# DEVELOPMENT OF WASTE COST MANUAL FOR SRS (U)*

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## ABSTRACT

A waste-cost manual was developed to enable determination of the cost of processing and managing the various waste types at the Savannah River Site (SRS). Data in the manual were based on FY 92 waste costs at SRS. Cost definitions and components are explained for each waste type. Methods and assumptions are described. A Microsoft Excel 3.0 spreadsheet was used to manage input of data and techniques. To illustrate the manual's use, a detailed analysis is given on determining low-level waste costs. The "first in-first out" method is presented as a simplified method to determine high-level waste costs. The methods used are adaptable to waste-cost determinations at other sites.

## INTRODUCTION

Waste costs are very significant concerns in any nuclear operation. To reach sound management decisions for handling waste, a knowledge of true life-cycle waste costs is required. The total life-cycle waste cost must include all waste-generation, current storage and treatment, future disposal, and monitoring expenditures. Economic evaluations require knowing which waste-cost components to use. Misapplying cost data can lead to wrong conclusions. For these reasons, an "SRS Waste-Cost Analysis" Manual (1) was developed to assist personnel in performing operational studies and options evaluations involving waste costs. The data and techniques in this manual will be used for evaluating waste-minimization alternatives, cost charge-back, waste-management options, and option comparisons for decontamination and decommissioning (D&D).

## COST DEFINITIONS

The definitions of different cost categories must be known and understood to use cost data effectively. Costs can be defined according to behavior such as the response to changes in the level of throughput or activity. Cost definitions used in this study are:

- relevant range- the span of waste throughput within which assumptions relative to fixed- and variable-cost behavior are valid;
- sunk costs - costs that already have been incurred, committed, or planned that are not impacted by waste-generation rates in the present or future (e.g., cost of existing facilities, capital costs for existing and new facilities required to handle legacy waste, regardless of current waste generation)
- variable costs - costs that vary in direct proportion to changes in the volume of waste throughput;
- fixed costs - costs that remain constant regardless of changes in the volume of activity or waste throughput;
- life-cycle waste costs - all costs (sunk, fixed and variable) expressed as present values, associated with management of a unit of waste (e. g., costs for handling, packaging, transporting, treatment, storage, disposal, closure, and post-closure monitoring waste).

Life-cycle costs are the "cradle-to-grave" costs from the time waste is generated to the end of its institutional control. The total costs provided in this study were the sum of the life-cycle costs' fixed and variable components for each waste type.

The waste type for which costs being evaluated and the waste treatment/storage/disposal process that the cost data are based upon must be defined. At SRS, Waste Management operates onsite facilities for the following waste types which are covered in this cost study (see Fig. 1):

- low level (solid) - defined in DOE Order 5820.2A as radioactive waste not classified as high-level waste, spent fuel or by-product waste; at SRS, solid, beta-gamma emitting waste, radiating less than 200 mrem/hr or 200 mR/hr at five centimeters from an unshielded container; must contain less than 10 nCi of transuranics per gram of waste;
- intermediate-level waste - an SRS term for the higher activity fraction of LLW that is beta-gamma emitting and radiates greater than 200 mrem/hr or 200 mR/hr at five centimeters from the unshielded container; may contain 10 to 100 nCi of transuranics per gram of waste;
- transuranic waste (TRU) - waste that contains greater than 100 nCi of transuranics (isotopes with an atomic number greater than uranium (92) and a half-life greater than 20 years) per gram of waste;
- hazardous waste - non-radioactive waste which contains constituents that RCRA lists as hazardous
- mixed waste - both hazardous (as described by RCRA) and radioactive waste;

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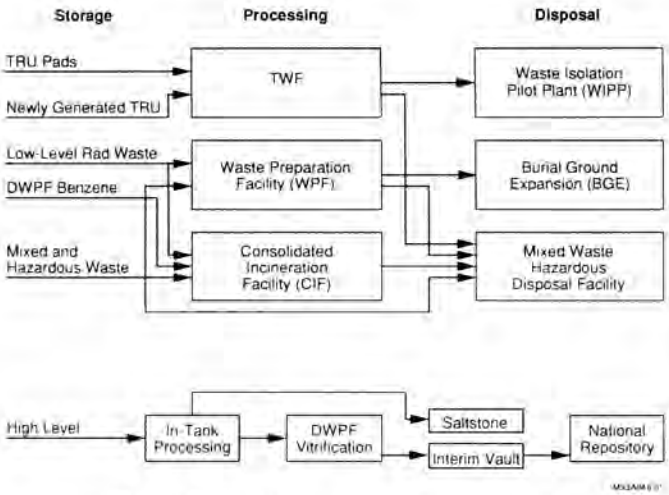


Fig. 1. SRS waste management overview.

- high level waste (HLW) - high-activity, liquid waste that results from reactor fuel/target processing in the 200-Area separations processes (See Fig. 2).

## METHODOLOGY

There are a multitude of activities associated with each waste type that contributes to the waste cost. In this study, these activities were grouped into cost categories and summarized for each waste type based on FY 92 costs in SRS's Annual Operating Plan (2). The costs are for SRS's waste facilities only and are based on the SRS's Waste-Forecast generation rates (3) for FY 92. The fixed portion of the costs will not be impacted by changes in waste throughput within a reasonable (relevant) operation range. This range covers most waste reductions that likely are to be considered in an economic evaluation such as a waste-minimization proposal.

For each waste type, costs were grouped into the following broad activity categories and summarized.

- waste generator costs - handling, characterization packaging, etc
- transportation costs - from generator to waste-management facility

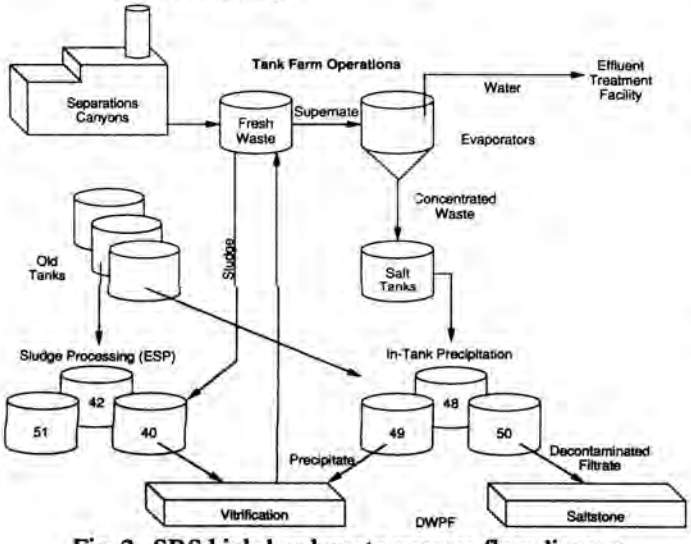


Fig. 2. SRS high-level waste process flow diagram.

- waste-management facility - treatment, storage and disposal, including replacement cost for disposal space
- disposal-site closure after the facility's capacity is reached
- monitoring (including surveillance and post-closure)

Direct and overhead costs (administrative, legal, etc.) were established for each waste type. A cost spreadsheet database was developed using Microsoft Excel, version 3.0, software. This spreadsheet became the model for SRS's waste costs. Any variables in the spreadsheet (cost or waste operations) can be changed, and the impact on waste costs will be calculated. Examples will be presented later in the paper. The cost model is intended to be a living document that must be updated periodically as site operating costs and conditions change. Many assumptions had to be made in developing SRS's Waste-Cost Manual and model. Personnel at other waste facilities must decide which methods and assumptions apply to their operations and adjust the model accordingly. After consideration, specific items were included or excluded in calculating SRS's waste cost as follows:

| Included | Not Included |
|---|---|
| generator costs (handling/packaging/ characterization costs) | raw material cost of waste |
| facility operating costs- including storage, treatment, etc. | existing facility capital costs (sunk) |
| transportation costs | DOE costs |
| projects (facility upgrades) | D&D costs |
| overhead cost allocations for direct costs | infrastructure capital costs |
| support services' direct cost | liability/risk costs (not monitoring, pre & post closure defined) |
| replacement storage/ disposal facilities | |

The specific cost items that were included then were designated as either fixed or variable as follows:

| Fixed | Variable |
|---|---|
| facility management | waste handling/ transportation |
| environmental-program development | records |
| regulatory compliance | origination/management |
| permitting | earth moving |
| equipment replacements/ required upgrades | replacement storage/ disposal capacity |
| quality assurance | waste packaging |
| preventive maintenance | waste inspection, sampling, characterization |
| fire protection/emergency management | radiation monitoring |
| records management/ system | job control/scheduling |
| operating-procedures development/management | waste treatment |
| training | |
| generator-waste certification program | |
| site planning and design | |
| health-protection program | |

The total cost for each waste type can be determined from the sum of the fixed and variable costs. The variable costs are reported on a volumetric basis so total cost can be determined by this formula:

Total cost = fixed costs + (unit-variable cost) (waste volume)

Because total costs in this study do not include sunk costs, they are not suitable to determine full-cost recovery. The costs in this study are not discounted and all are in 1992 dollars.

## RESULTS

Unit-variable costs for all waste types generated at SRS are summarized in Table I, using the cost model based on SRS's operating costs and forecast-waste throughput in FY 92. These costs are more appropriate and useful for financial-incentive studies.

## LOW-LEVEL WASTE COST

A more detailed analysis of SRS's solid, low-level waste (LLW) costs, including both total and fixed costs, is given in Table II.

At SRS, about 36% of LLW is compacted by a 5.34 ratio to reduce volume and waste-disposal costs. Costs for both compactable and non-compactable waste are presented. With this type of cost model, variables such as waste throughput or the percent of compacted waste can be changed easily. These two examples are illustrated in Table III.

In the first example, the volume of LLW waste is reduced by 10%, resulting in a $2.2 million cost reduction. In the other example, the amount of waste compacted is increased from 36% to 50%, resulting in a $2.3 million cost reduction.

Detailed cost analysis tables are provided for each waste type generated at SRS in the cost manual.

## HIGH-LEVEL WASTE COSTS

At SRS, high-level waste (HLW) comes from fuel-target processing operations and includes the liquid from both F- and H- Area canyons dissolution operations. The HLW is transferred directly to underground waste tanks where its identity is lost through processing and mixing with previously-generated HLW. SRS's HLW process diagram is given in Fig. 2. Following initial receipt, the liquid supernate is processed through evaporators. The remaining sludge and salt eventually will be processed for isolation in glass canisters and Saltstone, respectively, in the recently-constructed Defense Waste Processing Facility (DWPF). Evaporation/surveillance/sludge-production operations have been proceeding since initial SRS operations with about 85 million gallons of HLW received to date. Sludge/supernate-processing operations for this accumulated HLW are expected to begin in 1994 to vitrify the sludge (glass canisters) and produce saltstone from residual, decontaminated supernate.

The First In-First Out (FIFO) accounting method was used to simplify the cost calculations. FIFO can be used when programs associated with managing a waste stream are relatively constant. The incremental effect imposed by any new waste upon such a program will proportionally increase the total time the program expenditures are required. For example, generating high-level waste lengthens the total processing time for operations associated with high-level waste. Future processing costs were assumed to be incremental in predicting annual processing costs. When divided by the incremental waste volume, the resulting unit-variable cost represents the program costs incurred due to the proportional increase in time the program must operate due to additional waste generation. (4)

Costs that now are budgeted for the existing HLW operations, including DWPF, can be used as a reference for handling and isolating of any new HLW. The assumption can be made that new HLW adds a proportionate amount of time to the end of assigned operations for existing waste, and the cost for the new HLW is an incremental, variable cost related to continued DWPF and peripheral facility operations. This costing method eliminates the need to track new waste through all of the various cost centers and to determine each cost adder as a function of time. The costing method is applicable as long as the time between new waste generation and the estimated completion of DWPF operations is longer than a required aging time for new waste.

**TABLE I**
Unit-Variable Costs for New SRS Waste

| Waste Type | Pre-Disposal | | Capital | Disposal | Offsite | Total |
|---|---|---|---|---|---|---|
| | Material | Operating | | Closure | | Variable |
| Low-level solid ($/cu ft) | | | | | | |
| Noncompactable | 4 | 3 | 13 | 0.9 | | 21 |
| Compactable | 2 | 4 | 2 | 0.2 | | 9 |
| Interemediate Level ($/cu ft) | 47 | 37 | 61 | 0.9 | | 146 |
| Hazardous ($/cu ft) | | | | | | |
| Incineratable: Onsite | 5 | 226 | 22 | 0.1 | | 252 |
| Incineratable: Offsite | 5 | 214 | | | 137 | 355 |
| Nonincineratable | 5 | 388 | 210 | 0.7 | | 603 |
| Mixed ($/cu ft) | | | | | | |
| Incineratable | 5 | 103 | 167 | 0.1 | | 275 |
| Nonincineratable | 5 | 265 | 355 | 0.7 | | 625 |
| Transuranic ($/cu ft) | 22 | 80 | 22 | | 555 | 678 |
| Drummed | 47 | 80 | 22 | | 555 | 703 |
| Boxed | 39 | 80 | 83 | 0.9 | * | 202 |
| ILW* | | | | | | |
| High-Level, $/GAL HHW | | 58 | 4 | 0.4 | 12 | 74 |

*Reclassified TRU waste disposed of onsite.

**TABLE II**
Summary of Solid, Low-Level Waste Costs

| Task | Total 1000$/Yr | Fraction | | Fixed 1000$/Yr | Noncompacted Variable $/cu.ft. | Compacted Variable $/cu.ft. |
|---|---|---|---|---|---|---|
| | | Fixed | Variable | | | |
| Generator | | | | | | |
| - Manpower | 11,382 | 0.75 | 0.25 | 8,536 | 2.19 | 2.19 |
| - Package Noncomp. | 3,684 | 0.00 | 1.00 | | 4.44 | |
| - Package Comp. | 270 | 0.00 | 1.00 | | | 0.57 |
| Transportation | 1,149 | 0.00 | 1.00 | 0 | 0.88 | 0.88 |
| - Manpower | | | | | | |
| Waste Management | | | | | | |
| - Operating | 2,180 | 0.75 | 0.25 | 1,635 | 0.42 | 0.42 |
| - Support | 6,658 | 1.00 | 0.00 | 6,658 | 0.00 | 0.00 |
| - Capital (disposal facility | 11,599 | 0.00 | 1.00 | 0 | 12.64 | 2.37 |
| - Compactor Operating | 412 | 0.50 | 0.50 | 206 | 0 | 0.44 |
| - Package | 684 | 0.00 | 1.00 | 0 | 0 | 1.46 |
| Closure | 848 | 0.00 | 1.00 | 0 | 0.92 | 0.17 |
| Total | 38,866 | | | 17,035 | 21.49 | 8.50 |

Notes:
1. 1992 Generation Rate, cu ft/yr - noncompacted 830,000; compacted 470,000
2. compaction Ratio - assumed to be 5.34
3. total costs at projected 1992 waste generation rate
4. fixed costs may include some costs associated with existing waste
5. A single "fixed" monitoring cost of $2.1 million/yr will cover monitoring the Solid Waste Disposal Facility which includes several waste types.

The DWPF presently is scheduled to operate at 410 canisters per year, equivalent to 6.724 million gallons of fresh high-heat waste (HHW) per year. The cost is referred to as fresh HHW in order to differentiate a fixed-solids content from a fixed-waste volume where the solids content dictates the number of glass canisters. For H-Area operations (processing of enriched uranium/aluminum alloy tubes), 16,400 gallons of fresh HHW contains 75% of the waste solids put into in a glass canister. The remaining 25% comes from a highly-variable volume of low-heat and miscellaneous waste. Because the HHW component is proportional to the total solids sent to glass canisters, no error is introduced by using the fresh HHW as a reference, excluding the volume of low-heat and miscellaneous waste. (4)

The estimated cost for total HLW/DWPF at capacity throughput is $419 million per year. Thus, this variable-unit cost is $62.3/gal for fresh waste (see Table IV for cost analysis) and is applicable directly to the HHW generated in 1992 (estimated to be 55,000 gallons or about 1% of DWPF's annual capacity). Thus, the net future cost for 1992's fresh waste is about $3.4 million accrued to pay for an additional 0.01 year of DWPF operation at the capacity rate.

An additional cost accrues to transport and isolate the canisters in a planned federal repository. This cost currently is estimated to be $200,000/canister, which includes the lifetime cost for isolation. At 16,400 gallons of fresh waste equivalence per canister, this variable-unit cost is $12.2/gallon, bringing the total to $74.5/gallon for high-heat waste.

## CONCLUSIONS

The cost model and data developed are applicable only to waste at SRS. Many assumptions had to be made in developing this manual, and other sites should decide which assumptions apply to their situations and modify their models accordingly. SRS's manual primarily was intended for use in economic evaluations, such as waste-minimization options. The basis for the cost determinations must be understood by the user to avoid misapplication and erroneous conclusions.

## REFERENCES

1. G. H. STREET, I. M. MACAFEE, D. G. HOSTETLER, B. K. TAYLOR, J. P. HARLEY, M. E. GORDEN, "SRS Waste Cost Analysis", WSRC-RP-92-631, Westinghouse Savannah River Company, (1992)
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3. M. E. GORDEN, "Savannah River Solid Waste Forecast-FY92", WSRC-RP-91-807, Westinghouse Savannah River Company, (1991).
4. W. R. MCDONELL, "Economic Analysis of Projected High-Level Waste Immobilization Operations at SRS", DP-MS-86-92, E. I. du Pont de Nemours and Co., (1986).

**TABLE III**
Examples of Costs Changes Resulting from Solid, Low-Level Waste Process Variations

| | | Fixed Cost Million $ | Predisposal | | Variable Costs Million $ | Disposal | | Total Incremental Change Million $ |
|---|---|---|---|---|---|---|---|---|
| | | | Material | Operating | Capital | Closure | Offsite | |
| Unit and Fixed Costs | | | | | | | | |
| Noncompacted - $/cu ft | | | 4.4 | 3.5 | 12.6 | 0.9 | | |
| Compacted - $/cu ft | | | 2.0 | 3.9 | 2.4 | 0.2 | | |
| Total - Million $ | | 17.0 | | | | | | |
| Projected 1992 Amount | Amount Cu ft/yr | | | | | | | |
| Noncompacted | 830,000 | | 3.7 | 2.9 | 10.5 | 0.8 | | |
| Compacted | 470,000 | | 1.0 | 1.8 | 1.1 | 0.1 | | |
| Total | 1,300,000 | 17.0 | 4.6 | 4.7 | 11.6 | 0.8 | 38.8 | |
| Reduce Amount by 10% | | | | | | | | |
| Noncompacted | 747,000 | | 3.3 | 2.6 | 9.4 | 0.7 | | |
| Compacted | 423,000 | | 0.9 | 1.7 | 1.0 | 0.1 | 36.6 | -2.2 |
| Total | 1,170,000 | 17.0 | 4.2 | 4.3 | 10.4 | 0.8 | | |
| Increase Compacted Fraction to 50% | | | | | | | | |
| Noncompacted | 650,000 | | 2.9 | 2.3 | 8.2 | 0.6 | | |
| Compacted | 650,000 | | 1.3 | 2.6 | 1.5 | 0.1 | | |
| Total | 1,300,000 | 17.0 | 4.2 | 4.8 | 9.8 | 0.7 | 36.5 | -2.3 |

**TABLE IV**
Summary of High-Level Waste Costs

| | Conditions | |
|---|---|---|
| DWPF, Gal Fresh HHW per year* | | 6,724,000 |
| DWPF, Canisters/yr | | 410 |
| Gal SS/Gal Fresh Waste | | 4.50 |
| Gal Benzene/Gal Fresh Waste to Consolidated Incinerator (CIF) | | 0.08 |
| Gal LLLW/Gal Fresh Waste to Saltstone Facility | | 6.18 |
| | Total costs 1000$/yr | Incremental Costs $/gal |
| | **Task** | |
| Waste Management | | |
| - Tank Farm Operating | 162,091 | 24.1 |
| - DWPF Operating Cost | 159,533 | 23.7 |
| - Saltstone Operating Cost | 12,400 | 1.8 |
| - ETF Operating Costs | 31,243 | 4.6 |
| - CIF Operating Costs | 3,552 | 0.5 |
| - Capital | 20,000 | 3.0 |
| - Saltstone Vault | 27,232 | 4.1 |
| - Saltstone Vault Closure | 2,794 | 0.4 |
| Total Onsite | 418,845 | 62.3 |
| - Offsite Transport & Disposal | 82,000 | 12.2 |
| Total | 500,845 | 74.5 |

* Assumes most of High Heat waste comes from H-Canyon process.