WASTE REDUCTION AT THE SAVANNAH RIVER SITE (U)

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ABSTRACT

The Savannah River Site (SRS) is a key installation for the production and research of nuclear materials for national defense and peace time applications and has been operating a full nuclear fuel cycle since the early 1950s. Wastes generated include high level radioactive, transuranic, low level radioactive, hazardous, mixed, sanitary, and aqueous wastes. Much progress has been made during the last several years to reduce these wastes including management systems, characterization, and technology programs.

INTRODUCTION

The Savannah River Site is a key U. S. Department of Energy installation for nuclear production and research. Covering some 197,000 acres, the site is spread over parts of three South Carolina counties. The primary mission of the Site is to produce plutonium-239, tritium, and other special nuclear materials for use in the Nation's defense effort. Fuel and target elements are produced and then irradiated in one of three reactors before being processed for extraction of the plutonium and tritium. Uranium is recycled. The remaining solutions containing fission products and contaminated chemical wastes are sent to waste storage. Wastes generated on site include high level radioactive, transuranic, low level radioactive, hazardous, mixed, sanitary, aqueous and atmospheric emission wastes. The reduction of wastes generated and the proper handling of the wastes have always been a part of the Site's operation. This paper summarizes the current status and future plans with respect to waste reduction and reviews some specific examples of successful activities.

Existing Waste Generation, Treatment, and Disposal

A simplified summary of current waste treatment and disposal facilities is shown in Fig. 1. The quantities shown of each type of waste generated vary greatly depending on the mode of operation within each facility. The waste quantities shown in this figure were generated during FY90.

High Level Radioactive Liquid Wastes are stored in subsurface carbon steel waste tanks enclosed in concrete vaults. The majority of waste tanks are 4900 cubic meter double-wall steel tanks. In the storage tanks, the insoluble components of the waste (about 5%) settle to form a layer of sludge on the tank bottom. The radioactivity of fresh waste is reduced by about 70% in approximately two years of storage due to the decay of short-lived radionuclides. The liquid, non-sludge, layer is removed and evaporated. Through evaporation, the total liquid volume is reduced by approximately two-thirds to form a moist salt cake.

Low level wastewater is treated in an Effluent Treatment Facility. Through filtration, reverse osmosis, and ion exchange, polished water is discharged to an NPDES outfall. Contaminants are sent to the Z-Area Saltstone Facility, mixed with slag, flyash, and cement, and solidified in concrete vaults.

Low-level solid wastes are generated sitewide and are also being accepted from some offsite generators. Low-activity beta-gamma and low-activity alpha wastes packaged in carbon steel boxes (B-25 boxes) are currently being disposed in engineered low-level trenches (ELLT). A compaction program to reduce the volume of low-level radioactive waste began in FY88. There are two compactors in operation with volume reductions of approximately 8:1. The Landfill Monitoring Facility monitors non-contaminated waste from regulated areas to verify that it can be sent to the sanitary landfill as clean waste, rather than the Solid Waste Disposal Facility. An improved disposal technique, Greater Confinement Disposal (GCD), is being utilized for intermediate-level waste disposal. The GCD is constructed of reinforced concrete and provides a near zero release facility that will provide improved containment of radionuclides and require minimum maintenance after closure.

All transuranic waste is packaged and stored above ground on concrete pads so that it is readily retrievable for future treatment and disposal.

Nonradioactive hazardous waste is stored in Resource Conservation and Recovery Act (RCRA) permitted hazardous waste storage buildings and pads. Some of this hazardous waste is sent off site for incineration. Nonhazardous waste oil is burned for energy recovery at an SRS powerhouse.

Most of the mixed waste generated at the SRS is being stored in one of two South Carolina Department of Health and Environmental Control (SCDHEC) permitted mixed waste storage buildings until a treatment facility becomes operational.

The non-radioactive, non-hazardous wastes are shallow buried in the SRS Landfill. The Landfill is a 280,000 square meter fenced, controlled access waste site. The waste trenches are 3.6 to 5.4 meters deep and 6 meters wide with a sloped vehicle approach to the bottom. The Salvage operation recovers usable material for sale or use by other Federal or State agencies. An aluminum can recycle program has begun and paper and cardboard recycle is being developed.

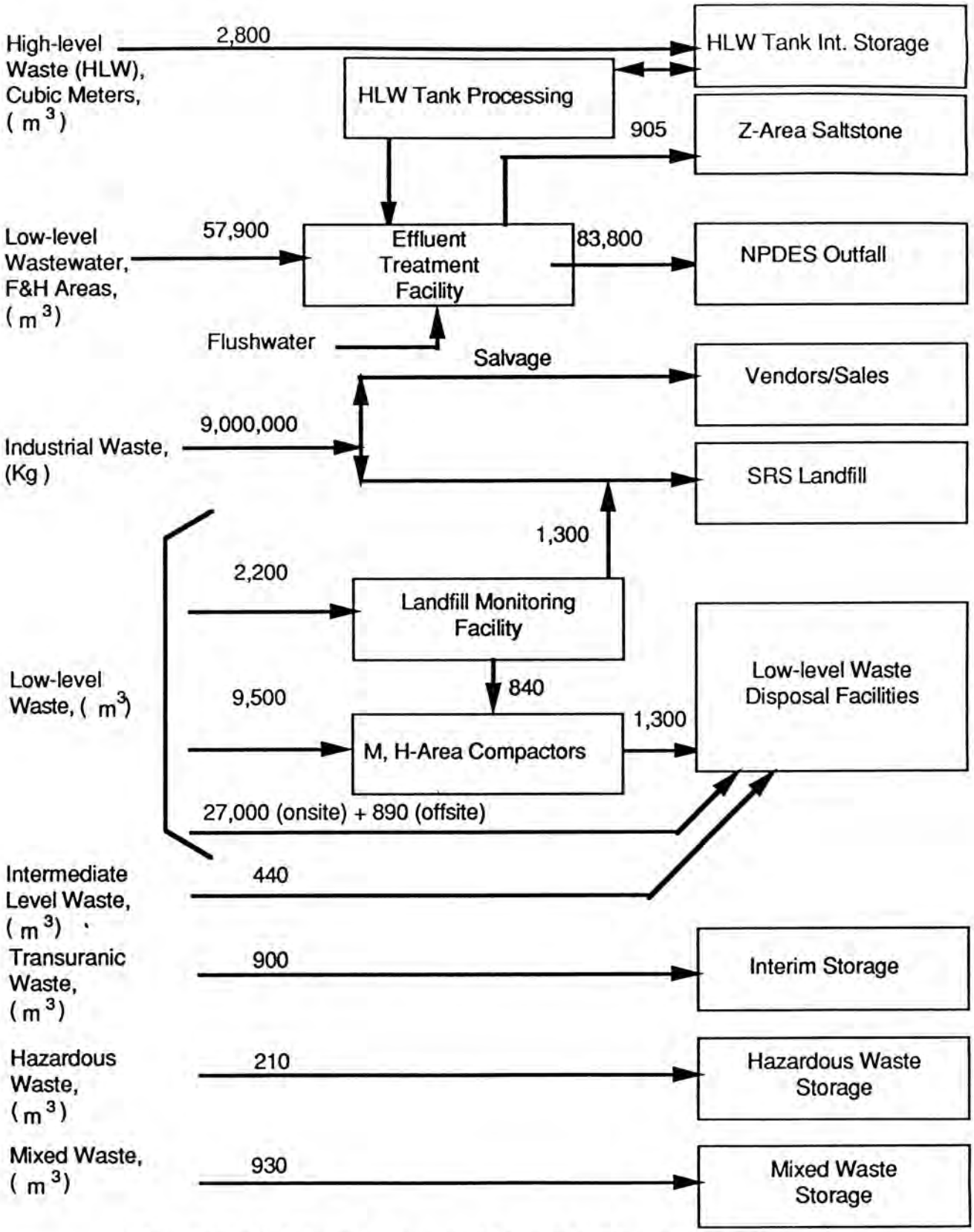

Fig. 1. Existing Solid Waste Treatment and Disposal Facilities, FY90 Waste Generation.

FUTURE WASTE TREATMENT AND DISPOSAL

Figure 2 shows the major changes that are being implemented for waste treatment and disposal. Major changes include the following.

High Level Radioactive Waste will be incorporated in a borosilicate glass matrix for permanent storage in a Federal Repository. The Defense Waste Processing Facility is scheduled to begin operation in 1993.

The Consolidated Incineration Facility is a $71M facility scheduled for completion in late 1993. This facility will incinerate combustible solid and liquid low level radioactive, hazardous, and mixed wastes.

The Hazardous Waste/Mixed Waste Treatment and Disposal Facilities provides a RCRA permitted facility for the disposal of hazardous and mixed waste. The disposal vaults will be above grade, zero release, concrete structures, with a double liner and leachate detection and collection system. These represent a $19.5M investment and are scheduled to be available for use in 1994. The treatment facility is currently being reviewed carefully and another $18M is expected to be added to the cost of these facilities.

The Waste Preparation Facility provides a centralized facility to volume reduce and stabilize low-level and intermediate-level radioactive waste prior to disposal in new below grade concrete vaults. The first concrete vault will be complete in late 1991 at a cost of $17M. The Waste Preparation Facility remains to be reviewed carefully and is currently a FY95 Line Item project.

The Transuranic Waste Facility is a $73M authorized project to process the TRU waste so that it will meet the acceptance criteria for the Waste Isolation Pilot Plant. This is being delayed because of uncertainty over the final waste-form criteria.

The Y-Area facility will be a $34M RCRA treatment and disposal facility that will solidify large volumes of mixed liquid wastes in vaults with double liners and leachate collection systems.

These new facilities and other modifications currently forecasted for the SRS to handle the wastes are expected to cost over $1.4 billion. Handling waste is very expensive and currently consumes over 25% of the Site's operating budget. The best solution to the problem is to avoid creating the problem in the first place. This is the objective of the SRS waste reduction program.

WASTE REDUCTION MANAGEMENT

SRS developed a sitewide integrated waste reduction plan which was provided to the Department of Energy at Savannah River (DOE/SR) on December 29, 1989 and revised on May 8, 1990. It is currently being revised again. Requirements of the program were provided to DOE-SR by DOE-Headquarters and by Federal and State Regulations. While many concurrent waste reduction activities have been and continue to be implemented at SRS, this plan fosters an increased focus on the reduction of all types of waste. The program strategy includes the following:

- Identification and characterization of all solid waste generated by SRS operations,
- Incorporation of waste reduction philosophy and principles into the day-to-day activities of operating and managing the site facilities,
- Selection and implementation of waste reduction projects for priority waste streams,
- Evaluation and reporting of program results.

The SRS waste reduction program is designed to meet all Federal and State environmental requirements including the Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments (HSWA), the Emergency Planning and Community Right-To-Know Act, South Carolina Department of Health and Environmental Control regulations, and DOE Orders. The specific DOE orders and guidance for this waste reduction are the DOE Waste Reduction Policy Statement dated June 27, 1990 issued by EH and EM, DOE Orders 5400.1, 5400.3 and 5820.2A, Implementation Guidance for DOE Order 5400.1 issued March 1990, and Implementation Guidance for DOE Order 5820.2A dated October 1988.

The Site has established an organizational structure to effectively support and implement the waste reduction programs as shown on Fig. 3. Westinghouse has appointed a member of senior management as the sponsor of the program to make certain that waste reduction receives proper management attention. A full time manager and staff have been assigned responsibility for coordinating the development, promotion, implementation and reporting of the Waste Minimization Program and activities. A central Waste Action Team (WAT) with representatives from the major operations, service, and staff groups has been established to develop strategy and coordinate the waste minimization program activities. Each of the major facilities has assigned one or more waste coordinators to lead the implementation of waste reduction activities in their specific areas.

The Waste Action Team has been very proactive in identifying waste reduction opportunities and establishing task teams for implementation. Some of the recent activities include the following:

- recycling of aluminum cans and paper
- procurement review of materials
- soil treatment

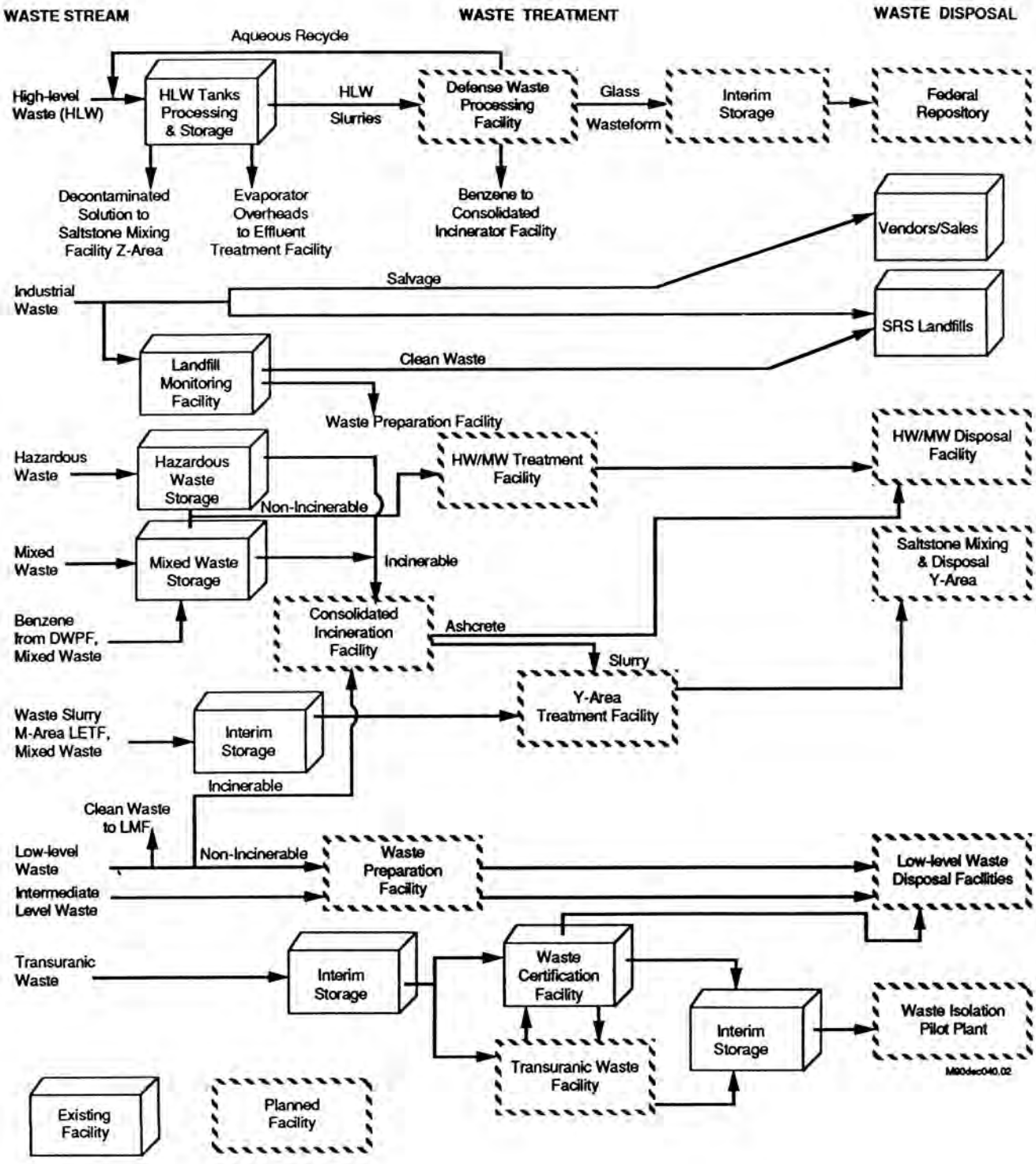

Fig. 2. Planned Waste Treatment and Disposal Facilities.

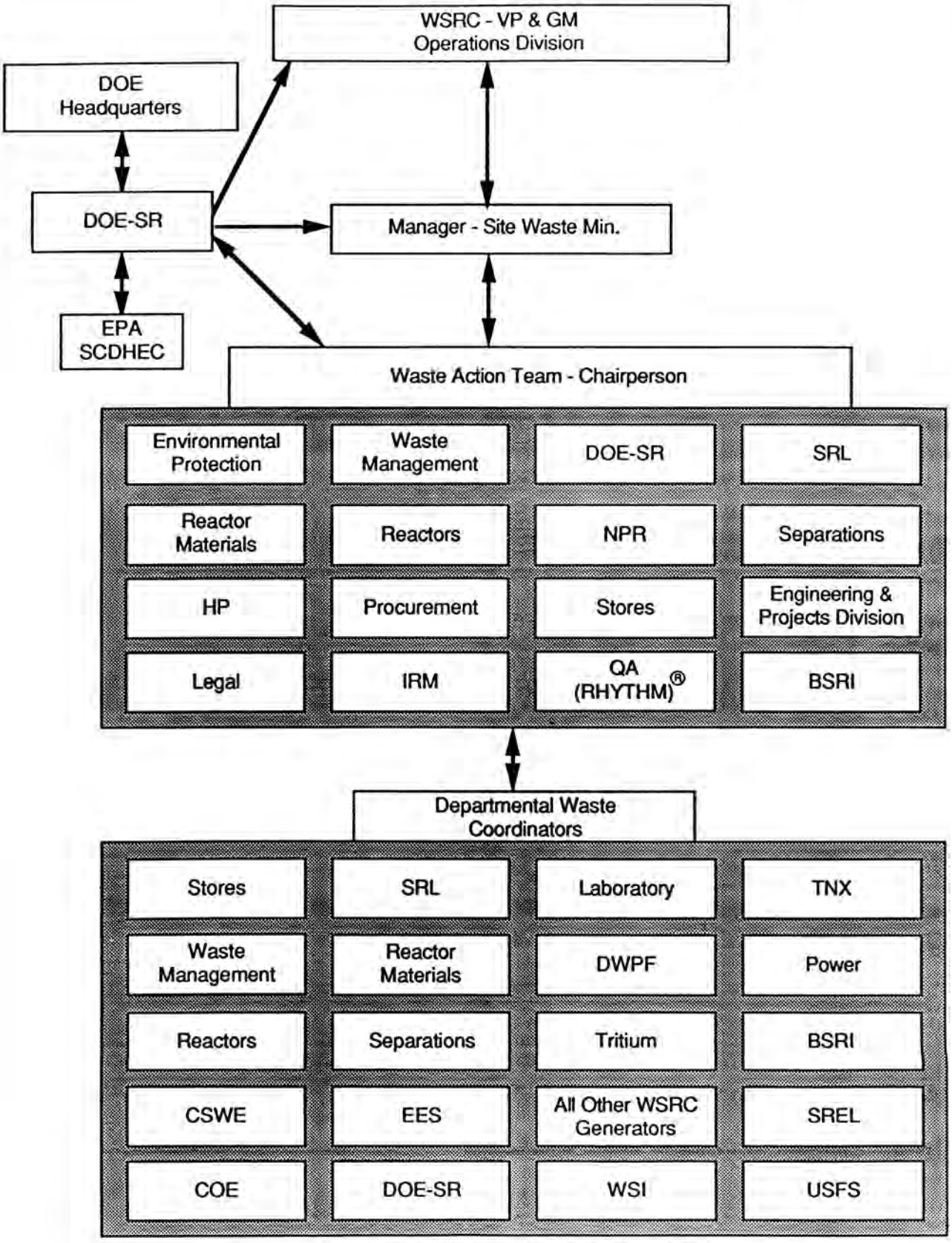

Fig. 3. Waste Reduction Program-Organization.

- Quality Improvement Suggestion System (QISS) review for waste reduction
- battery waste management
- waste reduction media campaign
- waste reduction in SRS newspaper
- railroad tie disposal
- waste generation baseline

Other management programs in place or in progress to promote waste minimization include the following:

- waste minimization policy
- site and area waste minimization plans with milestones
- baseline and goals for each area and eventually each wastestream
- incentive program
- measurements and indicators
- audit program
- procedure modifications
- employee awareness program
- process waste assessments

Characterization

A very important aspect of waste reduction is the ability to measure/track its progress. For DOE weapons type facilities, often, a majority of the on site activity is nonroutine, such as R&D, construction, maintenance, and decontamination and decommissioning. One of the significant challenges for these types of activities, not to mention routine activities, is to develop a means of measuring waste reduction progress.

The SRS Waste Characterization Program Plan consists of three phases; Phase I is Preliminary Data Collection and Compilation, Phase II is a Solid Waste Data Maintenance Plan, and Phase III is a Data Maintenance Program for other Treatment, Storage, and Disposal Facilities and Waste Streams.

Phase I of the Program involved the collection/compilation of 'currently existing' solid (RCRA) and radioactive waste stream data in a consistent format. This work required more than 3 man years of effort during July and August, 1990.

Several interesting things resulted from the Phase I data collection. First of all, a new level of awareness and concern about wastes was generated as a result of this exercise. Secondly, although currently existing information was collected, it was apparent that a certain amount of new information was generated as a result of this effort. Finally, the collection of this information centralized data, eased access to each waste stream 'owner,' was a source of waste stream (activity/process) information, provided the destination of waste streams, documented regulatory status and quantity, served as a baseline for a tracking system and waste reduction program, and helped avoid violations. The data also showed that of 840 wastestreams, 13% are already being recycled at SRS.

Phase II of the SRS Waste Characterization Program Plan addresses the data maintenance/upgrade issue. Phase II will consist of three important elements; a Waste Acceptance Criteria (for receiving wastes), a Waste Certification Program (for generators of waste), and a Waste Information Tracking System (WITS).

The Waste Acceptance Criteria (WAC) specifies the minimum type/quality of data acceptable for each waste stream as well as minimum packaging requirements. Each generator will have to sign a Waste Certification attesting to having met all of the requirements of the WAC. Finally, a central database system referred to as the Waste Information Tracking System (WITS), is currently under development. It will track wastes from cradle to grave and will allow flexible report generation. The WAC, Waste Certification Program, and WITS will be issued for initial implementation in the 2nd quarter of calendar year 1991. Currently also under development is a means of measuring waste reduction.

Phase III will include data from a sitewide air emissions inventory and a surface water characterization study. Phase II includes all waste streams received by the SRS Waste Management Department, but Phase III will add all wastes received by all other organizations on site.

It is hoped that with these rigorous acceptance criteria, tracking systems, and the multimedia approach, that wastes will not only be better managed, but will be more easily targeted for reductions in the future.

Waste Reduction Priorities, Successes, and Current Programs

Waste reduction at the Site is accomplished by following a hierarchy of environmental protection practices. The top priority is to eliminate or minimize the generation of waste through source reduction (see Fig. 4). Second, wastes that cannot be eliminated are evaluated for recycle potential and are reused, reclaimed, or used for other purpose. And last, waste is treated to reduce the volume, toxicity, or mobility prior to storage or disposal. There have been numerous waste reduction successes over the past several years, as well as current programs underway. This paper will discuss some of the more significant successes and current programs.

Source Reduction

Source reduction includes improved housekeeping, material substitution, procedure changes, process modifications, and redesign of products. Following are examples of some source reduction programs at SRS.

Non-Hazardous Scintillation Fluids - SRS uses approximately 4-cubic meters per year of scintillation fluids for radionuclide assay. Typical scintillation fluid wastes are hazardous due to organics such as xylene and toluene. In 1986, the laboratories switched to Opti-Fluor, a non-hazardous scintillation fluid, eliminating 1.5 cubic meters per year of a hazardous waste. The Health Physics Department was unable to use this replacement due to sensitivity needs. In 1990, an acceptable replacement for Health Physics was found, Ecolite. Use of this alternative eliminates 2.5 cubic meters per year of a hazardous waste.

Replacement of Lead Oil with Tin Oil - in the Reactor Materials Division, 90 wt gear oil and powdered lead were used as a lubricant in the laminar coextrusion of aluminum clad nuclear fuel and targets. The lead powder melted and wetted the steel/aluminum interface in the die throat, performing in a way no other known lubricant or system could match. This also generated approximately 30,000 kilograms per year of hazardous waste. Tin powder was shown to be just as effective as lead powder for lubrication. The change was made and a hazardous waste stream eliminated.

Cd-Plated HEPA Filter Frames - the reactor areas have in the past used HEPA filters with cadmium plated frames, which become mixed waste when removed from service. There is currently 29 cubic meters of filters and frames in storage at the mixed waste storage building and another 107 cubic meters in use. The cadmium plated frames will be replaced by stainless steel frames when they are changed out in about 3 years. This will eliminate a mixed waste stream.

In addition, the mixed waste in storage and in use (29 plus 107 cubic meters) will be reduced by 80% by removing the HEPA filter media from the cadmium plated frames before disposal.

Electropolishing - electropolishing of equipment is being developed as a method to reduce decontamination solution waste (1). Electropolishing removes fixed contamination. In addition, it can be used to prepare a metal surface to minimize the sites where particles of contamination can become entrapped. Electropolished surfaces pick up only 10% of the contamination that an unpolished surface does. Electropolished surfaces are also much easier to decontaminate (95% less decontamination solution needed). Electropolishing can be done through immersion or in-situ (wand) techniques. SRS is currently working with a vendor to develop a nitric acid based electropolishing technique that will be compatible with site waste disposal and is consulting with Battelle Pacific Northwest Laboratories.

Foam - application of decontamination solutions with foam is being pursued. (1) It is estimated that potentially 70 % of the liquid waste generated with normal decontamination methods could be eliminated with this technique. Foam applicators produce solutions which adhere to the surfaces being decontaminated, and provide a means to decontaminate surfaces more efficiently. The applicators cover a greater surface area per unit volume of chemical used due to the expansion properties of the foam.

Foam can be produced by a pressurized applicator. The solution is applied to the surface and subsequently rinsed. Initial testing is very promising demonstrating waste generation reduction of 70%.

Degreasing Solvent Elimination - in the processing of fuel and targets in the Reactor Materials Division, lubricants must be removed from the extrusions. This has been done with a two-step process involving an initial degreasing with Trichloroethane (TCE) followed by an aqueous caustic etching. When operating, approximately 12,600 Kilograms per year of TCE are used and subsequently disposed as a hazardous waste. Recently, TCE was replaced with Freon 113, a non-hazardous solvent, but one that should be replaced due to detrimental effects on the ozone layer.

A processing change is being developed that will completely eliminate the degreasing step. Subsequent to the caustic etching step, the extrusions are heated to check for blisters, which indicate non-bonding. Laboratory testing has shown that the heating step can simultaneously clean the extrusions and check for non-bonding, thus eliminating the degreasing step. The caustic etching step would then be done after the heating step. This change will be tested under production conditions to qualify the process.

Tritiated Oil with Mercury - in the Tritium process, tritium is pumped by liquid mercury pumps using a mechanical vacuum. Oil, from the mechanical pumps, that provides the vacuum is contaminated with tritium and mercury, which results in a mixed waste. There are currently 39 cubic meters of this tritiated oil with mercury in storage awaiting treatment in the Consolidated Incineration Facility.

The Tritium process is being updated with two major projects in the near future. The Replacement Tritium Facility will start up in 1992 and the Replacement Extraction and Processing Facility is a 1994 line item. Both facilities will utilize metal hydride pumping technology to transport tritium.[2] Metal hydrides absorb tritium when cool and release tritium when heated. No mercury or oil will be used in this pumping technology, thus eliminating a major mixed waste stream.

RECYCLE

Paper, solvent, or energy recycle, or waste segregation and recovery are forms of recycle to reduce waste. The following are examples of recycle programs at SRS.

Recycling of Aluminum Cans and Paper - SRS disposes of approximately 9,000,000 kilograms per year of waste in a sanitary landfill located on site. As is the case at many municipal landfills, the SRS landfill is near capacity. Disposal costs will increase drastically with a new landfill as a result of stricter environmental regulations soon to be enforced by the South Carolina Department of Health and Environmental Control (SCDHEC).

There are several programs underway to reduce the amount of sanitary waste. One of the programs is recycle. A pilot aluminum can recycle program began in several of the administration areas at SRS in May, 1990. Potentially, 1.5 million cans/year can be recycled at the SRS.

Paper (bond and computer paper, and cardboard) waste comprise greater than 50% of the total sanitary waste. Plans are to begin recycling this waste type in pilot areas by the first quarter of 1991.

Both pilot programs are expected to expand with ultimate inclusion of the whole site.

Lead Decontamination and Coating - there are approximately 165,000 kilograms of contaminated lead at the SRS that can be reused if decontaminated. Administrative controls are in place to minimize purchase of new lead. Development programs to reuse the contaminated lead include strippable coatings and chemical decontamination.

The effectiveness of chemical decontamination of lead using different solvents was demonstrated in both lab-scale and larger-scale tests. (1,3) However, there is a problem in removing the lead from the used solution. Precipitation techniques are ineffective. Ion exchange techniques require an unreasonable amount of media. A decontamination technique with less waste disposal problems was desired.

Nitric/Oxalic Acid is currently being tested to decontaminate lead. The waste generated is compatible with existing waste streams and would be processed in the DWPF to produce waste glass.

Strippable coatings are also being investigated as a way to protect lead used for radioactive shielding. Coated lead that is no longer needed for shielding may be decontaminated by cleaning or removing the protective coating. The lead could then be recoated and used in another radioactive application.

Recycling Center Complex - current plans are to construct a sitewide recycling center complex to be built and operated by Bechtel Savannah River Incorporated (BSRI). This facility will recycle hazardous wastes generated primarily by Construction, but also the rest of SRS. Some distillation equipment is on-hand to begin recovery of paint solvents. Table I shows the wastes that will *eventually* be recycled at this center and the current annual generation rate.

TABLE I

Recyclable Construction Waste

WASTE TYPE	AMOUNT - m^3/yr
Paint Solvent	15
Antifreeze	25
Lathe Coolant	5
Solvent Rags	15
Waste Paint	8
Freon 113	8
Silver Nitrate	4

As funding is available, buildings and labs will be constructed and additional equipment ordered.

TREATMENT

Another form of waste reduction is treatment. Examples include waste segregation, incineration, evaporation, compaction, and stabilization. The following are examples of treatments at SRS to reduce waste.

Clean Waste Segregation - in the past, all waste generated in a radiologically controlled area at SRS was considered a low-level radioactive waste. A program began by the Savannah River Laboratory demonstrated that, through administrative procedures, non-radioactive waste from non-contaminated areas in radiologically controlled areas can be segregated, verified as being non-radioactive, and disposed in the sanitary landfill.

In 1987, a sitewide program was begun to implement this practice. Non-radioactive waste generated in areas having no pure alpha or beta contamination is segregated in 0.125 cubic meter boxes. Health Protection surveys these boxes before the boxes are sent to a monitoring building. A waste curie monitor (manufactured by National Nuclear Corporation-Model WCN13) is used to verify the box contents are non-radioactive. The boxes are then sent to the Sanitary Landfill. This program currently saves SRS from disposing of approximately 1300 cubic meters per year of non-radioactive waste as a low level radioactive waste. More information on this program can be found in Ref. 4.

M-Area Waste - an electroplating operation in the Reactor Materials process has generated a sludge which is a listed F006 mixed waste. There are approximately 1025

cubic meters of sludge and 2850 cubic meters of associated supernate (concentrated wastewater) in storage tanks. The primary constituents of concern in the sludge are nickel, uranium, and nitrates.

A solidification/stabilization development program is currently in progress to treat the sludge to the RCRA LDR treatment standard so that the solidified wasteform may be disposed in a RCRA vault. The treatment program involves a pretreatment of the sludge before final solidification in a cementitious matrix. The pretreatment consists of a pressure filtration step with the addition of filter aids followed by washing the filter cake with a minimum amount of water and pressing it again. The washing step is used to remove a majority of the nitrate. Preliminary results indicate that the pretreated waste may meet the RCRA LDR treatment standard.

The wash water from the pretreatment of the sludge will then be processed with the supernate through an effluent treatment facility using precipitation and filtration and then qualified for release to an NPDS outfall. The 2850 cubic meters of supernate is already being treated this way. The sludge residue from the effluent treatment facility will eventually be processed with the sludge from the storage tanks. This process will eliminate the disposal of supernate.

In-Tank Precipitation Filters - a ceramic crossflow filter will be used to remove precipitated radioactive salts (Cs,K) in the high level radioactive waste In-Tank-Precipitation process. The precipitated salts will then be vitrified in a glass matrix in the Defense Waste Processing Facility.

The cross-flow filter consists of a bank of ceramic tubes encased in a stainless steel housing. During the filtration of the precipitated salts, the ceramic tubes eventually become clogged with highly radioactive cesium and potassium salts of tetraphenylborate. Back pressure flushing is used to prolong the life of the filters, but eventually they become plugged and have to be removed from service. The presence of mercury and the radiolytic breakdown of the tetraphenylborate salts, which produce benzene, makes these filters a mixed waste.

A program is underway to find a method of cleaning or reducing the amount of precipitate in the filters after they are removed from service. One option is to allow the filters to remain in the process room until radiolytic decomposition loosens the plugging. Another option is changing the design of the filter housing to allow a high pressure cleaning. Although the cleaned filters may still be classified as mixed waste, the removal of the precipitate is necessary to reduce radiation to manageable levels so the filters can be handled.

Contaminated Soil - approximately 4200 cubic meters per year of contaminated soil and debris is disposed as low-level radioactive waste at SRS. Most of this is generated from sites within operating areas. Some of the soil is contaminated, but much is non-radioactive or contains very low levels of contamination. With concrete vault disposal estimated at $1400 per cubic meter, the stake is high to reduce as much low level waste as possible.

Two major development programs are underway. SRS is working with the Westinghouse Science and Technology Center to develop soil segregation and washing technology.

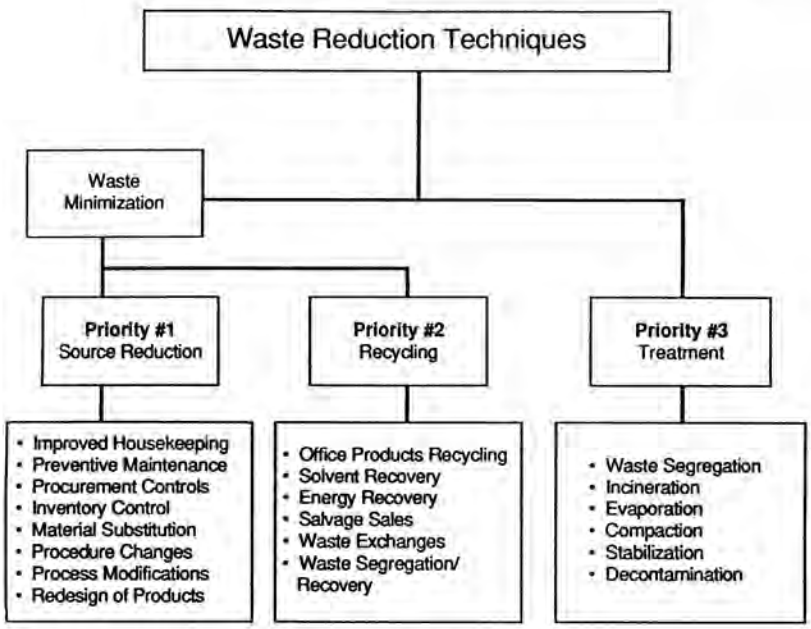

Fig. 4. Waste Reduction Priorities.

The process will mix the soil with water containing additives, agitate the mixture to break up the particles, and separate the sand from the clay fractions. Also under development is soil monitoring equipment to demonstrate that the soil is below levels of concern. SRL is exploring mechanical conveying equipment and detectors that will be needed for radiological assay and segregation of large volumes of soil.

Proposed SRL Liquid Waste Treatment - the experimental programs at the Savannah River Laboratory (SRL) currently generate approximately 500 cubic meters of liquid wastes per year. Except for very small volumes of organic solvents and oils, the majority of this waste is low activity (< 1,000 dpm/mL) or high activity (> 1,000 dpm/mL) aqueous waste. On occasion, fractions of SRL liquid waste have been declared mixed due to the presence of elevated concentrations of mercury, benzene, or other organic constituents. At this time, the aqueous waste is transported on trailers from the small SRL tank farm to evaporators in F-Area for volume reduction.

Strong commitment at SRL to total waste reduction and new regulatory restrictions dealing with the disposition of this liquid waste have lead to a proposal that treatment of the waste take place in the technical area where it is generated. Functional Design Criteria (FDC) are currently being developed for a liquid waste treatment facility that will provide centralized treatment, processing, and temporary storage of nonradioactive and radioactive laboratory liquid wastes.

The basic components of the process for treatment of combined high- and low-activity aqueous waste will be 1) filtration to remove most of the suspended solids, 2) ion exchange to remove mercury, organics and actinides, and 3) evaporation with overheads sent to the atmosphere *(see Fig. 5)*. Secondary waste will be immobilized for shipment to the appropriate on-site waste storage facility in a grouting and drumming module within the process building. A laboratory module will provide the ability to treat small, specialty wastes that may be generated. Liquid waste volumes at SRL are expected to be reduced by at least a factor of 100 when the treatment facility becomes operational.

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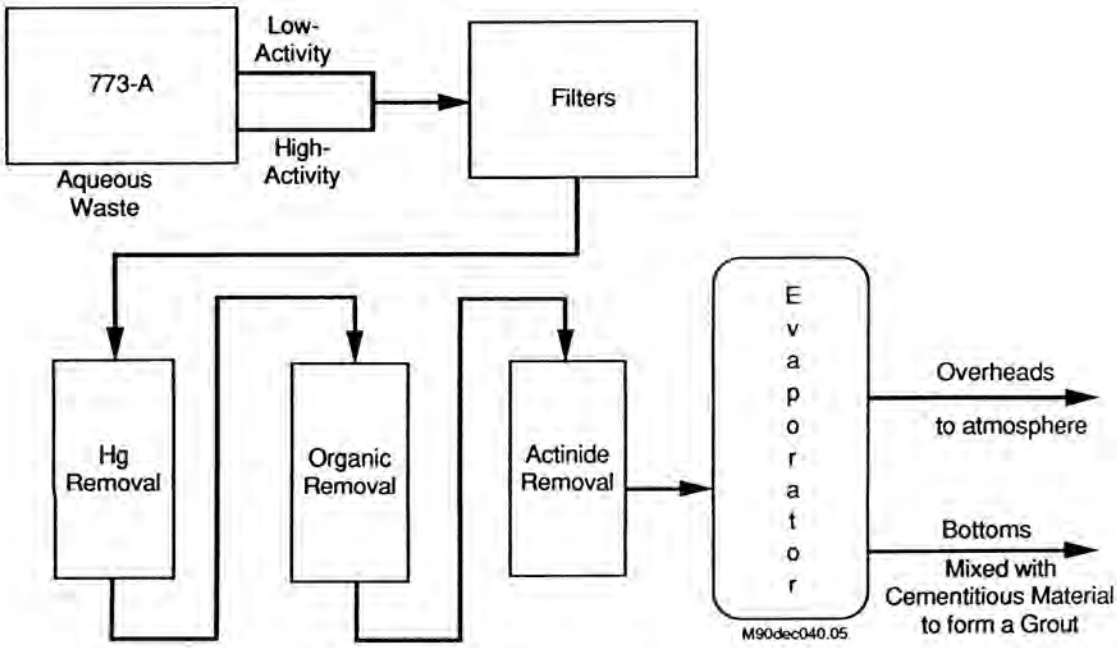

Fig. 5. Proposed SRL Liquid Waste Treatment.