APPENDIX I

LONG-RANGE WASTE MANAGEMENT PROGRAM

ERDA is preparing Defense Waste Documents for three ERDA nuclear installations (Savannah River Plant, Hanford Project near Richland, Washington, and Idaho National Engineering Laboratory) on alternative methods for long-term management of high-level radioactive wastes generated for national defense purposes. These documents will describe the current technological status and relative cost and risk of all reasonably available waste forms and storage modes. The reports, which should be issued for public review in 1977, will serve as the basis for the preparation of environmental statements on long-term management of high-level radioactive defense waste.

The text of this environmental statement applies primarily to current management practices for SRP radioactive wastes. Such practices could be continued even after shutdown of the SRP production facilities if the present level of surveillance and maintenance were continued. However, for long-range management, it may be desirable to provide methods requiring less direct control. Accordingly, the current management program is paralleled by a program to develop the technical information required for future waste management decisions, including safety and hazards analyses. This development program is discussed in this appendix.

Brief discussions are presented on three aspects of the development program for long-range management of high-level liquid wastes:

- Development of waste forms and conversion techniques.
- Comparison of alternative long-range management plans.
- Retrieval of waste from tanks for further processing.

A brief overview is also given of the development program for long-range management of radioactive solid wastes.

WASTE FORM DEVELOPMENT

Many of the methods for long-range management of high-level liquid wastes include the conversion of existing wastes to forms that are considered less reactive or dispersible and/or that contain essentially all of the radioactivity in a much smaller volume. Accordingly, a development program has been under way since 1973 to identify workable conversion processes and to define the properties of the resulting waste forms. Criteria for acceptable forms were examined, and properties of known conversion products and their applicability to existing SRP waste compositions were evaluated.[1] This study led to development work that has resulted in demonstrations of waste management technology in the following areas:

- Efficient removal of ^{137}Cs and traces of ^{90}Sr and $^{238,239}Pu$ from supernatant salt solutions by means of ion exchange, with subsequent fixation in zeolite.[2,3]

- Incorporation of both cesium zeolite from the above ion exchange process and the dried sludge phase into high-integrity forms of concrete and borosilicate glass.[4,5,6,7]

- Characterization of the properties of the above waste forms, including leach rate, strength, radiation stability, and thermal stability.[8,9]

- Demonstration of short-term compatibility of both concrete and glass waste forms with steel container materials.

- A more-complete characterization of the actual SRP waste supernates, salts, and sludges by improved analytical methods.

- Evaluation of mineralization processes for SRP wastes.[10,11]

Additional development and analytical work on waste forms and conversion processes is under way in the areas of:

- Efficient separation of sludge from supernatant salt solutions by centrifugation and washing.

- Problems that might result in moving from laboratory-scale to production-scale equipment and to larger containers of heat-generating waste forms.

- Longer tests of compatibility between waste forms and container materials under simulated storage conditions.

- Possible improvements in properties of waste forms by changes in formulations.

- Extensive testing of new wiped-film type evaporators for drying the residual decontaminated salt solution after ion exchange removal of cesium, as well as for possible improvements in current evaporator operations.
- Fault tree risk analyses of the various processes.

ALTERNATIVE PLANS

Options that may be feasible for long-range management of high-level liquid wastes are being compared to the continued storage of crystallized salt and insoluble sludge in double-wall tanks. A large number of alternatives are being evaluated that include various combinations of the waste forms and waste locations listed below.

Waste Form	Present (sludge, salt, supernate).
	Fused salt (including sludge).
	High-level intermediate forms (dry sludge, cesium zeolite).
	Inert forms (concrete, glass).
Waste Location	Present (double-wall tanks).
	SRP surface storage facility.
	SRP bedrock.
	Offsite surface storage facility.
	Offsite geologic facility.

Alternatives are being assessed to identify those plans that are most feasible, to compare their relative costs and risks, to determine the additional research and development required, and to identify other major factors that must be considered in the final selection of long-range waste management methods. Preliminary engineering design studies have been undertaken to help confirm the technical feasibility of the plans, to establish probable costs for the various options of processing and storage, and to determine reasonable schedules for implementation.

The option that has been investigated most completely for its applicability to SRP waste features an inert solid form (concrete or glass) for the high-activity fraction of the waste and interim storage in retrievable containers in a surface facility with intent of eventual removal to a federal repository. Development work to date has verified that this option is technically feasible. Preliminary assessments have also shown that implementation would require about 10 years once a decision is made to proceed.

Even with the expected long-term stability of this system, the principal of retrievability is retained so that, if a different mode or location of storage should be more desirable in the future, the waste containers could be moved. In this option, the residual salt, obtained after segregation of the high-activity fraction and containing less than 0.1% of the total activity, is also placed in retrievable containers for storage. Cost estimates for this option will be used as a basis for normalizing the more general comparative costs developed for the full range of alternatives mentioned above.

The concept for this solidification and retrievable storage option involves the following steps: 1) removal of waste from the tanks, 2) separation of the sludge from supernate by physical processes such as centrifugation and filtration, 3) removal of the cesium and some other radioisotopes from the supernate by ion exchange, 4) incorporation of the sludge and the cesium into a high-quality waste form such as concrete or glass, 5) evaporation of the residual supernate solution to a salt cake (containing less than 0.1% of the total activity), 6) interim storage of containers of the high-level waste form in a natural convection air-cooled facility, 7) eventual transport to an ERDA repository such as an underground salt cavern, and 8) storage of containers of the residual salt in a facility needing no special means of heat removal.

As discussed in the preceding sections, research and development to date has included a waste tank sampling program to characterize the waste, preparation and evaluation of promising waste forms in shielded cells using actual waste, evaluation of container materials using simulated waste, demonstration of cesium removal at small and intermediate scales using actual supernate, small-scale tests of centrifugal sludge-supernate separation using actual waste, and engineering and cost studies assuming concrete or glass as the product form for the high-activity fraction.

RETRIEVAL OF SRP HIGH-LEVEL LIQUID WASTES FOR FURTHER PROCESSING

Current practices in the management of SRP high-level liquid waste result in the accumulation of waste in two forms; a crystallized salt containing most of the ^{137}Cs, and an insoluble sludge containing most of the ^{90}Sr plus the much smaller amounts of $^{238,239}Pu$. Many of the methods for long-range management of this waste require that these materials be removed from existing tanks for additional processing. The salt is easily redissolved, but the insoluble sludge requires additional effort because it can become a hard compact layer at the bottom of the storage tanks under the influence of aging, hydrostatic pressure, and the temperatures resulting from heat generation by radioactive decay. Also, sludge removal methods must consider the network of horizontal cooling coils located close to the bottom of most of the waste tanks.

It has been demonstrated at SRP that aged, settled sludge can be removed by breaking it up with high-velocity jets of water and pumping out the resulting slurry with centrifugal pumps. This technique was used in several waste tanks after development in a mockup facility. Therefore, it has been shown that none of the possible options for long-range management are foreclosed by the continuation of current practices.

Greater than 95% of a 1.5-ft layer of aged sludge was removed in the initial demonstration of this technique.[12] The waste tank contained 12 internal support columns and two layers of cooling pipes 2 in. and 5 in. above the bottom of the tank and about 4 ft apart horizontally. Five jet assemblies, supplied by high-pressure pumps mounted above the tank, were installed through risers in the top of the tank to extend nearly to the bottom of the tank. The centrifugal pumps were also installed through four of these risers for removal of the slurry from the bottom of the tank. Periscopic examination of the tank following sludge removal revealed no residual accumulations of sludge. The slurrying operation was not followed by any chemical cleaning, which may be required to remove any sludge remaining in mechanically inaccessible areas of the tank. Later laboratory studies indicate that greater than 90% of the sludge remaining after slurrying can be removed by chemical cleaning.

Although this technique was successful in removing almost all the settled sludge, it added several hundred thousand gallons of water to the total volume of waste to be managed. Therefore, an alternative is being developed in which the sludge is removed by means of low-pressure jets of recirculated supernate. The method consists of:

- Dissolving and transferring the salt using pumps or steam jets.
- Slurrying the accumulated sludge by means of low-pressure jets of the same supernates.
- Immediately transferring the resulting slurry from the tank.

Several recirculating pumps plus a transfer pump would be installed in each sludge tank. In addition, recirculating pumps would be used to keep the slurry in suspension in the mix or hold tank in which the sludge-supernate mixture is prepared for further processing steps.

Following the hydraulic slurrying and removal of most of the sludge from a waste storage tank, chemical cleaning and then rinsing with relatively clean water (such as overheads from waste evaporator operation) would be required to remove residual sludge. In preliminary tests on small samples of actual SRP sludge, about 80% of the residual sludge was dissolved by a single cleaning treatment by a solution containing oxalic acid. The remaining 20% of the sludge still contained most of the residual activity, so additional sluicing and chemical treatment would be required to further clean the tank.

The first demonstration of this technique is proposed for Tank 16 in H Area. As discussed in the text of the environmental statement (page II-105), no more waste is being added to this tank because of its history of leakage. Waste remaining in the tank is in the form of a residual sludge layer about 20 inches thick. Removal of this sludge will not only provide further verification of the applicability of hydraulic techniques, but will demonstrate the possible effects of hydraulic treatment on a cracked tank and will make possible the evaluation of additional techniques for final chemical cleaning and preparation of the tank for decommissioning.

LONG-RANGE MANAGEMENT OF RADIOACTIVE SOLID WASTES STORED IN BURIAL GROUND

Similar considerations to those discussed above apply to the types of waste now stored in the burial ground at SRP, and there is considerable interaction between the two development programs. Options for the long-range management of radioactive solid wastes range from continuing current burial ground practices as described in the text of this environmental statement to recovering the long-lived radioactive fraction for incorporation in an inert matrix such as concrete and shipping the waste offsite for geologic storage.[13] As in the case of the high-level liquid waste, the range of alternatives allows a number of intermediate possibilities. These include various reduced-volume forms resulting from sorting, compaction, incineration, and storage in both onsite and offsite surface and geologic storage locations. These alternatives are being assessed fully with respect to their relative costs and risks for future decision-making with regard to long-range waste management.

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