STATE-OF-THE-ART NUCLEAR LAUNDRY WASTE WATER TREATMENT SYSTEM

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ABSTRACT

While adopting stricter controls, many organizations throughout the commercial and government sectors have and are increasing the frequencies and types of activities which require the use of more protective clothing. Concurrently, these same organizations are continuing to implement efforts to reduce radioactive and hazardous wastes, as well as minimizing effluents and discharges to the environment. As a result, interest in nuclear laundry facilities have increased. Such facilities include provisions for laundry handling, washing, drying, and monitoring. The washers and dryers are the workhorses of the facility, however, the waste water treatment system is the key to the success of a nuclear laundry facility design. Waste water treatment can vary from simple filtration and monitored discharge to a sophisticated treatment train achieving recycle quality water supplies.

INTRODUCTION

Throughout the Industry, evaluations of laundry and laundry support facilities have included the following considerations:

- Needs/Requirements
- Off-site Services vs. On-site Operations
- "Throw-away" Protective Clothing vs. Reusable (Launderable) Protective Clothing
- Capital vs. Operating Expenses
- Waste Minimization
- ALARA
- Best Available Technology
- Liabilities
- Equipment Maintenance
- Maximize Efficiency of Operations
- Consolidation of Operations
- Wet vs. Dry Cleaning

All of these considerations are studied to generate the most cost-beneficial approach for each organizations specific applications.

The total facility design must include considerations for radiation monitoring of potential release points including liquid, airborne, and the actual laundry items. Access control and personnel routes must be carefully planned to reduce radiation exposures. Likewise, efficient material handling (and automation) needs to be addressed to reduce exposures. Although all of these features are important to the operation and safety of a facility, the purpose of this paper is to share some key ideas in the design of the waste water treatment system. An example design for a "State-Of-The-Art" Nuclear Laundry Facility will be used to illustrate these key ideas and features.

EXAMPLE FACILITY DESCRIPTION

Figure 1 illustrates a general arrangement layout of an example wet-wash nuclear laundry facility. This example facility was designed to accommodate a laundry capacity of 5,500 lbs. per 8 hour shift, as well as non-cloth items such as respirators.

The design incorporated the following features:

- Four washers (350 lbs. per batch)
- One spare washer (260 lb. per batch) to be used for maintenance and emergency period
- Four dryers (175 lb. per batch)
- Respirator washing/drying system (300 per shift)
- Radiation Monitors
  - Automated and portable clothing monitors
  - Personnel friskers
  - Area monitors
  - Air sampling (portable and fixed)
- Four sorting hoods (with ventilation)
- Occupancy of 20 people per shift
- Waste Water treatment
  - Lint/Suspended Solids Filter
  - Charcoal Absorber
  - Mixed bed demineralizer
  - Kinetic Precipitator capability (optional)
    or
    Ultraviolet Sterilizers
- Automated loading/unloading of wet and dry laundry

The laundry system is designed to effectively remove radioactive materials, organics, and biological growth from soiled and dirty items with minimal handling by workers. The primary components are automated washers and dryers connected by conveyors used to unload washers and load dryers. The washers utilize separate openings for loading and unloading to avoid recontamination of laundered

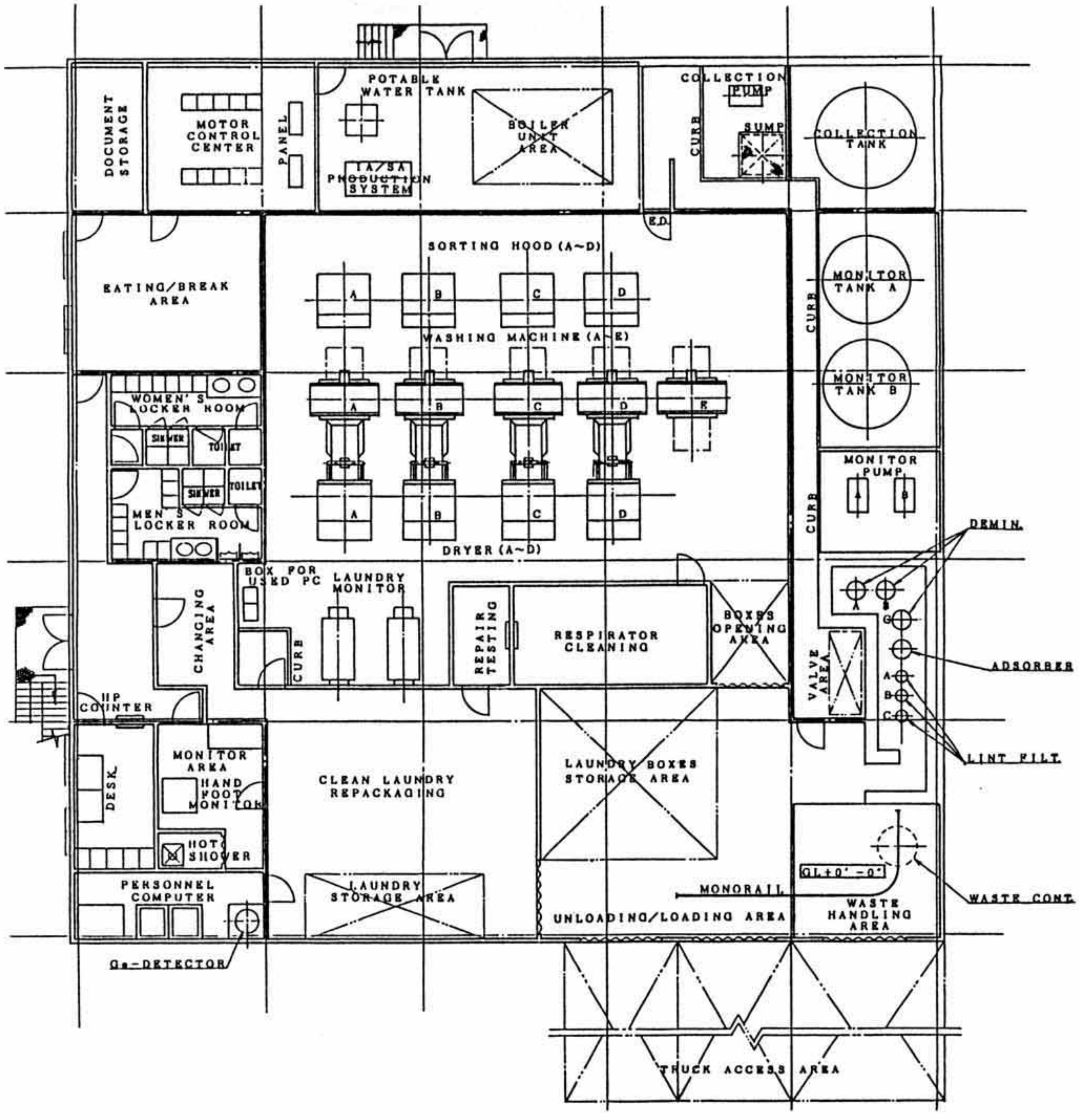

Fig. 1. Example general arrangement (nuclear laundry facility).

items. Conveyors can be added between the sorting hoods and washers to further decrease radiation exposures.

This example facility design is flexible since the design could be expanded or contracted to meet various capacity requirements. For example, the facility illustrated in Fig. 1, while utilizing four washers (@ 350 lb per batch each) has a maximum capacity of 2.8 million lbs. per year (assuming 2 shifts per day, 8 hours per shift, and 5 days per week). The design can be altered to utilize larger washers (up to 650 lb per batch) or more washers to increase capacity.

The washer-dryer lines are also designed to separate laundry from different generators in order to prevent cross contamination of laundry.

The respirator cleaning system(s) can also be used to clean hard hats, as well as respirators. Adding additional respirator cleaning systems will increase washing and drying capacities and waste water quantities.

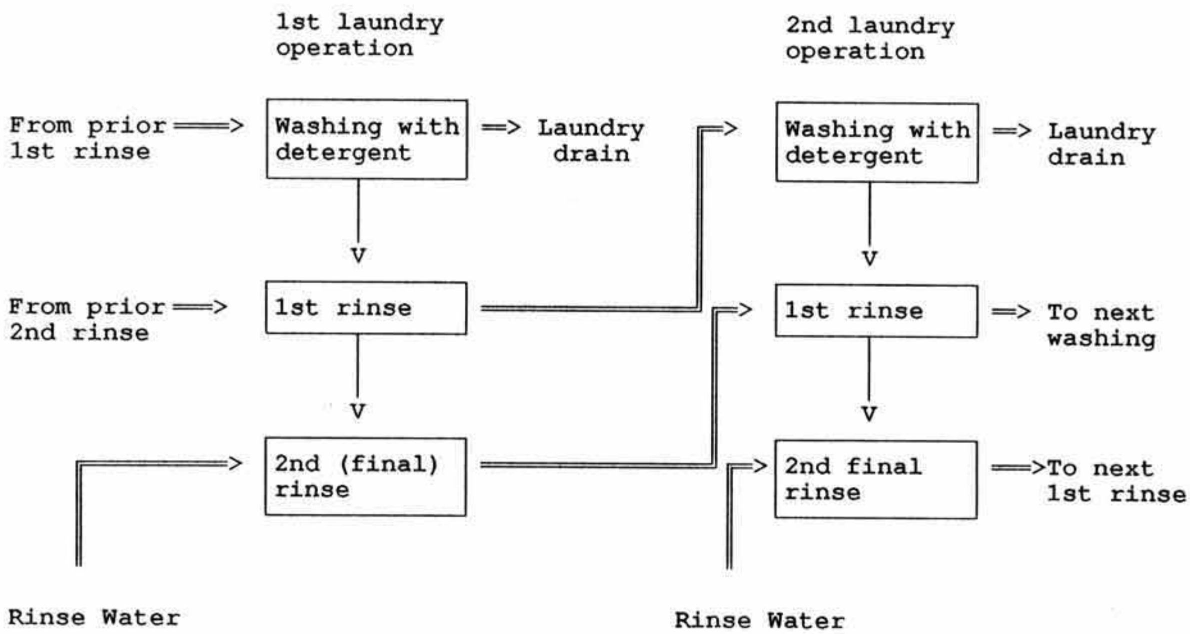

Fig. 2. Laundry water utilization.

Washing machines and waste water systems will be able to utilize detergents, surfactants or cleaning agents that are commercially available, free of phosphates, borates, and other environmental pollutants, are non-ionic; and are biodegradable. In order to reduce the volume of wastewater, rinse water would be reused in the washing machines as illustrated in Fig. 2.

This method can reduce water volumes by approximately one-third (1/3). Most of the activity (approximately 80%) is removed in the washing stage. During the first rinse cycle about 13% of the activity is removed and 7% is removed from the second and final rinse. Additional rinse cycles can be programmed into the washing cycles should it be necessary.

WASTE WATER TREATMENT SYSTEM

Normal Operation

Figure 3 illustrates a waste water treatment system that removes suspended solids, organics, and radioactive materials and allows the discharge of water that meets regulations for hazardous and radioactive materials. Under normal operating conditions in which the activity levels are very low, the laundry waste water would be filtered for lint and particulates and then discharged after sampling. For high activity waste water, this system would additionally utilize activated carbon and ion-exchange resins to meet the discharge regulations of 10CFR20.

The major components in this system are:

- 1 collection sump (1,100 gal)
- 1 collection tank (6,000 gal)
- 3 lint filters (5 gpm each)
- 1 Charcoal absorber (15 gpm)
- 3 waste demineralizers (15 gpm each:in series)
- 2 monitor tanks (5,000 gal each)

The system capacity was established at 15 gpm (21,500 gpd) with a 10% or more allowance for laundry waste water to be treated within a seven hour period.

The three major types of processing equipment used in the example system (Fig. 3) are: 1) The JGC lint filters which reduce suspended solids, which are comprised mainly of lint, 2) the charcoal absorber for the removal of organics and fine suspended solids which are removed from the waste stream to reduce the loads on the demineralizers, and 3) the waste demineralizers to reduce the concentration of radioactive materials in the waste water.

The JGC lint filter is a non-backwashing filter media which consist of short polyester fibers secured randomly in a 1/2 - 1 inch diameter fitting. This filter has a high capacity for retaining suspended solids, and is not as easily clogged if compared with conventional cartridge filters, bag filters or strainers.

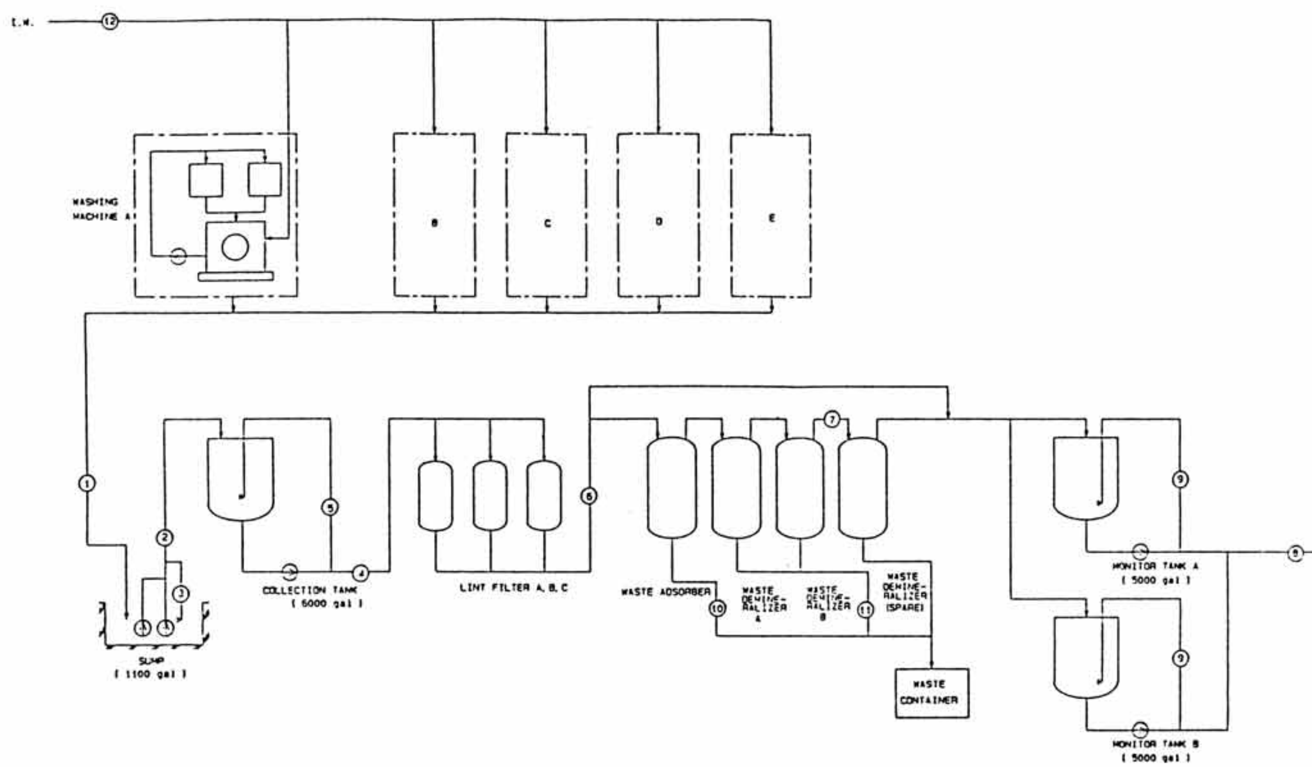

Fig. 3. Waste water treatment normal discharge system.

tank inlets is normally used to minimize the use of activated carbon and/or ion exchange resins depending on the waste water quality following filtration. This option allows for the possible decrease of operational cost under normal (low activity) daily operating conditions.

The JGC lint filter, the activated charcoal absorber, and the demineralizer system would function together to remove organics, particulates, and radioactive contaminates. Test results from a treatment system test setup are given in Fig. 4. Activity decontamination factors would be typical for mixed-bed demineralizer systems, or about 10^3.

Treated water is received in the monitor tanks. One monitor tank is used for receiving treated water while the other is used for discharge. The Monitor tank is batch sampled to confirm that the contents meet release criteria. Additionally, a continuous monitoring system is provided in the discharge line in order to confirm that activity levels are below discharge limits.

Agitation/recirculation lines are provided for the waste water collection sump and each of the tanks to prevent settling or precipitation of solids and to ensure that a representative sample is taken in the monitor tanks. If necessary, the system allows for the addition of NaClO to the collection tank to prevent biological growth.

Not shown in Fig. 3 is a return line from the monitor tanks to the collection tank to be used in the situation where treated water does not meet the discharge limits. Such an instance may occur following filtration only. The monitor tank contents would be returned to the collection tanks and would be reprocessed using the charcoal filter and the mixed-bed demineralizers.

Spent filters, activated carbon, ion exchange resins, and sludges from the kinetic precipitator are transferred to a waste container and dewatered by a dewatering and drying system. No mixed waste would be generated by this system.

Recycle Option

In order to greatly reduce the amount of water and contaminants discharged to the environment, a water recycling option could be added to the normal treatment system configuration described in Fig. 3. Figure 5 illustrates this additional equipment as follows: 1) a recycle line to reuse water for the washing machines, 2) sterilizers (or kinetic precipitators), 3) a 1 micron filter, 4) a demineralized water production system, and 5) a demineralized water storage tank.

Ion exchange resins will be utilized to remove radioactive materials as was the case in the normal discharge system

Item	RUN 1		RUN 2		
	Supplied liquid	Treated water	Supplied liquid	Treated water	
Conductivity [μs/cm]	446	4.1	384	5.1	Not specified
Organic [mg/ℓ]	110	14.3	95	14.1	<30
SS [mg/ℓ]	30	2	50	8	Scarcely present
TDS [mg/ℓ]	378	8	395	58	<500
Turbidity [degree]	33	<5	—	<5	<10
COD [mg/ℓ]	41	12	60	15	<30
Lactic acid [mg/ℓ]	131	N.D.	125	N.D.	Not specified
Test flow sheet					

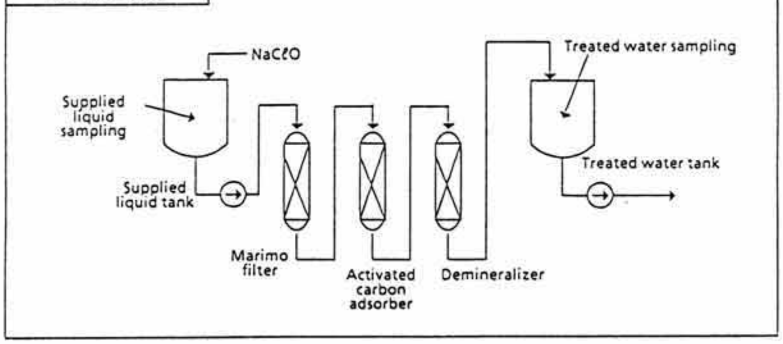

Fig. 4. Results of waste water treatment test for recycle water system.

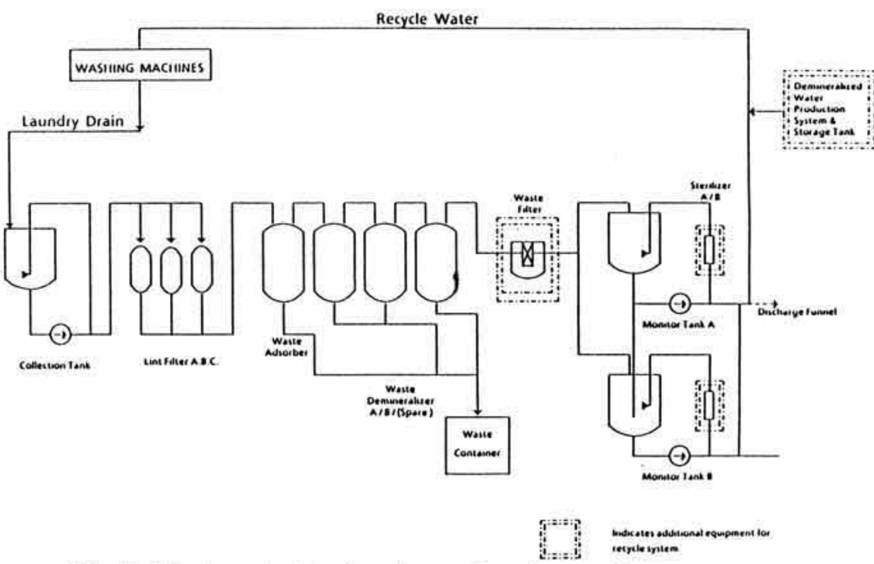

Fig. 5. Waste water treatment recycle system options.

(Fig. 3). The removal of fine particles which may escape the demineralizers will be accomplished by a 1 micron filter installed downstream of the demineralizers.

In order to recycle treated water to the washers, ultraviolet sterilizers would be installed. Additionally, a demineralized water generation system and storage tanks will be needed to prevent the unnecessary consumption of ion exchange resin due to high conductivity water which may come from the normal facility water supply. For specific applications where conductivity and/or bacteria need to be specifically controlled, the addition of a non-chemical kinetic precipitator would replace the ultraviolet sterilizers and could resolve both water quality concerns. This option operates efficiently but does produce waste sludges.

From testing and experience, it is estimated that a typical nuclear laundry utilizing a recycling system can experience a reduction of discharged water to one-fifteenth (1/15) that of a normal discharge system. For radioactive material discharges, it is estimated that concentrations discharged can be reduced to 1/180 to 1/500 of the normal discharge system. This is dependent on isotopic makeup of the waste water. Table I provides data from a computer

TABLE I

Radioactivity Content of Liquid Effluent

Nuclide	Activity of Laundry Waste (uCi/cc)	DF	Discharge Activity (uCi/cc)	MPC
Cr-51	1.6E-06	1000	1.7E-09	5.0E-02
Mn-54	4.2E-07	1000	4.2E-10	3.0E-03
Co-58	7.4E-06	1000	7.4E-09	3.0E-03
Co-60	6.0E-05	1000	6.0E-08	1.0E-03
Cs-134	5.9E-07	20	2.9E-08	3.0E-04
Cs-137	1.6E-06	20	7.8E-08	4.0E-04
I-129	3.6E-07	1000	3.6E-10	1.0E-05
Tc-99	3.8E-07	1000	3.8E-10	5.0E-03
Ni-63	2.6E-05	1000	2.6E-08	8.0E-04
H-3	1.9E-06	1	1.9E-06	1.0E-01
C-14	1.6E-07	1	1.6E-07	2.0E-02
Fe-55	2.3E-04	1000	2.3E-07	2.0E-02
TOTAL	3.3E-04		2.5E-06	

Note: Calculation based on Treatment Media Consisting of JGC Filter, Charcoal, and IX Resin

TABLE II

Volume of Secondary Waste from the Water Recycle System

Item	Marimo Filter	Activated Carbon	Ion-Exchange Resin
Treated volume per unit volume	5000 gal/ft^3	330 gal/ft^3	670 gal/ft^3
Treatment volume	1.2 x 10^6 gal	1.2 x 10^6	1.2 x 10^6
Volume of waste generated	240 ft^3	360 ft^3	1800 ft^3

simulation of a waste stream treated with the waste water treatment system describes in this paper. The isotopic makeup represents a typical nuclear laundry facility waste stream.

While increasing the water utilization rate and decreasing discharge volumes and concentrations, the recycle option will generate an increase in secondary wastes. Table II illustrates the estimated volume of secondary wastes for a recycled system with isotopes and concentration listed in Table I. The total volume of secondary waste generated, for the water recycle option, is approximately 10 times greater than that of a normal discharge treatment.

CONCLUSION

Because of the complexity of the economics and technical requirements and considerations for a nuclear laundry facility, a systematic approach must be taken to integrate technologies, equipment, and needs. The bottom line is that the building of a laundry facility must provide its owner/operator with benefits, performance and cost savings. The equation must include present and future operations, capital and operating expenses, regulatory issues, secondary waste generation and disposal, and budgets. Although each site/organization may have different operating parameters, the evaluation process for a nuclear laundry is roughly the same. The waste water treatment system described in this paper is capable of meeting the needs of an efficient, cost effective nuclear laundry facility.