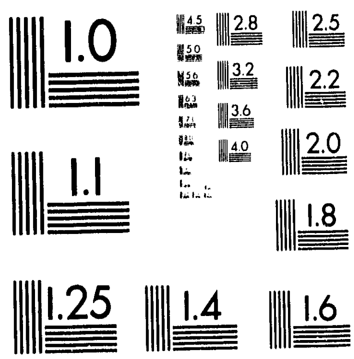
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HIGH LEVEL RADIOACTIVE WASTE MANAGEMENT FACILITY DESIGN CRITERIA (U)

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HIGH LEVEL RADIOACTIVE WASTE MANAGEMENT

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INTRODUCTION

This paper discusses the engineered systems for the structural design of the Defense Waste Processing Facility (DWPF) at the Savannah River Site (SRS). At the DWPF, high level radioactive liquids will be mixed with glass particles and heated in a melter. This molten glass will then be poured into stainless steel canisters where it will harden. This process will transform the high level waste into a more stable, manageable substance.

The radioactive waste will be treated in the tank farms at the site. Treatment of the waste separates the high-level and low-level portions . The low-level portion, which is 93 percent of the total waste, will go to the Saltstone Facility, where it will be solidified as a cement inside large concrete vaults. The high level portion will be pumped to DWPF where it will be mixed with fine particles of borosilicate glass. The glass and waste mixture will be fed into a melter and vitrified at a temperature near 2,100 degrees Fahrenheit. The molten glass will then be poured into stainless steel canisters two feet in diameter and ten feet tall. The process is expected take approximately 15 years to handle the current inventory of high-level waste.

After the canisters are filled, the outside of each canister is cleaned and decontaminated. The canisters are then sealed by a welding process. These canisters will be temporarily stored in a nearby building, containing below-ground concrete vaults, until a federal repository is ready.

This paper will discuss the structural design requirements for this unique one of a kind facility. A special emphasis will be concentrated on the design criteria pertaining to earthquake, windand tornado, and flooding.

PROCESS DESCRIPTION

The radioactive waste waters are generated by various SRS production, process and laboratory facilities. The high level waste is stored in tanks to isolate the radioactive wastes from the environment, plant workers and the general public, .

•This tank storage of HLW allows radioactive decay by aging, and removes soluble salts from the waste water by evaporation and/or ion exchanges.

• The accumulated sludge and salt solutions are pretreated to allow management of these wastes at other waste water treatment facilities (i.e., DWPF) for conversion to more stable forms and placement in permanent disposal facilities.

To accomplish the above objective, the Tank Farm contains 51 large underground storage tanks to receive and age the waste streams, five evaporation systems to remove soluble salts, a precipitation/filtration system (in-tank precipitation) to pretreat the salt solutions, a sludge washing system (sludge processing) to pretreat the accumulated sludges, and a transfer system to transfer the wastes.

The above description is shown in the attached flow diagram, Figure 1-1.

FACILITY DESCRIPTION

This waste processing facility is a unique, technology. It is comprised of various segments, which are listed below, chronologically delineating the function of each segment. The main facility is primarily above ground with few segments below grade. The DOE Order 6430.1A *"General Design Criteria" (GDC)* is a primary document that establishes the mandatory minimum acceptable requirements for design of DOE non-reactor nuclear facilities.

The ground breaking for the facility was held November 8, 1983. The DWPF complex consists of 16 segments that are categorized depending on their performance level. These segments are listed below:

1) Vitrification Building: High hazard, Category I structure

2) Sand Filter Building: Low hazard, Category I structure

3) Fan House: Low hazard, Category I structure

4) Glass Waste Storage Building - Vault Area: (Moderate hazard, Category I structure

5) Glass Waste Storage Building Area: Low hazard, Category III structure

6) Glass Waste Storage Building - Office/Vault Vent: A general use facility, Category III structure

7) Service Building: A general use facility, Category III structure

8) Administrative Building: A general use facility, Category III structure

9) Exhaust Stack: A low hazard facility, Category III structure

10) Auxiliary Pump Pit: A high hazard facility, consisting of a below grade concrete pit with covers, a steel superstructure, and a building to house the ventilation system, Category I structure

11) Low Point Pump Pit: A high hazard below grade facility, Category I structure

12) Failed Equipment Storage Vault - Vault: A low hazard facility, but Category I structure

13) Organic Waste Storage Tank: A moderate hazard facility, designed as Category III structure

14) Chemical and Industrial Waste Treatment: A high hazard facility, designed as Category III structure

15) Bulk Frit Storage Facility: A general use building, designed as Category III structure

16) Cold Chemical Feed Storage Facility: A high hazard facility, designed as Category I structure

The facility complex is essentially 100% complete. Testing using water rather than waste, began in September, 1990. Cold-chemical-run testing, in which the entire DWPF process is tested using non-radioactive simulated waste, was conducted successfully on April, 1993.

Waste qualification testing, which will verify that the process is fully capable of meeting US DOE technical requirements specified for canistered glass waste product, is scheduled to start in November, 1993.

After certification that the DWPF process is fully capable of control of operations and production of a high quality product meeting all federal, state, and environmental requirements, initial radioactive operation will begin. This is scheduled for June, 1994. (These dates are subject to change).

The structural design criteria for the facility consists of three major areas: earthquake, wind and tornado and flooding. The following is a description of the of these design criteria as they apply the DWPF.

EARTHQUAKE

The DWPF seismic design criteria were developed by Blume and Associates, and were based on site-specific studies. These criteria were reviewed and approved by an independent panel of experts. Table 1-1 below summarizes the Blume Seismic Criteria for the design-basis earthquake(DBE).

TABLE 1-1 **Blume Seismic Criteria for DBE**

TYPE OF ANALYSIS	DYNAMIC
Controlling earthquake	Charleston
Site-modified Mercalli intensity (MMI)	VII
Intensity - Acceleration Relationship	Murphy and O'Brian
Peak Ground Acceleration (PGA)	0.2 g CDBE
Return period (Annual Probability of Exceedance, 2×10^{-4})	5000 years
Response Spectra	Blume Site - Specific
Allowable Damping (NRC Reg Guide 1.61)	
Welded steel structures and pre-stressed concrete	3%
Bolted steel structures and reinforced concrete	7%
Equipment and piping	5%
Floor Response Spectra, see Figure 1, 2	NRC Methodology
Soil - Structure Interaction (SSI)	NRC Methodology

There are three levels of earthquakes identified for DWPF, and these levels are used to design the DWPF systems, structures, and components. The three levels considered in the design of the DWPF are: design-basis earthquake, investment-protection earthquake and uniform building code. These levels are described in Table 1-2 below:

TABLE 1-2 **EARTHQUAKE DEFINITION FOR DWPF**

EARTHQUAKE DEFINITION FOR DWPF	
Design-Basis Earthquake (DBE)	The DBE is the most severe seismic event considered credible at the SRS and represents the design basis seismic accident for safe analysis purpose. Following a DBE, the health and safety of the public must be protected, but there is no requirement that DWPF be capable of resuming operation.
Investment-Protection Earthquake (IPE)	The IPE has a lower 'g' level and higher probability of occurrence than the DBE. Following an earthquake at the IPE level, damage to equipment would be expected and operations would be shut down. However, no damage that would prevent the DWPF from being restored (following repairs, cleanup, etc.) should occur as a result of an IPE.
Uniform Building Code (UBC) - 1979	The UBC earthquake provisions are used for all systems, structures, and components not designed to meet PBE and/or IPE requirements.

The structures, systems, and components are classified as follows:

CATEGORY I (Maximum Resistance) These are structures, systems, and components that by virtue of either the client's direction or the safety assessment process, must withstand the effects of both design-basis earthquake and design-basis tornado loads.

CATEGORY II (Intermediate Resistance) These are structures, systems, and components that are not Category I, but whose failure could endanger a Category I structure, system, or component. Adequate structure separation is provided to ensure that the detrimental interaction with a Category I structure does not occur, or an analysis is performed to show that the failure of a Category II structure will not prevent the Category I structure from performing its safety function.

CATEGORY III (Standard Resistance) This is structure, system, or component that is not classified as a Category I or II and is designed in accordance with the provisions of conventional codes (1979 - UBC).

DBE For facilities required to be designed to withstand this level of earthquake, the seismic loads are based on a maximum ground acceleration of 0.2 g in the horizontal direction and 0.67 x 0.2 g in the vertical direction.
The seismic design of DBE-resistance structures and components is based on elastic dynamic analysis. Time history, response spectra, and soil structure interaction (SSI) are considered as appropriate in the design.

WIND AND TORNADO

Category I and II facilities are designed for extreme winds and tornado loads (including the tornado generated missiles) in accordance with design criteria DDI-02. The tornado design basis given in the DDI-02 is based on the tornado wind-speed risk model developed by the institute of disaster Research and Department of Civil Engineering, Texas Tech University. The risk model was developed using statistical analysis of records of tornadoes that occurred in the region surrounding the Savannah River Site. Common frequency statistics used for these natural phenomena hazards include a return period and an annual probability of exceedance of 2×10^{-7}. Time of occurrence, intensity, initial touch down point, path length, and path width were also used in the analysis.

However, Category III facilities are designed for extreme wind loads in accordance with ANSI A58.1-1982. The effective velocity pressure, q_z (psf), at any height Z (ft) above ground is based on ANSI A58.1-1982 using the following equation:

$$q_z = 0.00256\, K_z\, (IV)^2$$

Where:

K_Z = velocity pressure coefficient at height z and exposure C (as given in Table 6 of ANSI A58.1-1982)

I = Importance factor (1107) for winds and 1.0 for tornadoes as given in Table 5 of ANSI A58.2-1982)

V = Basic wind velocity (100 mph for winds and 280 mph for tornado)

Therefore, the effective velocity pressure at SRS for the DWPF is

q_Z = 29.3 x K_Z (for Category III facilities based on straight winds)

q_Z = 200.70 x k_Z (for Category I and II facilities based on tornado)

Category I and II facilities are also designed to withstand impacts of tornado missiles where applicable. The tornado-generated missiles used for the design of the DWPF structures are listed in Table 1-3.

TABLE 1-3 TORNADO-GENERATED MISSILES

Missile	Weight (lbs)	Maximum Protected Area (Ft^2)	Minimum Cross Section Area (Ft^2)	Horizontal Velocity (MPH)	Vertical Velocity (MPH)	Maximum Height (Ft)
Timber Plank 4" x 12" x 12'	139	11.50	0.29	115	77	200
Standard Steel Pipe 3" DIA x 10;	75.8	2.92	0.0155	100	67	100
Utility Pole 13.5" DIA x 35'	1490	39.4	0.99	95	64	30
Automobile	4000	100.0	20.0	40	27	30

FLOOD DESIGN CRITERIA

At the DWPF, there is no free-water surface elevation associated with probable maximum flooding, seismic dam breaks, surge of seiche, ice jam formation or other events that could approach minimum plant grade. This is also true when coincident wind and associated waves are assumed. Therefore, there are no flood elevations that govern the structural design in regard to buoyancy and static water force.

RESULTS

The technical merit of this unique design is that it is a shielded cell-type structure.

- It provides isolation of process equipment from operating personnel.

- Environmental and public in two parallel shielded cells.

- Cells may be dimensioned for a single row of process vessels.

- Each facility is equipped with cranes for handling and transfer of high radioactive waste in order to make a connection between the process equipment and operating personnel.

CONCLUSION

- The structural design provides assurance for the full containment of high-level radioactive waste above the ground.

- The facility is capable of withstanding the impacts of Natural Phenomena Hazards (NPH) without adverse effects to environment and public health.

- The unique process developed is state-of-the-art. The process flow diagram attached explains the silent features of the vitrification process.

REFERENCES

1. DDI-02 *Detailed Design Instructions for Structural Design for the Defense Waste Processing Facility.*
2. DOE Order 6430.1A *"General Design Criteria"*, April 6, 1989
3. UCRL - 15910 *"Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards.*
4. ANSI A58.1 - 1982 *American National Standard, Minimum Design loads for Building and Other Structures.*
5. UCRL - 53 526 Rev. 1 *Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Engergy Sites.*

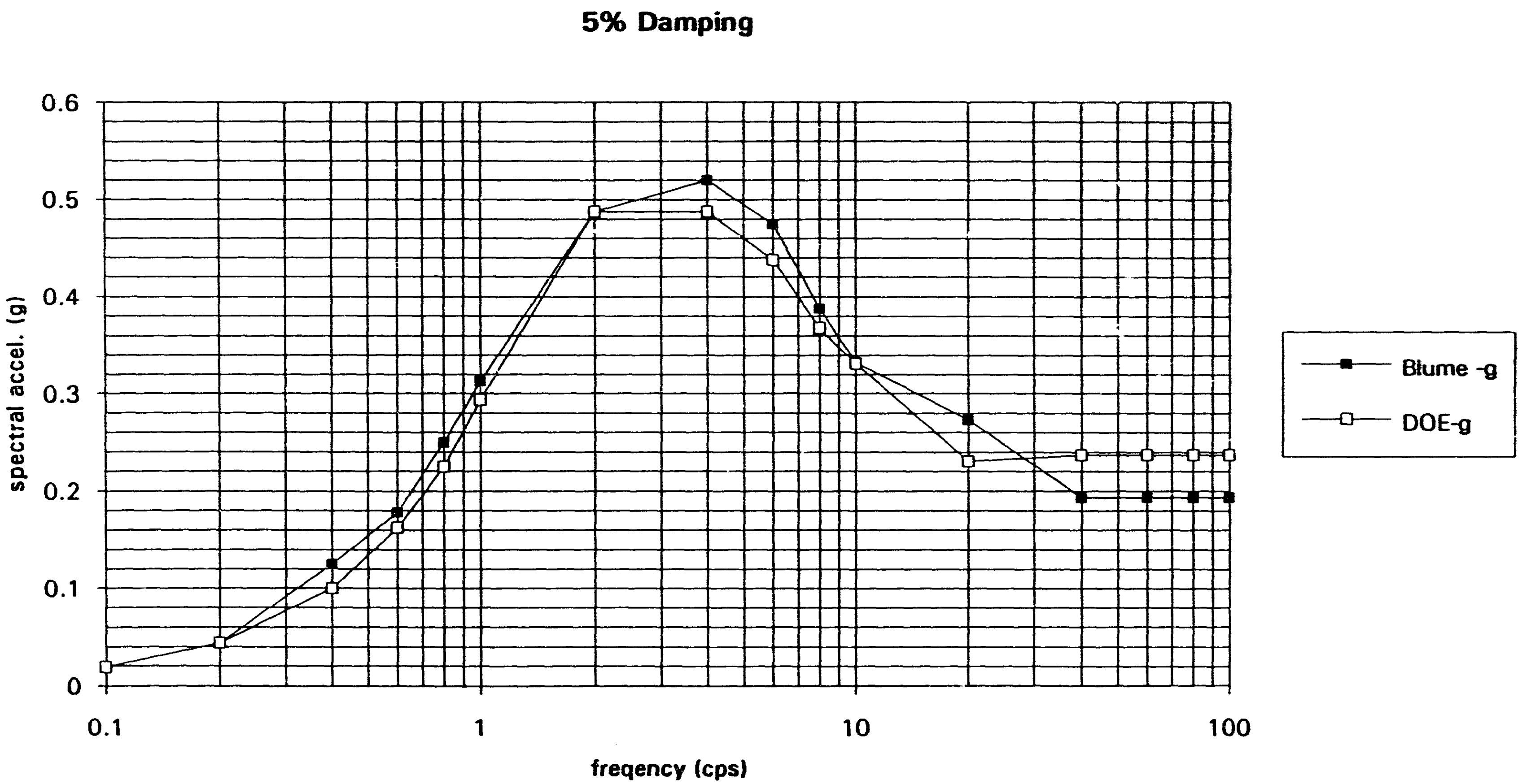

5% Damping
0.6
0.5
0.4
0.3
0.2
0.1
0
spectral accel. (g)
0.1
1
10
100
freqency (cps)
Blume -g
DOE-g

FIGURE - 1

7% Damping

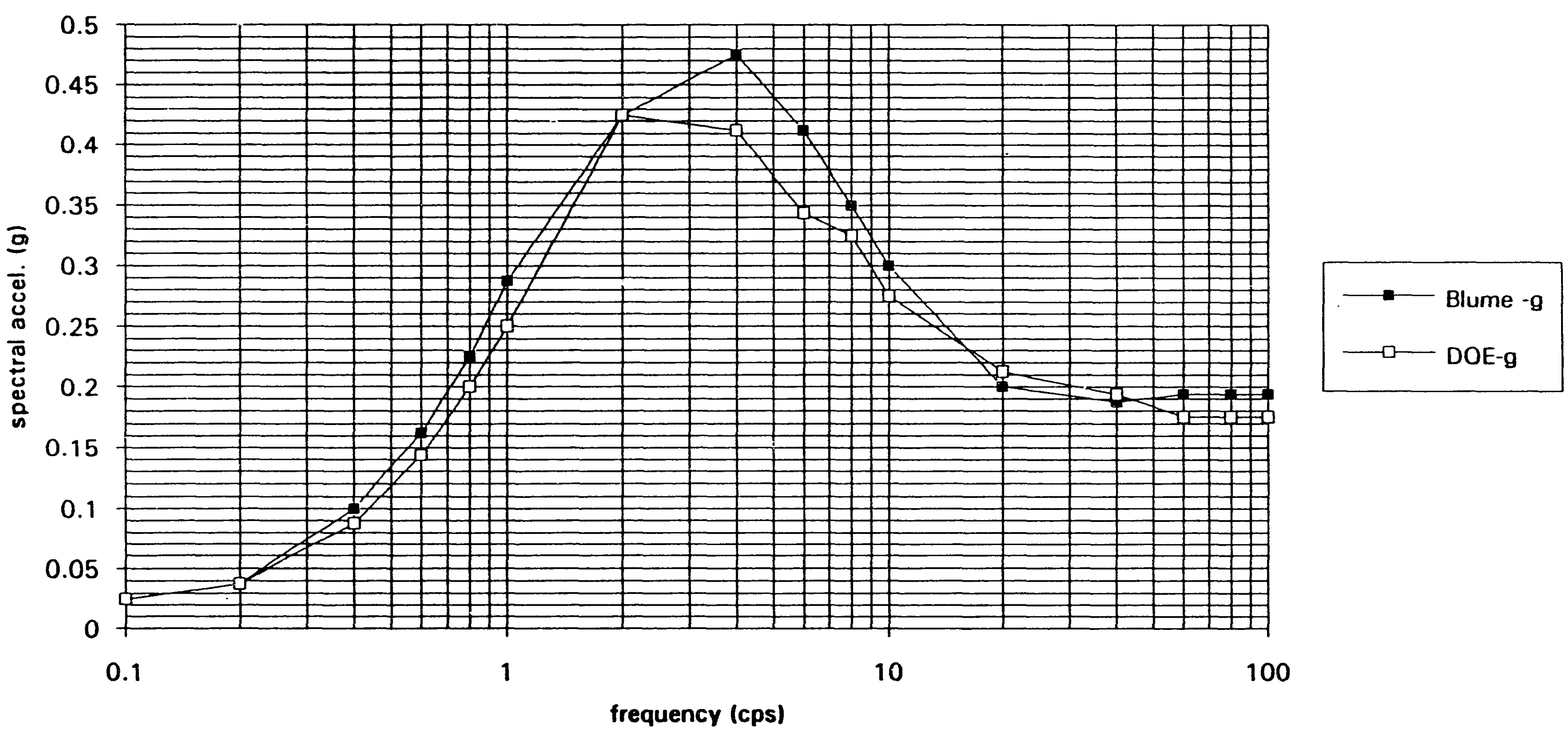
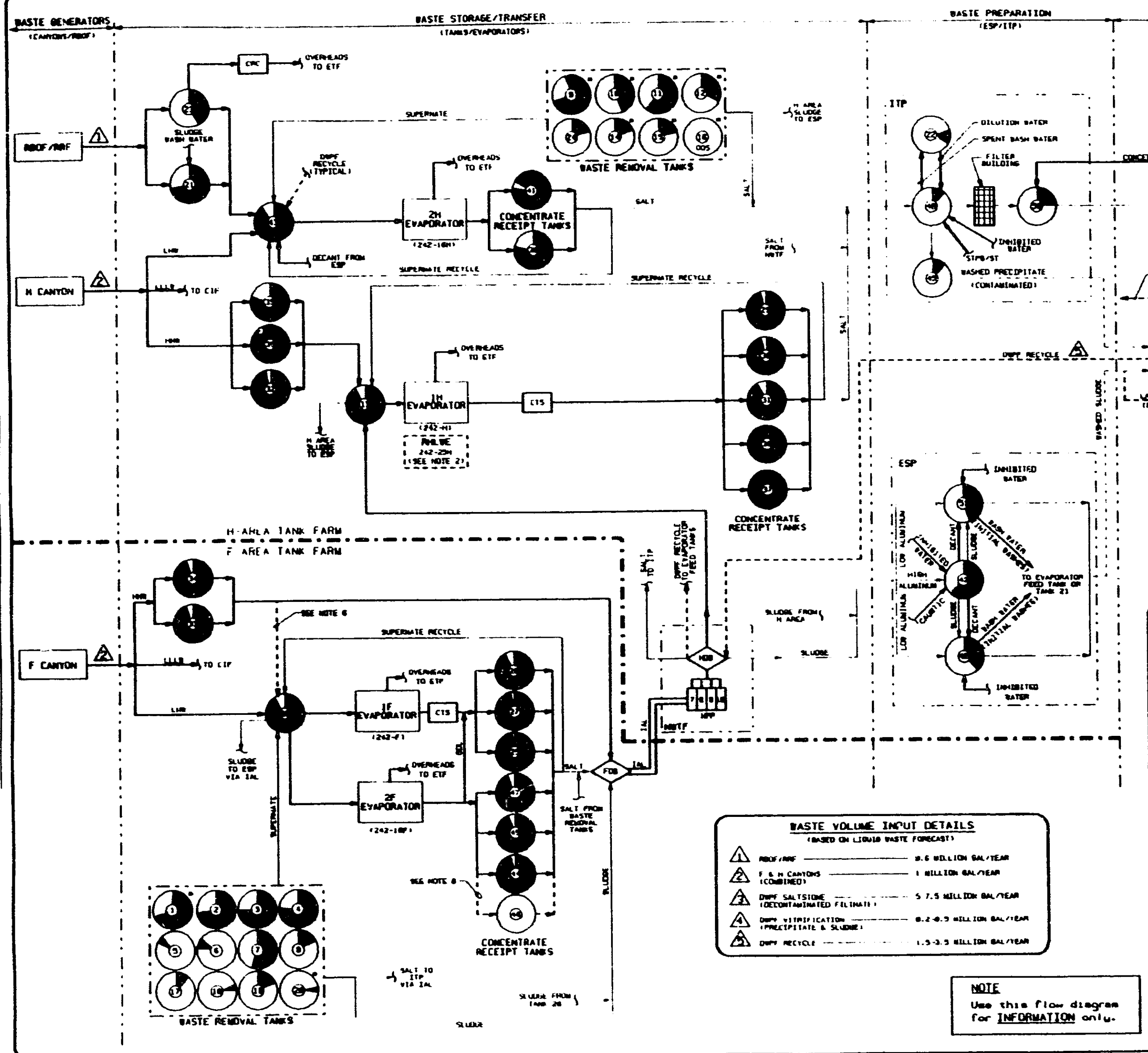


FIGURE-2

Page



WASTE VOLUME INPUT DETAILS

(BASED ON LIQUID WASTE FORECAST)

1	RBOF/RRF	0.6 MILLION GAL/YEAR
2	F & H CANYONS (COMBINED)	1 MILLION GAL/YEAR
3	DWPF SALTSTONE (DECONTAMINATED FILTRATE)	5 7.5 MILLION GAL/YEAR
4	DWPF VITRIFICATION (PRECIPITATE & SLUDGE)	0.2-0.5 MILLION GAL/YEAR
5	DWPF RECYCLE	1.5-3.5 MILLION GAL/YEAR

NOTE

Use this flow diagram for INFORMATION only.

LEGEND

- CIF CONSOLIDATED INCINERATION FACILITY
- CRC CESIUM REMOVAL COLUMNS
- CTS CONCENTRATE TRANSFER SYSTEM
- DWPF DEFENSE WASTE PROCESSING FACILITY
- ESP EXTENDED SLUDGE PROCESSING
- FDB F AREA DIVERSION BOX
- GDL GRAVITY DRAIN LINE
- HDB H AREA DIVERSION BOX
- HHW HIGH HEAT WASTE
- HPP PUMP PIT (H AREA)
- IAL INTER-AREA LINE
- ITP IN TANK PRECIPITATION
- LHW LOW HEAT WASTE
- LLLW LIQUID LOW LEVEL WASTE
- NWTF NEW WASTE TRANSFER FACILITY
- OOS OUT OF SERVICE
- RBOF RECEIVING BASIN FOR OFFSITE FUEL
- RHLWE REPLACEMENT HIGH LEVEL WASTE EVAPORATOR
- RRF RESIN REGENERATION FACILITY
- ST SODIUM TITANATE
- STPB SODIUM TETRA PHENYL BORATE

TANK FARMS

TYPE OF TANK	TANK NO.S	AREA
TYPE I TANK (720,000 GALLONS)	1-8	F AREA
	9-12	H AREA
TYPE II TANK (1,030,000 GALLONS)	13-16	H AREA
TYPE III TANK (1,300,000 GALLONS)	25-28	F AREA
	29-32	H AREA
	33-34	F AREA
	35-43	H AREA
	44-47	F AREA
	48-51	H AREA
TYPE IV TANK (1,300,000 GALLONS)	17-20	F AREA
	21-24	H AREA

* TANKS WITH CRACKS

GENERAL NOTES

1. DOTTED LINE SHOWS FACILITY OR PROCESSES CURRENTLY NOT IN OPERATION.
2. WHEN REPLACEMENT HIGH LEVEL WASTE EVAPORATOR IS PLACED IN SERVICE, TANK 32 WILL BECOME THE FEED TANK AND 1H EVAPORATOR AND TANK 13 WILL BE TAKEN OUT OF SERVICE. FURTHER, TANKS 35 AND 36 WILL SWITCH FUNCTIONS.
3. IT IS WASTE MANAGEMENT'S OBJECTIVE TO EMPTY ALL TYPE I, II, & IV TANKS AND REMOVE THEM OUT OF SERVICE AS EARLY AS POSSIBLE.
4. THERE ARE MANY DIVERSION BOXES NOT SHOWN HERE WHICH HELP TO ROUTE WASTE TO VARIOUS TANKS TO COPE WITH THE LEVEL AND TYPE OF WASTE IN THE TANKS.
5. WASTE CONTENTS ARE SHOWN BY COLORED SEGMENTS PROPORTIONAL FOR EACH TANK ACCORDING TO ITS INDIVIDUAL OPERATING LIMIT EXCEPT FOR WASTE REMOVAL TANKS (TANKS 1-12, 14-20, AND 24) WHICH ARE SHOWN ACCORDING TO THEIR MAXIMUM FILL LIMITS. THE DATA DATE IS DECEMBER 31, 1992. BASED ON LIQUID WASTE FORECAST WSRC-RP-92-1304. THE CONTENTS ARE COLOR MATCHED AS SHOWN BELOW.

EMPTY — SALT — SLUDGE — SUPERNATE — TANK NUMBER

6. F-AREA WILL BE PROCESSING HIGH HEAT WASTE IN THE FUTURE.

LIQUID WASTE PROCESSING FLOW DIAGRAM

DATE: JANUARY 4, 1993

PREPARED BY: ASOKA P. PILLAI

DRAWN BY: KAREN A. BARLEY

DATE FILMED

4/7/94

END