

**U.S. DEPARTMENT OF ENERGY  
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT**

**PRESENTATION TO  
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD**

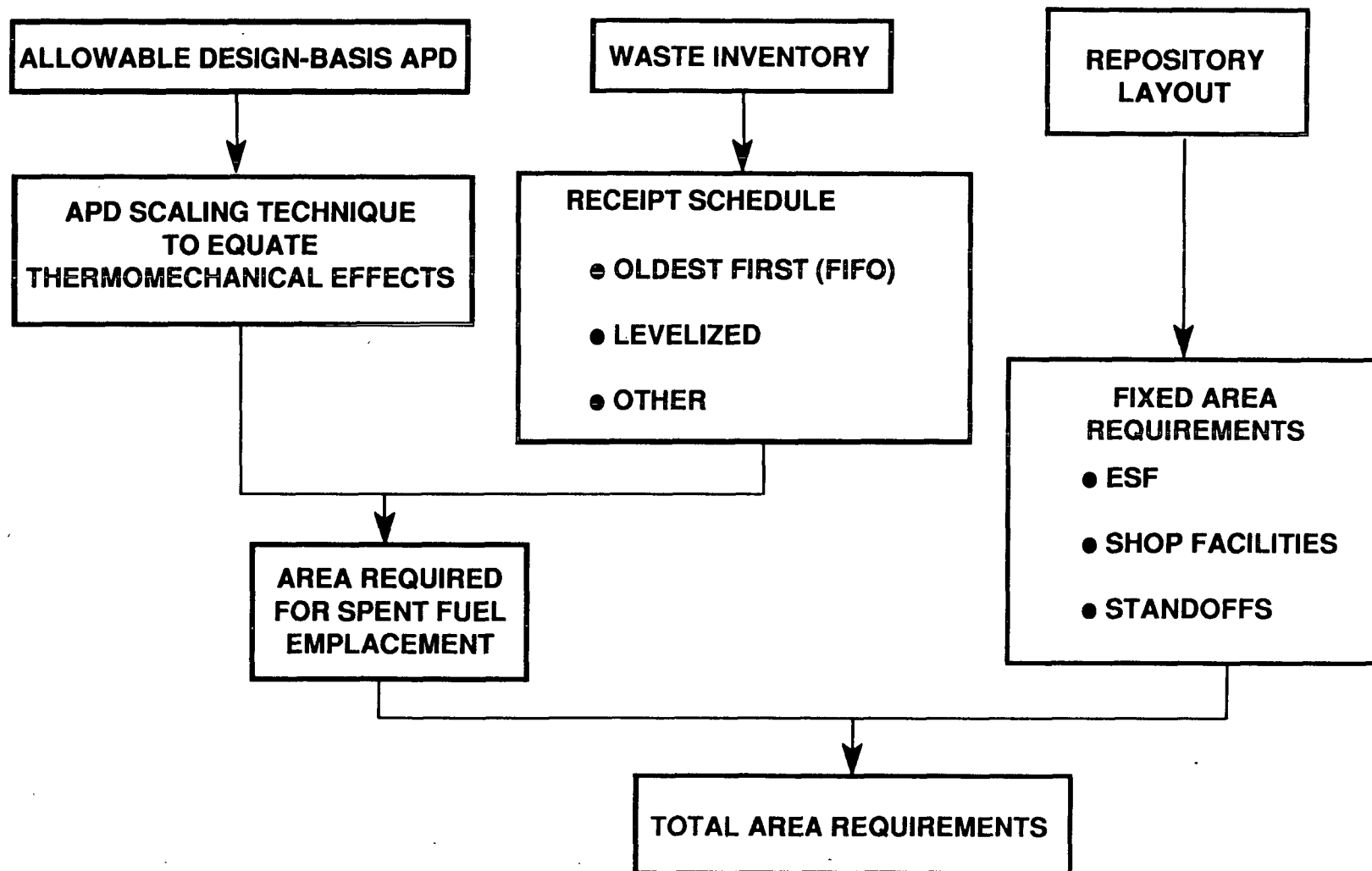
**SUBJECT: DESIGN APPROACH - WASTE  
CHARACTERISTICS & INVENTORY,  
AREAL POWER DENSITY, AND  
LAYOUT DEVELOPMENT**

**PRESENTER: ERIC E. RYDER**

**PRESENTER'S TITLE  
AND ORGANIZATION: TECHNICAL STAFF, GEOMECHANICAL ANALYSIS AND  
TESTING DIVISION  
SANDIA NATIONAL LABORATORIES  
ALBUQUERQUE, NEW MEXICO**

**MARCH 19-20, 1990**

# DETERMINATION OF AREA AND LAYOUT REQUIREMENTS



# ORNL CHARACTERISTICS DATABASE

## ASSEMBLIES DATABASE

- PHYSICAL DESCRIPTION OF INTACT FUEL ASSEMBLIES
- PHYSICAL DESCRIPTION OF SPENT FUEL DISASSEMBLY HARDWARE
- RADIOLOGICAL DESCRIPTIONS OF SPENT FUEL DISASSEMBLY HARDWARE

## NON-FUEL ASSEMBLY HARDWARE DATABASE

- PHYSICAL DESCRIPTION OF NFA HARDWARE
- IDENTIFICATION OF TYPES OF FUEL ASSEMBLIES WHICH UTILIZE THE HARDWARE
- IDENTIFICATION OF REACTORS WHERE HARDWARE IS USED
- RADIOLOGICAL DESCRIPTION OF DISCHARGED NFA HARDWARE

## HIGH LEVEL WASTE DATABASE

- PHYSICAL , CHEMICAL, AND RADIOLOGICAL PROPERTIES OF HIGH LEVEL WASTE

# ORNL CHARACTERISTICS DATABASE

(CONTINUED)

## RADIOLOGICAL DATABASE

- DATA ABOUT RADIONUCLIDES AT DIFFERENT BURNUPS AND DECAY TIMES
- ADDITIONS COVERING:
  - CALCULATED INTEGRATED HEAT RELEASE
  - PHOTON AND NEUTRON DATA

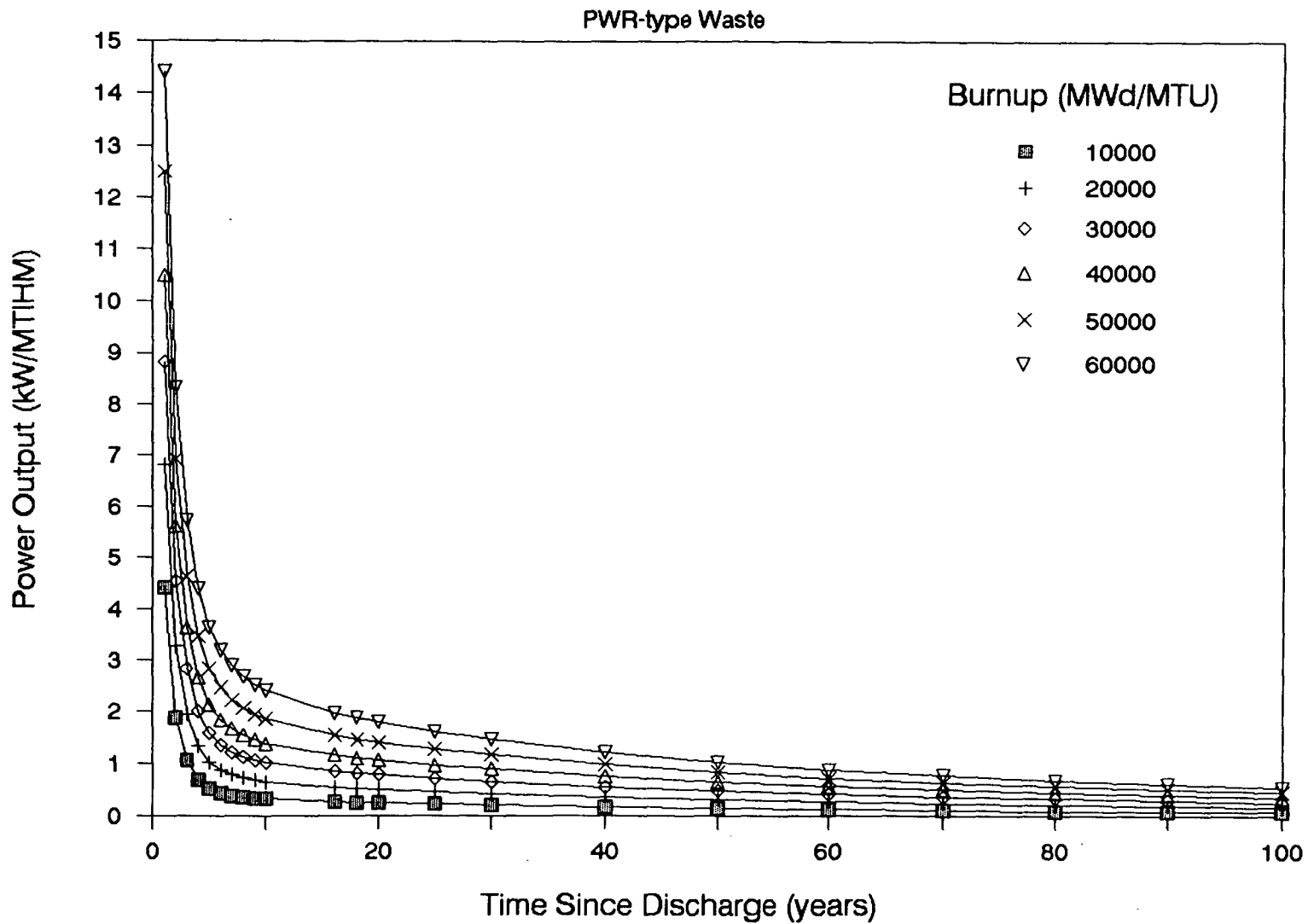
## QUANTITIES DATABASE

- QUANTITIES OF LWR SPENT FUEL ASSEMBLIES
- INCLUDES BOTH HISTORICAL AND PROJECTED DATA THROUGH 2037
- DATA TAKEN DIRECTLY FROM OFFICIAL INFORMATION PROVIDED BY THE ENERGY INFORMATION ADMINISTRATION AND PACIFIC NORTHWEST LABORATORIES

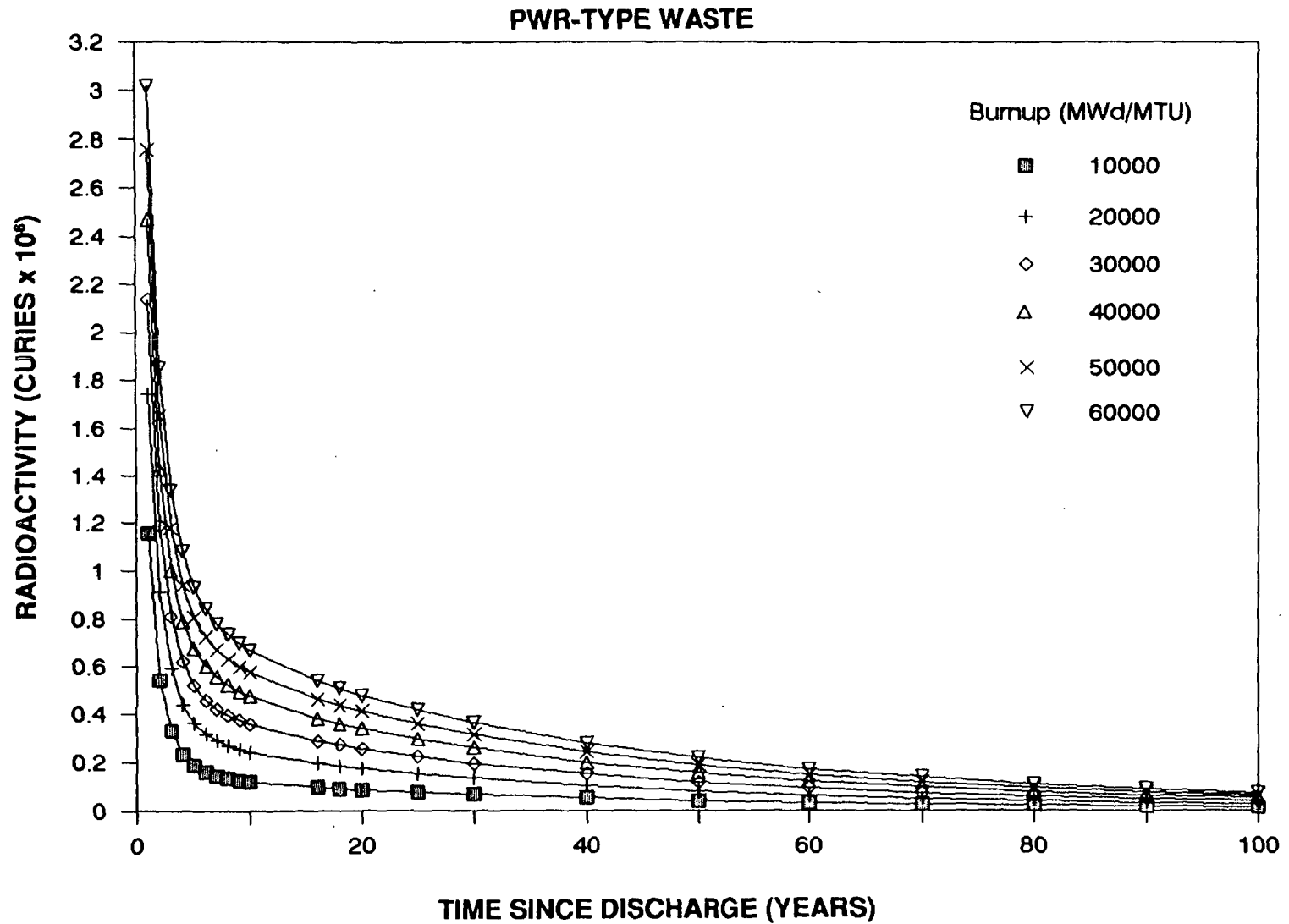
# TOTALS AND CALCULATED INTEGRAL HEAT RELEASE DATABASE SYSTEM

- PROVIDES DATA ON THE TOTAL RADIOACTIVITY (CURIES) AND HEAT OUTPUT (WATTS) FROM LWR SPENT FUEL AS A FUNCTION OF TIME AFTER DISCHARGE FROM THE REACTOR
- ORIGEN CODE USED IN CALCULATIONS
  - ORIGEN2 CODE PERFORMS TWO MAJOR COMPUTATIONAL FUNCTIONS, ISOTOPE GENERATION AND ISOTOPE DEPLETION, BOTH WITHIN THE CORE OF AN OPERATING REACTOR AND AFTER SHUTDOWN
- CALCULATIONS ARE BASED ON ONE MTIHM

# THERMAL DECAY CHARACTERISTICS



# RADIOLOGICAL CURVE

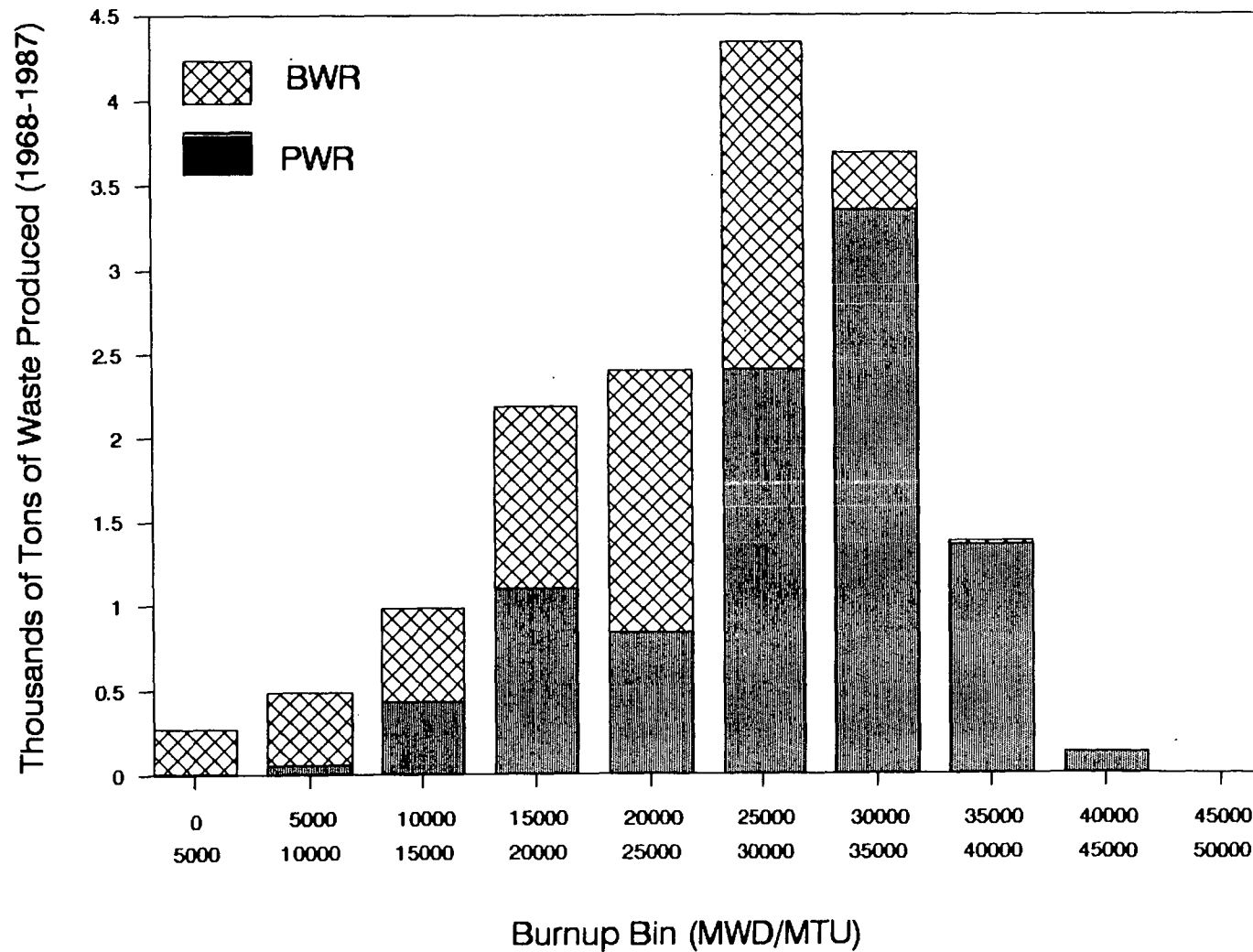


# **ORNL HISTORICAL AND PROJECTED WASTE INVENTORIES**

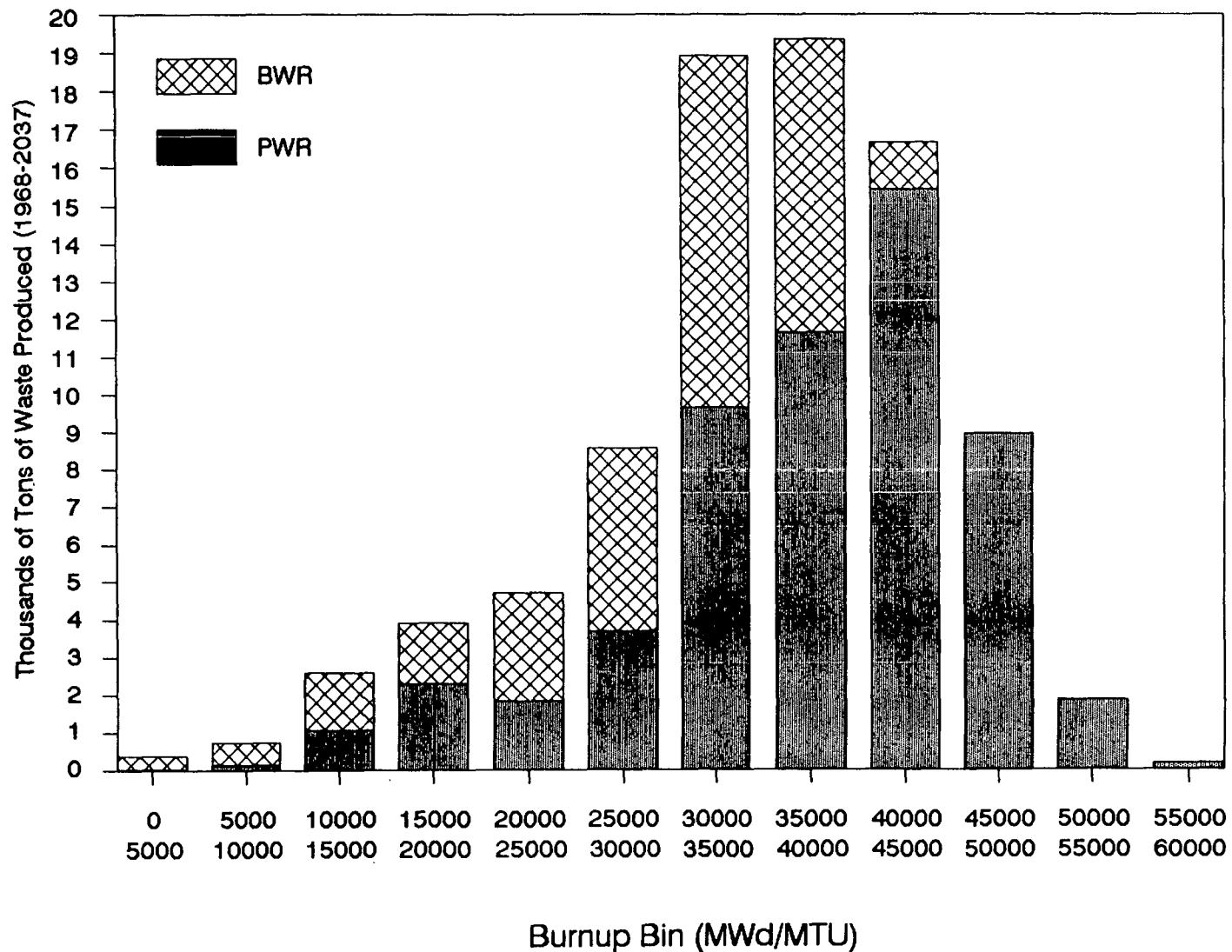
- **HISTORICAL INVENTORY (1968 THROUGH 1987) REPRESENTS APPROXIMATELY 16,000 TONS OF WASTE**
- **THE ONLY INVENTORY PROJECTION SCENARIO INCLUDED IN THE ORNL CHARACTERISTICS DATABASE IS THE "NO NEW ORDERS-EXTENDED BURNUP" CASE**
- **BASED ON THE ORNL PROJECTIONS, AN INVENTORY OF 87,000 TONS OF WASTE WILL BE AVAILABLE AT THE END OF DISCHARGE YEAR 2037**



# ORNL HISTORICAL WASTE INVENTORY (1968-1987)



# ORNL HISTORICAL AND PROJECTED WASTE INVENTORY (1968-2037)

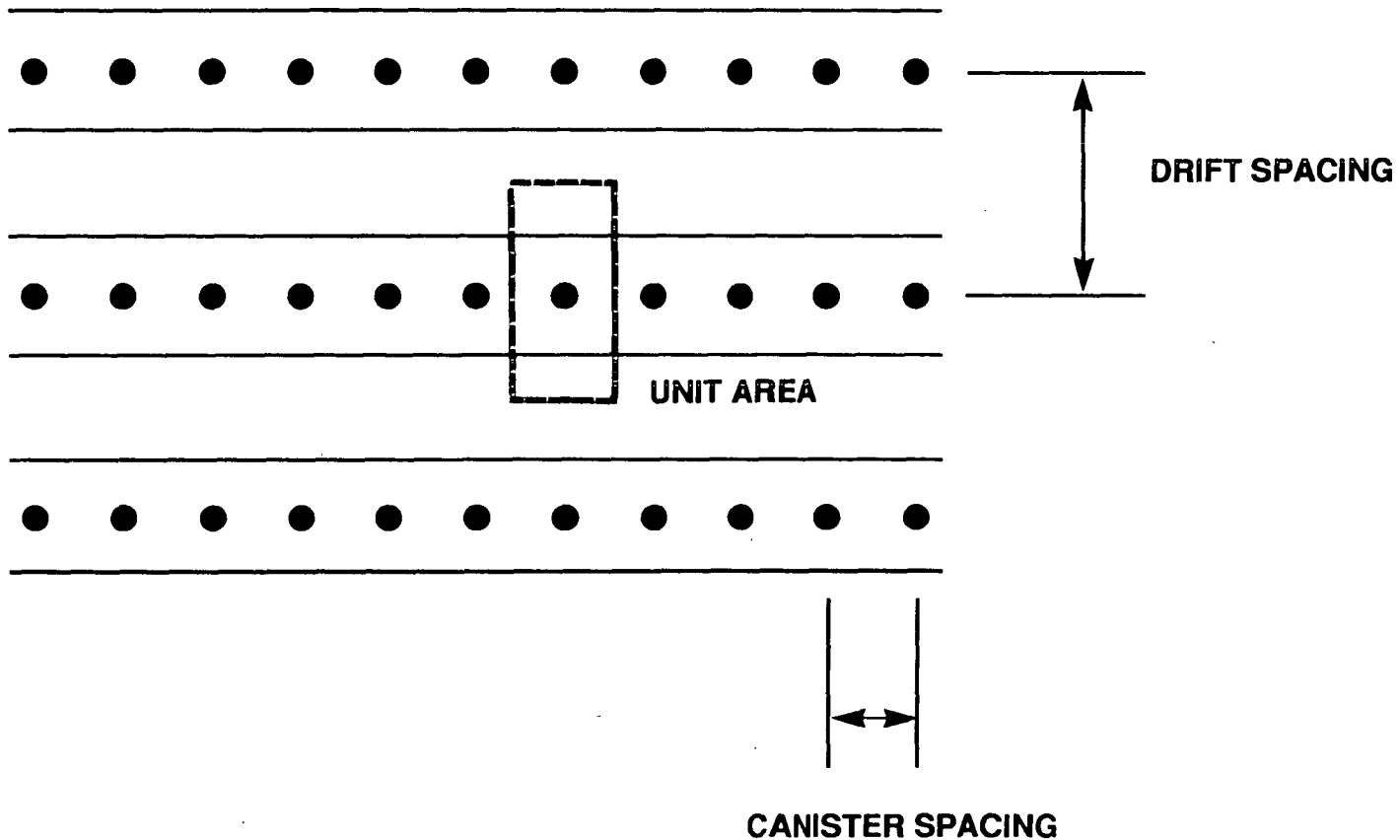


# ORNL CHARACTERISTICS DATABASE

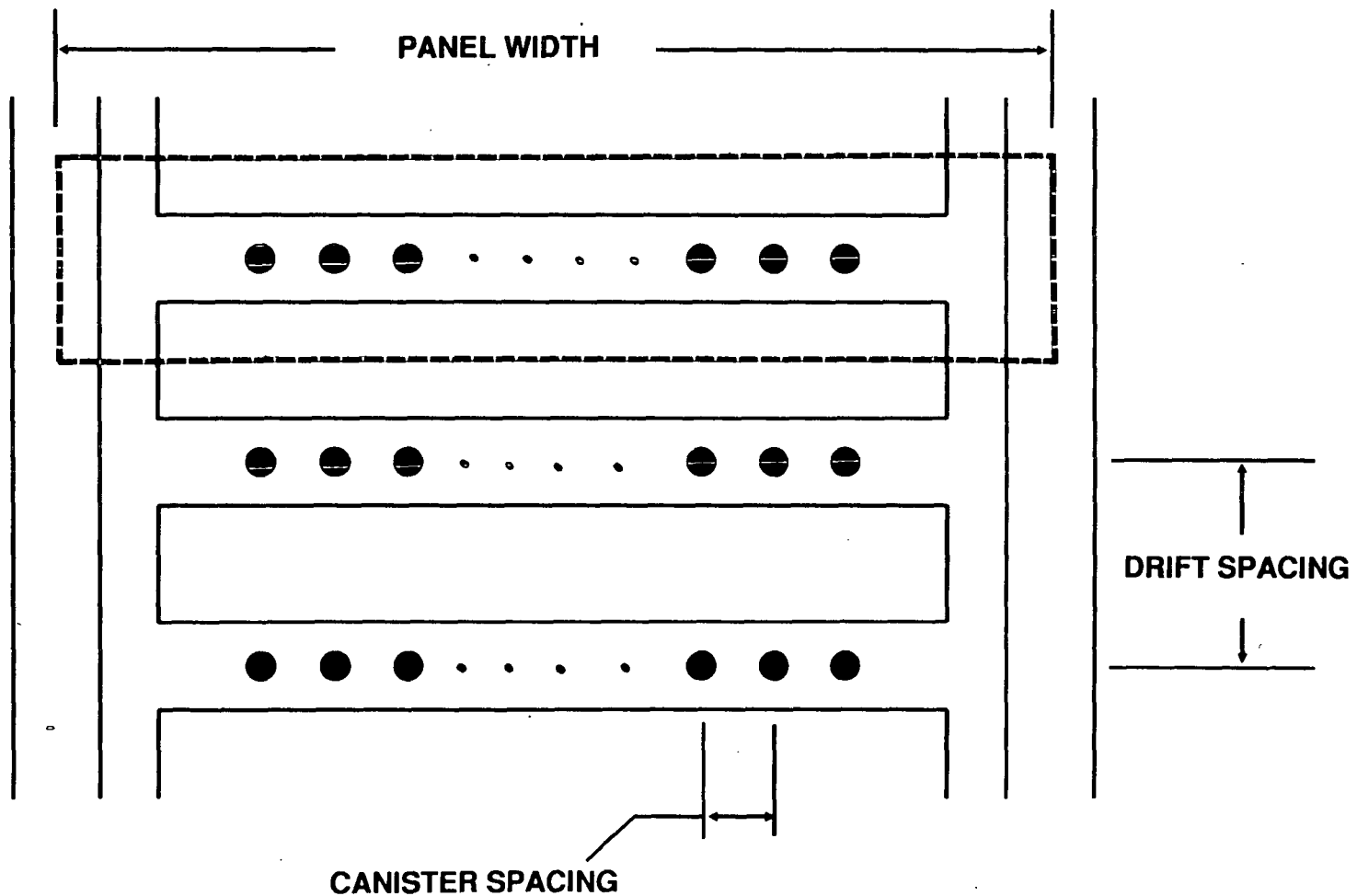
## SUMMARY

- **PHYSICAL DESCRIPTION INFORMATION PROVIDED BY FUEL ASSEMBLY MANUFACTURER**
- **RADIOLOGICAL DESCRIPTIONS ESTIMATED USING ORIGEN2 COMPUTER CODE BASED ON MANUFACTURER SUPPLIED INFORMATION**
- **NEXT SCHEDULED UPDATE IN JULY 1990, THEREAFTER ON AN ANNUAL BASIS**
- **UNSCHEDULED UPDATES AS REQUIRED**

$$\text{LOCAL AREAL POWER DENSITY (LAPD)} = \frac{\text{INITIAL LOADING}}{\text{UNIT AREA}}$$



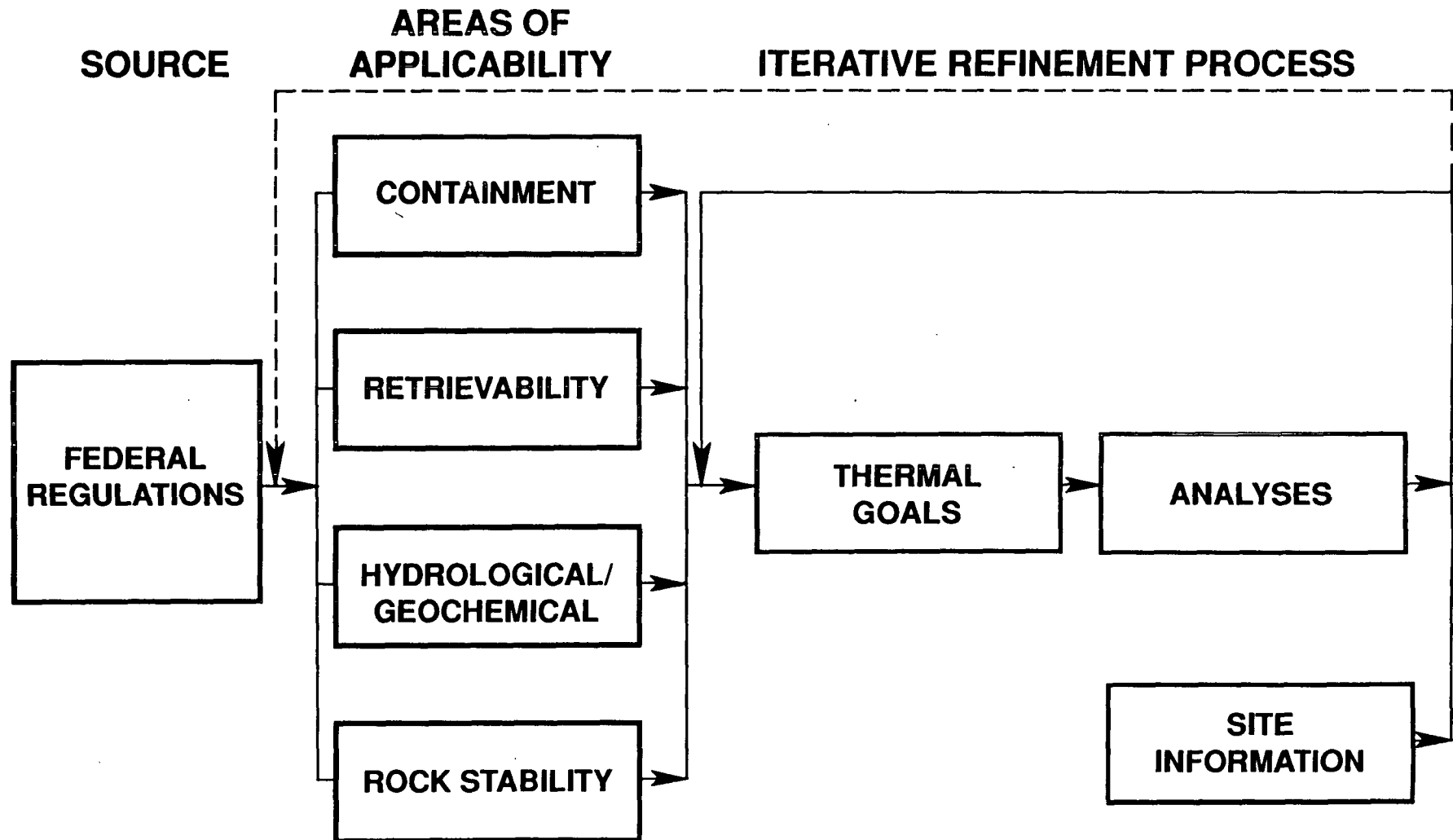
$$\text{AREAL POWER DENSITY (APD)} = \frac{\text{INITIAL LOADING}}{\text{UNIT AREA}}$$



# **AREAL POWER DENSITY (APD)**

- **HISTORICAL DESIGN-BASIS APD IS 57 kW/ACRE AS ESTABLISHED IN THE UNIT EVALUATION STUDY (JOHNSTONE ET AL., 1984)**
- **BASED ON WASTE CONCENTRATION THAT PRODUCED EMPLACEMENT DRIFT FLOOR TEMPERATURES ON THE ORDER OF 100° C**
- **BECAUSE OF CHANGES IN THE REPOSITORY VENTILATION DESIGN, THE 100° C EMPLACEMENT DRIFT FLOOR TEMPERATURE IS NO LONGER A CONSTRAINT**

# THERMAL DESIGN GOAL DEFINITION PROCESS



# SCP THERMAL GOALS

## PERFORMANCE MEASURE

## GOAL

CLADDING INTEGRITY

CONTAINER CENTERLINE  $T < 350^{\circ} \text{C}$   
BOREHOLE WALL  $T < 275^{\circ} \text{C}$

NEAR-FIELD ROCK MASS  
INTEGRITY

ONE METER FROM BOREHOLE  
 $T < 200^{\circ} \text{C}$

ACCESS DRIFT WALL  
TEMPERATURE

$T_{\text{wall}} < 50^{\circ} \text{C}$  FOR 50 YEARS

TEMPERATURE CHANGE IN  
ADJACENT STRATA

TSw2 - TSw3 INTERFACE  
 $T < 115^{\circ} \text{C}$

SURFACE ENVIRONMENT

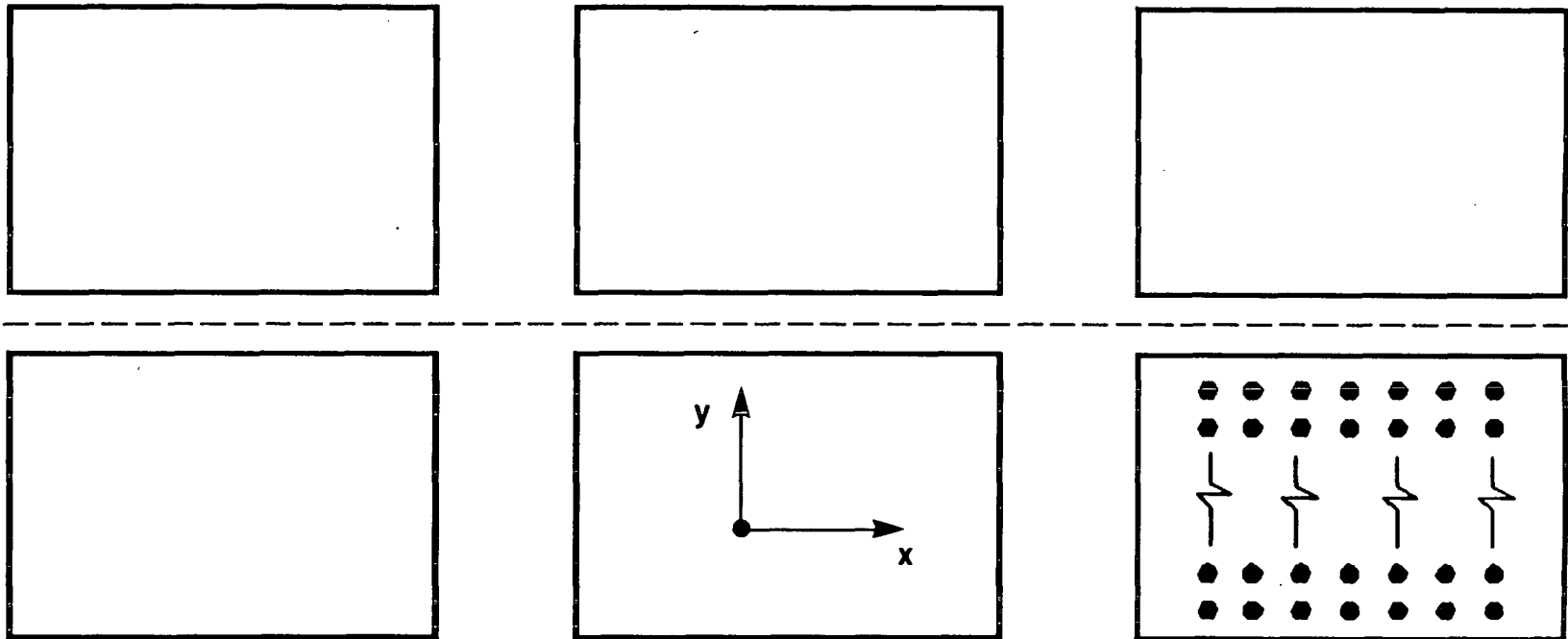
TEMPERATURE CHANGE  $< 6^{\circ} \text{C}$

LIMIT CORROSIVENESS OF  
CANISTER ENVIRONMENT

MAXIMIZE TIME SPENT ABOVE  
BOILING IN BOREHOLE  
ENVIRONMENT

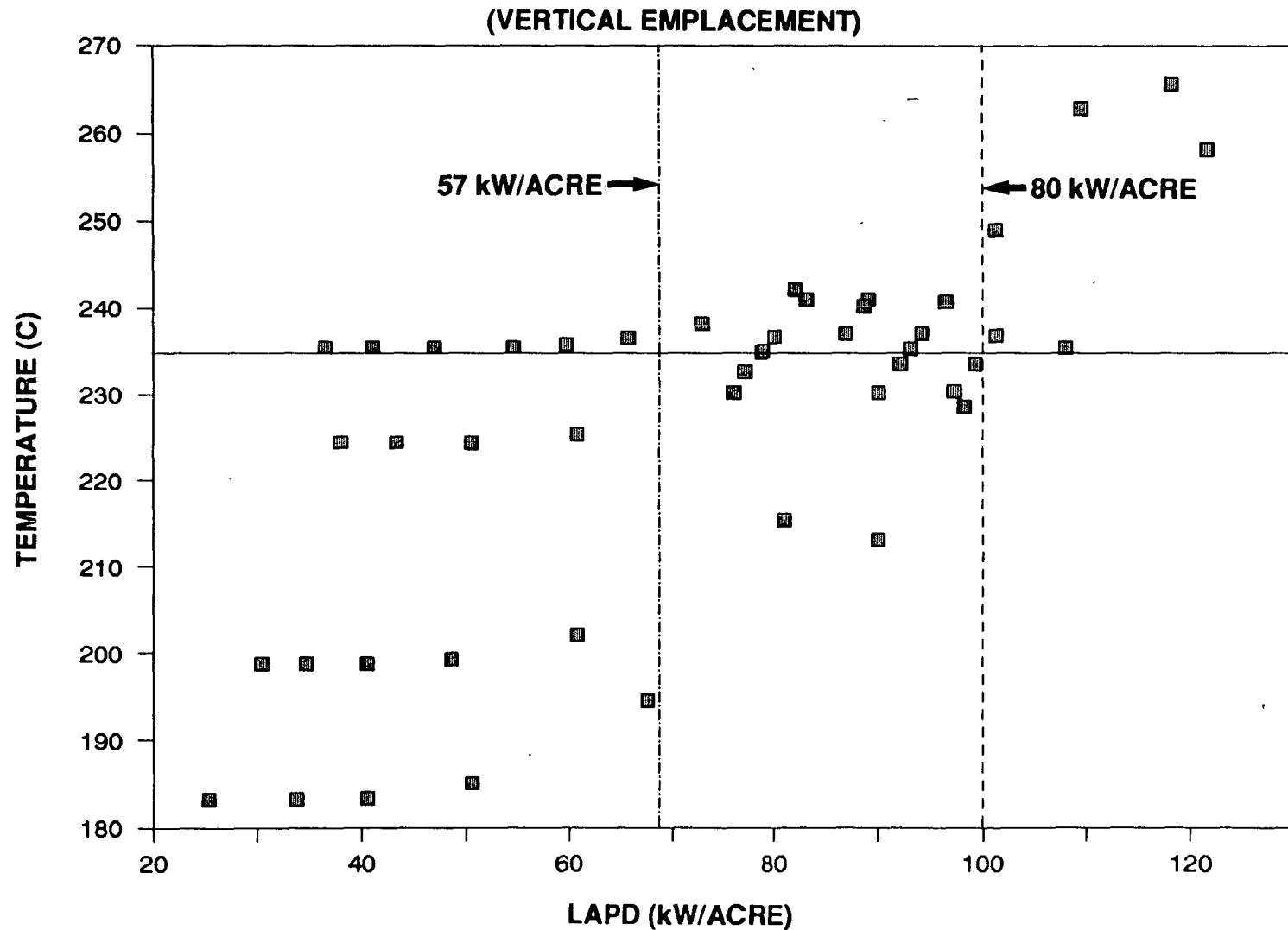


# REPOSITORY MODEL

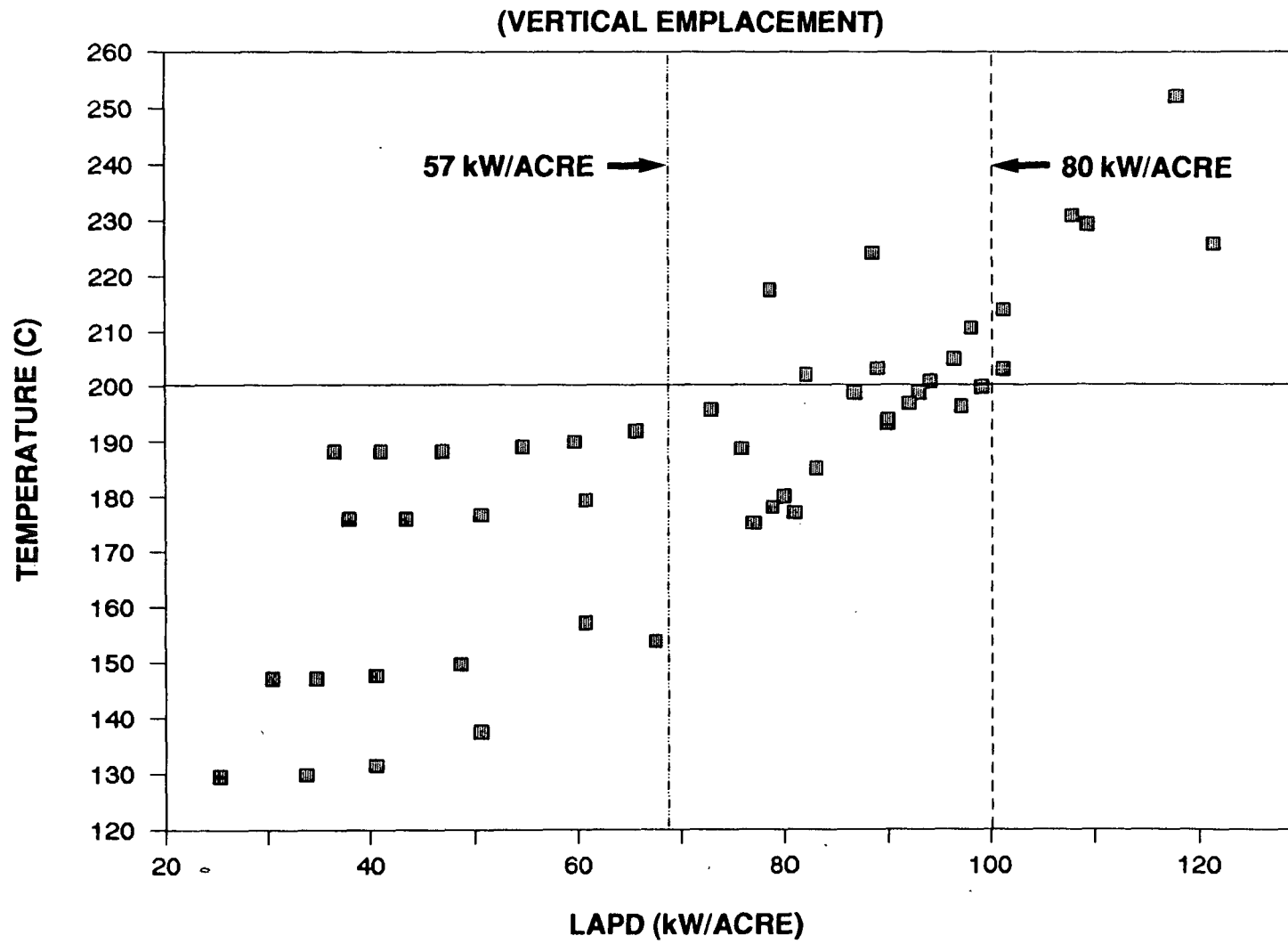


- **ANALYTICAL SOLUTION (3-D LINEAR SUPERPOSITION OF HEAT-GENERATING POINTS AND CYLINDERS)**
- **SIMPLIFIED SIX-PANEL GEOMETRY**
- **FUEL MODELED AS 60% PWR AND 40% BWR (HYBRID CANISTERS) ASSUMED TO BE TEN YEARS OUT-OF-REACTOR**
- **SIMULTANEOUS EMPLACEMENT**

# PEAK BOREHOLE WALL TEMPERATURE vs LAPD



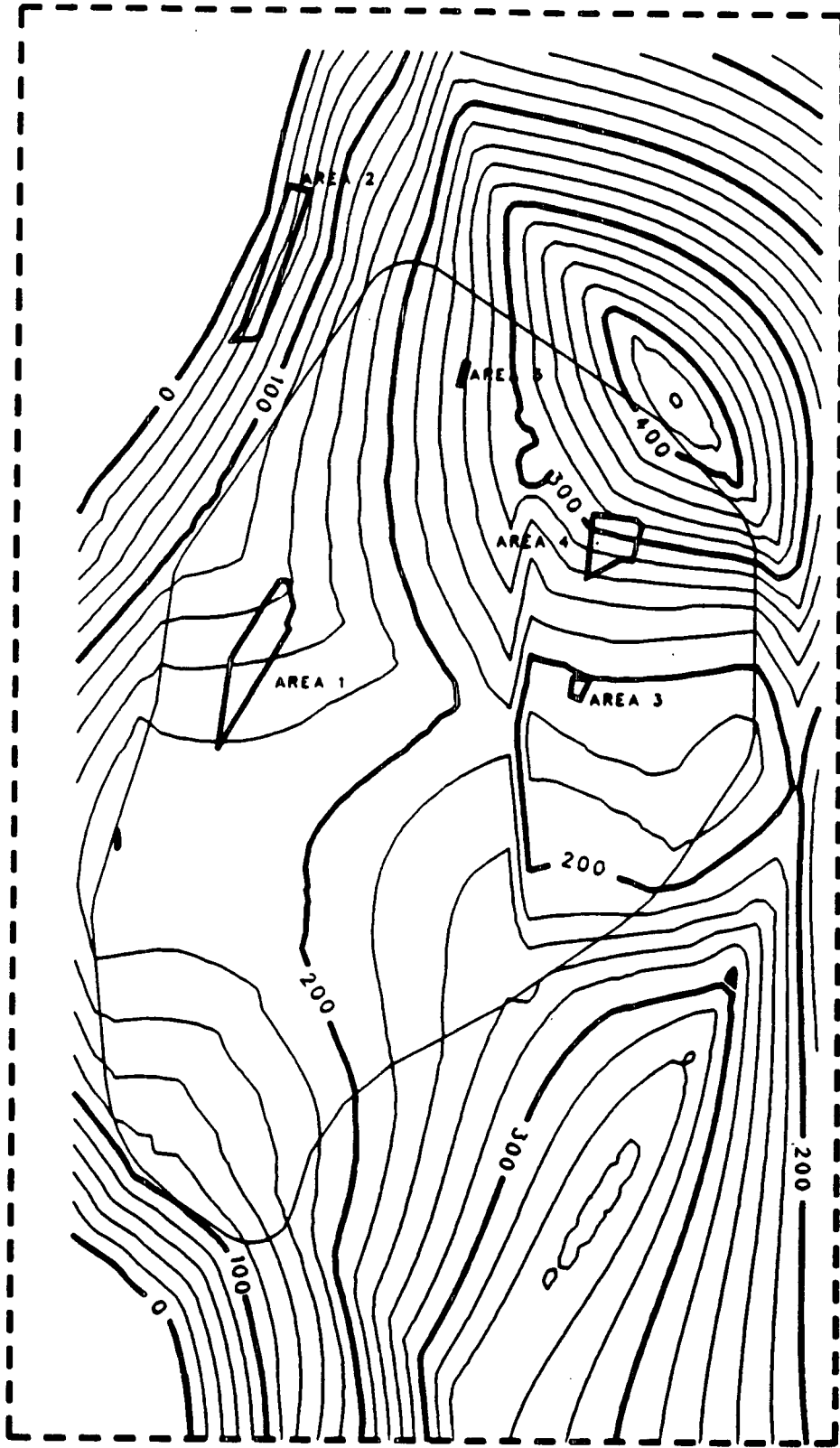
# PEAK ONE-METER TEMPERATURE vs LAPD



# TSw3 STANDOFF

N772500  
E556250

N772500  
E566250



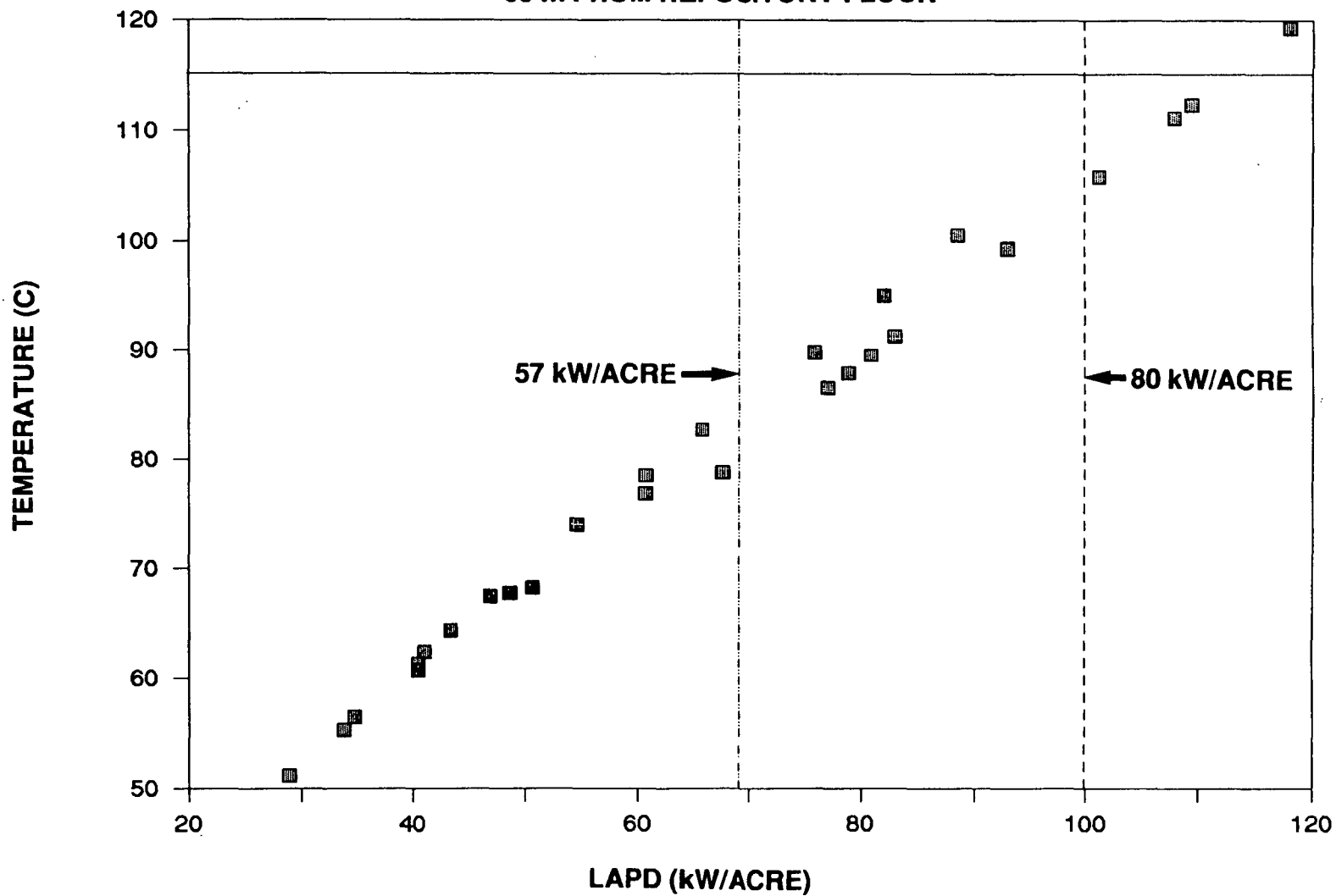
N755000  
E556250

N755000  
E566250

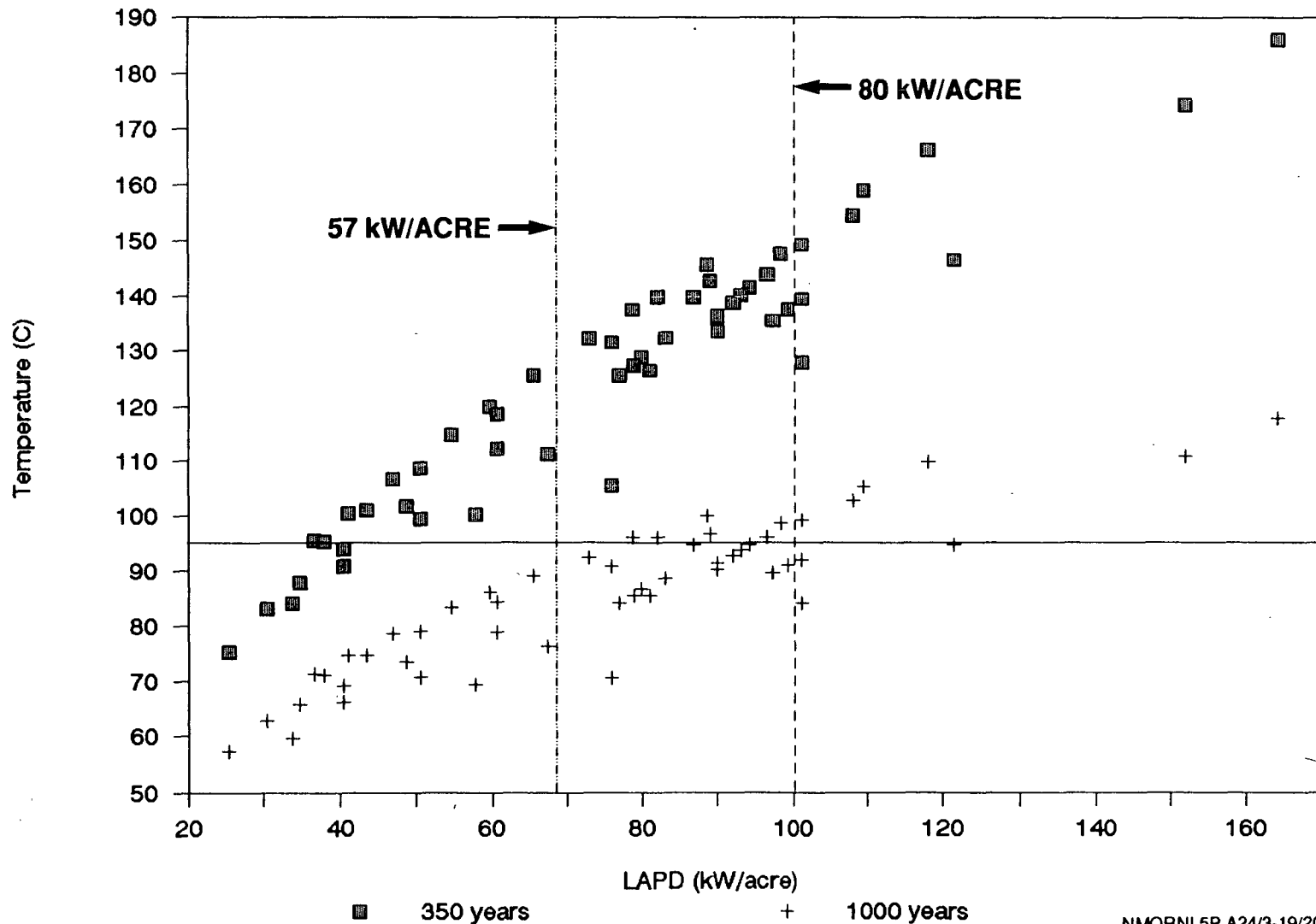
CONTOUR INTERVAL OF 20 FT  
THICKNESS OF UNIT TWS2

# TSw2/TSw3 INTERFACE PEAK TEMPERATURE

60 m FROM REPOSITORY FLOOR



# BOREHOLE WALL TEMPERATURE vs LAPD (VERTICAL EMPLACEMENT)



# APD SUMMARY

- **HISTORICAL DESIGN-BASIS APD OF 57 kW/ACRE EASILY SATISFIES ALL CURRENT SCP THERMAL GOALS**
- **ADDITIONAL THERMAL CALCULATIONS INDICATE THAT THE DESIGN-BASIS APD COULD BE RAISED TO 80 kW/ACRE**

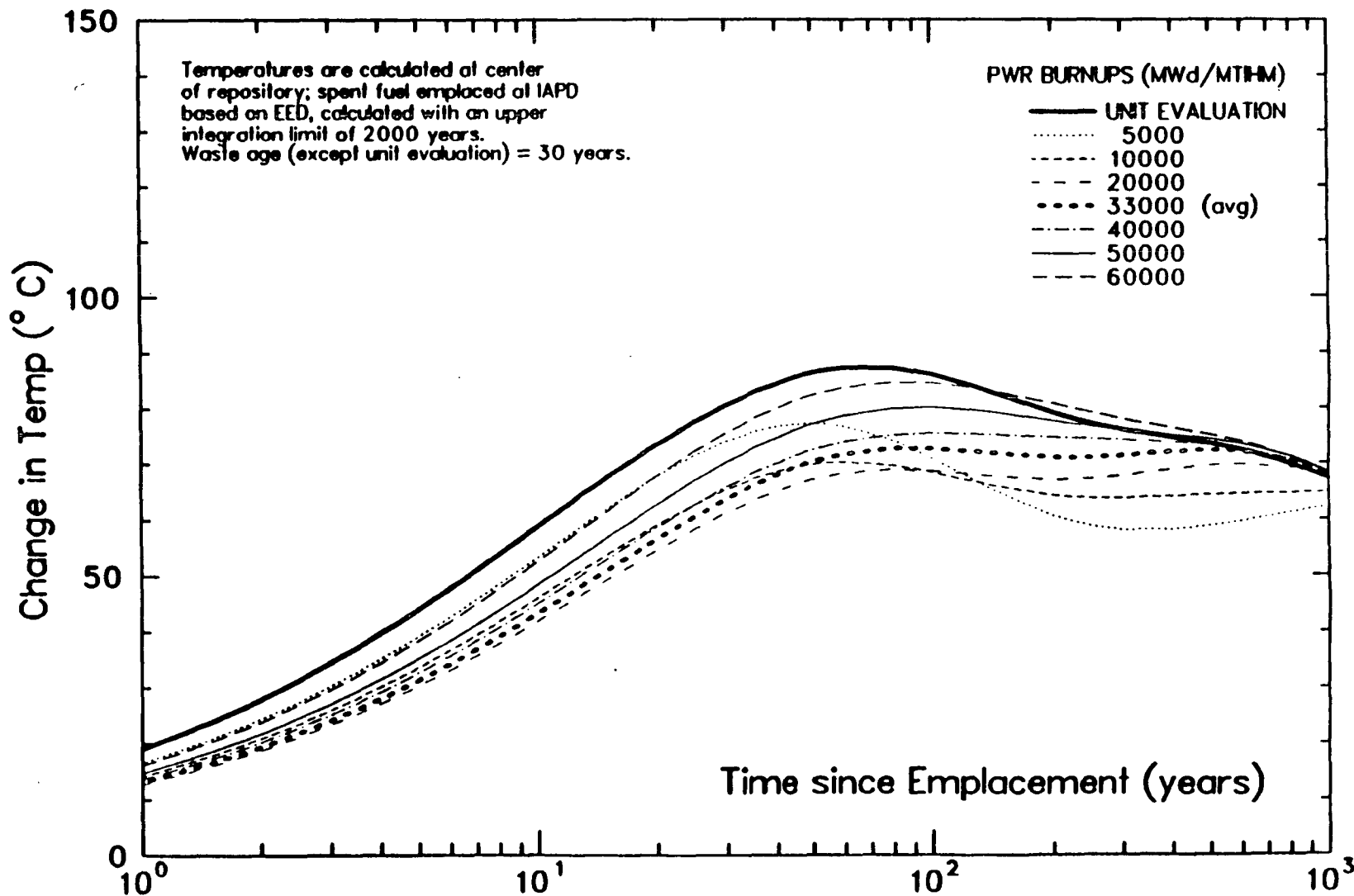
# **APD SCALING TECHNIQUES**

**THE TWO CURRENT METHODS OF SCALING  
WASTE EMPLACEMENT CONCENTRATIONS ARE:**

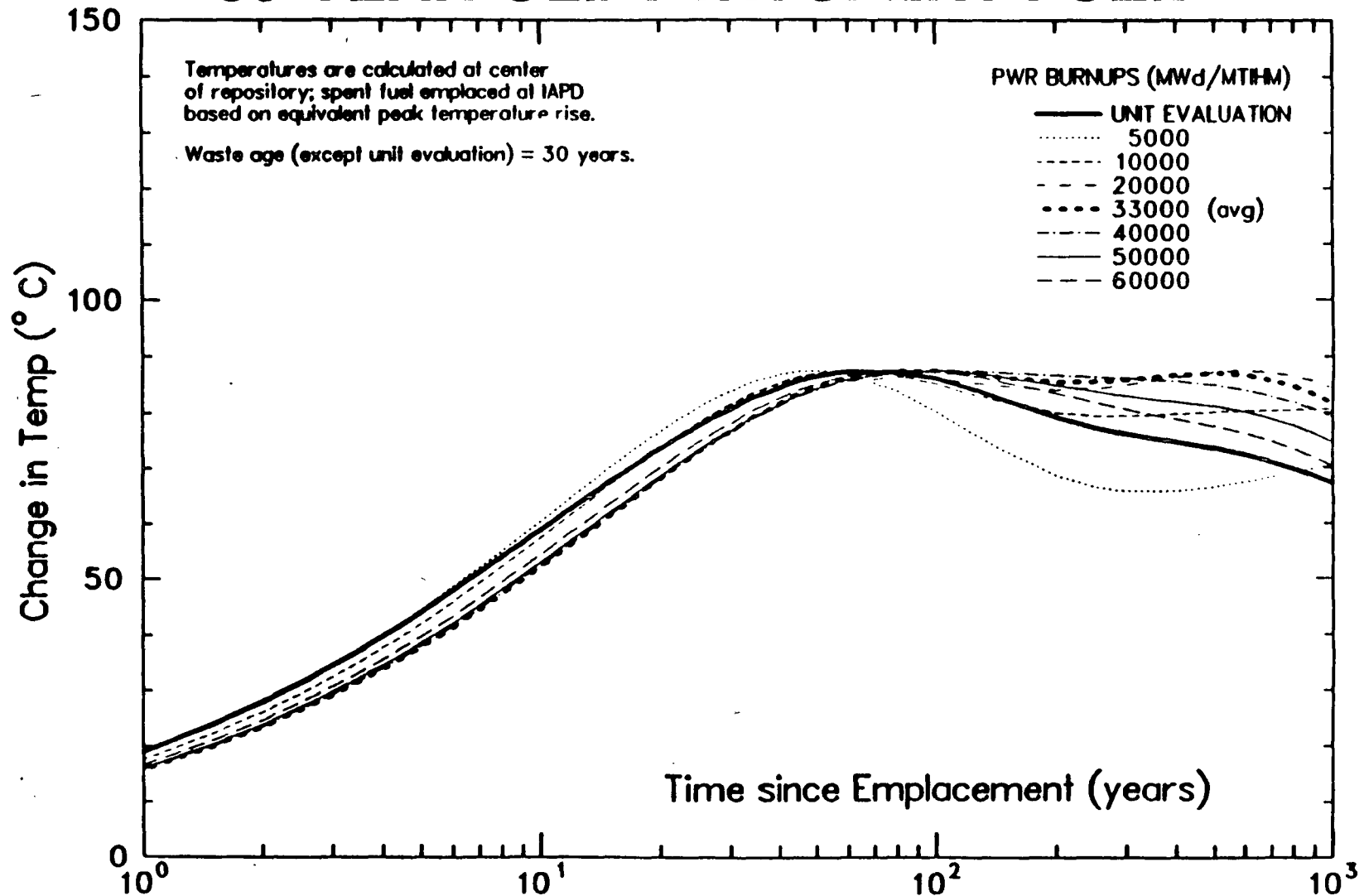
- 1. EQUIVALENT ENERGY DENSITY (EED) CONCEPT**
- 2. EQUIVALENT PEAK TEMPERATURE RISE (EPTR)  
CONCEPT**



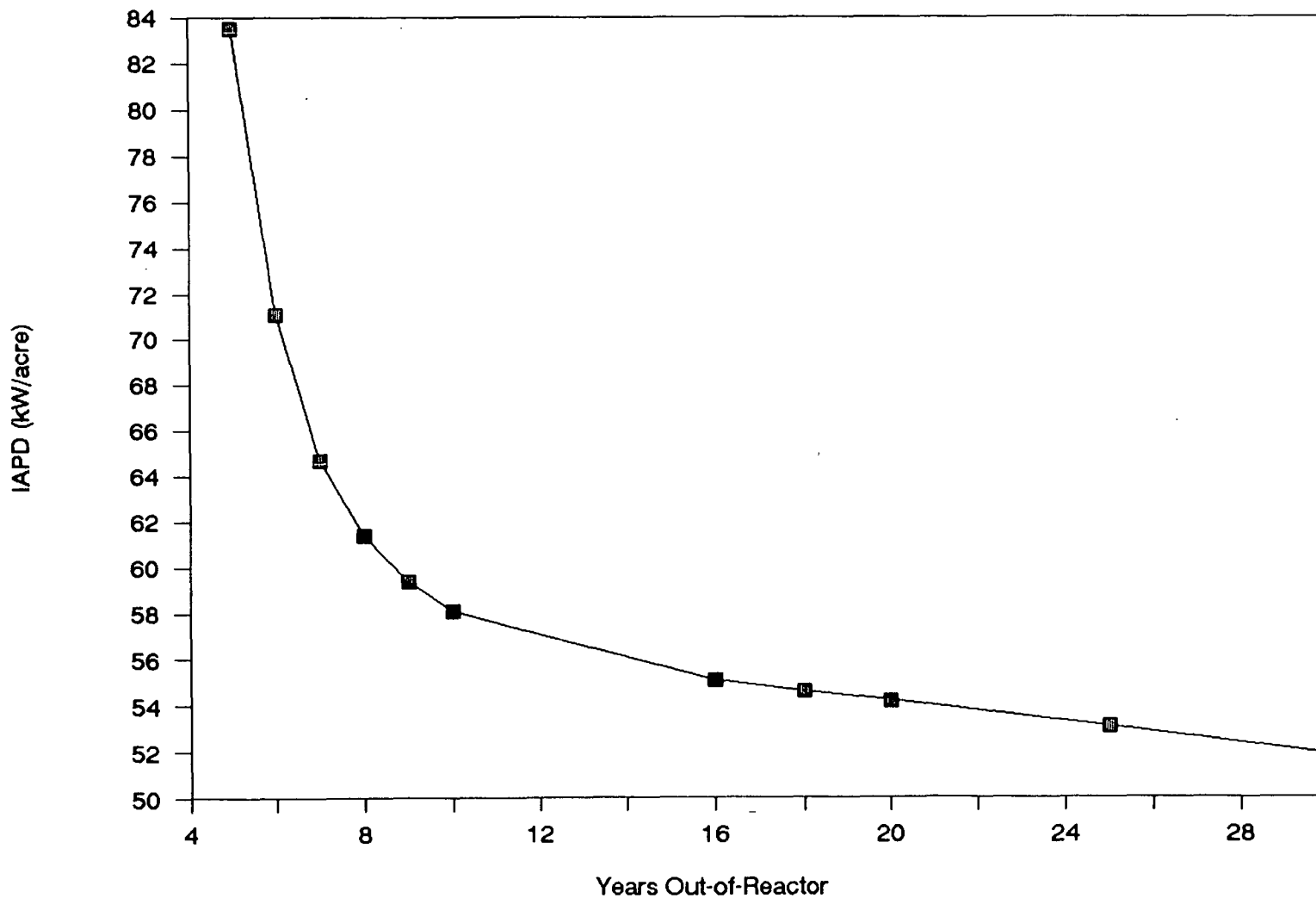
# TEMPERATURE HISTORIES OBTAINED USING EQUIVALENT ENERGY DENSITY OF 30-YEAR-OLD PWR SPENT FUEL



# TEMPERATURE HISTORIES OBTAINED USING EQUIVALENT THERMAL LOAD OF 30-YEAR-OLD PWR SPENT FUEL



# INITIAL APD AS A FUNCTION OF WASTE AGE FOR PWR FUEL WITH A BURNUP OF 10,000 MWd/MTU FOR A DESIGN BASIS APD OF 57 kW/ACRE



# WASTE RECEIPT SCHEDULES

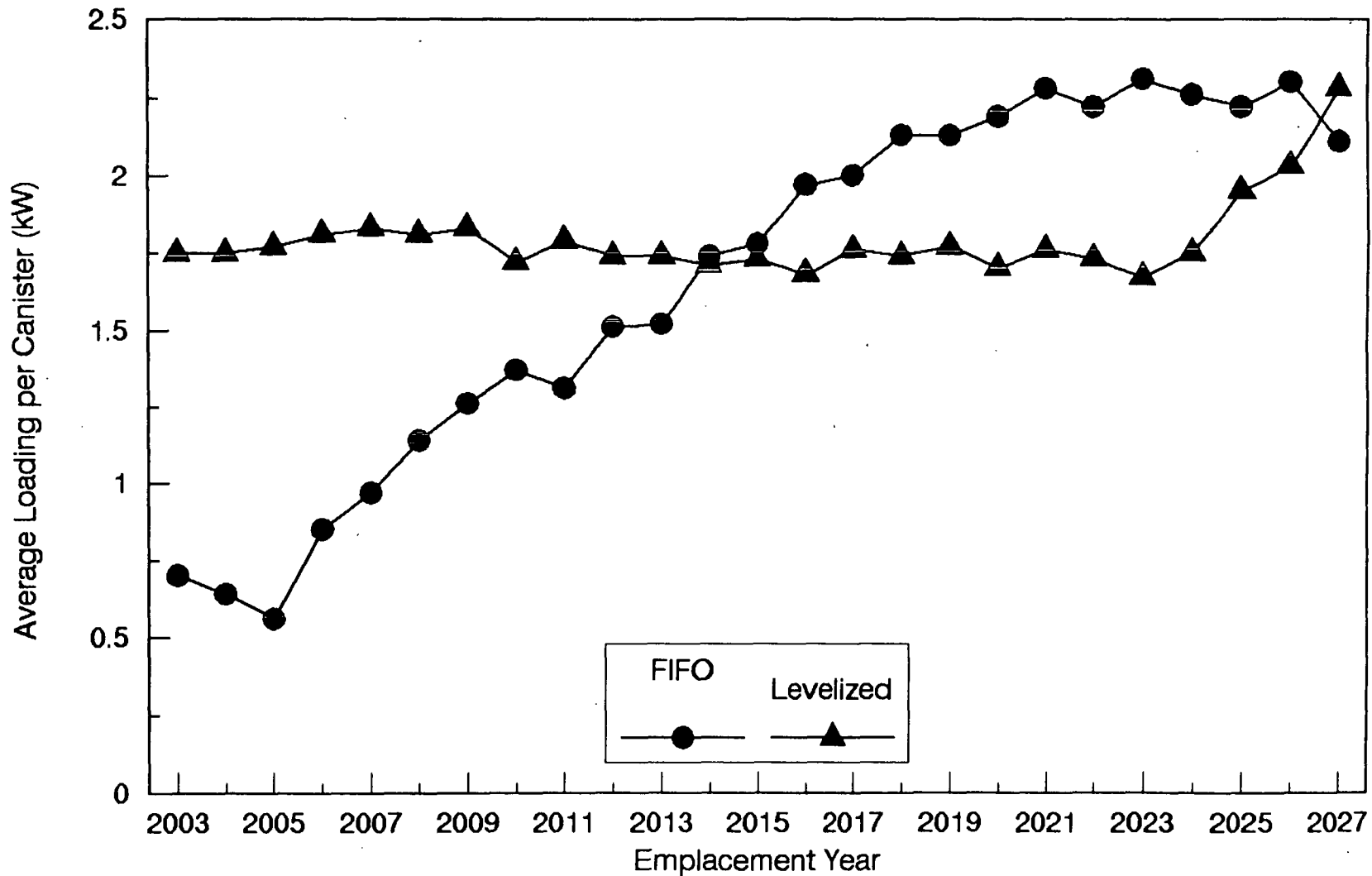
## FIFO OR "OFF"

- THE DESIGN-BASIS OF THE SCP-CDR WAS "OLDEST FUEL FIRST," THAT IS, THE OLDEST (AND RELATIVELY LOW BURNUP) FUEL WOULD BE EMPLACED FIRST FOLLOWED BY PROGRESSIVELY YOUNGER (AND HIGHER BURN-UP) FUEL
- THE RESULTING WASTE STREAM EXHIBITS THE CHARACTERISTICS OF MONOTONICALLY DECREASING AGE AT EMPLACEMENT AND A CORRESPONDING INCREASE IN AVERAGE BURNUP

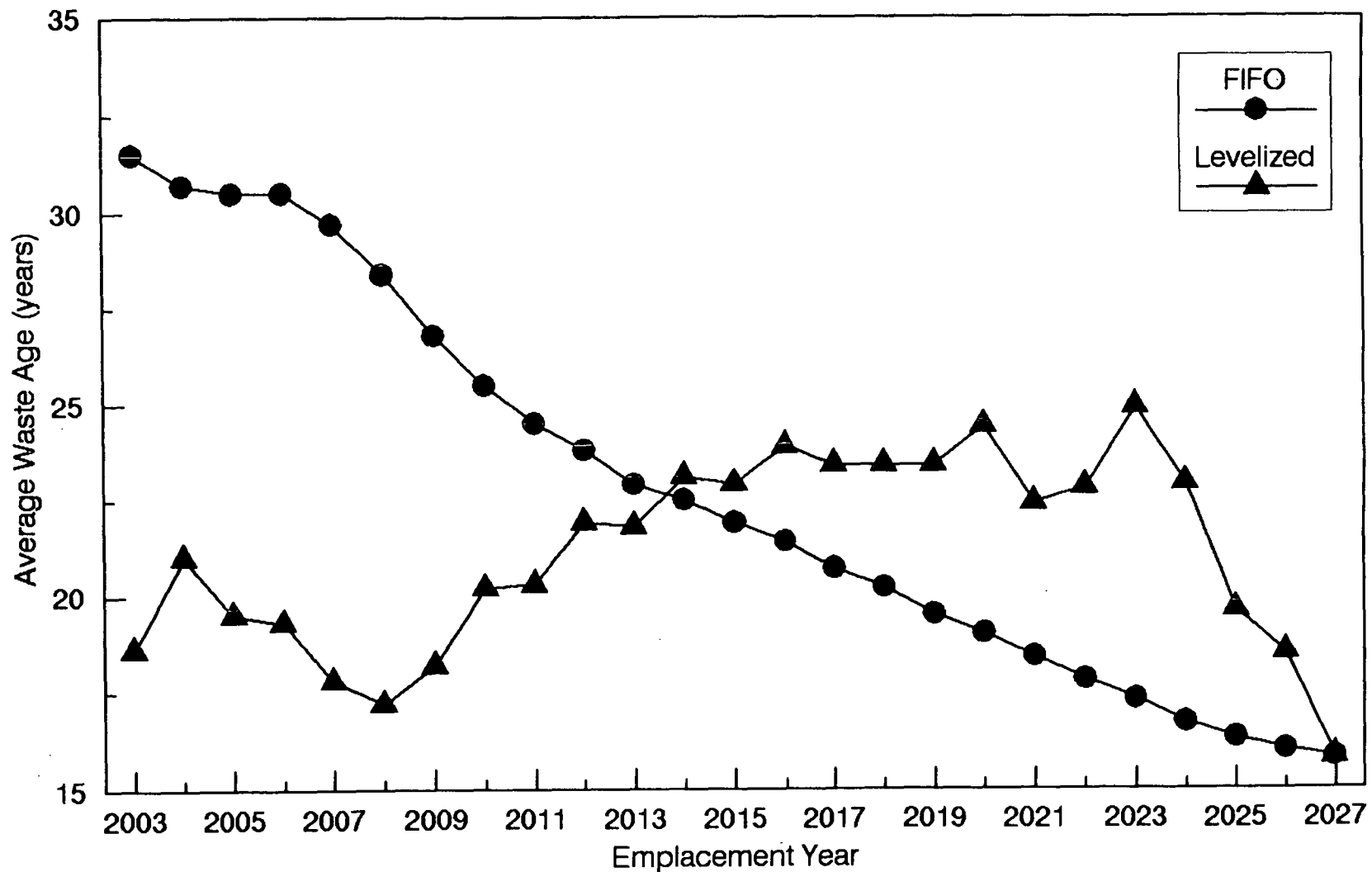
## LEVELIZED

- A "LEVELIZED" RECEIPT SCHEDULE REFERS TO A WASTE STREAM THAT IS CHOSEN FROM THE AVAILABLE INVENTORY SUCH THAT THE WASTE EXHIBITS NEARLY LEVELIZED YEARLY ENERGY DENSITY AND AGE

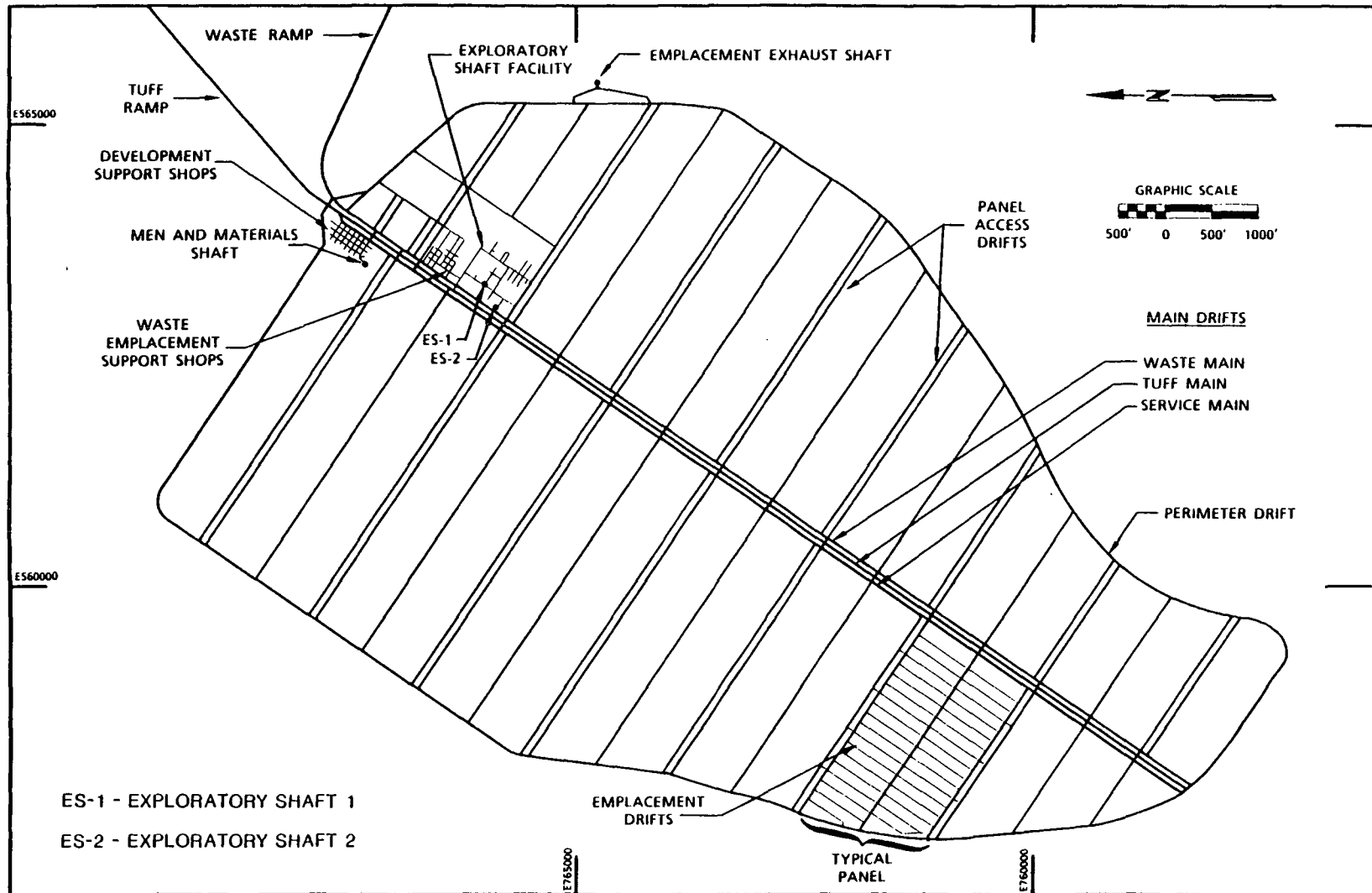
# YEARLY AVERAGE CANISTER LOADING FOR FIFO AND LEVELIZED EMPACEMENT



# AVERAGE AGE OF WASTE RECEIVED AT REPOSITORY FOR FIFO AND LEVELIZED EMPLACEMENT



# SCP/CDR REPOSITORY LAYOUT



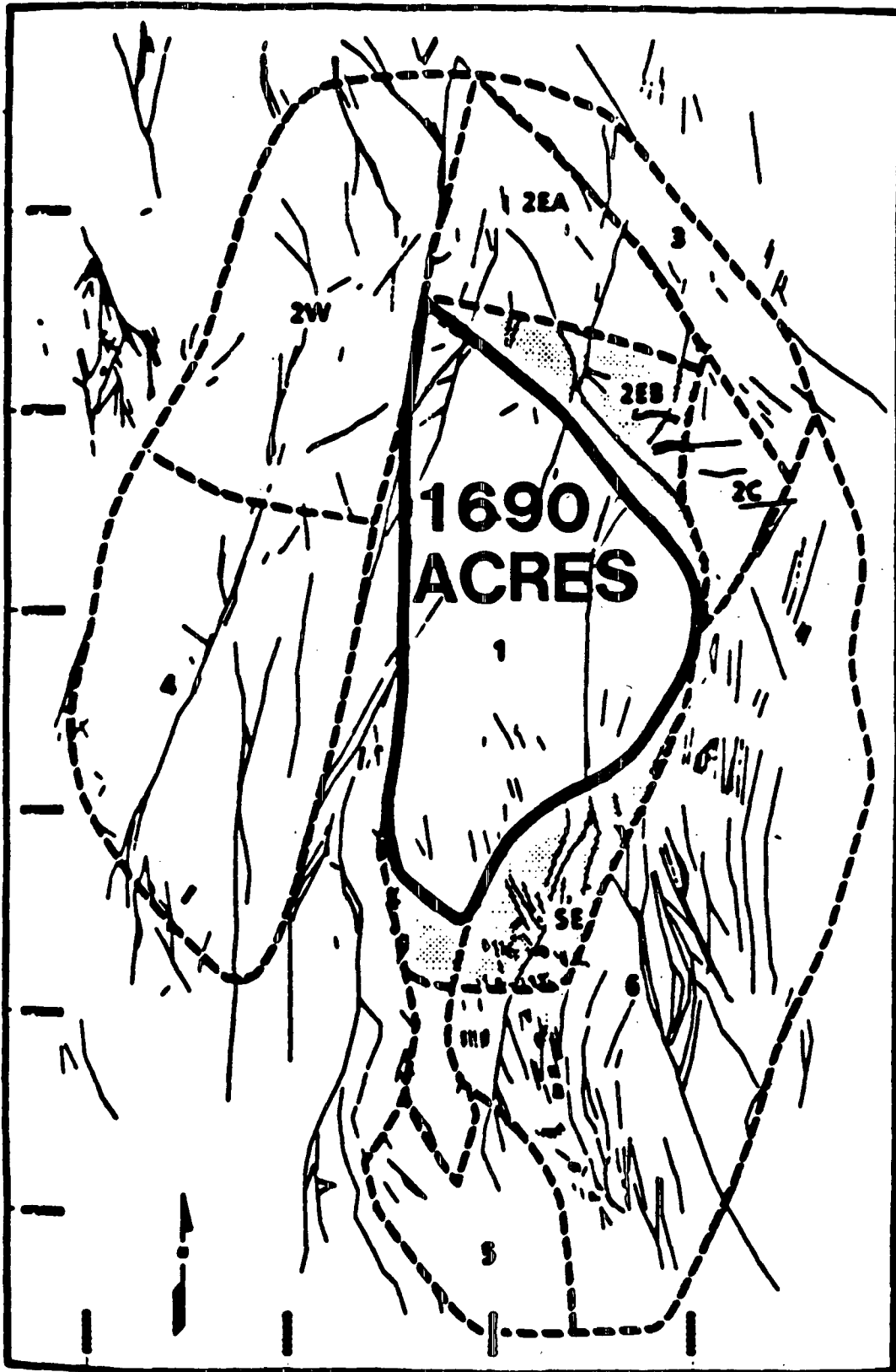
# AREA REQUIREMENTS FOR A 2003 EMPLACEMENT START DATE (FOR VERTICAL EMPLACEMENT)

DESIGN-BASIS APD  (kW/acre)	RECEIPT SCHEDULE							
	FIFO				LEVELIZED			
	SF	DHLW	FIXED	TOTAL	SF	DHLW	FIXED	TOTAL
57	1157	93	182	1432	1147	93	182	1422
80	826	93	182	1101	818	93	182	1093

\* Areas listed are in acres



# PROPOSED EXTENSION TO PRIMARY AREA



# **FACTORS THAT IMPACT AREA REQUIREMENTS**

## **APD**

- **THE HIGHER THE ALLOWABLE DESIGN-BASIS APD, THE LESS AREA THAT IS REQUIRED FOR WASTE EMPLACEMENT**

## **DELAYED START DATE**

- **AS THE EMPLACEMENT START DATE BECOMES LATER, THE FUEL INVENTORY AGES, THEREBY PRODUCING LESS HEAT. UP TO A POINT, THEREFORE, AREA SAVINGS IN WASTE EMPLACEMENT CAN BE GAINED BY ADDITIONAL AGING. A POINT OF DIMINISHING RETURNS EXISTS, HOWEVER, AT WHICH IT IS NOT PHYSICALLY POSSIBLE (BASED ON EXTRACTION RATIO LIMITS AND GEOMETRIC CONSTRAINTS ON CANISTER-TO-CANISTER SPACINGS) TO EMPLACE THE AGED (COLDER) WASTE AT THE REQUIRED INITIAL APD**

# EFFECT OF AGING WASTE ON YEARLY AVERAGE CANISTER LOADING FOR A FIFO EMPLACEMENT SCHEDULE

