U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Repository Design Objectives

Presented to:
Nuclear Waste Technical Review Board

Presented by:
Paul Harrington
Department of Energy
Yucca Mountain Site Characterization Office

January 30-31, 2001
Amargosa Valley, Nevada

YUCCA MOUNTAIN PROJECT

Presentation Contents

- **High level objectives; representative specific objectives**
- **Relative importance of objectives**
- **Considerations that will influence relative importance of objectives**
- **Considerations in establishing operational flexibility**
- **General observations on key tradeoffs**
- **Low temperature waste package scenarios**
- **Utilization of repository capacity**
- **Summary**

Objectives for the Repository Design

- **Manage the uncertainty in postclosure performance**
  - **Near field environment affects waste package corrosion rates**
  - **Allow free drainage between emplacement drifts**
  - **Manage thermal effects on the host rock**
- **Manage the design to obtain reasonable assurance of postclosure performance margin**
- **High licensing probability/protective of public health and safety**
  - **Pre- and postclosure predicted exposure acceptably low**
- **Adequate flexibility for future changes**
  - **Ability to adjust thermal operating mode without significant design changes**

Objectives for the Repository Design

(Continued)

- **Cost/Schedule acceptability**
  - **Both cost and schedule conform to budget constraints**
- **Adequate constructability, operability, and maintainability**
  - **Continued emphasis on policy regarding personnel safety**

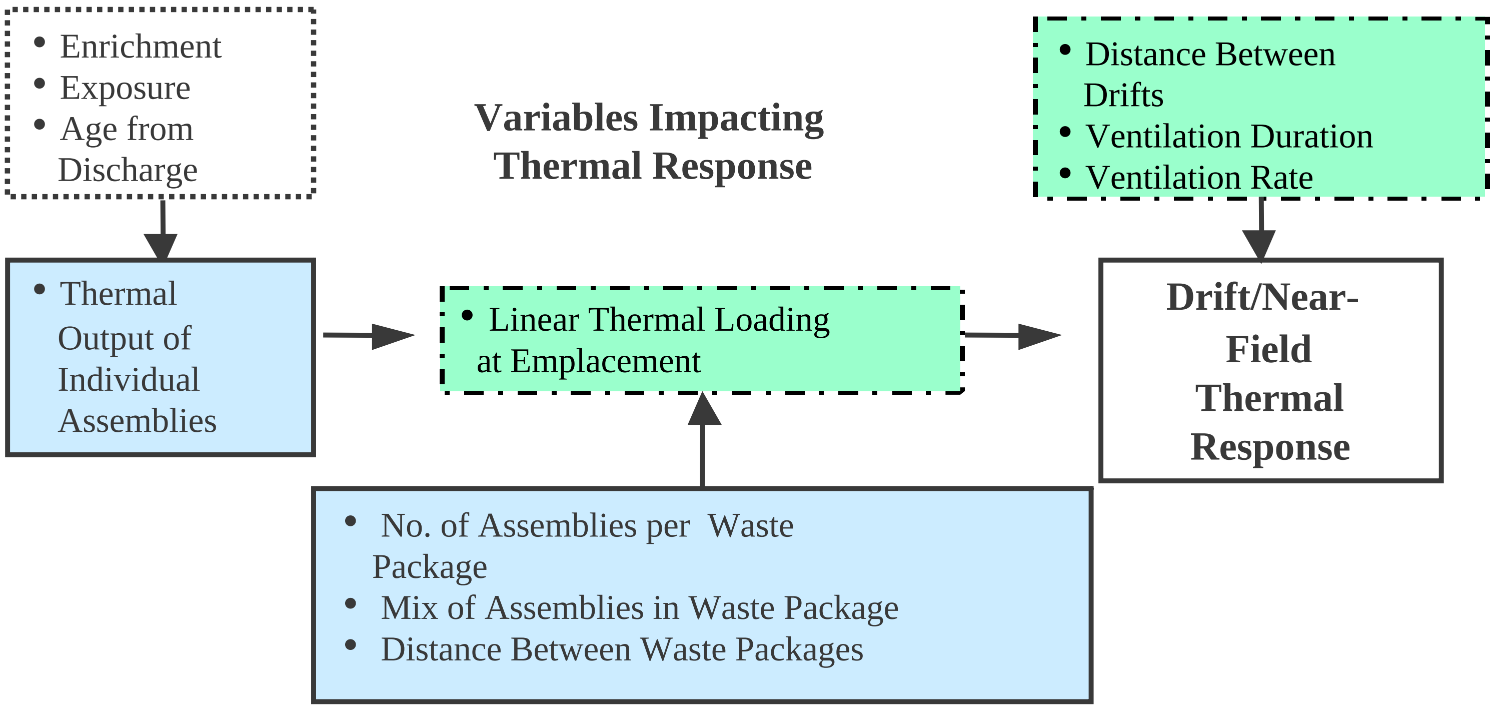
Relative Importance of Objectives

- **Relative importance of design objectives to support Site Recommendation not yet established**
- **DOE ranking of criteria to support LADS decision**
  - **Public safety as measured by postclosure performance**
  - **Demonstrability of postclosure performance in licensing**
  - **Preclosure worker safety**
  - **Flexibility to accommodate design changes and improvements in understanding**
  - **Cost**

Influences on Determination of Relative Importance of Objectives

- **Decision process to be chosen will determine how relative importance of objectives will be formulated**
- **Continued focus on new information and understanding that allows reconsideration of relative importance of objectives**

Considerations in Establishing Operational Flexibility



General Observations on Key Tradeoffs

- **Lower temperatures may reduce uncertainties in localized corrosion, rock alteration, and coupled processes in the natural system**
- **Higher temperatures allow use of shorter total emplacement drift length that must be excavated. This reduces the probability of industrial accidents during construction and operation, reduces net costs, increases personnel safety**
- **Aging before emplacement has little additional effect for long ventilation periods; long term decay characteristics dominate**

General Observations on Key Tradeoffs
(Continued)

- Long (multi-century) ventilation may introduce additional licensing and modeling uncertainties
- With closure in ~100 years, wide waste package spacing or substantial aging is required to meet a low waste package temperature objective
- Higher areal mass loading provides more flexibility with respect to the location of the potential repository within the characterized area, the ability to adapt to the discovery of regions that should be avoided, and the ability to increase capacity (if authorized)

Engineering Activities Addressing Uncertainty Issues

- **Low thermal loading design is a surrogate for decreased uncertainty in the repository design**
- **Design concepts have been developed to limit waste package surface temperature – may reduce uncertainty in localized corrosion**
- **Conceptual work on this issue has demonstrated a range of scenarios which may be used for the design**
- **A low thermal loading scenario will be included in the SR design**

Low Temperature Waste Package Scenarios

- **Selected scenario must meet following criteria:**

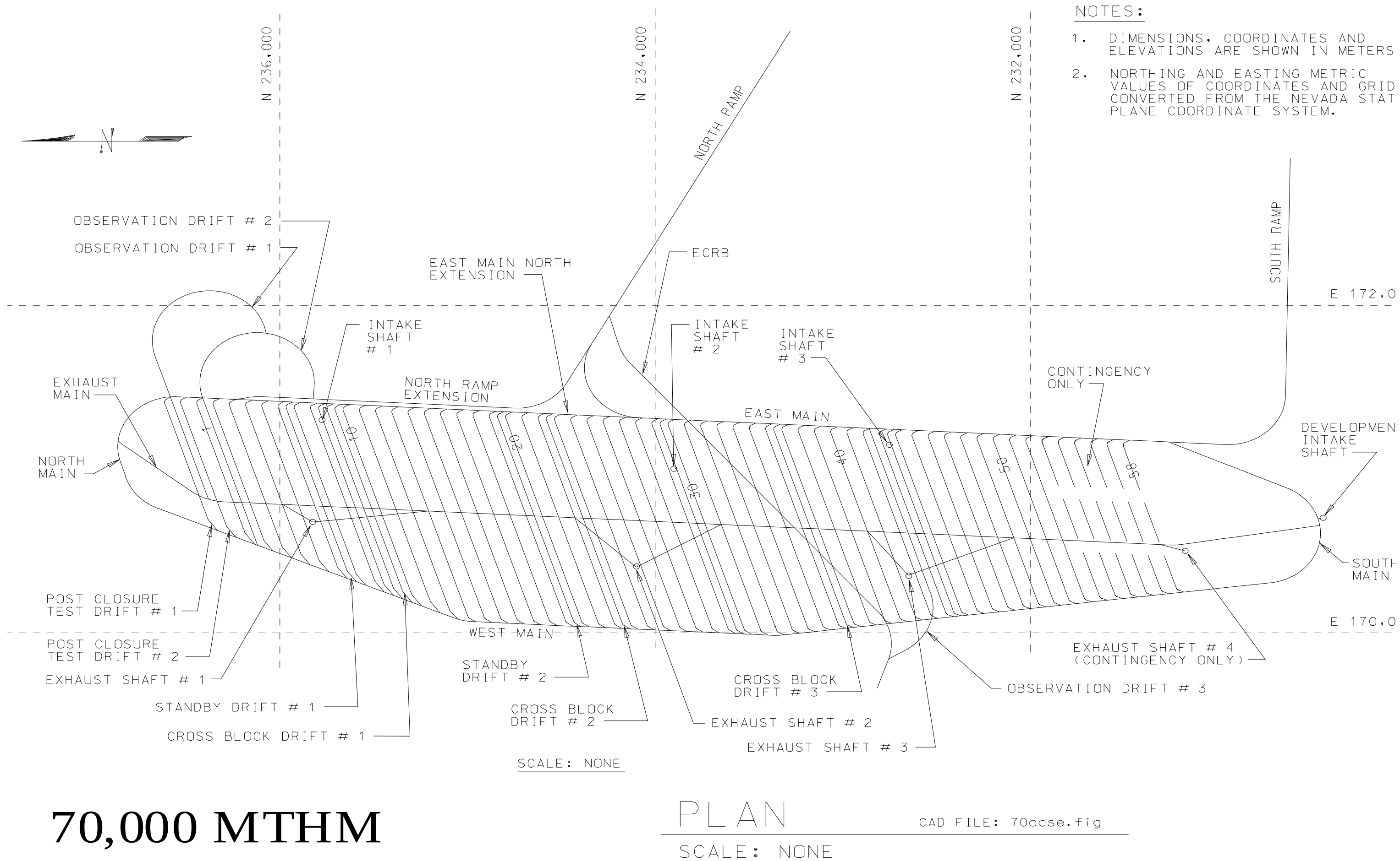
  1. **Meets proposed NRC release standard**
  2. **Average 85 degree C or lower peak nominal waste package surface temperature or maintain relative humidity less than 50% (postclosure)**
  3. **Limit drift wall temperature to average of 96 degree C or less**
  4. **Achieve criteria 2 and 3 with up to 300 years ventilation after last emplacement using forced, natural or combination of ventilation methods**
  5. **Accommodate at least 70,000 MTHM for emplacement considering both upper and lower blocks**
  6. **Limit surface aging of SNF**
  7. **Areal mass loading between 85 MTHM/acre and 25 MTHM/acre (EIS constraints)**

Low Temperature
Waste Package Scenarios

- **Scenarios must possess following attributes:**

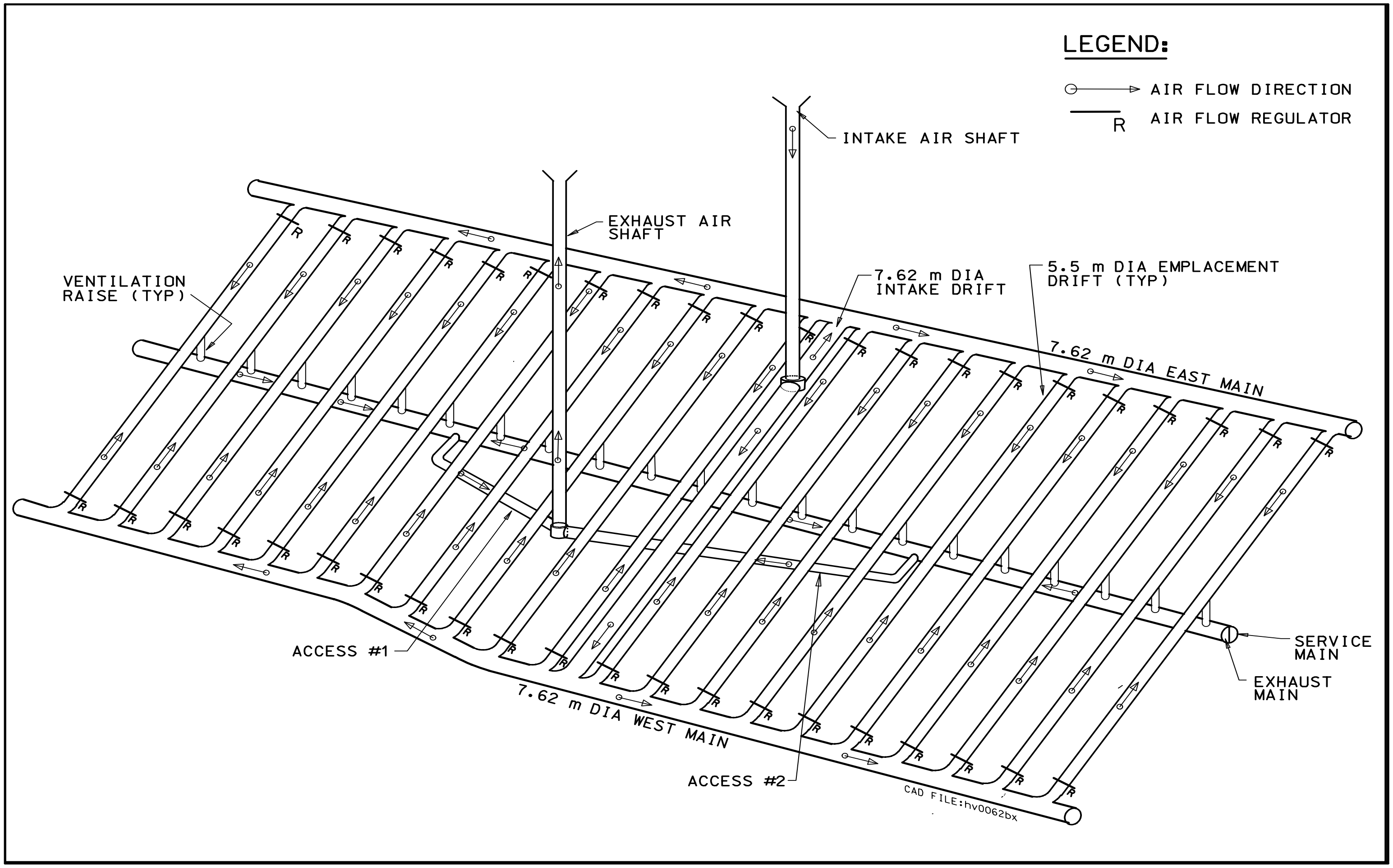
  1. **Meet criteria**
  2. **Present the possibility of consideration of other low temperature features**
  3. **Be a base for sensitivity studies of attributes which vary from those of the selected scenarios**

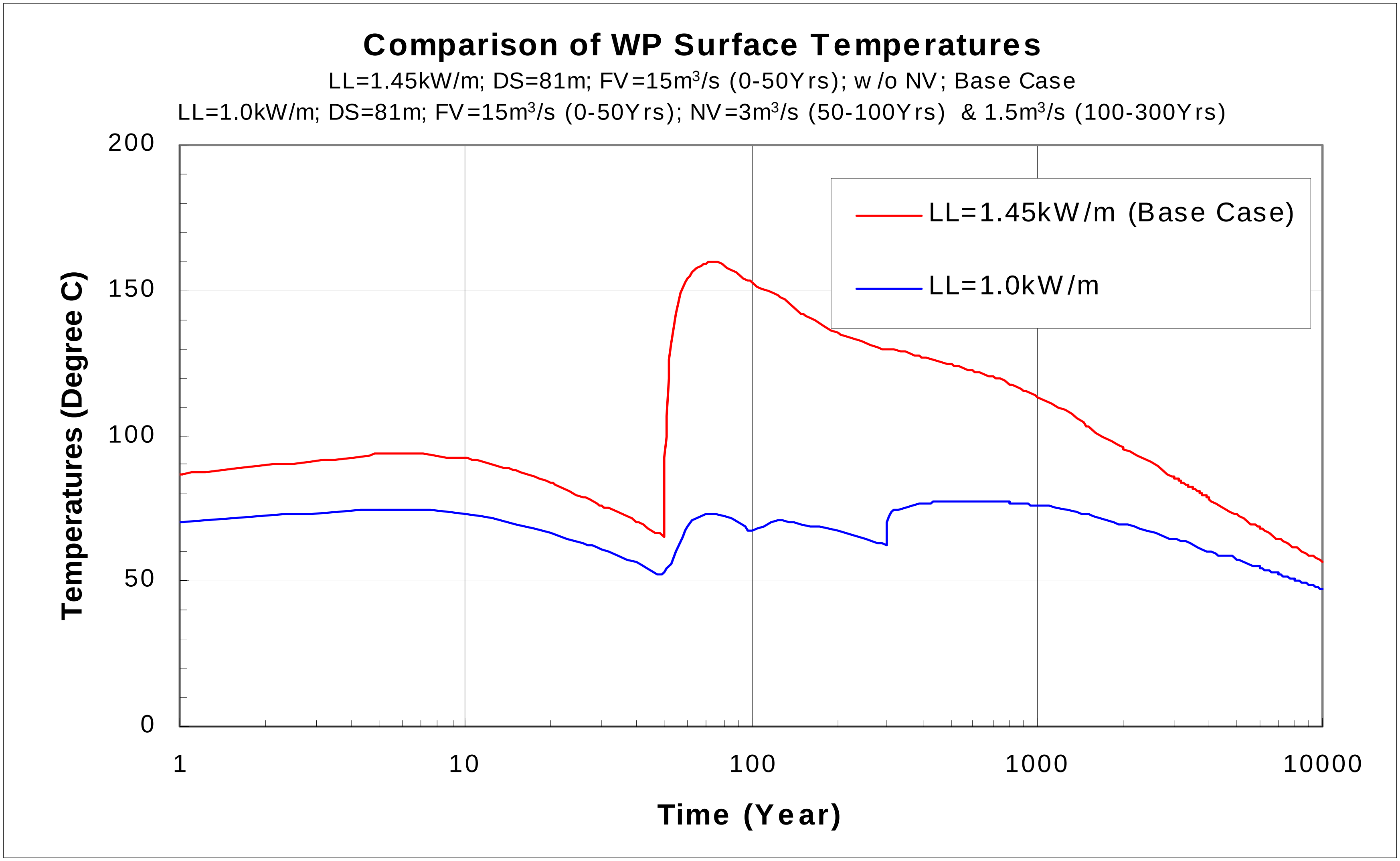
Impact of Reduced Thermal Load on Layout



70,000 MTHM

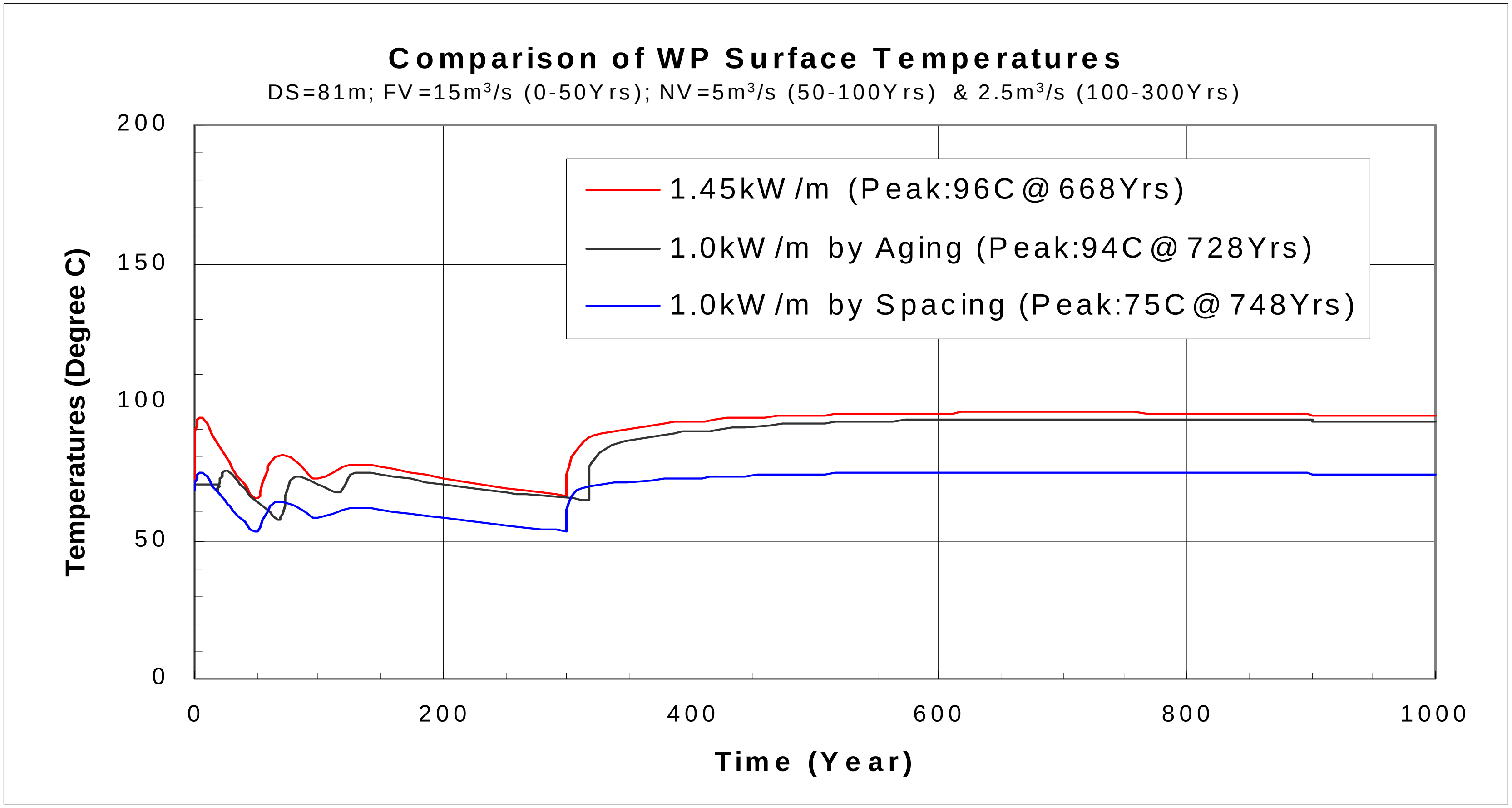
3D Cell Schematic





Comparison of WP Surface Temperatures
LL=1.45kW/m; DS=81m; FV=15m³/s (0-50Yrs); w/o NV; Base Case
LL=1.0kW/m; DS=81m; FV=15m³/s (0-50Yrs); NV=3m³/s (50-100Yrs) & 1.5m³/s (100-300Yrs)
Temperatures (Degree C)
200
150
100
50
0
1
10
100
1000
10000
Time (Year)
LL=1.45kW/m (Base Case)
LL=1.0kW/m

Aging vs. Spacing to Achieve Line Load



Low Waste Package Temperature Cases

Parameter	**Reference Design and Operating Mode**	**Example Objective Sets for 70,000 MTHM Inventory**					
		Lower Waste Package Temperature through Extended Ventilation and Increase in Emplacement Area			Lower Waste Package Temperature through Increased Emplacement Area and Limited Period of Forced Ventilation		Lower Drift Wall Temperature and Relative Humidity through Natural Ventilation
		Scenario 1 “Selected”	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
Number of waste packages	~11,000	~11,000	~16,000	~11,000	~11,000	~11,000	~11,000
Waste package spacing (m)	0.1	2	0.1	0.1	6	2	0.1
Surface Aging (years)	0	0	0	0	0	30	0
Avg. linear thermal loading at emplacement (kW/m)	1.45	1	1	1.45	0.7	0.5	1.45
Drift center-to-drift center spacing (m)	81	81	81	120	81	81	81
Emplacement period (years)	25	25	25	25	25	~60	25
Years of forced ventilation after end of emplacement period	~25	50	50	300	100	75	50
Years of natural ventilation after end of forced ventilation	0	250	250	0	0	0	Indefinite
Total emplacement drift excavated length (km)	60	80	80	60	130	80	60
Required emplacement area (acres)	~1,100	~1,600	~1,600	~1,700	~2,500	~1,600	~1,100
Average waste package maximum surface temperature (°C)	>96	<85	<85	<85	<85	<85	<96
Cost Over SR Design Basis (1999$ B)		+5	+10	+8	+8	+17	+4 @ 300 years actual indefinite
Cost Over SR Design Basis (Net Present Value $B)		+.8	+3	+.3	+2	+5	+.2 @ 300 years actual indefinite

Low Temperature Waste Package Scenarios

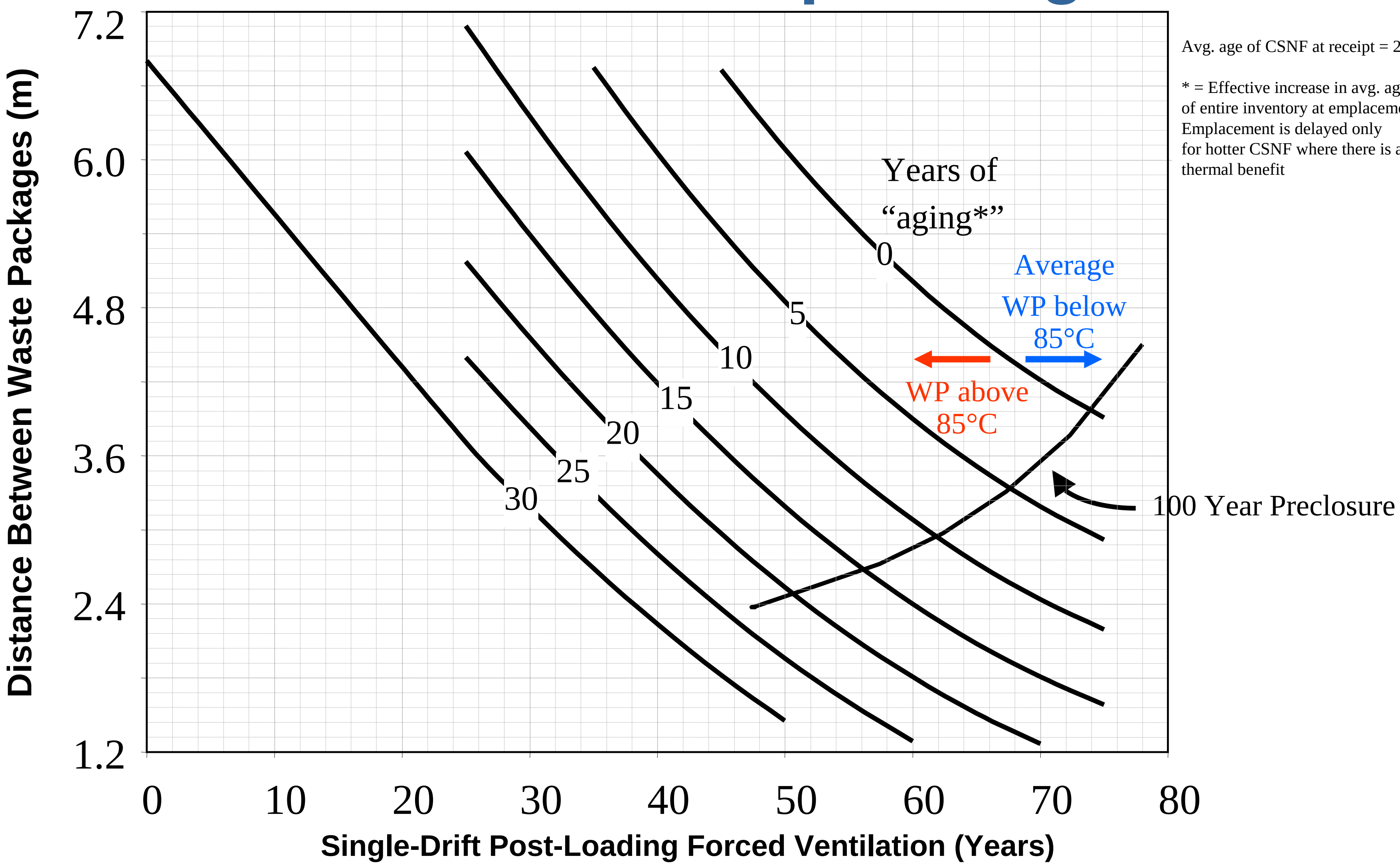
- **Major scenario attributes as follows:**

  1. **Extended forced and natural ventilation period, 2 meters WP spacing**
  2. **Smaller WPs, extended forced and natural ventilation**
  3. **Increased drift spacing to 120 meters, extended forced ventilation**
  4. **6 meters WP spacing, slightly extended ventilation period**
  5. **Aging up to 30 years, 2 meters WP spacing**
  6. **Indefinite ventilation period (fixed forced, indefinite natural ventilation)**

Low Temperature
Waste Package Scenarios

- **Scenario 1 selected as representative low temperature case for inclusion in SR**
- **Attributes of scenarios 2 though 5 to be considered further as modifications to scenario 1**
- **Scenario 6 will not be considered further due to indeterminate closure date**
- **Scenario 1 selected as best representative case because:**
  - **Can envelope major aspects of scenarios 2 through 5**
  - **Perceived to be less susceptible to changes (e.g., thermal conductivity, waste stream thermal load)**
- **Is not a binary choice for hotter vs. colder decision**

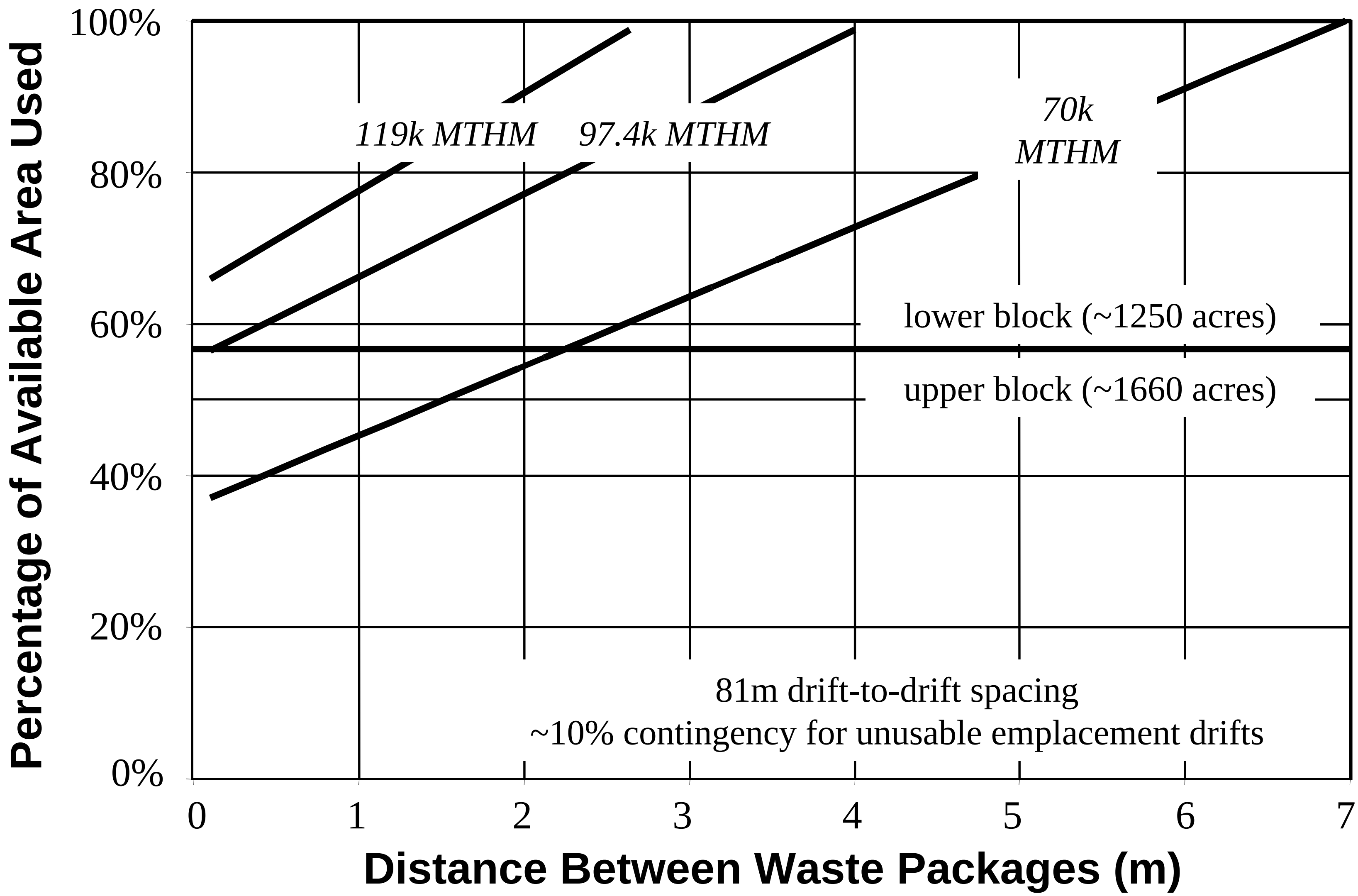
Average Waste Package Surface Maximum at 85°C Operating Curves



Avg. age of CSNF at receipt = 26 yrs.

* = Effective increase in avg. age of entire inventory at emplacement; Emplacement is delayed only for hotter CSNF where there is a thermal benefit

Utilization of Repository Capacity



Summary

- **Objectives for a repository design were reviewed**
- **Relative importance of objectives**
  - **Relative importance not yet established**
  - **Rankings of previously used criteria reviewed**
  - **Open to consideration of changes due to better information**
  - **Scales and relative importance of objectives will be formulated once decision process is determined**
- **A design can be developed that responds to the considerations of thermal operations and uncertainty with tradeoffs as noted**
- **Flexibility to factor in new/revised information must be retained**