THE HANFORD WASTE MANAGEMENT PLAN

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ABSTRACT

The Department of Energy and Rockwell Hanford Operations developed the Hanford Waste Management Plan to identify preliminary long range plans for the disposal of radioactive waste currently being stored and to be generated in the future at the Hanford Site near Richland, Washington. The plan also discusses low-level pre-1970 transuranic contaminated solid waste and soil sites that has already been disposed of at Hanford, but which is being evaluated for possible remedial actions to assure maximum long-term safety. The Hanford Waste Management Plan and a companion document, the Hanford Waste Management Technology Plan are used as the basis for all ongoing efforts associated with the final disposal of radioactive waste at Hanford.

INTRODUCTION

The Hanford Site currently has in storage a large percentage of the total volume of radioactive defense waste in the United States. Facilities presently operating and those planned in the future continue to produce high-level, low-level, and transuranic (TRU) waste that will require final disposal. The waste types and compositions vary widely because of the many diverse processes operated at Hanford since the early 1940's. This diversity results in an extensive interim management program and complex final disposal operation. The Defense Waste Management Plan (DWMP)[1] describes the national policy set forth for disposal of defense waste. The Hanford Waste Management Plan (HWMP)[2] expands on the Hanford portion of the DWMP and provides a proposed reference plan for the safe management and final disposal of existing and future wastes. Progress towards resolution of disposal actions is necessary to demonstrate responsible management of the production and waste management missions at the Hanford Site, to end perpetual storage of wastes at Hanford, and to take advantage of lower total disposal program costs offered by early action.

The HWMP also describes efforts underway to develop plans for possible additional action that may be required to further stabilize pre-1970 TRU contaminated solid waste burial sites and soil sites. These sites have already been disposed of, however, evaluations are being conducted to identify the need for remedial stabilization actions to assure maximum long term safety of these sites.

Waste at Hanford is divided into six categories to identify the optimum disposal method for each, including single-shell tank waste, double-shell tank waste, contaminated soil sites, stored and new solid TRU waste, solid waste burial sites, and encapsulated byproducts, ^{137}Cs and ^{90}Sr. Highest priority is given to disposal of double shell tank waste to minimize the need for new tank construction and dispose of future wastes as quickly after their production as practical. Stored and new TRU wastes are next in priority. Established national policy has already identified the Waste Isolation Pilot Plant (WIPP) for the potential disposal of TRU waste. Hanford disposal plans are being formulated to fit within the scope of the national policy. Single-shell tank wastes, contaminated soil sites, solid waste burial sites, and byproduct capsules are currently monitored and are considered to be stable and safe for several decades or longer.

Disposal Options

Three basic options are available for disposal of each waste type. In the geologic disposal option, the bulk of the waste will be retrieved, processed, and the most significant radionuclides immobilized and shipped to a federal deep geologic repository for final disposal. The in-place stabilization and disposal option provides for the isolation of wastes in place and the emplacement of appropriate protective barriers and markers. The continued storage (no action) option has the existing program of interim storage and active institutional control continuing indefinitely. These alternatives are being examined in conjunction with the ongoing preparation of the Hanford Defense Waste Environmental Impact Statement (HDW-EIS). The reference plan described below and in the DWMP serves as a reasonable planning base for the HWMP. Its implementation, however, is conditional on completion of the National Environmental Policy Act (NEPA) process. The reference plan represents a reasonable engineering approach and is a basis to provide a comparative analysis in the HDW-EIS.

Development Strategy

A variety of alternatives exist for the final disposal of Hanford waste. Studies were conducted to identify all available alternatives and provide engineering judgment to identify potentially sound options. Technologies for all alternatives will continue to be investigated until final decisions are made as a result of the NEPA process.

The essential first step in the resolution of the waste disposal challenge is the development of a plan identifying action necessary to effect final disposal. Concurrent with the preparation of the HDW-EIS, specific disposal options and the process steps necessary to implement those options have been identified. Criteria for selection of disposal options have been established and a reference disposal method chosen for each waste type that meets those criteria. Cost estimates and projected schedules have been prepared to assure integration with other national plans.

Criteria for Selection

Each potential disposal method and process has been evaluated based on the criteria listed below. As a result, the objective of the reference Hanford Waste Management Plan is to:

- provide for safe waste management and disposal,
- keep all disposal alternatives open until the HDW-EIS record of decision is reached,
- comply with emerging regulations and criteria,
- minimize waste processing and handling,
- achieve final disposal at the earliest practical date,
- levelize overall defense waste management budget, and
- minimize life cycle cost.

REFERENCE ALTERNATIVE

The reference Hanford Waste Management Plan is based on the ALARA concept, balancing concern for environmental impacts with monetary costs. Some wastes are disposed of in a geologic repository, the balance are disposed in-place or are processed to grout and placed in sub-surface disposal facilities. Existing single-shell tanks are disposed of in-place through stabilization techniques which include dome fill for subsidence control and emplacement of protective barriers and markers. Existing and future double-shell tank wastes are processed to separate the high-level and TRU waste fractions from the bulk of the waste. The high level (HLW) and TRU fraction is immobilized as glass and shipped to a federal repository for disposal. The low level waste (LLW) from double-shell tanks and the low level liquid waste resulting from processing and pretreatment activities is immobilized as grout and disposed of onsite in sub-surface trenches or existing tanks. Encapsulated waste is overpacked for deep geologic disposal and retrievably stored TRU waste is sent to WIPP for disposal. Low-level TRU contaminated solid wastes and soil sites already disposed of are further stabilized and isolated by emplacement of protective barriers.

To develop the reference plan, previous studies and evaluations were reviewed and conclusions compared to determine overall feasibility of each alternative for each waste type. National policy and emerging criteria were also examined to assure that elements of the reference plan would meet requirements established by appropriate regulatory agencies. To make a well balanced comparison, disposal processes were selected for each waste type and alternative which represented a reasonable basis for estimating environmental releases and disposal costs. The process steps selected are being evaluated to assure that their selection remains a reasonable one, particularly if the choice of that process step could conceivably bias the selection of an alternative. Each process step for the reference alternative is being further examined to determine what technology development must occur prior to the implementation of that process. Open technology issues are described and tracked in the Hanford Waste Management Technology Plan (HWMTP)[3]. A discussion of the reference plan for each waste type follows.

Double Shell Tank Waste

Double-shell tanks are used to store newly generated liquid wastes at the Hanford Site. The reference plan is to retrieve and process these wastes to immobile forms which are suitable for disposal and incorporates geologic disposal of high-level waste as glass. Low-level waste is disposed of as grout in sub-surface facilities. Existing facilities such as B Plant are to be used for pretreating waste prior to immobilization in new facilities, such as the Transportable Grout Facility (TGF) and the Hanford Waste Vitrification Plant (HWVP). These two facilities are discussed in later papers in this session[4,5].

Some of the wastes require pretreatment prior to immobilization as grout or glass. The processing techniques planned for the disposal of double-shell tank wastes are shown in Fig. 1. Cost/benefit studies show that there is a strong economic incentive to separate the high-level and TRU fractions from the remainder of the waste to minimize the volume of waste to be shipped to a geologic repository. Most of the pretreatment prior to immobilization is intended to concentrate the high-level and TRU wastes and make the smallest amount of glass practical. This not only reduces the amount of waste to be shipped to a repository, but also reduces the size of the immobilization facility required. The bulk of the double-shell tank waste can then be disposed of safely in the less costly sub-surface grout trenches.

Cladding Removal Waste (CRW) results from chemical dissolution of the Zircalloy cladding of N Reactor fuel in the PUREX Plant at Hanford. If CRW remained untreated, the entire volume of the neutralized sludge would have a high enough TRU concentration that it would require immobilization and disposal in a geologic repository. Studies have shown that costs incurred to vitrify the large volume of CRW sludge and dispose of it in a repository would approach $1 billion for that stream alone. Lanthanum nitrate pretreatment of the unneutralized stream has been shown to cause precipitation of the TRU fraction from the bulk of the waste, allowing separate disposal of the TRU fraction as glass in a geologic repository. It is anticipated that approximately 13 million gallons (4.9×10^4 M^3) of CRW sludge and supernate will be produced from PUREX operations through 1996.

Neutralized Current Acid Waste (NCAW) is a high level waste resulting from the reprocessing of spent fuel at PUREX. The NCAW sludge that forms after addition of NaOH contains the bulk of the high-level fission products and also a considerable amount of TRU isotopes. In the reference plan, the nearly three million (1.1×10^4 M^3) gallons of NCAW produced before 1996 will be transferred to B Plant where the sludge will be separated from the supernate and washed to remove the soluble low-level components. The ^{137}Cs will be removed from the supernate via ion exchange and blended with the washed sludge. If required for byproduct application, ^{137}Cs solids will be separated

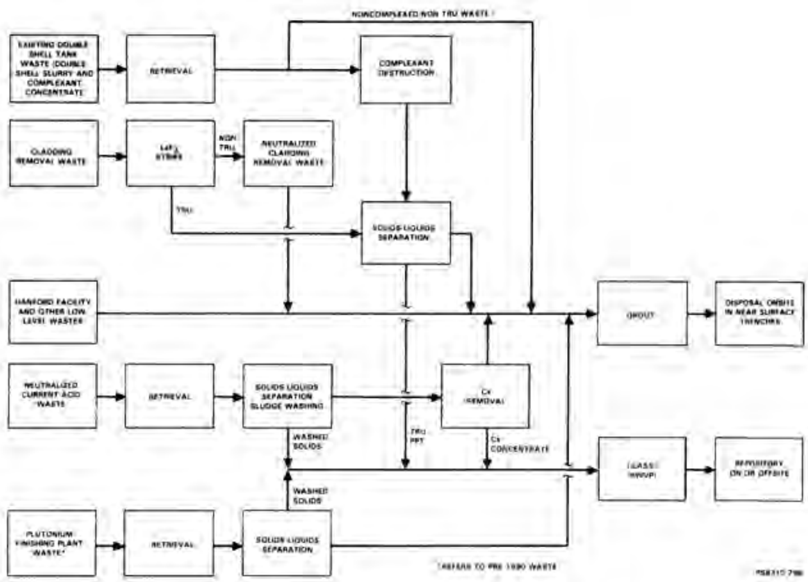

Fig. 1 Double-Shell Tank Waste Management Disposal Processing Logic.

purified, and encapsulated rather than blended with the sludge. The high-level/TRU fraction will be transferred to double shell tanks for storage until the HWVP is available.

Liquid waste from Plutonium Finishing Plant (PFP) operation is considered a TRU stream, with the majority of the high-level and TRU isotopes in the sludge portion. In the reference plan, the sludge will be centrifuged and washed to separate the low-level fraction for disposal as grout. The high-level/TRU fraction will be blended with other high-level wastes that have previously been separated for feed to the HWVP. Approximately one million gallons of PFP sludge (3.8×10^3 M^3) will be produced through 1990.

Existing double-shell tank waste consists of those wastes in double-shell tanks prior to FY 1984 and those to be added as a result of salt-well pumping of single shell tanks. Double-shell slurry (DSS) is a semi-solid material rich in sodium hydroxide that results from the final concentration of interstitial liquid from salt-well pumping and other dilute wastes. Complexant Concentrate (CC) is a liquid waste containing organic complexants resulting from the processing of pre-1972 PUREX NCAW to remove cesium and strontium. Because of the presence of the complexants, CC may contain significant quantities of TRU isotopes. Under the current reference plan, CC will be retrieved and pretreated in B Plant to destroy the complexants and separate the TRU portion for immobilization as glass. Double-shell slurry will also be retrieved and may be pretreated to separate any high-level or TRU fraction, although it appears that such pretreatment may not be necessary and the DSS can be disposed of directly as grout. There is currently about 7 million gallons (2.6×10^4 M^3) of CC and DSS stored in double-shell tanks with another 3-5 million gallons (1.1×10^4 - 1.9×10^4 M^3) produced through 1996.

Hanford Facility Wastes (HFW) are low-level liquid wastes received from facilities at the Hanford Site, including N Reactor. Most of the HFW is dilute sodium phosphate and sodium sulfate wastes, which will be processed directly to grout for disposal in subsurface trenches. Approximately 8 million gallons (3.0×10^4 M^3) of HFW will be produced after 1983.

Technical Issues: Several technical issues must be resolved prior to implementation of the reference disposal plan for double shell tank waste including:

- determination of TRU content and removal process for PUREX Cladding Removal Waste,
- characterization of the waste to provide chemical and radionuclide inventories,
- optimization of retrieval technology for implementation,
- optimization of waste pretreatment technology for specific application to implementation of waste feed pretreatment, and
- optimization of technology required for implementation of immobilization processes and waste forms.

The reference alternative was developed during the evaluation of over 300 other combinations of processing and disposal methods. Some of the criteria used during this evaluation included safety, compatibility with existing facilities, technical risk involved, final waste volume produced, and cost.

Single Shell Tank Waste

Single shell tanks were originally constructed for the storage of radioactive liquid wastes generated as a result of plutonium production and separation operations at Hanford. There are now 149 single shell tanks which have all been removed from active service. Waste concentration, supernate removal, and salt-well pumping operations have resulted in the removal of a large portion of the liquid from the single-shell tanks. Approximately 37 million gallons (1.4×10^5 M^3)

of wet solids remain, consisting primarily of salt cake, sludge, supernate, and interstitial liquid. The salt cake is mostly crystallized nitrate salts, while the sludge is mainly insoluble metal hydroxides that have precipitated from neutralized high level waste and cladding removal solutions. Interstitial liquid is trapped in the void spaces of the salt cake and supernate remains on top of the solid layers. About six million gallons (2.3×10^4 M^3) of pumpable liquid remains in single shell tanks and is being removed by the salt well pumping program and concentrated into double shell slurry.

In the reference plan, single-shell tank wastes are stabilized in-place by removing pumpable liquid from the tanks, drying or otherwise treating the waste if necessary, isolating piping risers, and other equipment from the outside environment, filling the tanks with loose gravel, and finally covering with a protective barrier and placing markers over the site. A demonstration of the application of protective barriers for in-place stabilization and disposal is planned. This demonstration is described in detail in Ref. 6.

Performance assessments and ongoing studies will continue to clarify the risks and benefits of the reference plan. Based on current information, it appears that it is safer and more cost effective to dispose of single shell tanks by in-place stabilization and disposal than by any other method. Several conclusions appear to be evident from studies being done in support of the HDW-EIS that fully support the reference plan, including:

- Routine and accidental radiological and nonradiological emissions are lower for the in-place stabilization and disposal method than for the geologic disposal option.
- Short and long term health effects are expected to be lower for in-place stabilization than for continued storage.
- Permanently committed resources are lower for the stabilization option than for geologic disposal.

Technical Issues: The following significant issues must be optimized prior to implementation of in-place stabilization and disposal of single-shell tanks, should the reference plan be selected:

- waste characterization of individual tanks and tank farms,
- evaluation of effects of organic complexants on radionuclide mobility and overall tank stability,
- studies of methods of dome fill and fill materials that will minimize unfilled void space to preclude subsidence, and
- optimization of protective barriers and markers to minimize potential for plant, animal, and inadvertent human intrusion.

The reference alternative for single-shell tank waste is considered to be the optimum method of safe disposal for this waste. Based on future performance assessment, however, a finding may ultimately be made that recommends recovery and processing of waste from one or more of the single-shell tanks. At this time the reference HWMP for single shell tanks serves as the planning basis for cost, schedule, and capital facility estimates.

Encapsulated Wastes

High level waste stored in single shell tanks at Hanford was processed through B Plant for separation of cesium and strontium fission products. The resulting solutions were converted to solid cesium chloride and strontium fluoride salts in the Waste Encapsulation and Storage Facility (WESF), encapsulated in double wall capsules, and stored in water basins. A total of 1579 cesium capsules and 600 strontium capsules were produced. At present, it appears that much of the cesium will be used by the byproducts utilization program as irradiation sources. At the end of their useful life, the capsules will be returned to Hanford and overpacked into a canister. Approximately four or five capsules are placed in each canister, based on allowable heat loading and capsule wall temperature limits. The canisters will then be shipped to a geologic repository.

Technical Issues: Several technology issues are still open, including:

- Tests are currently underway to define rates of corrosion at the inner wall of the cesium capsules. The tests are representative of worst case repository conditions. Analysis of the history of capsules with extended pool storage and those with a history of beneficial utilization is proceeding.
- Several issues remain relating to geologic disposal of capsules including heat load limitations imposed by rock formations, potential alternative disposal concepts, determination of the adequacy of the metal containers until the waste radioactivity decays to harmless levels, or conversion of the cesium to an immobilized waste form, such as borosilicate glass.

Current plans are to modify the WESF and install a capsule packaging facility to overpack the canisters prior to shipment to the geologic repository.

Contaminated Soil Sites

Disposal of low-level liquid radioactive wastes has routinely been accomplished by discharge to the soil below ground. This method of disposal takes advantage of both the favorable sorptive qualities of the soil and the relatively great depth to groundwater at Hanford. There are currently 340 contaminated soil sites at Hanford containing about 4×10^6 M^3 of soil. There are 25 TRU contaminated soil sites containing about 3.2×10^4 M^3 of soil resulting from past operations. Although these sites are already disposed of, the reference plan for contaminated soil sites results from an evaluation of potential actions to further stabilize these sites. Action planned if the reference alternative is selected includes characterization of soil sites, application of subsidence control, TRU immobilization if needed, and emplacement of protective barriers and markers.

The reference plan was developed because studies indicated that routine radiological and nonradiological releases were significantly lower for the stabilization alternative than for the geologic disposal altenative. Safety and environmental hazards are expected to be lower for the reference plan than if no action were taken. Total costs of in-place stabilization are estimated to be lower than for either of the other alternatives.

Technical Issues: Open technical issues associated with additional stabilization of contaminated soil sites are described in this section.

- optimization of subsidence control methods to prevent disruption of barrier and marker systems,
- development of techniques (e.g. in-situ vitrification) for immobilization of TRU areas within the soil sites should additional stabilization be found desirable, and
- optimization of protective barriers and markers similar to those described for single shell tanks.

Some of the LLW soil sites are still in use and will likely continue as long as processing facilities stay in operation. Interim stabilization is ongoing to prepare sites for remedial actions that may be taken.

Solid Waste Burial Sites

Radioactive solid wastes generated as a result of plutonium production and separation operations are disposed of by burial at Hanford. These wastes consist of TRU contaminated low-level solid wastes buried prior to 1970 and non-TRU solid wastes buried after 1970. There are currently 64 solid waste burial sites at Hanford containing approximately $5.2 \times 10^5 M^3$ of solid waste. Eleven of these sites are pre-1970 TRU solid waste burial sites and contain approximately $1.2 \times 10^5 M^3$ of waste.

Some remedial stabilization actions are recommended for these previously disposed sites. The reference plan requires the following actions: characterization, application of subsidence control to caisson voids and other susceptible areas, and placement of protective barriers and markers.

It is expected that a risk analysis being prepared in support of the HDW-EIS will indicate that additional stabilization is necessary to reduce long term risks. This option was developed because lower overall releases are expected if in-place stabilization actions are taken than if either of the other two alternatives (geologic disposal or no action) are selected.

Technical Issues: Technical issues remaining requiring closure prior to implementation of the reference plan are similar to those described for contaminated soil sites.

Stored and New TRU Solid Waste

Solid TRU waste generated after 1970 is segregated from other solid wastes and placed in 20 year retrievable storage in drums or burial boxes. There are currently approximately $1.3 \times 10^4 M^3$ of contact handled (CH) TRU waste and 37 M^3 of remote handled (RH) waste stored at Hanford.

The reference plan for retrievably stored and new TRU solid waste complies with national plans for shipment to WIPP (beginning in 1989). Stored CH-TRU waste containers are planned to be retrieved and shipped to the Waste Receiving and Processing (WRAP) facility for shredding and grout immobilization as needed and subsequent packaging in WIPP certifiable containers. Transuranic waste generated after 1984 is to be packaged at the point of origin in WIPP certifiable form, if possible, for direct shipment WIPP when it opens. Waste not certifiable without processing will be transferred to WRAP.

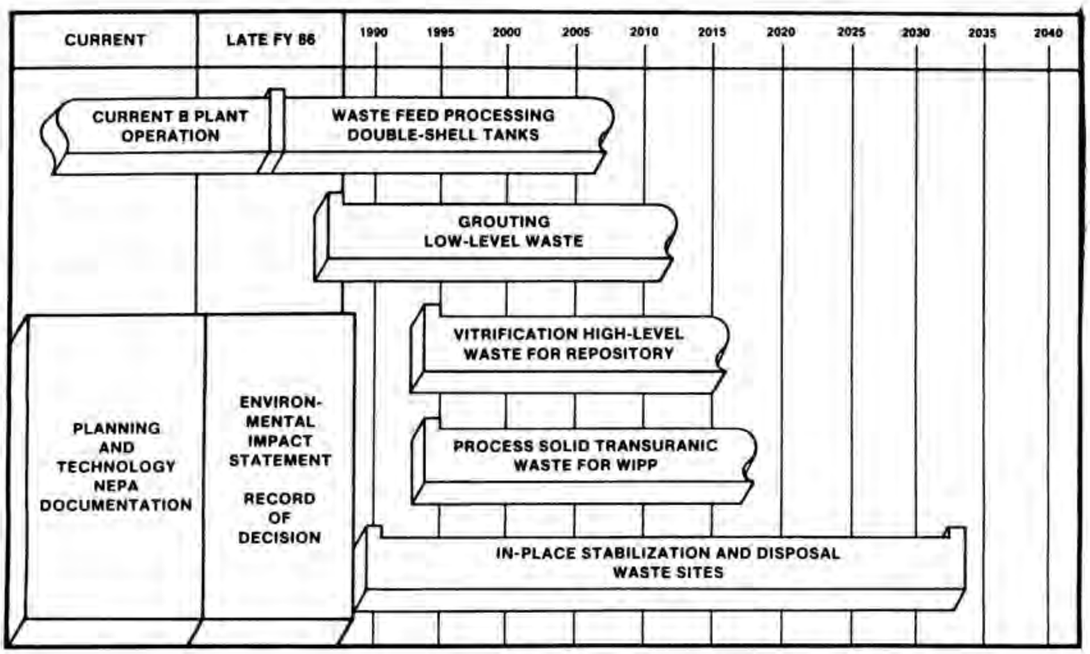

Fig. 2. Hanford Defense Waste Management Program Summary Schedule, Should the Reference Plan Be Selected.

Technical Issues: A number of technical issues remain to be resolved prior to implementation of the reference plan for TRU solid waste, including:

- Technology and equipment for routine non-destructive assay and examination of TRU waste drums has been developed by Los Alamos National Laboratory and is being transferred and adapted to meet Hanford requirements.

- The contact-handled WRAP facility is currently in the preconceptual design phase. Development activities are ongoing for equipment, including NDA, NDE, shredding and immobilization units, and facilities for processing non-shreddable wastes.

- Methods for retrieving and handling subsurface remote-handled caisson waste and processes for treating the waste in a remote handled processing facility are being investigated.

A Transuranic Storage and Assay Facility (TRUSAF) is being constructed in an existing facility at Hanford in the interim period before the CH-WRAP facility is available to provide non-destructive assay and examination capabilities for newly generated TRU solid waste.

COST AND SCHEDULE SUMMARY

The Hanford Waste Management Plan represents an aggressive effort to implement safe, cost effective disposal techniques for all radioactive waste generated and/or stored at the Hanford Site. Figure 2 shows a summary schedule of waste management disposal operations at Hanford. Initial pretreatment of double shell tank waste will begin in FY 1986 and will continue through 2007. The HWVP is scheduled to start operation in FY 1994 and will be complete by 2008. Canister shipments to a federal repository will begin in 1998. Stabilization operations for single shell tanks are currently underway. A demonstration of the disposal technique is scheduled to begin in 1987 with final disposal beginning in 1991. Single shell tank disposal operation is expected to be complete by 2030.

The capsule packaging facility at WESF will operate from 1996-2003, with repository shipments expected to occur starting in 2001. Interim stabilization operations for contaminated soil sites are underway and are expected to be complete by 1988. Final disposal operations are planned to start in 1991 and be complete in 2010. A demonstration of the final disposal techniques is scheduled to occur for solid waste burial sites starting in 1987, with actual final disposal operations scheduled for 1992-2010. The TRUSAF facility for TRU solid waste will be operational in 1985 and will be replaced by the CH-WRAP facility in 1994. A remote handled TRU waste processing facility is planned for operation in 1995-1999. Contact-handled TRU waste containers are expected to be shipped to WIPP through about 2015.

Figure 3 graphically depicts the costs of final disposal for all Hanford Site defense waste. Costs shown include waste storage and surveillance, technology development, capital expenditures, and disposal operations and total an estimated $4.5 billion (FY1986 dollars) through the year 2030.

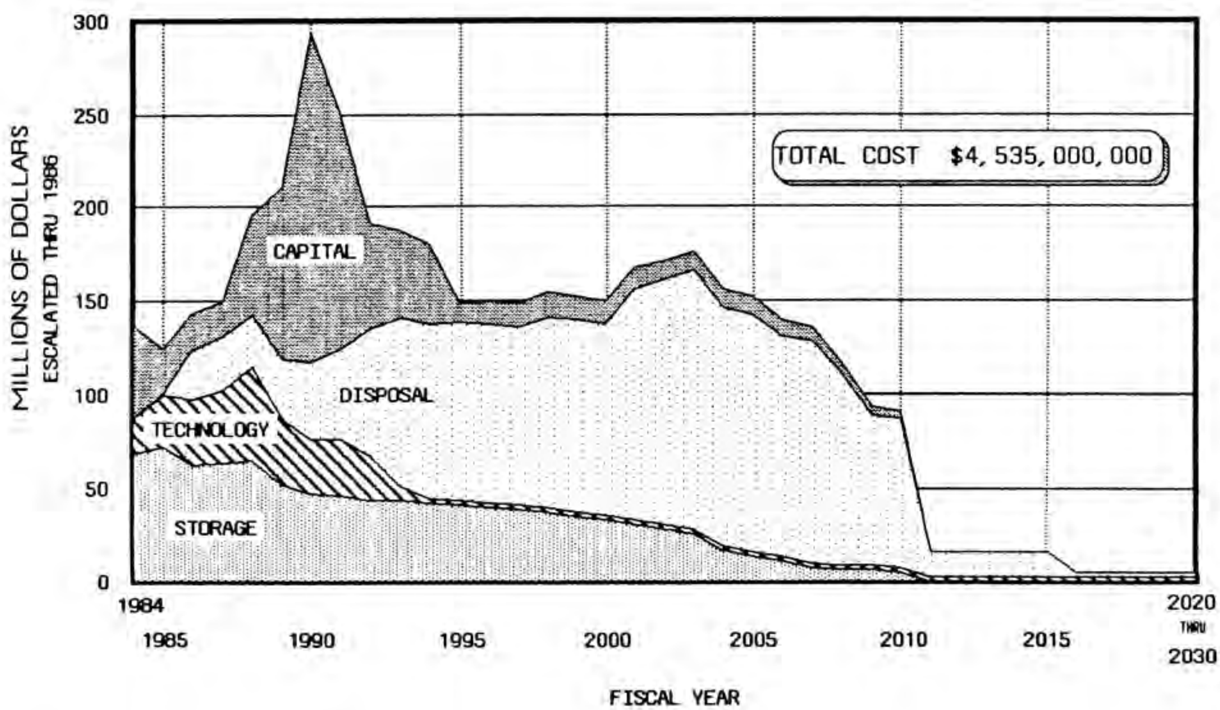

Fig. 3. Costs For The Total Hanford Waste Management Plan, Should The Reference Plan Be Selected

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