of glass (devitrification) or concrete has been ignored.

Degradation of waste forms would only be expected if they are exposed to high temperatures and pressures for extended time periods. This phenomenon is not expected to affect the risk analysis of offsite transportation.

L-78 33. page VI-2 - Table VI-2. Total canister miles for 3000 mile distance is acceptable. However, that for 1500 is not understandable.

There were errors in the composition of the table. The correct values for 1500 mi are 0.8×10^7 for glass; 1.2×10^7 for concrete; 1.2×10^7 for dry powder; and 2.0×10^7 for fused salt. These typographical errors do not affect the results of the analysis.

L-79 34. page VI-6 - Tables VI-4 and VI-5. Except for drivers and crew the total dose in man-rem (Column 2) appears to be in error. Are there other factors not mentioned in the text?

There were several typographical errors in Table VI-4. The corrected values for Table VI-4 are given in the following table:

Corrected Values for Table VI-4

2	9.2×10^{-2}	4.6×10^{-2}
2	7×10^{-4}	3.5×10^{-4}
6,875	4.3×10^{-2}	6.5×10^{-6}
10	9×10^{-3}	1.8×10^{-3}
85,000	2.3×10^{-3}	1.2×10^{-7}

Also, the maximum individual dose to brakemen in Table VI-5 should be 7.5×10^{-4} instead of 1.5×10^{-3}, and the last value in Table VI-5 should be 4.8×10^{-7} instead of 4.8×10^{-5}.

The population doses for traffic and onlookers were calculated assuming all persons in one of these categories was exposed to the same radiation field as described in the text. On this basis, all people in the category would receive the same dose, and the total population dose for the category would equal the number of people exposed times the dose determined for each person in the category. This average individual dose is not reported in Tables VI-4 and VI-5, but can be obtained by dividing the Total Population Dose for a category by the number of people exposed in the category. However, an estimate was made of the maximum individual dose for the categories. These qualitative estimates of maximum individual dose are given in Tables VI-4 and VI-5. It is emphasized that the population dose for traffic, onlookers, and general public will, therefore, not equal the population times the maximum individual dose.

L-80 35. page VI-13 - Table VI-13. Maximum individual dose to lung from ^{137}Cs should be 1.2 not 0.12. Add population size to footnote.

The dose should be 1.2 and this was a typographical error and does not affect the analysis. Population size is 203,000.

L-81 36. page VIII-4 - Table VIII-1. Footnote a. The ratio of 1/6 only applies when the dose to bone and whole-body are equal. For example a ^{90}Sr dose commitment to the whole-body of 1 rem would result in a dose to the bome of 400 rem. The ratio for Pu is 40. Therefore, to normalize for health effects each nuclide would have to be considered individually, i.e., 1 rem whole-body would be equivalent to 66 rem (400/6) to bone for ^{90}Sr and 6.6 rem (40/6) for Pu.

Radiation dose to the bone, regardless of radionuclide delivering the dose, is assumed to be one-sixth as effective in producing health effects as an equivalent dose to the whole body. Thus, to obtain an "equivalent" whole body dose, the bone dose was divided by 6 and then added to the true whole body dose. For purposes of comparing health effects of the various plans considered, this is considered to be an adequate approximation. (See page X-7 of ERDA 77-42/1)

L-82 37. page VIII-9 - Table VIII-3. Exponent errors.

These were typographical errors and do not affect the analysis. Correct exponents are for ^{238}Pu: 8.3×10^{-5} and for ^{239}Pu: 1.0×10^{-6}; 3.0×10^{-5} and 3.7×10^{-3}.

L-83 38. page VIII-13 - Sabotage. The total environmental dose commitment should be addressed.

The dose commitment to the maximum individual and to the population is addressed in Tables VIII-6 and VIII-7 of ERDA 77-42.

L-84 39. page VIII-14 - Table VIII-8 gives the areal ground levels for several radionuclides out to 60 km. What would be the potential effect through the milk pathway for ^{137}Cs and ^{90}Sr? Since a sabotage event could occur at any particular time, what would be the commited man-rem dose to the population of Augusta if it happened to be in the prevailing wind direction?

See response to Comment L-83. Also, as indicated in response to Comment L-70, the most populous sector, which includes Augusta, was used to calculate population doses.

L-85 40. <u>Appendix A</u>

page A-3. The 1080 Ci/yr of tritium will not be retained in the seepage basin, but an equivalent amount will be released to and/or exchanged at the water-air interface. An equilibrium inventory will, however, build-up and approach 5000 Ci if operations were to continue for about 10 years. During the proposed 5 years of solidification operations about 4220 Curies will accumulate in the basin. Refer to comments under appendix B for a reference regarding tritium releases at Savannah River.

DOE agrees that tritium will not be retained in the seepage basins. As indicated in the response to the comment on the same subject (L-95), DOE would assume 30% of the tritium released to the seepage basin should be evaporated or exchanged and become airborne. This is equivalent to 530 Ci/yr and this amount should be removed from the 1080 Ci/yr retained in the seepage basin.

L-86 page A-10. Table A-6. Table is incorrect. Activity abandoned in place should be given in total curies, not Ci/year. The total tritium inventory in the basin at the end of 5 years would be determined as follows:

Input rate to basin, I = 1780 Ci/yr
fractional release rate, λ = 0.35 yr
(From Figure B-3)
then the total inventory (Q) at any time, t, is given by the relationship

$$Q = \frac{I}{\lambda} (i-e)^{-\lambda t}$$

after 5 years

$$Q = \frac{1780 \text{ Ci/yr } (0.83)}{0.35 \text{ yr}^{-1}}$$

$$Q = 4220 \text{ Ci}$$

Both Tables A-1 and A-6 show the rate of activity abandoned in place for each year of operation. It is obvious then that if the process is operated 5, 10, or 20 years, the accumulation will be larger than that shown in Tables A-1 and A-6. Also, see response to L-88.

L-87 For the case of Strontium and tritium these would indeed be expected to reach the creeks at a rate given in Appendix B, figure B-3.

A comparison between Tables A-1 and B-1 will show that the amount of strontium and tritium reaching the creeks will be lower for the concrete plant than for the F and H canyons.

L-88 page A-11. Table A-7. Should be the total inventory in Curies at the time of abandonment, not Ci/yr. If the 1060 Ci of tritium was determined in the same manner as was Table A-6, then it is incorrect as would be the activity for the other nuclides listed.

At the time of preparation of this appendix, it was elected to express the risk of activity abandoned on a yearly basis. Selection could have been on an assumed campaign basis but the assumption on campaign length would introduce additional uncertainty.

L-89 page A-13. Pathways to man. It may be of little significance in comparison to the dose from immersion and inhalation, but deposition onto vegetation by impaction will occur regardless of particle size especially under windy conditions.

DOE agrees that deposition on vegetation is small and therefore not included in this discussion.

L-90 page A-18. Table A-12. ^{90}Sr and ^{137}Cs should be included. Footnote b not applicable to this table.

^{137}Cs is included on Table A-12. No ^{90}Sr was released via this path thus Table A-12 does not shown ^{90}Sr. DOE agrees with EPA that either footnotes should be included.

L-91 table A-11. Independent dose commitment calculations differ considerably (higher) than those stated in the table. Particularly for ^{90}Sr in bone.

DOE is not familiar with the independent dose commitment calculations referred to by EPA. Therefore, no response is offered. DOE dose calculation methodology was addressed by response to comment L-47.

L-92 page A-19. Table A-13. Would tritium be of any significance here?

Tritium will not be significant here because tritium content of the SRP high-level waste is very low (Table III-7 of ERDA 77-42).

41. Appendix B

L-93 Page B-3

table B-1. The last two columns in the fourth table are in error. The activity abandoned in place in the seepage basins must be in terms of total activity, not Ci/year. If the source terms in Table B-9 and the release rates in Figure B-3 are correct, then the total activity for tritium would be determined as follows:

Source Term, I = 26,200 Ci/year

Fractional release rate, $\lambda = 0.35\ yr^{-1}$ (T 1/2 = 2 yrs)

At equilibrium the source term must equal the release rate (I=R) so that the total quantity (QA) of tritium in the basin at anytime, and at the instant of input termination would be:

$$Q = \frac{I}{\lambda}$$

$$Q = \frac{26,200\ Ci/yr}{0.35\ yr^{-1}}$$

Q = 75,000 Ci -- not 15,700 Ci

Similar calculations may be made for the other isotopes.

The last two columns in the fourth table were prepared to show the risk of operating F and H canyons for an average year and is based on measured data for the years 1968-1974. The tables are structured in this fashion as indicated on page B-1 to serve as data input to determine the risk from the solidification plant. These tables are not in error.

DOE agrees that after long periods of operation the 15,700 Ci of tritium shown in Table B-11 does not represent an equilibrium value. Table B-11 gives the component of activity abandoned in the seepage basin from an average year of operation of the F and H Area canyon processes. As indicated above, this value was identified to serve as a basis for estimation of a comparable value for the solidification plant.

L-94 table B-2 and B-3. These are duplications of data presented in Table B-1.

Table B-1 is intended as a summary table and does include data from other tables in the Appendix.

L-95 Page B-11

Assuming that all of the strontium is in the form of ^{90}Sr and by using the fractional release rate from figure B-3 ($0.1\ yr^{-1}$), then the equilibrium inventory in the seepage basin would be:

$$\frac{2.1\ Ci/year}{0.1\ yr^{-1}} = 21\ Ci$$

If 5% of this is assumed to reach the stream, then 1.0 Ci/year would be a conservative figure to use.

The response to this comment is the same as the response to the comment on tritium abandoned in place above.

L-96 It is stated that 40% of the annual tritium input (10,500 Ci) migrates to the stream. This leaves the remaining 60% unaccounted for. This amount (15,700 Ci) is released to the atmosphere at the surface - air interface of the seepage basin. This should be mentioned under atmospheric releases. (Reference: - Horton, J. H., et col. Vol. 5, No. 4, April 1971). Environmental Science & Technology.

Of the 26,200 Ci/yr tritium released to the seepage basin (Table B-9), 10,500 Ci/yr was released to plant streams (Table B-6), and 15,700 Ci/yr listed on Table B-10 is assumed to be abandoned in place. EPA is correct. Some of this tritium activity would be released to the atmosphere from these seepage basins. This has been determined to be about 30% of the tritium input or about 7,800 Ci/yr and would reduce the amount abandoned in place by a like amount. In determining the offplant releases and dose commitment for operation of the F and H canyons, this results in only a fraction of the releases and dose commitment. For example, for the year 1978 this pathway accounted for seven man-rem dose commitment to the 100 km population surrounding the F and H canyon facilities.

Page B-13

L-97 table B-10. The last two columns in this table are in error. Refer to comment under page B-3.

As indicated in the response to the previous EPA comment (L-93). DOE does not consider the last two columns on Table B-10 to be in error.

Page B-14

L-98 The data presented in Table B-11 are incorrect. This is not the activity that remains in the seepage basin. As mentioned earlier, the 15,700 Ci of tritium is the amount of tritium that is exchanged with atmospheric H_2O at the basin surface. The actual tritium inventory at the cessation of operations would be 75,000 Ci. The rate of removal after abandonment would depend upon whether or not the basin were covered. If uncovered, the tritium inventory would be removed at the fractional rate of 0.35 yr^{-1} (Figure B-3). If covered, then at the rate of 0.14 yr^{-1} (10,500 Ci/yr 75,000 Ci).

The release and/or decay of the other radionuclides in Table B-11 will also be a function of the release rates given in figure B-3, but should not be significantly affected by a covering.

As indicated in the response to the Comment L-96, the 15,700 Ci of tritium assumed to be abandoned for each year of operation does include 7,800 Ci of tritium that is expected to evaporate or exchange with H_2O in the air and become airborne. Other radionuclides actually represent amount of activity that would be abandoned in place.

Radionuclides shown on Table B-11 (other than tritium and ^{90}Sr) would be retained in the basins and decrease as shown on Figure B-3 due to decay only. ^{90}Sr would slowly migrate through the soil between the seepage basins and the streams. The rate of migration would depend upon the amount of water reaching the area of the seepage basin. As indicated above, if the basins were filled and protected from in-leakage of water, the rate of movement of this ^{90}Sr would decrease and become only that associated with decay.

Page B-16

L-99 Some typographical errors appear in figure B-3. Cesium and Strontium should not appear in the total beta curve, since they are identified independently. Also the ^{89}Sr curve would be different from the ^{90}Sr curve due to its much shorter half-life.

DOE agrees that cesium and strontium should not be listed following the total beta on figure B-3. ^{89}Sr and ^{90}Sr were combined on the $^{89,90}Sr$ curve because no separation between the two radionuclides of strontium was made in determining source data (Table B-8). In preparing Figure B-3, the more conservative assumption was made that all of this strontium was ^{90}Sr, which has the longest half-life.

Page B-19

L-100 Paragraph titled "Canyon accidents not resulting in release to the environment" refers to Table B-14 which lists five accident situations which could possibly lead to potential environmental releases. This paragraph needs further explanation of the assumptions used to reach this conclusion.

The results presented in Appendix B are summarized from the probabilistic risk evaluation in the reference (DPSTSA-200-1). All of the canyon accidents addressed in the reference document are summarized in Table B-14. Appendix B addresses the canyon accidents which would result in a release to the environment on pages B-4 through B-19. The section entitled, "Canyon Accidents not Resulting in a Release to the Environment" is included to address all of the accidents which were not included in the earlier Appendix B discussions because they result in no release to the environment.

D-ERD-A00126-SC
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460
Apr 25, 1977

Mr. W. H. Pennington
Director, Office of NEPA Coordination
U.S. Energy Research and Development
Administration
Washington, D.C. 20545

Dear Mr. Pennington:

The Environmental Protection Agency has reviewed the draft environmental statement issued by the Energy Research and Development Administration entitled, "Waste Management Operations at Savannah River Plant (SRP), Aiken, South Carolina (ERDA-1537)." The stated purpose of the draft statement was to provide a detailed analysis of the actual and potential environmental effects associated with waste management operations at the Savannah River Plant.

Responses are given on pages K-29 through K-34 of ERDA-1537.

We were pleased to note that both the history of Waste Management Operations and the Future Waste Management Program were very candidly presented in the appendices. EPA is encouraged to see this type of information and we welcome the opportunity to review the documents being prepared for the SRP, Hanford, and Idaho installations on *alternative methods for long-term management of high-level* radioactive wastes at these three sites. Such work will not only help to resolve the waste management problems at Federal facilities, but the information should be helpful in solving the commercial waste management problem as well.

In December 1973, EPA commented and provided suggestions with respect to Federal Register Notice 38 FR 2195. In particular, we indicated the subjects we believe necessary for inclusion in the environmental impact statement being prepared for the Hanford Facility. The comments which follow are supplemental to those above and are based on the assumption that production operations and radioactive releases at SRP will continue at about their present level for the foreseeable future.

As a part of the waste management plan at SRP, it is stated that the "waste management operations use only a small fraction of the plant site and that this fraction will require surveillance and control for the foreseeable future; and further that decommissioning will be addressed as part of the longer range waste management program." Although EPA agrees that there should be a long-range plan for nuclear waste management and decommissioning of facilities, assessment of the impacts of decommissioning should be done at the same time the necessary funding is allocated.

The draft statement indicates that the "R" and "L" production reactors are in "stand-by" condition. If the production of weapons materials at SRP will in fact be maintained at the present level, it could be assumed that decommissioning of these units is a very real possibility. Thus, the final statement should give a more detailed plan for these stand-by units and if they are eventually to be decommissioned, this should be clearly stated and procedures and time-tables representing the decommissioning effort provided.

The various reviews of the SRP wasge management plan indicate that bedrock storage remains a possible option for long-term waste storage at SRP. In commenting on the draft EIS for Bedrock Disposal in March 1972, EPA expressed its grave concerns regarding the potential environmental impact of this disposal option. If bedrock storage is still a viable option, then it should be more specifically addressed, with particular attention paid to the question of isolating shafts and tunnels from the Tuscaloosa aquifer, the principal water supply for most of southeastern Georgia. It is EPA's opinion, however, that further investigation is needed to define more precisely such factors as the geological and hydrological conditions that determine the usefulness of sites such as SRP for waste disposal and to better determine the effects of heat and radiation on the enclosed rock media.

Including the general comments and concerns stated above, EPA has the following specific comments:

1. Page III-32: "...individuals served by the water treatment plants consume 1200 ml of water each day." Doses are calculated based on this level of consumption. Since, however, the Drinking Water Standards are based on 2 liters/day consumed, the impact assessment should be readjusted to reflect this higher volume.

2. Page III-28: "...dose commitment means radiation dose equivalent that will be received in a lifetime (70 years) by population groups..." We believe this method does not reflect the total environmental impact. It is EPA's position that the potential total environmental impact in subsequent years is best estimated by calculating the "environmental dose commitment," the sum of all doses to individuals over the entire time period that radionuclide persists in the environment in a state available for interaction with humans. The environmental dose commitment is usually expressed for a period of 100 years recognizing that it is difficult to estimate the population growth much beyond this time period.

3. Page I-12: "...long-term offsite effects of SRP releases to the surrounding population will be much smaller than the effects in the year of actual release..." This statement should be clarified since cancer has a long latency period.

4. Tables III-33 and III-34 appear to imply that the total whole body population doses from atmospheric releases from Vogtle Nuclear Plant (VNP), Barnwell Nuclear Fuel Plant (BNFP), and Savannah River Plant (SRP) should be additive since the plant sites are so near to one another. The inference drawn from these tables is that BNFP operations would have a significant effect on the whole body population dose from atmospheric releases as compared to the corresponding dose calculated for SRP in 1975. We would suggest that two scenarios be offered, one with SRP doses and another with combined doses from BNFP, VNP, and SRP. This would give a broader spectrum of possible off-site population doses.

In light of our review and in accordance with EPA procedure, we have rated the Savannah River waste management operations as LO (Lack of Objections) and classified the draft statement as Category 2 (Insufficient Information). If you or your staff have any questions concerning our classification or comments, please don't hesitate to call us.

Sincerely yours,

Rebecca W. Hanmer
Director
Office of Federal Activities (A-104)

104 Davey Lab.
Penn. State University
University Park, Pa.
16802
13 November 1978

W. H. Pennington
Mail Station E-201, GTN
Department of Energy
Washington, D.C., 20545

Dear Mr. Pennington:

Enclosed are my comments on the Draft Environmental Impact Statement, Long - Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant, DOE/EIS-0023-D. Please note that the opinions expressed are not necessarily those of The Pennsylvania State University.

M-1 Table IV-6 presents the total activity of several isotopes, and is very useful. I note that the listed activity for ^{90}Sr is 1.3×10^{8} curies, wheras Krugmann and von Hippel (Science, 197, P 883-885, 26 August 1977) reach an estimate of 1.6×10^{8} curies at a somewhat earlier date. I would ask that table IV-6 be expanded to show all the isotopes listed in tables IV-3 and IV-4.

M-2 There is an obvious misprint at the top of page B-5. Also, the last line on page B-7 lists the half life of ^{129}I incorrectly.

I received my copy of the Draft EIS on 2 November, and have put this together as quickly as possible.

Sincerely,

W.A. Lochstet

The total ^{90}Sr activity in reconstituted waste listed in Table IV-6 is based on analyses of representative high-level sludge samples and is shown corrected for decay through 1985.

Table IV-6 is shown as a summary of the most important radioisotopes as an aid to the reader who may not be interested in the detail given in Tables IV-3 and IV-4.

The misprint on page B-5 of the draft EIS has been corrected in the final EIS (EPA was changed to ERDA). The half-life of ^{129}I was corrected from 1.6×10^{7} years (in the draft EIS) to 1.7×10^{7} years in the final EIS.

Radiological Impact of
Long-Term Management
of Defense High-Level
Radioactive Wastes
Savannah River Plant
by
William A. Lochstet
The Pennsylvania State University*
November 1978

M-3 The draft Environmental Impact Statement on the long - term management of high-level radioactive wastes at the Savannah River Plant (Ref. 1) attempts to evaluate the public health consequences of the disposal of this waste. Some of this information was discussed in a previous report of ERDA (Ref. 2). The consequences are evaluated for a population within a 150 km radius of SRP for the first 300 years. It is suggested that radiation exposures outside these limits can be ignored, and that the consequences inside this bound are minimal (Ref. 1).

It is suggested that the linear, non-threshold hypothesis for the relation of health consequences to radiation exposure is a gross overestimation of the consequences. The justification for this position is the January 1975 Report No 43 of the National Council on Radiation Protection (NCRP) (Ref. 1, P XII -1 to XII -2 and P XII -12). This position is not supported by subsequent research. The August 1975 Report of K.Z. Morgan (Ref. 3) argues that the linear hypothesis is not conservative and points to a report of Baum which showes health effects proportional to the square root of the dose. This arguement was presented in a discussion of alpha emitting nuclides. An earlier report (1970) of Stewart and Kneale had established linearity to X - ray exposure for infants (Ref. 4). The BEIR II report of 1977 (Ref 5) used the linear non-threshold hypothesis for its evaluation of the cost-benefit analysis of medical x-rays. The report of Mancuse et al. (Ref. 6) suggests that for protracted doses, the doubling doses for some cancers are only a few rads. This is a much larger effect than would be expected from the high dose data. Perhaps the upcoming report of the BEIR committee will address this area. In the meantime, lacking any guidance as to how non-conservative the linear non-threshold theory is, or what exact hypothesis is appropriate, the linear, non-threshold hypothesis should be used for public health purposes, and will be used here.

* The opinions and calculations contained herein are my own, and not necessarily those of The Pennsylvania State University. My University affiliation is given here for identification purposes only.

Recently, much literature has dealt with the prediction of health effects from low levels of ionizing radiation. The most broadly accepted reports on these effects are the BEIR Report (1972) by the National Academy of Sciences and the UNSCEAR Report (1977) by the United Nations Scientific Committee on the Effects of Atomic Radiation. The National Academy of Sciences is currently preparing to release an update of the BEIR Report.

This environmental statement adopts the linear dose-health effect relationships derived from the BEIR Report by the Environmental Protection Agency (EPA). No threshold dose is assumed for health effects. These dose-effect estimates are quite uncertain and may or may not overestimate the actual effects. The following is a quote from the EPA analysis of the fuel cycle ("Environmental Analysis of the Uranium Fuel Cycle," EPA-520/9-73-003B):

> "The numerical risk estimates used are primarily from the BEIR Report. What must be emphasized is that though these numbers may be used as the best available for the purpose of risk-cost benefit analyses, they cannot be used to accurately predict the number of casualties. For a given dose equivalent, the BEIR Report estimates a range for the health impact per million exposed persons. For example, the BEIR results from a study of the major sources of cancer mortality data yield an absolute risk* estimate of 54 to 123 deaths annually per 10^6 persons per rem for a 27-year followup period. Depending upon the details of the risk model used, the BEIR Committee's relative risk** estimate is 160 to 450 deaths per 10^6 persons per rem. It is seen that the precision of these estimates is at best about a factor of 3 to 4, even when applied to sample populations studied on the basis of the same dose rates. The application of the BEIR risk estimates to exposures at lower dose rates and to

* Absolute risk estimates are based upon the reported number of cancer deaths per rad that have been observed in exposed population groups, e.g., Hiroshima, Nagasaki, etc.

** Relative risk estimates are based upon the percentage increase of ambient cancer mortality per rem.

M-3 contd

population groups more heterogeneous than those studied increases the uncertainty in the risk estimates. Considering the limitations of presently available data and the lack of an accepted theory of radiocarcinogenesis, emphasis should be placed on the difference in risk estimates between the various procedures and countermeasures discussed in this report rather than on the absolute numbers. Where the absolute numbers must be used for risk-cost-benefit balancing, it should be revised as new information becomes available. Notwithstanding these disclaimers, it is also pertinent to note that we are in a better position to evaluate the true risks and the accompanying uncertainties from low levels of radiation than from low concentrations of other environmental pollutants which might affect populations...."

The somatic dose-effect relationship factors derived by the EPA are neither upper nor lower estimates of probability but are computed on the same basis as the probability characterized as "the most likely estimate" in the BEIR Report; that is, they are averages of the relative and absolute risk models considered in the BEIR Report.

Concerning genetic effects of radiation, the EPA position is that the range of risk estimates set forth in the BEIR Report is so large that such risks are better considered on a relative basis for different exposure situations than in terms of absolute numbers. The range of uncertainty for the "doubling dose" (the dose to double the natural mutation rate) is 10-fold (from 20 to 200 rads); and because of the additional uncertainties in 1) the fraction of presently observed genetic effects due to background radiation, and 2) the fraction of deleterious mutations eliminated per generation, the overall uncertainty is about a factor of 25. The EPA uses a value of 200 serious genetic effects per 10^6 person-rem. This value may either underestimate or overestimate the genetic effects of radiation because of the uncertainties involved.

Integration of the population exposures through 10,000 years has been added to Section V-C.3 of the EIS. The results of this integration show the small additional impacts of the long-lived isotopes.

M-4 It is suggested that the Sr, Cs and Pu in the SRP waste could be processed into a glass and disposed of in a geological formation (Ref. 1). It has been recently pointed out by McCarthy et al (Ref. 7) that under the conditions expected during the first few years of such burial, that such glass would disintegrate. Furthermore, the dependability of the geological barrier to provide isolation has been found inadequate by the USGS (Ref 8) and by the EPA (Ref. 9). The disposal of a glass waste form in a geological depository must be reevaluated.

Section IV of the final EIS has been expanded to include more information on alternative waste immobilization forms. Although this section concludes that borosilicate glass appears to be a satisfactory waste form for SRP wastes under the expected repository conditions, other waste forms are being evaluated. It is expected that the final waste form decision will be made in 1984 considering the compatibility of the waste form with the host rock and with the container and engineered barrier materials. The proposed R&D program will be undertaken with sufficient flexibility so as not to foreclose any reasonable alternative waste forms under consideration prior to completion of a project-specific environmental review. A large R&D program is being conducted on other advanced waste forms at a variety of national laboratories, universities, and industrial plants.

Evaluation of the dependability of geological barriers is beyond the scope of this EIS. Future environmental analyses will address the options for disposal of SRP wastes, including the dependability of geologic barriers.

M-5 It has been suggested that after 300 years, the wastes become harmless. There are some very long half lives involved, such as the 1.7×10^7 years of ^{129}I. Further the law requires full consideration for such a long time period. Footnote 12 of NRDC v. USNRC, 547 F. 2nd 633 (D.C. Cir. 1976), states in part:

> We note at the outset that this standard is misleading because the toxic life of the wastes under discussion far exceeds the life of the plant being licensed. The environmental effects to be considered are those flowing from reprocessing and passive storage for the full detoxification period.

This portion was upheld in Vt. Yankee Nuclear Power v. Natural Res. D.C., 98 S.Ct.1197, 1209 (1978). Thus the full time period of the radioactive decay must be considered. There is no comparison made with background. The existance of severe health consequences from background radiation in no way invalidates the health consequences due to SRP wastes.

As examples, some of the consequences of two isotopes present in SRP wastes ^{129}I and ^{238}U will be considered. The total quantity of waste to be generated at SRP is taken to be 80×10^6 gallons (Ref. 2, P I - 7) without evaporation in the year 1985.

In the final EIS, integrated population exposures were included for a time period out to 10,000 years (see Section V-C of the final EIS). The period of maximum risk is before ^{90}Sr and ^{137}Cs have decayed (300 years). The integrated impact out to 10,000 years shows the small additional impact of the long-lived isotopes.

M-5 contd The 80 x 10^6 gal. of waste produced at SRP contained a concentration of ^{238}U of 6 x 10^{-7} Ci/gal. (Ref. 1, P. IV-3). This implies a total of 480 curies or 1.4 x 10^6 kg of ^{238}U. Recently, Kenford (Ref. 13) has pointed out the importance of the subsequent decay thru radon - 222. This has also been reviewed by R.L. Gotchy of the NRC staff (Ref. 14). This decay of the ^{238}U will ultimately produce a total of 2 x 10^{14} curies of ^{222}Rn. If the ^{238}U is deposited in a cavern under SRP it is expected to be only 1500 feet below the surface (Ref. 1, P IV-17). This is fairly good protection against erosion, but it should be noted that the grand canyon is three times as deep. It is impossible to be certain of the fate of such material over very long time periods. It will be assumed that on the average this material will be at the surface about 1/2000 of the time, and thus, the radon will be free to escape into the atmosphere. To provide a basis for estimate it is assumed that the world population remains at its current level. The NRC has recently done this, assuming a U.S. population of 300 million (Ref. 14, P.3) with the result that the release of 1 curie of ^{222}Rn from a typical mill tailings pile in a western state will result in a total dose of 0.56 person - rem to the bronchial epithelium, for the total population. Thus the expected dose is 5.6 x 10^{10} person - rem to the bronchial epithelium. The NRC estimate of cancer risk is 22.2 deaths per million person-rem to the bronchial epithelium. (Ref. 14, P. 7). Even though this estimate is too low it will be used here. The result is an expectation of 1.2 x 10^6 cancer deaths.

These million deaths are attributable to the SRP wastes. The fact that more people will die of other causes in no way effects this estimate, or its result to these people. If an added burden is made to the radiation exposure, it must be considered, regardless of how small. To ignore it would produce an invalid cost - benefit analysis. In Calvert Cliffs Coordinating Committee v. USAEC, 449 F. 2nd 1109 (D.C. Cir., 1971) the court stated:

> We conclude, then, that Section 102 of NEPA mandates a particular sort of careful and informed decision - making process and creates judicially enforcable duties .... But if the decision was reached procedurally without individualized consideration and balancing of environmental factors -- conducted fully and in good faith -- it is the responsibility of the courts to reverse. (emphasis added)

Thus, these matters must be considered fully and honestly.

Our analysis of the impacts due to bedrock disposal do not assume that the bedrock caverns is ever exposed to the atmosphere. We know of no way to predict this occurrence nor to support the assumption that the wastes would contact the air 1/2000 of the time over the next 4.5x10^{10} years (10 half lives of U-238). We also cannot envision a pathway for the entire population of the U.S. to be uniformly exposed to any release of Rn-222 from the SRP bedrock, much less constantly over hundreds of years. Our conservative analysis of the health effects of bedrock disposal predict 28 possible health effects over a 10,000-year period.

M-5 contd The average concentration of ^{129}I in fresh SRP waste is given as 1×10^{-6} Ci/gal (Ref. 1, P IV-3). With a total volume of 80×10^{6} gal as presented above, the total ^{129}I activity is 80 curies. To simplify matters, suppose that these 80 Ci become uniformly diluted in the stable iodine of the biosphere. I suggest that this may be due to the failure of the geological containment after a mere million years and another million years is required to wash away the waste. There may be as much as 100×10^{9} metric tons of iodine available to the biosphere. This defines a steady state concentration diminished only by radioactive decay. The iodine content of a standard thyroid is 7 milligrams (Ref 10). From this, the activity in a standard thyroid can be found, and in turn, using the methods of ICRP publications 10 and 2 (Refs. 10 and 11) the dose is obtained. If the world population is assumed to remain at its present number of 4 billion the total dose can be found. If this summed over the total decay of the ^{129}I, the result is 3.4×10^{7} person-rem to the thyroid. Following the method of EPA (Ref. 12, P.D-17) which uses the linear non-threshold hypothesis to estimate cancer risk, a total of 340 to 450 thyroid cancers is estimated. At current rates, 57 to 110 of these would be fatal. This should be added to the estimate of 6.1×10^{5} person-rem in the case of abandonment (Ref. 1, P. XII-14) which would yield 122 dead using the factor of 200 deaths per 10^{6} person-rem (Ref. 1, P. I-3).

We know of no pathway which would result in the uniform distribution of approximately 500 kg of I-129 in the biosphere of the entire earth, especially if that I-129 is in a large mixture of radioactive wastes within a bedrock cavern.

References

1 "Draft Environmental Impact Statement, Long-Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant" DOE/EIS-0023-D, Draft, Department of Energy, July 1978

2 "Environmental Statement, Waste Management Operations, Savannah River Plant", ERDA - 1537, Energy Research & Development Administration, September 1977

3 "Suggested redustion of permissable exposure to plutonium and other transuranium elements" K.Z. Morgan, American Industrial Hygiene Association Journal, 36, P567 - 575, August 1975

4 "Radiation Dose Effects in Relation to Obstetric X-rays and Childhood Cancers", Alice Stewart and G.L. Kneale, Lancet, 1970, P. 1185-1188.

5 "Considerations of Health Benefit-Cost Analysis for Activities Involving Ionizing Radiation Exposure and Alternatives", National Academy of Sciences, BEIR II Report, 1977

6 "Radiation Exposures of Hanford Workers Dying from Cancer and other Causes", T. Mancuso, A. Stewart and G. Kneale, Health Physics, 33 P 369-385, 1977

7 "Interactions between Nuclear Waste and Surrounding Rock", G. H. McCarthy et al, Nature, 273, P. 216-217, 1978

8 "Geologic Disposal of High-Level Radioactive Wastes - Earth-Science Perspectives" USGS, Circular 779, 1978

9 "State of Geological Knowledge Regarding Potential Transport of High-Level Radioactive Waste from Deep Continental Repositories", EPA/520/4-78-004, EPA, 1978

10 International Commission on Radiological Protection, Publication No. 2, Pergamon Press, 1959

11 International Commission on Radiological Protection, Publication No. 10, Pergamon Press, 1968

12 "Environmental Radiation Dose Commitment: An Application to The Nuclear Power Industry", EPA-520/4-73-002, EPA, 1974

13 Testimony of Dr. Chauncey R. Kepford, "Health Effects Comparison for Coal and Nuclear Power: in Three Mile Island (No. 50-320) operating license hearings, and portions of transcript related, in which the NRC staff supports his numbers.

14 Affidavit of R.L. Gotchy, "Appendix", "Radiological Impact of Radon - 222 Releases", USNRC, in the matter of Three Mile Island Unit 2, (Docket No. 50-320), January 20, 1978

NINETY-FIFTH CONGRESS
CONGRESS OF THE UNITED STATES
HOUSE OF REPRESENTATIVES
Environment, Energy, and Natural Resources
Subcommittee
of the
Committee on Government Operations
Rayburn House Office Building, Room B-371-D-C
Washington, D.C. 20545
October 12, 1978

Honorable James R. Schlesinger
Secretary
Department of Energy
Washington, D.C. 20545

Dear Mr. Secretary:

N-1 I am in receipt of your draft environmental impact statement entitled "Long-Term Management of Defense High-Level Radioactive Wastes," which is dated July, 1978. I find this EIS to be deficient in facts and analysis.

For example, if one reads the alternatives with care, it appears that there is hardly any difficulty in providing a technological fix to the waste problem. All we need to do is select one, which may or may not have more risk associated with it.

The description of the technology leads one to believe that the technology is proven. There is little there to indicate that many of the assumptions about the technology are merely hypothetical. For example, there is now serious and growing debate about the long-term safety of processing the waste to glass. Apparently, recent research has shown that vitrification of nuclear wastes is not considered to be a solution now, which is not indicated in your EIS.

The document has been revised with the addition of Section IV D to cover the subject of alternative waste immobilization forms. Although this section concludes that bonosilicate glass appears to be a satisfactory waste form for SRP wastes under the expected repository conditions, other waste forms are being evaluated. It is expected that the final waste form decision will be made in 1984 supported by another environmental review. The proposed R&D program will be undertaken with sufficient flexibility so as not to foreclose any of the reasonable alternative waste forms under consideration prior to completion of a project-specific environmental review.

N-2 There are questions about salt dome storage as well. This was brought out very clearly in a recent GAO report.

The status of technology of the various ultimate waste disposal alternatives is covered in the reference "Draft EIS, Management of Commercially Generated Radioactive Waste," DOE/EIS-0046-D (April 1979), as indicated in Section V-G. The method for disposal of the SRP wastes subsequent to immobilization will be the subject of a future environmental review and is not in the scope of the EIS. The proposed R&D program is sufficiently broad in its initial stages that the only disposal alternatives which would be foreclosed are rock melting and reverse well disposal which are represented by Alternative 3 in this EIS.

N-3 This EIS raises more questions than it addresses. There is a significant amount of on-going R&D in the nuclear waste management area that isn't reflected in this EIS, e.g. work in ceramics and synrock. In fact, this EIS seems to be oblivious to current work and may have been written ten or so years ago.

Advise me as to how this EIS will be rewritten and what alternatives will be considered.

Sincerely yours,

LEO J. RYAN
Chairman

R&D on synrock, ceramics, and other alternative waste forms has been included as Section IV-D of the final EIS.

UNITED STATES DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON, D.C. 20240
ER 78/763
Oct 20, 1978

Mr. W. H. Pennington, Director
Division of Program Review
and Coordination
Office of NEPA Affairs, EV
Department of Energy
Washington, D. C. 20545

Dear Mr. Pennington:

O-1 Thank you for your letter of July 31, 1978, transmitting copies of the Department of Energy's draft environmental impact statement for Long-Term Management of Defense High-Level Radioactive Wastes, Savannah River Plant, Aiken and Barnwell Counties, South Carolina.

Our comments are presented according to the format of the statement or by subject.

General

No discussion was found of the possibility that the waste may have value as a source of rare isotopes at some future time. Possibly this consideration should be included among the "difficult-to-quantify" factors that are summarized on Table I-2. If this is a credible possibility, it would probably be evaluated in the same way as the factor identified as "Potential for regrets if future economics or technology indicates a better method." That factor might simply be reworded to include both considerations by adding: ". . . for disposal, or an economic method of separating valuable isotopes from the waste."

The possibility that the high-level waste may become of value at some future time as a source of rare isotopes is discussed in Section V-F, "Secondary (Indirect) Environmental Effects of Alternatives." For clarity, footnote a of Table I-2 and footnote b of Table XIII-2 have been revised.

Groundwater

O-2 The analyses of groundwater movement should consider existing vertical hydraulic gradients, as described on pages 19 through 21 of the NAS report 1/and should assess impacts of changes in vertical gradients that are expected as results of stresses induced by the proposed bedrock storage of radwastes, as indicated on pages 23 through 31 of the NAS report.

The vertical gradients in the crystalline metamorphic rock used in the NAS Report assume that the difference in head between the Coastal Plain sediments and that in the metamorphic rock is distributed across the upper 500 feet of crystalline rock. There is some evidence that there is no vertical gradient in the upper 1000 feet of metamorphic rock, but that the entire gradient between the rock and the Tuscaloosa occurs across the saprolite. This evidence comes from long-term water level measurement of an upper zone and a lower zone in one bedrock well. The gradient in the upper 500 feet of metamorphic rock was used in the NAS analysis as a worst-case assumption. The details of previous hydrologic analyses are not presented because the bedrock storage option is not being recommended for R&D funding.

1/ National Academy of Sciences, 1972, An evaluation of the concept of storing radioactive wastes in bedrock below the Savannah River Plant Site, Report by the Committee on Radioactive Waste Management, National Academy of Sciences, National Research Council.

0-3 The engineered corrective action to reduce aquifer exposure in the event of release of radionuclides would involve drilling test wells to determine the boundaries of acceptable dilution. The final statement should indicate whether the probable three-dimensional distribution of any accidental releases to the aquifer has been analyzed on the basis of the physical, chemical, and hydraulic characteristics of the aquifer and aquicludes--a logical first step in planning a successful drilling program to delineate the distribution of escaped contaminants. It is not clear whether induced hydraulic gradients resulting from onsite groundwater withdrawals of wells in the Tuscaloosa aquifer have been considered in the analysis of the movement of contaminants. Furthermore, because of the long time periods involved and the probable increased use of the Tuscaloosa aquifer as the population grows, it would seem appropriate to assess the potential for any significant changes in direction and magnitude of hydraulic gradient toward "worst-case" hypothetical heavy pumping at the reservation boundary. The final statement should indicate whether interception and withdrawal of contaminated groundwater has been considered as a possible mitigating measure.

In this generic treatment the population doses from contamination of the Tuscaloosa aquifer given in Sections V, XII, and XIII are believed to be upper-bound estimates based on pessimistic assumptions described in the backup document (ERDA 77-42, Section V). Assumptions leading to contamination of the acquifer include an earthquake either cracking the bedrock or causing failure of the access shaft permitting contact of the wastes with the acquifer. Fifty thousand users begin drinking the water 100 years after the contamination. Analyses of the environmental impacts of the alternatives take no credit for potential corrective actions. Corrective actions considered include 1) drilling test wells to determine the extent of contamination and 2) repair of access shaft to re-isolate the wastes. Interception and withdrawal of contaminated ground water has not been considered as a possible mitigating measure. Should this method be proposed for final disposal of the SRP wastes, detailed analyses such as those suggested would be included in a project-specific environmental review.

Biota

0-4 This section contains no supportive data for the statement, "Radiation releases . . . have had no significant effect on the wildlife." If scientific studies have been conducted and statistical analyses performed which substantiate this conclusion, summaries of these data should be included and all work referenced. If no such data are available, the statement would be eliminated or corrected to indicate that it is subjective judgment.

This section should also include a more detailed discussion of the onsite biota at the site, as this information is essential to a determination of the project's impacts on fish and wildlife resources. Available data on endangered and threatened species should be presented.

The text was changed to state that ongoing monitoring shows that the SRP contribution to the ^{137}Cs content of fish and deer is minor. Summaries of studies conducted at SRP are included in the referenced document ERDA-1537, p. II-178 to II-184.

Detailed discussion of biota on the SRP plantsite is given in the referenced documents (ERDA Reports DP-1323 and ERDA-1537). Field surveys will be conducted to identify the biota affected by proposed projects. Survey results and potential impacts on endangered or threatened species will be discussed in project-specific EIS's.

Alternative 3

0-5 Plans include allowing storage space for radiolytic gas above the wastes in the bedrock caverns as noted on page IV-19. However, the statement should assess the impacts of the potential gas drive, which the NAS report calculated to be equivalent to that of 1,500 feet of water after 25 to 30 years. (Calculations of the gas drive, according to the NAS report, were based on allowing 20 million cubic feet for storage of gas and inleakage instead of the 17 million cubic feet suggested on page IV-19 of the draft statement.) The possibility of mitigation measures such as gas absorption or venting should be evaluated.

For the purpose of this EIS, conservative generic impact studies are presented to estimate the upper bound impacts which could result from credible occurrences. Any impacts resulting from failure of the bedrock cavern due to radiolytic gas pressure drive are expected to be of much lower magnitude than those resulting from the presumed earthquake scenario and, therefore, would not significantly affect the results of this EIS.

0-5 The explosion hazard for gases generated by decomposition
contd of water and other constituents of the wastes should be addressed--at least by reference. (See NAS report, pages 38, 45, 46.)

Impact on Plant and Animal Communities

0-6 The first paragraph of this section on page V-2 states that "no change would be expected in the welfare of any endangered species on the site." Since the draft statement does not identify the endangered species that might be impacted, this judgment appears to be premature. We believe that the presence or absence of any endangered or threatened species in the area should first be documented; the final statement should describe the methodology used. If any such species do occur within range of the proposed action, potential impacts should be identified and a Section 7 consultation should be initiated.

The detailed discussion of biota in ERDA-1537 is incorporated by reference. Endangered species identified on the site include the bald eagle, redcockraded woodpecker, Kirtland's warbler, and alligators. No effect on these species is expected from the conduct of the proposed R&D program.

As stated in response to Comment No. 0-4, field surveys will be conducted in support of project-specific proposals and will determine if endangered species are within the range of the proposed action. If so, potential impacts will be identified and a Section 7 consultation will be initiated in the project-specific environmental review.

Potential Effects from Normal Operations for Each Alternative

0-7 The final statement should address the potential effects of long-term, low-level radiation exposure on humans and on plants and animals. Although only limited data is available on chronic dose-effect relationships, an effort should be made to discuss this topic as fully as possible.

The biological effects on human populations of low levels of ionizing radiation are discussed in Response M-1. Because of the uncertainties involved in deriving dose-health factors, absolute values calculated from such factors are of questionable value. Since health effects from man-made radiation do not differ in kind, probability, or severity from the effects from natural radiation, we have chosen to evaluate radiological impact from the alternatives in this EIS by comparison with natural radiation exposure. For all alternatives considered, the population doses are a very small fraction of the natural dose to the population. Furthermore, these population doses from alternatives are within the range of variation of natural radiation exposure.

The radiation doses to biota other than humans are due primarily to direct irradiation from transportation of radioactive materials and atmospheric release of radioactive materials during facility operation; these doses are similar in magnitude for all biota. The BEIR Report concludes that no other living organisms are much more radiosensitive than human beings. The health effects in a given population of other life forms are thus similar in magnitude or smaller than for human beings. Because the analyses have shown there are no substantial radiation-related environmental impacts in the human population, there should be significant impact on other life forms.

Comparison of Risks with Natural Background and Standards

0-8 We note "As detailed in other sections of this report, estimated exposures to the general population for the various alternative plans for long-term waste management are far below exposures from naturally occurring radioisotopes . . . ." This fact is emphasized throughout the statement; however, equal emphasis is not given to the fact that this radiation is in addition to radiation exposure from naturally existing radioisotopes. As mentioned in the preceding paragraph, only limited data exist on the effects of long-term exposures of plant and animal populations and human populations to low-level radiation. The final statement should indicate that little is known about the potential long-term impacts of continuing to increase the radiation levels to which individuals, as well as fish and wildlife, are daily exposed. We believe this is especially important, as the draft statement contends that successful demonstration of long-term management of high-level radioactive wastes could have an important sociopolitical bearing on the public acceptability of nuclear power generation and thus result in greater utilization of nuclear power.

All radiation doses for the alternatives considered in the EIS are incremental, or in addition to natural radiation exposure. However, as discussed in Response 0-7, these doses are very small fractions of natural radiation exposure and are within the range of variation of natural exposure.

Also, see Responses M-3 and 0-7 for discussion of radiation health effects.

Reduction of River Water Exposure

0-9 The corrective action proposed to reduce river water exposure from radionuclides entering the Savannah River as a result of the tank farm's abandonment, or sabotage, or being struck by an airplane assumes that contamination pulses on the river would last "at most a day or two." As was pointed out previously in our comments on the ERDA draft statement, the migration of radionuclides from the tanks to the river would be a complex long-drawn-out process that would be likely to affect the river for much longer periods. There is no evidence that a detailed analysis has been made of the range of consequences due to abandonment, sabotage, or an airplane crash. We believe the estimates of corrective action ranging from $2 to 5 million (table XII-11, p. XII-18) are unrealistically low.

In this generic EIS and its backup reference (ERDA 77-42), assumptions believed to be pessimistic were used to provide worst-case estimates of sabotage, airplane crash, abandonment, etc. No credit was taken for corrective actions in the impact analyses after abandonment. The corrective actions are only provided to indicate that some readily available, reasonably inexpensive actions exist which could result in significant impact reduction.

Minor Comment

0-10 A date is needed for the measurements on which the contours are based in figure III-5, Flow in Tuscaloosa Aquifer.

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,

Larry E. Meierotte
SECRETARY

The date for the measurements on which the contours in Figure III-5 are based is about 1958. However, long-term hydrographs for selected wells dating back to 1952 show that there has been no progressive decrease or increase in water levels in the Tuscaloosa aquifer. Thus, the map is applicable to the present hydrologic regimen in the Tuscaloosa.

OFFICE OF THE GOVERNOR
Atlanta, Georgia 30334
George Busbee
GOVERNOR
Norman Underwood
EXECUTIVE SECRETARY
January 8, 1979

Mr. W. H. Pennington, Director
Division of Program Review and Coordination
Office of NEPA Affairs
Department of Energy
Washington, D. C. 20545

Dear Mr. Pennington:

P-1 In August, 1978 the Georgia State Clearinghouse received a copy of DOE/EIS-0023-D, entitled "Draft Environmental Impact Statement - Long Term Management of Defense High-Level Radioactive Wastes at Savannah River Plant." As you know, in my letter of August 10, 1977 to you, I transmitted extensive detailed comments provided by our technical staff on a preliminary report, ERDA 77-42/1 and 2, on the same subject as the recent Draft EIS (see attached).

Even though you initially expressed a desire to have comments from Georgia by November of 1978, we have waited until now to complete our review of the Draft EIS because we also wanted to compare the policy aspects with the recent document, "Report to the President by the Interagency Review Group on Nuclear Waste Management." Our technical staff has now completed its review and prepared the attached comments.

The efforts by the DOE at the Savannah River Plant are inconsistent with the IRG Report to the President in that they represent a uni-lateral approach to the continued advancement of a bedrock storage concept for SRP high level wastes. Also, DOE has proceeded to spend the taxpayers' money to foster the bedrock storage concept in spite of strong opposition by the State of Georgia, the U. S. Environmental Protection Agency, and the National Academy of Sciences. As I indicated in my letter to the former Administrator of ERDA, Dr. Seamons and again, in my August 10, 1977 letter to you, Georgia is unalterably opposed to any repository that could conceivably result in the radioactive contamination of Georgia's underground water resources. It is quite apparent that DOE is proceeding to further develop a bedrock storage facility at the Savannah River Plant with a complete disregard of Georgia's position and concern in the matter. You are advised that I am requesting the Georgia Attorney General to become thoroughly briefed on DOE's efforts in the event that Georgia has to exercise all available options to protect the health and safety of the citizens of our State.

All work on the bedrock storage concept was indefinitely postponed in November 1972. The alternative of an R&D program on disposing of the SRP wastes in bedrock was included in this EIS as an alternative required to be analyzed under NEPA to the preferred alternative which is to proceed with an R&D program to provide the required information for immobilization of the Savannah River Plant wastes, consistent with the recommendations of the IRG.

P-1 contd I would appreciate your timely and substantive response to Georgia's position in this highly important matter.

Sincerely,

George Busbee
GB/jsm

Review of DOE/EIS - 0023 - D, "Draft Environmental Impact Statement; Long-Term Management of Defense High Level Wastes; Savannah River Plant - Aiken, South Carolina"
by
State of Georgia

P-2 (1) In May, 1977 a document was issued by DOE (ERDA), ERDA 77-42/1&2, which presented preliminary information about several different alternatives for management of high level wastes at SRP. The purpose of that document was generalized and vague. The purpose for the recent draft EIS is even more confusing. It appears that DOE has developed the draft EIS around three of the original twenty-three alternatives without attempting to explain the process for decision making. The key question is what action is going to be taken that requires this draft EIS.

The purpose of this document is to explore the environmental implications of a large research and development program aimed at providing the information required to replace interim tank storage of the wastes with immobilization for long-term management. The Foreword and Summary have been modified to respond to this comment. The three alternatives in this EIS include the full range of potential environmental impacts which could result from any of the 23 alternatives in ERDA 77-42.

P-3 (2) The summary sheet for the draft EIS states: "There are no substantial environmental impacts associated with nuclear radiation for any of the three alternatives." This statement is not only incorrect, it represents a complete disregard of Georgia and EPA's position of opposition to bedrock storage at SRP because of the potential contamination of the Tuscaloosa Aquifer. It certainly reflects DOE's lack of technical credibility as well as its lack of political sensitivity in this particular instance.

The basis for the statement that there are no substantial environmental impacts arising from nuclear radiation for any of the three alternatives is discussed in Section XIII, "Environmental Trade-Offs Among Alternatives," and is related to a comparison of the offsite risks from the alternatives with risks from natural background radiation to the surrounding population.

Appendix A points out that there is significant opposition to bedrock disposal of radioactive wastes under the SRP site, and all work on the bedrock disposal concept was stopped in 1972, partly as a result of political considerations by the U.S. Atomic Energy Commission.

P-4 (3) On page I-1 of the summary statement, DOE states that *the high-level nuclear wastes has been and is continuing to* be stored safely in underground tanks that are engineered to provide reliable storage of the waste isolated from the environment. This statement is inconsistent with the information contained in ERDA-1537 entitled, "Waste Management Operations; Savannah River Plant, Aiken, South Carolina." On page III-85 of ERDA-1537, an area of soil around Tank No. 8 is described as having been contaminated by an overflow of acid wastes containing Cesium-137. Soil depths of one to fourteen feet were contaminated with an estimated 5,000 curies of cesium-137 radioactivity. Additional information is presented which describes several other failures which resulted in leaks of various radionuclides to the environment.

The Savannah River Plant is well along into an interim waste management program of retiring older tanks and transferring the waste to new, double-walled, stress-relieved tanks that are not expected to leak. The small leaks and spills that have occurred in the past are contained in the soil near the tanks, and pose no threat to the rest of the environment.

P-4A (4) The draft EIS states that "disposal" means that waste is retrievable with only moderate effort. One of the three alternatives considered in the report is direct injection of the high level waste slurry into a bedrock cavern. It is inconceivable that disposal by this alternative could mean that retrievable could take place with only moderate effort. Since the waste slurry would be highly acid in character as well as radioactive, the damage done to the receiving rock strata might prohibit removal on an economically feasible basis.

In both Section I, Summary, and Appendix C, Glossary, it is explicitly stated that a disposal concept includes no expectation of retrievability. However, we expect the NRC to require retrievability for up to 50 years and the difficulty of retrieving the waste slurry from the bedrock would be a significant disadvantage to its use.

P-5 (5) On page III-9 of the draft EIS, a discussion of the flow of ground water in the Tuscaloosa aquifer is presented. DOE states that on the basis of piezometric measurements, the Tuscaloosa water flows from the Aiken Plateau in a curved path to the Savannah River valley. This same information was also presented in a more detailed manner at a meeting on May 3, 1977 between Georgia representatives and Mr. Wendell Marine of DuPont's Savannah River Laboratory. At that meeting, the Georgia State Geologist expressed reservations about interpretation of the piezometric data. For example, the Georgia State Geologist indicated that his information indicated that there was leakage and crossover from the Tuscaloosa aquifer into other formations where groundwater patterns were in a circulatory south by southeast direction. The current draft EIS doesn't even discuss this possibility. Because of the concern expressed by Georgia, EPA, and the National Academy of Sciences in regard to the potential contamination of the groundwater, it would appear that DOE should have devoted considerably more detail to this important subject.

Within the vicinity of SRP, no aquifer above the Tuscaloosa has a head lower than Savannah River level, thus water moves preferentially toward the Savannah River. Even though there is a small upward gradient from the Ellenton formation to the Congaree as shown in Figure III-4, these formations are separated by a clay that appears to be continuous over a large region and prevents gross transfer of water. To the southeast in the vicinity of Savannah, Georgia, a large cone of depression exists in the Principal Artesian Aquifer which overlies the Tuscaloosa. This probably creates a much larger head differential between the two aquifers and upward leakage might occur. However, the water in the Tuscaloosa formation beneath Savannah has not passed beneath SRP as shown in Figure III-5.

P-6 (6) The section of the draft EIS related to seismicity is completely inadequate. As it is written, it tends to leave the impression that there is no activity in the area and that there is nothing about which to be concerned. In addition to the Charleston, S.C. earthquake in 1886 which registered an intensity of X on the Modified Mercalli Scale, several other seismic activities have occurred in the area. The Earthquake Data Service of the National Oceanic and Atmospheric Administration publishes updated lists of such occurrences throughout the United States. The following is a partial list of earthquakes recorded in the vicinity of the Georgia-South Carolina border.

Year	Date	N. Lat.	W. Long.	Intensity
1903	Jan. 23	32.1	81.1	VI
1912	June 20	32.0	81.0	V
1971	May 19	33.3	80.6	V
1971	July 13	--	--	VI
1972	Feb. 3	35.0	80.4	V
1974	Aug. 2	33.9	82.5	V
1974	Nov. 5	33.7	82.2	III
1974	Nov. 11	32.9	80.1	VI

Detailed site seismic data is included in ERDA-1537 and is incorporated in this EIS by reference. ERDA-1537 includes a description of the Charleston earthquake and its relationship to the SRP site as well as other historic data on seismicity.

P-7 (7) It is interesting to note that in ERDA 77-42/1 & 2, such items as "modern tanks" are used to describe the storage containers for the high level acid wastes. This same vagueness occurs in the recent draft EIS. DOE uses the term, "type III tank," without describing it. This is a controversial question and requires elaboration by DOE. At SRP and Hanford where carbon steel tanks have been used in lieu of stainless steel, stress cracks, deterioration, leaks, and other problems have developed. It is difficult to understand why DOE keeps failing to describe what kind of tank that will be used should Alternative No. 1 be chosen for high level waste management.

The use of the underground double-shell high-level waste storage tanks was considered in the following environmental documents:

1. "Final Environmental Statement - Waste Management Operations, Savannah River Plant," ERDA-1537, September 1977.
2. "Environmental Statement - Additional High-Level Waste Facilities, Savannah River Plant," WASH-1580, August 1974.
3. "Environmental Statement - Future High-Level Waste Facilities, Savannah River Plant," WASH-1528, April 1975.

Recently, DOE was directed by the United States Court of Appeals for the District of Columbia (NRDC vs. Administrator, ERDA/DOE) to prepare a supplement to ERDA-1537 to address certain specific design and safety features of these high-level waste storage tanks. This supplemental EIS is in preparation and will be issued for public review and comment. The Type III tank is described in detail in ERDA-1537, p. II-90 to II-96. This is a subsurface, 1.3 million gallon carbon steel tank with a full height carbon steel secondary liner all enclosed within at least 2.5 feet of concrete. The primary tank is fully stress relieved to inhibit stress corrosion cracking.

P-8 (8) The discussion of "risk" is inadequate and very misleading throughout the entire draft EIS. In some cases the calculated risks are based on only limited and narrow assumptions without consideration of the total picture. This is particularly true for Alternative No. 3 because the groundwater movement, population served, and other factors assumed by DOE are incorrect.

Some aspects of the risk assessment depend upon bounding, or upper limit assumptions, because some systems are not presently designed in enough detail to allow more formal risk methodology to be applied. Such assumptions are necessary only for some of the abnormal events, and are discussed in Section V-C, Potential Effects from Abnormal Events for Each Alternative.

It is the technical judgment of the preparers of this document and its references that the factors used in risk analysis of Alternative 3 are either measured and correct, or are reasonable upper-limit assumptions.

P-9 (9) Many important issues raised during Georgia's review of the earlier report, ERDA 77-42/1 & 2, were not even considered in the preparation of the draft EIS because it is devoid of any reference to the problem. Those issues still continue to be valid and are hereby included as part of the review of the draft EIS. In addition, because of the relationship of the earlier report on Waste Management Operations (ERDA-1537), Georgia's comments on this document are also attached as part of its review of the draft EIS (DOE/EIS-0023-D).

DOE has used its best efforts to ensure that all substantive comments on ERDA 77-42 were taken into account in preparing this Programmatic EIS. The Governor of Georgia's comments, and responses by DOE, are included in this appendix also. The comments on ERDA-1537 were considered in the past, when that document was prepared in final form.

Review of ERDA 77-42/1&2, "Alternatives for Long-Term Management of Defense High-Level Radioactive Waste".
by
State of Georgia

P-10 1. In the "Foreword", the document states that the purpose of the report is "to provide other Government agencies and the public with information"--- and "to serve as a basis for discussion and judgement in future decision making". It also states "the document presents factual information---". After reviewing the report in some detail, it is fairly easy to conclude that these objectives were not met. It looks as though the person who established the objectives and the people that did the preparation of the report didn't communicate with each other. The information presented in the report is based on a large number of assumptions that are not qualified, or verified, and might easily lead management people in Government to make costly decisions without having a well defined basis.

The objective of the DOE high-level waste management program is to isolate the waste from the environment for long enough or in secure enough manner that it will pose negligible risk to human welfare. The purposes of ERDA 77-42 are to describe the different alternatives along with their probable relative costs, risks, and uncertainties; and to raise the issue of methodology for decision-making in nuclear waste management. This EIS further forms the issues for developing the research and development program to manage radioactive high-level waste. Final decision on the immobilization process and the waste form will be supported by subsequent environmental documentation. Specific comments on assumptions have been addressed within.

P-11 2. The Foreword also states that the document "does not take into account social and public policy issues". This appears to be an attempt to get around having to enumerate certain concerns that might influence decision makers. The definition of a social or public policy issue must be different than the context in which they are currently defined in governmental circles today. If the contamination of a groundwater source that serves all of Southeast Georgia is not a public issue they must be using a pretty unconventional definition of the term. Also, if transportation is not a public issue then I don't know what would be classified as such. It is tempting to speculate that the authors of the report do discuss a social issue when it supports their objective, whatever that might be. As an example, on page II-15 of the report it states --- "some social implications --- are discussed below".

Future funding of bedrock storage is not recommended in DOE/EIS-0023 and the method was included in ERDA 77-42/1&2 for the required completeness of the analysis. "Social and public policy issues" are addressed to the extent that they relate to environmental impacts and will be addressed further in any future documentation in support of a specific facility for the management of high-level waste at Savannah River.

P-12 3. In many sections of the report such terms as "modern tanks", "reliable isolation of waste", "modern design", and "old waste tanks of the best type available" are used. Its almost as though the definitions of such terms are carefully avoided so that the decision makers" minds are not clouded with certain information. As an example, a controversial issue has arisen at SRP and Hanford regarding the type of tank and tank design used to presently store high level waste. The carbon steel tanks have been used in lieu of stainless steel tanks and as a result stress cracks, deteriation, leaks, and other problems have developed. How is the term "modern" to be interpreted? Does this mean the continued use of carbon steel or does it mean the use of stainless?

As used in the subject document and similar documents concerning SRP programs, the terms "modern tanks" and "modern design" refer to the class of waste tanks constructed since 1966 and/or currently under construction. These tanks, locally designated "Type III," differ from earlier SRP tanks primarily in that the primary vessel (inner steel tank) of the Type III design is fully stress-relieved by <u>in-situ</u> heat treatment after fabrication. This heat treatment relieves the high internal stresses "locked into" the steel in the process of seam welding together the many separate plates from which the tank is fabricated; elimination of these "locked in" stresses (locally often much higher than stresses induced by hydraulic loading of the vessel) eliminates a primary requisite for stress corrosion cracking and thereby is a major advancement in maintaining the integrity of the tanks. The Type III tanks also incorporate several other improvements over the tanks of earlier design, including full-height secondary tanks, air cooling under the bottom of the primary tank, bottom-supported cooling coils (in all but two of the earlier Type III tanks), improved and tighter steel specifications, provisions for detection of leaks through the <u>secondary</u> vessel (except in the first seven Type III tanks), and numerous improvements of smaller scope. The Type III tank is described in detail on pages II-90 to II-96 of ERDA-1537. There are no plans to make SRP waste tanks of stainless steel for reasons discussed under Comment 22.

P-13 4. On page II-5 of the report, the authors use a very narrow approach based on a limited viewpoint to lead a reader to believe that the release of radioactivity to the environment would not be too dangerous. I specifically refer to the following paragraph:

"Liquid releases from SRP would be absorbed in the soil or diluted many orders of magnitude by the onsite creeks and swamps and by the Savannah River before reaching drinking water users. Even if diversion systems fail and no corrective actions are taken, no large individual doses can occur."

They are actually referring to the high level waste stored in the carbon steel tanks at SRP and the statement leaves the distinct impression that the surrounding natural resources can be used as a back up control because the plutonium, strontium, ceasium, and other radioactive isotopes would be diluted in concentration. Evidently the authors are still firmly committed to the old phrase, "the solution to pollution is dilution". This approach really destroys the professional credibility of the authors.

It is not the intent of DOE to imply that dilution is an acceptable method of handling the disposal of radioactive wastes. DOE is firmly committed to a multiple barrier approach to long-term waste management. These barriers involve (1) Administrative control (2) engineered safety systems (3) passive physical containment of waste (4) integrity of the waste form itself and (5) location of the waste relative to parts of the environment used by man. The purpose of the referenced statement is to show that even in the unlikely event that the first four barriers would fail, the fifth barrier (dilution) would ensure that no significant harm would come to the offsite water users.

P-14 On page II-9, the report states that all the geologic disposal options would require construction and observation of large-scale exploratory shafts for a time period long enough to give a high level of confidence of their continued integrity after sealing. It fails to mention that criteria for making these judgments are not available and there is no current definition for "high level of confidence". Again, this approach misleads a decision maker who is not as technically well-grounded in the subject.

This statement is emphasizing that confidence in geologic systems cannot be obtained from wells alone, a point emphasized by the NAS Report. It is not intended to be exhaustive in the tests or criteria that would be applied to an <u>in situ</u> test facility.

P-15 6. On page II-14, Table II-3 lists the incremental cost/risk for plan No. 22 as a base for all other plans. There is no explanation of the term "base" yet all the rest of the factors for Table II-3 relate to it.

Incremental cost/risk analysis is used in the Programmatic EIS in Table XII-5 through XII-9, and the explanation of the basis is given in Section XII-A.3.

P-16 7. The subject of transportation is improperly handled in the report. The statements do not reflect a current understanding of this complex national issue. They do not reference current NRC publications such as NUREG-0170, NUREG-0073, or NUREG-0015. Also the authors do not give any indications of any awareness of the national controversy associated with transportation through large urban areas. On page II-6 they say the risk from transportation is very low while on page III-1 they say that the disadvantage of shipping offsite to a Federal Repository is the risk and cost incurred during transportation.

The approach taken in this Programmatic EIS and its backup reference, ERDA 77-42, toward transportation risks was to assume a generic transportation environment and bounding physical assumptions to arrive at the conclusion that radiation related transportation risks are small. The statement that transportation risk is a disadvantage to shipping waste offsite is not inconsistent with the finding that transportation risk is small - particularly in view of the finding that risks from all aspects of the alternatives presented are small.

DOE is aware of the studies, recently completed and in progress, covering radioactive materials transportation, and the results of these studies and any regulations following from them will be taken into account in any project-specific EIS involving transportation off the SRP site. However, the research and development, design, and testing program covered under this Programmatic EIS is not sensitive to details of future offsite transportation scenarios. Therefore, DOE maintains that the subject of transportation is handled properly for purposes of this document.

P-17 8. Throughout the whole report risks are calculated and left as pure numbers without any qualifying statements that justify their authenticity. As an example, risk factors are given for many different aspects of bedrock storage at SRP as it relates to the Tuscaloosa aquifer. Yet on page III-3, the following statement is made:

"Because the consequences of the wastes migrating into the aquifer are potentially very high, it would be necessary to establish with great certainty that there are no mechanisms which would allow the waste to migrate before sufficient decay". In other words, they admit that they don't know what to expect with any degree of certainty within the aquifer but they go ahead and calculate risk factors, assign costs to them and conclude that slurrying the wastes into a bedrock facility at SRP is the lowest cost alternative.

Many of the risks covered are known to a high degree of certainty from experience with operations of similar facilities. Other risks, particularly from sabotage, are known with less certainty. The basic data involved in the structure of the risks are available in the EIS and its references, so that the reader may use his own assessment of unlikely probabilities, etc., to arrive at risks if he so desires.

The bases of the risk assessments for unusual events and for normal operations are discussed in Sections V-B and V-C, and a discussion of the sensitivity of the results is given in Section XII-C.

P-18 9. Table III-2 on page III-4 lists the molar concentrations of the non-radioactive components of the SRP high level wastes. It is interesting to note that the waste is 3.3 molar in sodium nitrate ($NaNO_3$). The contamination of the Tuscalloosa aquifer with millions of gallons of nitrate bearing wastes of this concentration is in direct conflict with efforts to reduce nitrates in wastewater effluents and from other sources.

DOE does not intend to take any action that has significant probability of releasing nitrate to any body of water in harmful amounts.

P-19 10. The key to all the alternatives except for continuation of storage in liquid form is the application of technology to resuspend existing salt cakes and/or transfer the wastes for chemical precipitation and solidification. There is very little mention of the fact that there are serious doubts about the application or existence of such tehcnology at the present time. On page III-16 there is a very weak statement to this effect:

"Sludge removal and tank cleanout have been demonstrated but improved technology is currently being developed."

Current operations at Savannah River are demonstrating the technology in question and results are included regularly in monthly reports. The success in tank cleanout has been the result of improved technology that is continuing to be developed.

P-20 11. It is interesting to note the differentation in canning. If lower level wastes are to be stored at SRP in an onsite storage facility they plan to double can it. However, if high level waste is going to be put into a bedrock cavern (where it has a big potential for contaminating the groundwater) they plan to only single can it. If they store high level waste on the surface they not only are going to double can it but one will be stainless steel. (page III-25)

The process for waste containerization covered in this Programmatic EIS includes a single stainless steel canister. Later plans may feature additional canning of the waste, depending upon details of the storage or disposal environments. The research and development, design, and testing program covered under this document is not sensitive to later decisions regarding additional canisters.

P-21 12. In Alternate Plan 22 on page III-28, it is mentioned that before the bedrock storage cavern concept can be implemented, there will have to be, drilling and exvacation of an exploratory shaft and tunnels. There is no mention of the fact that there are two existing such tunnels already in existence at SRP (statement made by Mr. Wendel Marine of DuPont Savannah River Laboratory to DNR Representatives on May 3, 1977).

There are no shafts or tunnels in existence at SRP. Mr. Marine denies making such a statement.

P-22 13. Alternate Plan 23 assumes continued storage of wastes as sludge and damp salt cake in double walled underground tanks similar to those commonly in use at SRP. There is no mention of problems with these tanks even though they indicate more than twenty years experience. Why are stainless stell tanks not considered as an alternative? The present tanks are carbon steel and along with those ar Hanford, have become a national controversial issue.

The use of stainless steel rather than mild (carbon) steel for SRP waste tanks has been considered in depth several times by Savannah River Plant technical groups. Included in the evaluations were safety, technical, and economic considerations. Austenitic stainless steels are susceptible under specific conditions to the same forms of corrosion that can damage carbon steels, including stress corrosion cracking promoted by chlorides, caustic, and/or fluorides. Pitting and/or intergranular corrosion can occur due to chlorides, fluorides, nitrates, chromates, and other ionic species, especially in heat-affected zones near welds. The susceptibility of stainless steel pipes and vessels to rapid and complete penetration due to trace quantities of chloride is widely known. These shortcomings do not render stainless steel unfit for radioactive waste storage; but, as with mild steel, they do require that the specific chemical nature of waste being stored and changes that may occur during storage must be known, and must be amenable to control and adjustment so that conditions corrosive to the steels are avoided. SRP waste properties relevant to storage in mild steel tanks have been well characterized by 25 years' operating experience and laboratory studies, which provide a high level of confi-

P-22 contd dence in the longevity of the stress-relieved carbon steel tanks of current design. A similar level of confidence in storing SRP wastes in stainless steel tanks could be obtained only after extensive tests and changes to the separations processes.

In general, stainless steel waste tanks are used or proposed for storage of radioactive wastes in the acidic state, rather than the alkaline state used at SRP. The primary advantages of acidic waste storage are (a) less waste volume per unit of reactor fuel processed, and (b) substantially less insoluble material (sludge) in the stored waste. The former advantage applies primarily to waste from nonalloyed fuels; where fuels of highly enriched uranium alloyed with aluminum are used, as in the SRP HM process, or where aluminum is added as a processing reagent, the quantity of nonvolatile solids in acidic waste from a given amount of fuel is not substantially lower than it would be in alkaline waste. The lower sludge content of acidic waste is a significant advantage in wastes from high-burnout fuels from power reactors (military or commercial), because removal of fission product heat liberated directly into the liquid phase (by fission products in solution) is much more efficient than removal of the same amount of heat from the sludge that would be present if the waste were alkaline. This mandates the use of acid storage (and stainless steel tanks) for power reactor high-heat wastes, but not for SRP reactor wastes at current operating rates and parameters, where the maximum fission product heat yield can be readily removed from the sludge layer characteristic of alkaline wastes.

Now that the stress corrosion cracking problem has been overcome by stress-relieving the newer (and all future) waste tanks and by close attention to steel quality and waste composition (especially the ratio of inhibiting OH^- and NO_2^- ions to aggressive NO_3^- ions), mild steel is considered to be just as safe and effective for storage of SRP wastes as stainless steel would be. In addition, storage of wastes in alkaline form offers some inherent safety advantages for SRP: (a) the inclusion of the majority of the radionuclides in an insoluble and relatively immobile sludge phase, (b) the relatively low mobility of alkaline waste in SRP soil due to soil pluggage by hydroxide ion, and (c) the greater retention under alkaline conditions of radionuclides by ion exchange with the soil.

Complete conversion of SRP waste management practices to the storage of radioactive wastes in acid form is not feasible because of the large amount of alkaline waste already on hand and because some SRP wastes are inherently alkaline, e.g., the cladding removal waste from the Purex process (for nonalloyed uranium fuel). Concurrent operation of separate facilities for acid and alkaline waste storage would not be economical. Also, the only nonvolatile solids in current alkaline wastes, that would not be present in acid wastes, are the various sodium salts (nitrate, nitrite, carbonate, sulfate, and hydroxide). In the reference process, these

P-22 contd

sodium salts will be separated from the fission products and other compounds in the waste when the latter two salts are vitrified and packaged for final disposal. Hence, the salts will not contribute to the bulk of the vitrified wastes to be disposed of.

P-23 14. On page V-12, the statement is made that about 10,000 nuclear weapons have been stored for at least ten years without a sabotage incident. Does this mean that there have been no attempts or that none have been successful:

The analysis implies that no sabotage attempts have been successful.

P-24 15. On page V-18, leach rate experiments are described and the time to release 1% of the Cs-137, Sr-90, and gross alpha radioactivity is calculated. Yet, the experiments were conducted on cylinders only one half inch in diameter by one half inch high. One can only speculate as to the magnitude of scale up errors involved in going to full scale.

Leach results from the small samples were used for conservatism and to approximate conditions of cracking of larger monoliths. Scaleup from small sizes to larger sizes, with lower surface-to-volume ratio, would result in lower releases from leaching.

P-25 16. On page V-41 it is assumed that there is a potential 50,000 users of Tuscaloosa aquifer drinking water. Another ERDA report (DP-1438) describes a technical assessment of Bedrock Waste Storage at SRP and it is from this reference that the number of 50,000 is obtained. It is interesting to note that any information from DP-1438 was carefully excluded from ERDA-1537 an environmental statement about waste management operations at SRP. They have so confused the whole subject of waste management through a piecemeal approach, one can only speculate as to the credibility of the information used and the conclusions drawn from it.

Present waste management operation only are covered in ERDA 1537. Since present operations do not involve the Tuscaloosa aquifer, there was no utility in discussing bedrock disposal and its risk to the aquifer in that document. This Programmatic EIS, and its references, are concerned with long-term options for future disposal of the waste and therefore are the proper place to discuss bedrock disposal.

P-26 17. On Page V-42, a very important point is raised in regard to the possibility of an explosion. Radiolysis will cause hydrogen and oxygen to form in a bedrock cavern thus creating a potentially explosive atmosphere. Should an explosion occur inside the cavern, the consequences are really unknown. It will place stress on the cavern and the aquifer and increase the chances of water movement thus increasing the potential for additional contamination of the aquifer. The authors dismiss this event as being without consequence.

As stated in the text of ERDA 77-42, the hydrogen explosion possibility has been analyzed in the bedrock reference (DP-1438) and the consequences from such an explosion were found to be insignificant. DOE has seen no scientific evidence presented to invalidate that conclusion.

P-27 18. On page V-43 of the report, the consequence of an earthquake in relation to a bedrock cavern at SRP and the Tuscaloose aquifer are discussed. The authors assume that the water flow rate is through the aquifer to the Savannah River and that the flow rate is quite low. Thus they postulate that any rupture of wastes into the aquifer would be confined to plantsite for several thousand years and that only the 50,000 people that move onto the plantsite and use the water have to be taken into consideration. Hydrogically and geologically speaking, these are improper assumptions. The water from the Tuscaloosa aquifer feeds into the principal artesian aquifer which serves all of Southeast Georgia.

The geologic term "Tuscaloosa" is used from North Carolina to Louisiana to designate an Upper Cretaceous sand with clay layers and lenses. The hydrologic regimes within this formation are much more local in extent. Thus, even though the Tuscaloosa is a large and prolific aquifer in Georgia, none of this water comes from South Carolina due to discharge at the Savannah River. The "Principal Artesian Aquifer" of Georgia is equivalent to the Ocala limestone of Eocene age, and its principal cone of depression is at Savannah, 100 miles away from SRP. Water in the relatively local Tuscaloosa circulation system in the SRP vicinity does not contribute to the Principal Artesian Aquifer at Savannah.

P-27 contd The consequences of contaminating this invaluable water supply would be technically, socially, and politically disasterous for the people of Georgia. Any acceptance of the possibility of contamination of this water supply by radioactive nuclides such as those of plutonium, strontium, and cesium would be irresponsible.

P-28 19. On page V-44 and V-45, the assumption is made that plutonium would be bound in the rock of a cavern and thus not move into the surrounding groundwater. There is really no good basis for this assumption because there are other mechanisms that impact the movement of plutonium other that absorption. As an example, plutonium movement has been demonstrated at the low level waste burial facility in Maxey Flats, Kentucky due to water transport through faults, cracks, and fissures in the geological formations.

Most of the plutonium is in insoluble form. Investigations would have to assess the controls on plutonium migration before storage of radioactive waste in bedrock caverns was implemented. However, no R&D for geologic disposal is being proposed.

P-29 20. On page VI-3 the authors give criteria and assumptions which they use in calculating dose rates for transportation of canned waste. They do not cite any references, experience, or any other basis for the assumptions. Since they are inconsistent with those recently used by Sandia Laboratories in the preparation of NUREG-0170 for the U.S. Nuclear Regulatory Commission, one can only assume that the authors just created them on their own.

Details of assumptions and sources of data are given throughout Section VI, and references for Section VI are given on page R-4 of ERDA 77-42. The assumptions used are intended to be generic and bounding and are generally more pessimistic than those covered in NUREG-0170. See Response P-16, above, also.

P-30 21. On page VI-15, the conclusion is reached that the risks due to transportation accidents are so small that the contribution is negligible to the overall risks. The authors have failed to properly consider that there is no management system currently being used either by U.S. DOT or by U.S. NRC to keep track of the transportation of nuclear materials. This in itself increases the potential consequences should an accident occur. The authors also did not properly assess the possibility of contamination of surface water supplies during the course of transportation accidents. Other factors such as the use of a population density of 250 people per square mile and the use of an undefined type of a shipping cask also render their conclusions inappropriate.

The portion of the comment regarding potential surface water contamination is incorrect - the subject is covered on page VI-12 of ERDA 77-42. See also Response P-16, above.

P-31 22. On page IX-8, it is stated that the storage of SRP wastes in the bedrock under the SRP site has been studied for over 20 years. There is no mention of the opposition by U.S. EPA, the State of Georgia and the National Academy of Sciences recommendation against bedrock storage, or the fact that futher work of this concept was ordered stopped in the early 1970's. Again, it is also interesting to note that even though twenty years of experience had been accumulated at SRP with bedrock storage investigations, it was excluded from the Environmental Statement on Waste Management Operations at SRP (ERDA-1537) published in 1976.

Opposition to bedrock disposal by the State of Georgia and the U.S. EPA has been noted in the Summary. A discussion of bedrock disposal was not given in ERDA-1537 because that EIS dealt only with current waste management operations.

P-32 23. On page X-33, in the Sensitivity Analysis Section, the authors admit that the contamination of the Tuscaloosa aquifer has the largest risk but they try to soften the statement and lead the reader to a directionalized conclusion by indicating that there are promising possibilities for corrective action. They carefully point out that this alternative is "by far the least expensive".

DOE believes the facts presented regarding the risks of bedrock disposal and the possibility of corrective action are true and present upper bounds useful for programmatic decision-making.

P-33 24. On page X-35, the statement is made:
"___ corrective action could be taken if some responsible, organized society exists in the future".

It should be pointed out that corrective actions could have been taken during the last twenty years to have a sound national nuclear waste management program for defense wastes but they weren't taken. The assumption made by the authors is greatly over simplified because the issues and technology application are considerably more complex than the statement would lead one to believe.

The quoted statement refers to mitigating measures which may reduce the actual environmental insult from that conservatively estimated in the document. Corrective actions such as these have been taken in the past in response to radioactive releases in the waste tank farm to mitigate the consequences of that leak. The Interagency Review Group on Nuclear Waste Management (IRG) has attempted to formulate a sound national nuclear waste management program for defense wastes. DOE intends to adopt the following IRG recommendation pending appropriate environmental review:

> "The IRG recommends the DOE accelerate its R&D activities oriented toward improving immobilization and waste forms and review its current immobilization programs in the lights of the latest views of the scientific and technical community. Since final processing of defense waste has been deferred for three decades the IRG also recommends that remedial action, including immobilization of the waste, should begin as soon as practicable."

P-34 25. On page X-36, the authors suggest that atmospheric exposure could be reduced by the installation of a rapid warning system that would be activated in the event of a release of radioactivity. The statement is made:

"The warning network might be any combination of in-place sirens, roving automobiles with loud speakers, commercial radio and television announcements, C.B. radio, operators ringing telephones, and the civil defense warning system".

It is interesting to speculate that if all these were employed, there would be a need to calculate a "panic" risk factor and thus come up with a dollar value for the human lives lost in the process. It is irresponsible to consider this type of communication as a back up for reduction of atmospheric exposure. The back up has to be in place well ahead of this type of process.

Any rapid warning system deployed in the future would probably be accompanied by an education process to minimize panic if the system were actually ever used. DOE is not aware of any methodology for calculating a panic risk factor or an estimate of any lives that might be lost due to panic. However, recent experience at the Three Mile Island nuclear reactor would indicate that no public casualties would be incurred from panic.

STATE OF GEORGIA COMMENTS
REGARDING:
Draft Environmental Statement - "Waste Management Operations - Savannah River Plant; Aiken, South Carolina", ERDA - 1537 (October, 1976)
December 15, 1976

A review of the Draft Environmental Statement for the Savannah River Plant Waste Management Operations has been completed. The following comments are in order:

A. Non-radioactive Wastewater Discharges

1. The E.I.S. indicates (II-46) that spent drum cleaning solution is discharged without treatment in 16,000 gal. batches "after analyses to confirm acceptability of the release." The "analysis" to determine "acceptability" clearly applies only to radioactive contamination. Discharge contains 10,000 lb/yr of trisodium phosphate and 9,000 lb/yr of phosphoric acid. Raw discharge of this wastewater does not reflect good waste treatment practice and would not comply with minimum treatment requirements in Georgia.

2. According to the E.I.S. (II-53), various unspecified wastewater sources contribute to the trade waste system which is "designed to handle ordinary waste chemicals that are not contaminated beyond trace levels." Although "trace levels" clearly refers to radioactive contamination only, this wastewater is discharged untreated. Throughout this E.I.S., the assumption seems to be that any processing waste not contaminated with radioactive material requires no treatment. Non-federal public and private facilities are not generally allowed the luxury of discharging all process wastewater untreated after merely confirming that it is not radioactive.

3. Analytical laboratory wastewater is discharged without treatment (II-46). No chemical or biological characterization of this wastewater is given.

4. The E.I.S. states (II-55, 56) that sulfuric acid and sodium hydroxide used as regenerants in the deionized water systems in the Reactor and Separations areas are discharged after "moderate neutralization." Water regenerants in the Heavy Water area don't even receive "moderate" neutralization. Moderate neutralization or non-neutralization does not appear to constitute good wastewater treatment practice as would be required by various State and Federal regulations for non-Federal facilities.

5. Coagulant chemicals and suspended solids removed in water treatment facilities are discharged back to the Savannah River (II-55,56). The draft E.I.S. indicates (V-15) that alternative procedures were studied but rejected as uneconomical. Discharge of solids removed in water treatment plants back to surface waters by non-Federal facilities

Responses are given on pages K-17 through K-25 of ERDA-1537.

has not been allowed in various permits issued by EPA. These non-Federal facilities are not generally allowed the alternative of ignoring such requirements because they are considered uneconomical.

6. The E.I.S. indicated (V-15) that conversion from chromate-containing to organic corrosion inhibitors is being studied. The Georgia Environmental Protection Division is presently requiring other dischargers in the same area to either discontinue use of metallic inhibitors or provide treatment to remove the metals from the wastewater. The Division sees no good reason why a more lenient standard should be applied to this Federal facility.

7. The report states that the use and disposal of polychlorinated biphenyls (PCB's) at SRP has been specifically controlled since 1972. How were they previously handled before 1972 when they weren't controlled? Since PCB has been detected in sediments from Four Mile Creek and Pen Branch it would be reasonable to expect that this residual concentration is a result of operations prior to 1972. The conclusion presented that off plant sources may be the primary contributors of PCB may not be correct. A detailed discussion of this issue is necessary and in particular its probable relationship to any possible future actions that might be needed to remove previously deposited PCB.

8. In Section III-73 of the report, the concentration of several parameters in Ash Basin effluent water is compared with Drinking Water Standards. This presentation shows the concentration of selenium to be at 0.02 parts per million in the effluent vs 0.01 parts per million for the drinking water standard. This is double the standard yet there is no discussion of the significance or impact presented in the report.

9. In Section V-15 of the report under "Alternatives Studies but not Adopted", it is indicated that alternative methods for water treatment associated with chemical discharges to seepage basins are not economically feasible. There is no discussion of what methods were studied nor is there any indication of the basis for reaching the conclusion that was reached. This could be a very important issue as it relates to the equilibrium adsorption of radionuclides in the soils beneath the basins. (This is discussed further in additional comments for radiological discharges).

B. <u>Non-radiological Atmospheric Discharges</u>

1. The report indicated (III-59) that the calculated contributions to the annual average SO_2 ambient concentration at the SRP boundary is less than 33 micrograms per cubic meter. This compares to the Georgia standard of 43 micrograms per cubic meter. This is 76 percent of Georgia's standard and essentially means that any industrial development on the Georgia side of the Savannah River near SRP must

be limited. Fuel burning equipment of the capacity being used should reasonably not be allowed to make such a reported impact. In effect, it is endangering the economic development of Georgia.

2. The report gives conflicting efficiencies of the electrostatic precipitators that were installed in November, 1975. On page II-60 a value of greater than 99% is reported while on page III-61 they report a value of 95%. Also, no increment of particulate contribution to the ambient air by SRP is reported in the EIS.

3. Under normal conditions there should be no significance from other non-radioactive air emissions, however, there is a possibility that hydrogen sulfide odor could be detected during adverse meterological conditions.

C. Radiological Issue Comments

1. About 80-130 million gallons of water containing various radionuclides are discharged to several different seepage basins at SRP. In addition to the radionuclides other chemicals are also discharged to these sam basins (600,000 lbs of HNO_3, 200,000 lbs of NaOH, 12,000 lbs of H_3PO_4, 1200 lbs Na_2-Cr_2O_7, and 50 lbs of H_g.) The report makes a strong case for the ion exchange capability of the soil in the retention of the radionuclides, however, there is no evidence presented to show any recognition of the effect of the chemicals on the adsorption capability of the soils. If transport models are being used to predict the distribution and concentration of radionuclides in the groundwater contacting the soils, how have the shifts in equilibrium adsorption due to the chemicals been factored into the models?

2. The EIS (III-78) considers the additive impact of other non-SRP facilities. One such facility is the proposed Barnwell reprocessing facility and the report indicates that 16,000,000 curies of Kr-85 will be discharged via atmospheric releases from Barnwell. SRP discharges 520,000 curies of Kr-85 per year itself. These numbers compare to the SRP guide release number at 950,000 curies. Very little attempt is made in the report to discuss the additive impact of both facilities in relationship to SRP's waste management program. This is an important issue and it should be discussed thoroughly in both Chapters II, III, and IV of the report.

3. In section V-6 of the report, alternatives associated with Kr-85 atmospheric discharges are discussed. It is stated that there are no plans for an active research program aimed at Kr-85 removal from effluent gases during fuel reprocessing and that pertinent R/D at other sites will be followed for possible application. This is improper consideration of the whole issue. We agree that research is not necessary at SRP and it is not necessary elsewhere either because it has already been completed and commercial

equipment for Kr-85 removal is available <u>now</u>. This is supported by ERDA's own contractor, Battelle, in its preparation of ERDA-76-43 report entitled "Alternatives For Managing Wastes From Reactors and Post-Fission Operations in the LWR Fuel Cycle". Georgia expects ERDA to exercise its responsible role in the establishment of an abatement plan and timetable for the control of Kr-85 releases to the atmosphere. This should be treated properly in the EIS before it is released in final form. Georgia's position has already been expressed on this issue regarding the proposed Barnwell facility (see Governor Carter's letter attached).

D. <u>Bedrock Storage Issue</u>

The EIS for the SRP does not cover the use of the SRP site for permanent storage, particularly bedrock storage. ERDA has indicated that it is beyond the scope of this report because a separate EIS on long range waste management plans is currently in preparation. Georgia objects strongly to this piecemeal consideration of waste management plans because current operations and future plans must be tried together because of the long half-life of many of the isotopes in question.

The concept of using SRP for bedrock storage has already been postulated by ERDA and work has occurred on site. This is discussed in WASH-1202 (1972, 1973). In addition report, SRO-TWM-76-1, states that bedrock storage is the "principle" candidate for long term storage. Since bedrock storage has already been advocated and original projections of FY-81 were indicated for beginning of actual storage, this is an issue that is not long range. The present draft EIS must consider this issue and Georgia must insist that the EIS <u>not</u> be issued in final form until it is considered.

Since the fresh water aquifer which serves all of South Georgia lies underneath this geographical area Georgia is very concerned about any attempt to establish a bedrock storage site in the vicinity of SRP. In 1972, Governor Carter established Georgia's position of opposition to bedrock storage at SRP and that position still remains unchanged. (See attached letter).

The question of seismic activity in a geographical sphere of influence which could incorporate SRP has been treated very poorly in the current draft EIS, on page II-160 the report indicates that on the basis of three centuries of recorded history of earthquakes, an earthquake above an intensity of VII on the modified Mercalli scale would not be expected at SRP. Yet a few sentences later the report states that during the past 100 years, the area within a 100 mile radius of the SRP has experienced one shock of intensity X, one shock of intensity VIII, two shocks of intensity VII, and twelve shocks of intensity V. At first reading these two statements appear to be in conflict with each other and more explanation is necessary. Also, the

Richter scale is usually used to report earthquake activity to the general public so if the modified Mercalli scale is going to be used in the EIS, the intensity levels should be identified as in the following examples:

Modified Mercalli Intensity Scale	
XII	Damage nearly total; Large rock masses displaced.
XI	Rails bent; Underground pipeline out of service;--------
X	Most masonry and frame structures destroyed with their foundations; Serious damage to dams; Large landslides--------
IX	General Panic; Masonry destroyed--------
VIII	Twisting, fall of chimneys, Factory stacks, Monuments, towers, and elevated tanks--------
VII	Damage to masonry; Small slides; Concrete irrigation ditches damaged--------

The report mentions the Bel Air Fault northwest of Augusta, Georgia and admits that the rate and character of its movement has not yet been resolved, nor has its significance to the techtonic framework of the eastern U.S. been determined. The many other faults in this area of Georgia are not even mentioned in the report. The poor treatment of the seismic activity in the EIS helps to reaffirm Georgia's position on bedrock storage.

Office of NEPA Affairs
U. S. Department of Energy
Washington, D. C. 20545

June 3, 1979

Dear Sir:

Q-1 This is in reference to your draft environmental impact statement entitled "Long-Term Management of Defense High-Level Radioactive Wastes" for the Savannah River Plant in Aiken, South Carolina. I have reviewed this statement and have the following comments to make:

1. It would be helpful if you would state what the level of background radiation is at SRP and the surrounding area. This should be given in rems per year and rems per calendar quarter.

The calculated annual background radiation level in the vicinity of SRP is 120 mrems and is given in Section III.B (page III-12) of this EIS.

Q-2 2. It is not clear if there was a review of current studies that suggest that exposure to low levels of radiation could be harmful to humans.

The potential effects of exposure to low-level radiation has been considered in developing the health effects estimates given in Tables XI-5 through XI-9. Additional discussion is given in response to Comment M-3.

Q-3 3. In reference to the probability of sabotage; a sabotage attempt on SRP need only be effective in disrupting normal operations and bringing media attention for the attempt to be successful. An attack on SRP would accomplish both of these, which are the primary goals of terrorism. Also, with the current backlash against nuclear power, the probability of a sabotage attempt is greater.

The SRP has a continuously evolving safeguards program to guard against sabotage. However, sabotage has been analyzed in the technical reference document for the EIS (ERDA 77-42) and potential environmental impacts summarized for inclusion in the EIS (Tables V-12 through V-16).

Q-4 4. Why are there no restrictions on farming land that could become contaminated by P238,239 in the event of a leak? It should be remembered that farming operations cause large amounts of particulates to be released into the air. If a field is contaminated by P238,239 and farming operations are allowed to be conducted on it, there is a chance that workers may inhale these materials.

In the unlikely event of a leak, the contaminated area will be restricted to the SRP site and corrective actions will be taken. Examples of land contamination and corrective actions are given in Section XI of this EIS.

Q-5 5. Costs and cost differences should not be important considerations in choosing an alternative. The safest form of management should be chosen regardless of costs.

Cost is only one of the many factors important in the selection of a proper waste management program. In making its final decision, DOE will consider environmental, technical, and social factors as well as cost.

Thank you for providing the opportunity to comment on this statement, which hopefully will be of assistance to you. I would appreciate receiving three (3) copies of the final statement.

Sincerely,

Bennie Ricardo Brown, III
Simon's Rock Early College
Alford Road
Great Barrington, Mass. 01230

APPENDIX C

GLOSSARY OF TERMS AND ABBREVIATIONS

actinides
The radioactive elements with atomic number of 89 through 103. The name is taken from actinium, the first member of the series.

activation
The process of making a material radioactive by bombardment with neutrons, protons, or other nuclear particles.

activity
A measure of the rate at which radioactive material is emitting 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).

AEC
Atomic Energy Commission (discontinued with formation of ERDA and NRC on January 19, 1975).

alpha particle (α)
A positively charged particle emitted by certain radioactive materials. It is made up of two neutrons and two protons; hence, it is identical with the nucleus of a helium atom.

aquifer
A water-bearing layer of permeable rock or soil.

background radiation
The varying radiation of man's natural environment. It results from cosmic rays and from the naturally radioactive elements of the earth, including those within man's body.

biota
The animal and plant life of a region.

burial ground
An area specifically designated for the shallow subsurface disposal of solid radioactive wastes.

cal
Calories.

calcine
Material heated to a temperature below its melting point to bring about loss of moisture and oxidation to a chemically stable form.

Note: Many of these terms are given special definitions to refer to their specific use in this statement.

canyon building
A heavily shielded building used in the chemical processing of irradiated fuel and target elements. Operation and maintenance are by remote control.

cask
A container that provides shielding and containment during transportation of radioactive material. The shielding is normally lead and/or steel, or uranium.

cc
Cubic centimeters (1 cc = 1 mL).

cfm
Cubic feet per minute.

cfs
Cubic feet per second.

CG
Concentration Guide.

Ci
Curies.

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 radiation dose standards. (Usually 50 years or until biological equilibrium is reached.)

CRC
Cesium Removal Column, a deionizer used to remove ^{137}Cs ions from evaporator condensate.

curie
The basic unit used to describe the intensity of radioactivity in a sample of material. One curie (Ci) equals 37 billion disintegrations per second.

decay
The spontaneous radioactive transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. Every decay process has a definite half-life.

decommissioning
Decommissioning operations remove facilities such as reprocessing plants, waste tanks, and burial grounds from service and reduce or stabilize radioactive contamination. Decommissioning concepts include:

- Decontaminate, dismantle and return area to original conditions without restrictions.
- Partially decontaminate, isolate remaining residues, and continue surveillance and restrictions.

deionizer
A vessel containing ion exchange resins, used for removing positively or negatively charged ions from liquid.

DF
Decontamination factor, the ratio of the concentration of a constituent in the feed stream to that in the treated effluent.

Diatometer
An instrument to measure the concentration of microscopic diatoms in water as an index of water quality.

disposal (of radioactive waste)
Operations designed to eliminate wastes from existence on earth or permanently isolate them from mankind and his environs with no expectation of retrieval after emplacement. Isolation concepts include:

- Placement in subsurface geologic formation using technologies that offer no practical method for recovery.
- Emplacement into or beneath sea floors.
- Emplacement in ice sheets.

Elimination concepts include extraterrestrial disposal and transmutation.

dose
The energy imparted to matter by ionizing radiation per unit mass of irradiated material at a specific location. The unit of absorbed dose is the rad.

eluate
The liquid resulting from removing the trapped material from an ion exchange resin.

ERDA
Energy Research and Development Administration (the nuclear program components of ERDA were formerly part of the AEC). Became part of the Department of Energy established October 1, 1977.

final storage
Storage operations for which 1) no subsequent waste treatment or transportation operations are anticipated, and 2) conversion to disposal is considered possible.

fission products
Nuclei formed by the fission of heavy elements. Many are radioactive. Examples: strontium-90, cesium-137.

flocculent
Noncrystalline (wooly, cloudy, flakelike) particles suspended in a liquid. Such particles are caused by addition of a flocculating agent to a liquid, and can then be filtered out of the liquid.

FRC
Federal Radiation Council (now part of EPA).

gal
Gallons.

g/L
Grams per liter.

gpm
Gallons per minute.

ground water
Water in the zone of saturated aquifer beneath the land surface.

half-life, biological
The time required for a living organism to eliminate, by natural processes, half the amount of a substance that has entered it.

half-life, radiological
The time in which half the atoms in a radioactive substance disintegrates.

HHW
High heat waste (high-level liquid waste that requires auxiliary cooling).

HEPA
High efficiency particulate air filter. A type of filter designed to remove 99.9% of the particles down to 0.3 μm in diameter from a flowing air stream.

high-heat liquid waste
Liquid waste containing sufficient thermal energy to require some supplemental means of cooling, such as cooling coils.

high-level liquid waste
The aqueous waste resulting from the operation of the first-cycle extraction system, or equivalent concentration wastes from subsequent extraction cycles, or equivalent wastes from a process not using solvent extraction, in a facility for processing irradiated reactor fuels.

high-level waste
(a) high-level liquid waste, or (b) the products from solidification of high-level liquid waste, or (c) irradiated fuel elements, if discarded without processing.

ICRP
International Commission on Radiological Protection.

ICPP
Idaho Chemical Processing Plant, near Idaho Falls.

interim storage
Storage operations for which 1) monitoring and human control are provided, and 2) subsequent action involving treatment, transportation, or final disposition is expected.

Concepts for interim storage include bulk and unitized storage of solid, liquid, and gaseous wastes.

Alternative interim storage technologies include:

- Tank storage of liquids
- Canister storage in air-cooled vaults
- Spent fuel storage in water basins.

ion exchange
A reversible chemical reaction between a solid and a fluid mixture by means of which ions may be interchanged.

isolation
A term encompassing both final storage and/or disposal in geologic formations.

km
Kilometers (1 kilometer = 1000 meters or 0.621 mile)

LHW
Low-heat waste (high-level liquid waste that does not require auxiliary cooling but may contain significant quantities of radionuclides).

long-lived nuclides
Radioactive isotopes with half-lives greater than about 30 years. Most long-lived nuclides of interest to waste management have half-lives on the order of thousands to millions of years (^{239}Pu - 24,400 years; ^{99}Tc - 2.1×10^5 years; ^{129}I - 1.7×10^7 years).

M
Molar.

m
- Meter.
- As prefix — see "milli."

man-rem
The total radiation dose commitment to a given population group; the sum of individual doses received by a population segment.

mg
Milligrams.

Micro (μ)
Prefix indicating one millionth (1 microgram = 1/1,000,000 of a gram or 10^{-6} gram).

mil
One thousandth of an inch.

milli
Prefix indicating one thousandth.

mL
Milliliters.

MM
Modified Mercalli (scale of earthquake intensities).

mol
Mole — the amount of a substance that has a weight numerically equal to the molecular weight of the substance.

molar
Designation of the concentration of a solute in a solution [a solution that is 1.0 molar (1.0M) in NaOH contains 1.0 mol of NaOH per liter].

mph
Miles per hour.

mR
Milliroentgen.

mrem
Millirems.

nano
Prefix indicating one thousandth of a micro unit (1 nanocurie = 1/1000 of a microcurie or 10^{-9} curie).

natural uranium
Uranium as found in nature. It is a mixture of the fertile uranium-238 isotope (99.3%), the fissionable uranium-235 isotope (0.7%), and a minute percentage of uranium-234.

nCi
Nanocuries.

NCRP
National Council on Radiation Protection and Measurements.

noble gas
A chemically inert gas; e.g., xenon, argon, and krypton.

NRC
Nuclear Regulatory Commission (formerly part of AEC).

nuclide
Any atomic nucleus specified by its atomic weight, atomic number, and energy state. A radionuclide is a radioactive nuclide.

overpack
Secondary (or additional) external containment for packaged nuclear waste.

PNL
Pacific Northwest Laboratories, Richland, Washington.

pCi
Picocuries.

pH
A measure of the hydrogen ion concentration in aqueous solutions. Acidic solutions have a pH from zero to 7. Basic solutions have a pH from 7 to 14.

pico
Prefix indicating one millionth of a micro unit (1 picocurie = 1/1,000,000 of a microcurie or 10^{-12} curie).

piezometer
A well used for measuring the water pressure, or head, of subsurface aquifers.

plant stream
Any natural stream on the SRP site. Surface drainage of the site is via these streams to the Savannah River.

ppm
Parts per million.

ppb
Parts per billion.

psi
Pounds per square inch.

radioactivity
The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

radionuclide
An unstable nuclide of an element that decays or disintegrates spontaneously, emitting radiation.

rem
A quantity used in radiation protection to express the effective dose equivalent for all forms of ionizing radiation. It is the product of the adsorbed dose in rads and factors related to relative biological effectiveness.

repository
A location containing wastes in storage or disposal.

resin
An organic polymer. It is used in the text to refer to synthetic ion exchanger materials.

retention basin
An excavation, either lined with an impermeable material or unlined, to receive aqueous streams for temporary storage. Retention basins are used when necessary for temporary storage of cooling water or storm drainage that might be contaminated. After sampling, this water may be processed further or transferred to a seepage basin or an onsite stream.

seepage basin
An excavation in the ground to receive aqueous streams containing chemical and radioactive wastes. The water evaporates or seeps from the basin through the soil column to the ground water and ultimately to the streams that drain the plantsite. Insoluble materials settle out on the floor of the basin. Soluble radioactive materials move with the water or are removed by ion exchange with the soil. Seepage basins are surrounded by earthen dikes to prevent the entrance of surface water, and levels are controlled to prevent overflow from the basin system.

seismicity
The tendency for the occurrence of earthquakes.

separations
Chemical processes used to separate nuclear products from byproducts and from each other.

short-lived nuclides
Radioactive isotopes with half-lives no greater than about 30 years; e.g., ^{137}Cs and ^{90}Sr.

solidification
Conversion of radioactive waste to a dry, stable solid.

SRP
Savannah River Plant.

SRL
Savannah River Laboratory.

steam jet
A device to move liquids from one place to another by suction and entrainment in moving steam.

stress corrosion
Chemical corrosion that is accelerated by stress concentrations.

supernate
That portion of high activity liquid waste that contains fission products (primarily ^{137}Cs) in solution. Other portions are the insoluble sludge and crystallized salt.

tank farm
An installation of interconnected underground tanks for the storage of radioactive high-level liquid wastes.

transuranium elements

Elements above uranium in the periodic table; that is, with an atomic number greater than 92. All 13 known transuranium elements are radioactive and are produced artificially. Examples: neptunium, plutonium, curium, californium.

transuranic waste

Any waste material measured or assumed to contain more than a specified concentration (e.g., presently 10 nanocuries of transuranium activity per gram of waste) of transuranic elements.

USGS

United States Geological Survey.

waste, radioactive

Equipment and materials (from nuclear operations) that are radioactive or have radioactive contamination and for which there is no recognized use or for which recovery is impractical.

water table

The upper surface of the ground water.

zeolite

Any of various hydrous silicates that can act as ion exchangers.

μ

Mu, a prefix — same as "micro."

μCi

Microcuries.

μg

Micrograms.

μm

Micrometers.

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