YUCCA MOUNTAIN PROJECT

Studies

Repository Thermal Management

Presented to:
Nuclear Waste Technical Review Board

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October 22, 1997

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

Agenda

- The MGDS thermal goals
- Comparison of thermal goals and design performance
- Extension to overall MGDS performance
- Influence of ventilation on thermal behavior
- Options to decrease clad temperature (to compensate for other components that heat it)
- Summary

Thermal Loading Assumptions - 1

- **High range (80-100 MTU/acre)**
  - Rationale: Accommodates 70,000 MTU in characterized area, has projected acceptable performance, has reduced footprint and cost
  - Risk Mitigation: Alternate Areal Mass Loadings (AMLs) (e.g. 36 and 115 MTU/acre)
  - Controlled Design Assumption: Key 019
- **WP spacing set by its MTU ("point loading")**
  - DHLWPs in gaps between large Waste Packages
  - Drift spacing maximized within AML and temperature limit constraints, WP spacing minimized, reduced costs
  - CDA Key 077

Thermal Loading Assumptions - 2

- Zeolite temperature limit
  - < 90˚C at 170 m below repository horizon
  - Sets AML (85 MTU/acre)
  - Rationale: Maintain sorption capability; do not dehydrate clinoptilolite or convert it to analcime
  - CDA Design Concept SubSurface (DCSS) 025
- Drift wall temperature limit
  - < 200˚C
  - For the reference drift diameter, sets drift spacing (28 m) and hence WP spacing
  - Rationale: Limit thermal stress. Stay below cristobalite phase change (225-230°C)
  - CDA DCSS 023

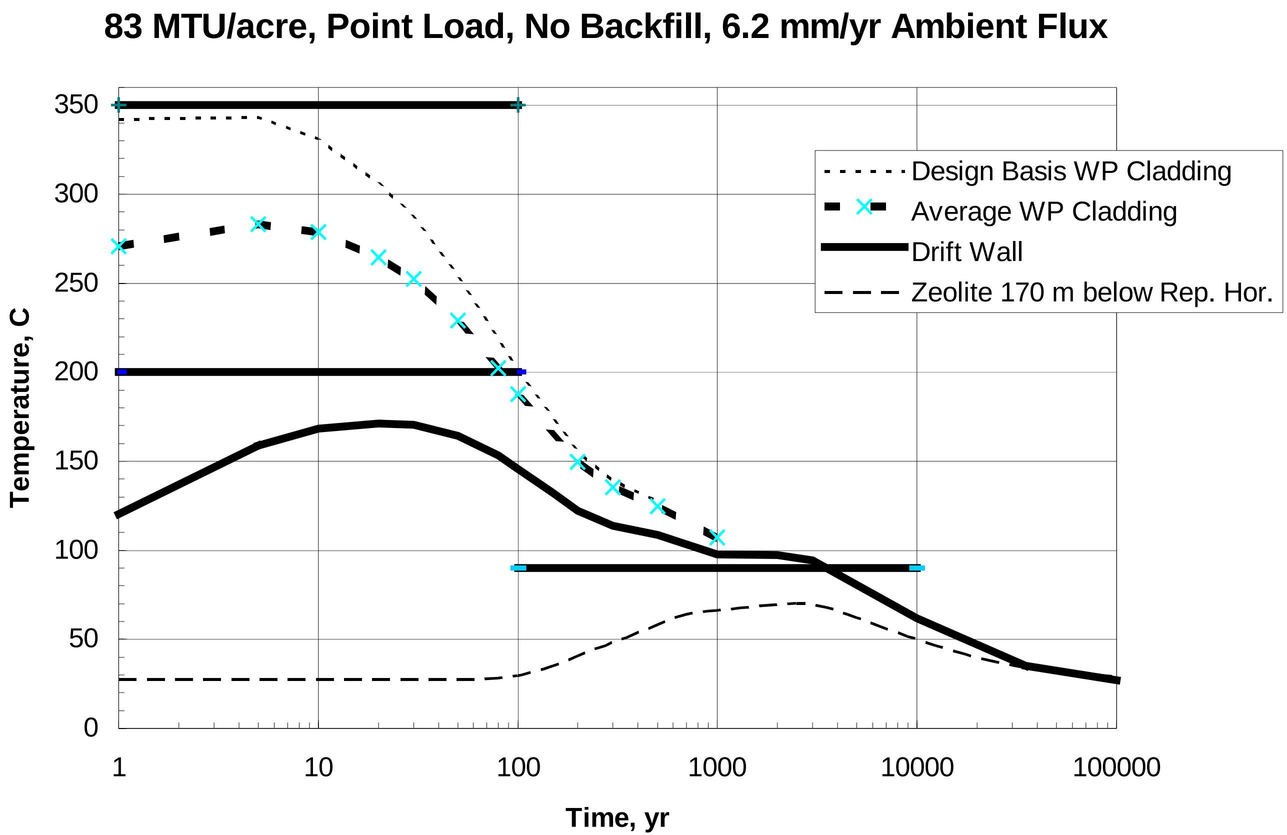
Thermal Loading Assumptions - 3

- Cladding temperature limit
  - < 350°C
  - Rationale:
    - » One to two orders of magnitude peak dose rate reduction for cladding credit
    - » Intact Zircalloy cladding is > 98% of received waste (1.15% stainless steel clad, < 0.1%perforated Zircalloy)
    - » Intact Zircalloy cladding is extremely resistant to corrosion, limiting radionuclide mobilization
    - » Radionuclide mobilization requires two independent failures:
      - Perforation (creep rupture) due to rod pressure rise
      - Early WP failure (< 150 yr, waste > 200°C), free oxygen will oxidize UO_2 thru clad perforation, consequent swelling will unzip clad [drift atmosphere may be pure water vapor at that time]
  - CDA DCWP 001

Thermal Loading Assumptions - 4

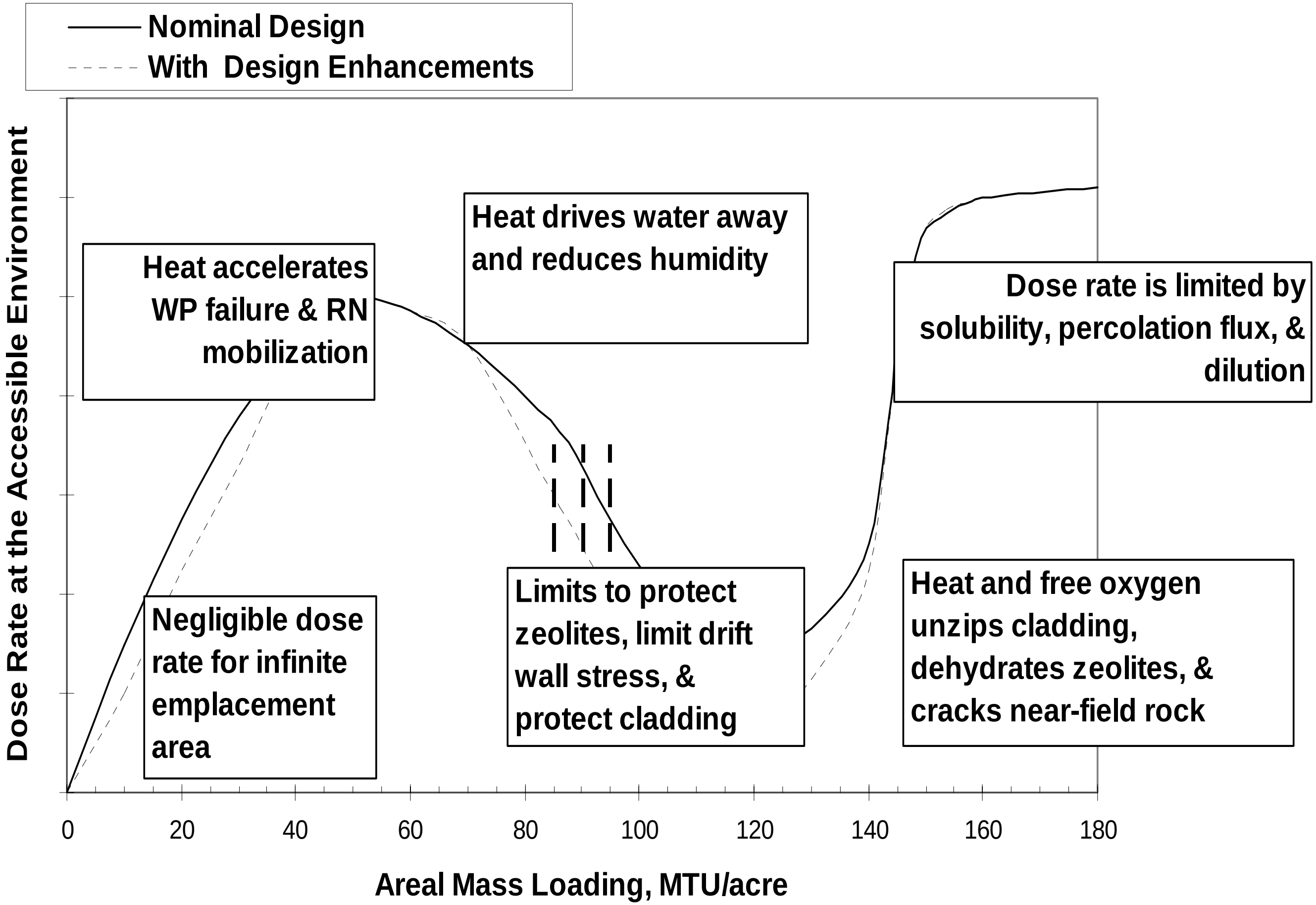
- **Other temperature limits**
  - **Shafts/ramps: < 35°C (ignoring ventilation)**
    - » **CDA DCSS 023**
  - **Main drifts: < 50°C**
    - » **CDA DCSS 023**
  - **PTn < 115°C**
    - » **CDA DCSS 031**
  - **Surface temperature rise < 2°C**
    - » **CDA EBDRD 3.7.G.4**

Design Limits vs Calculated Temperatures

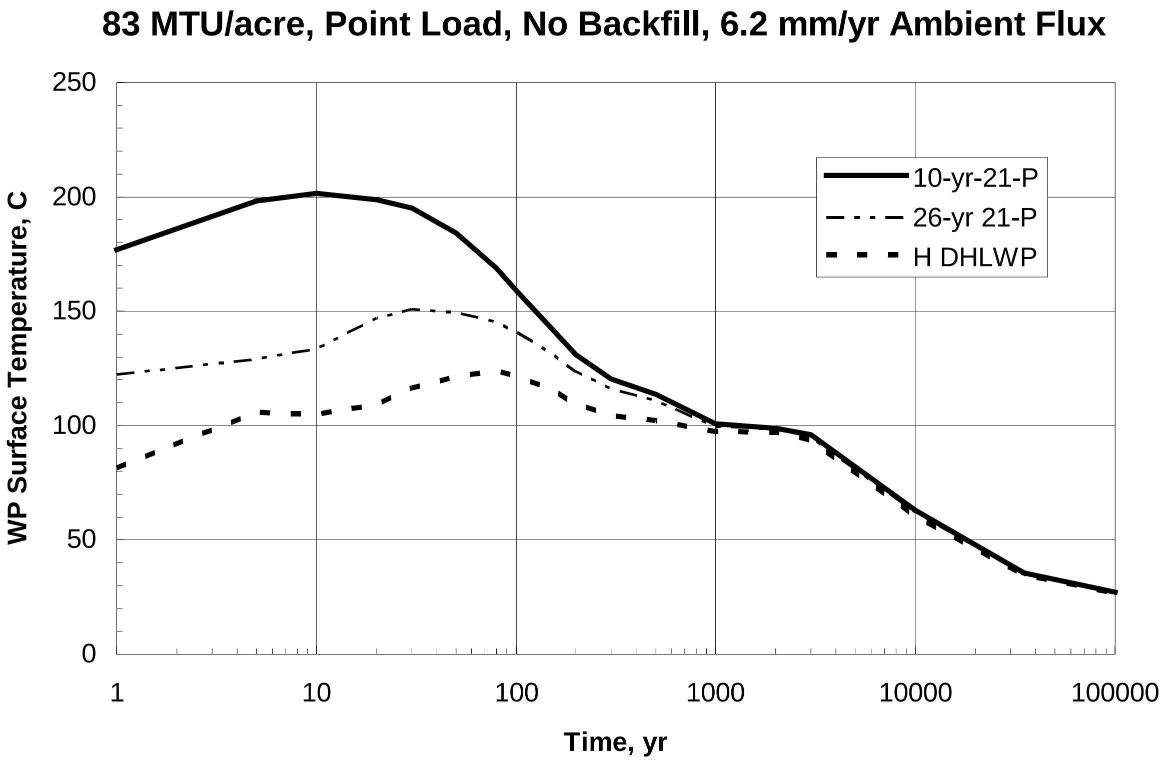


22.5 m drift spacing

Notional Dependence of Dose Rate on Thermal Loading

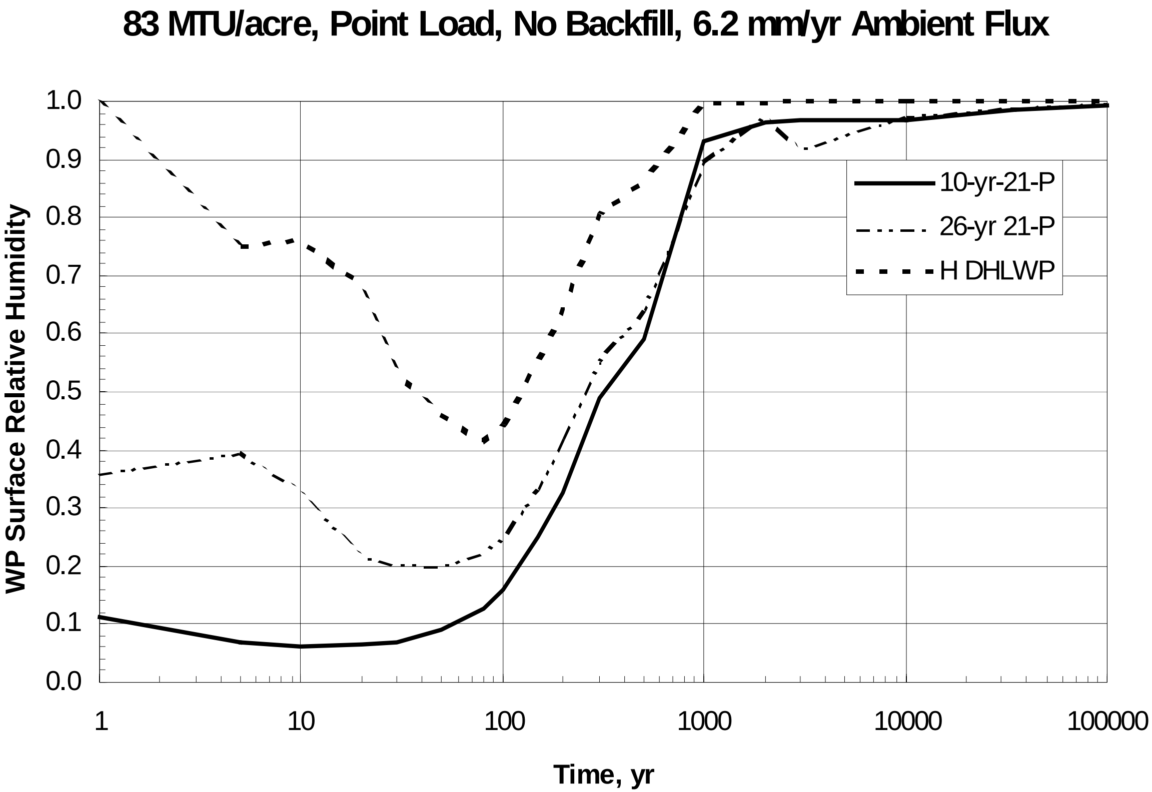


Calculated WP Surface Temperatures



22.5 m drift spacing

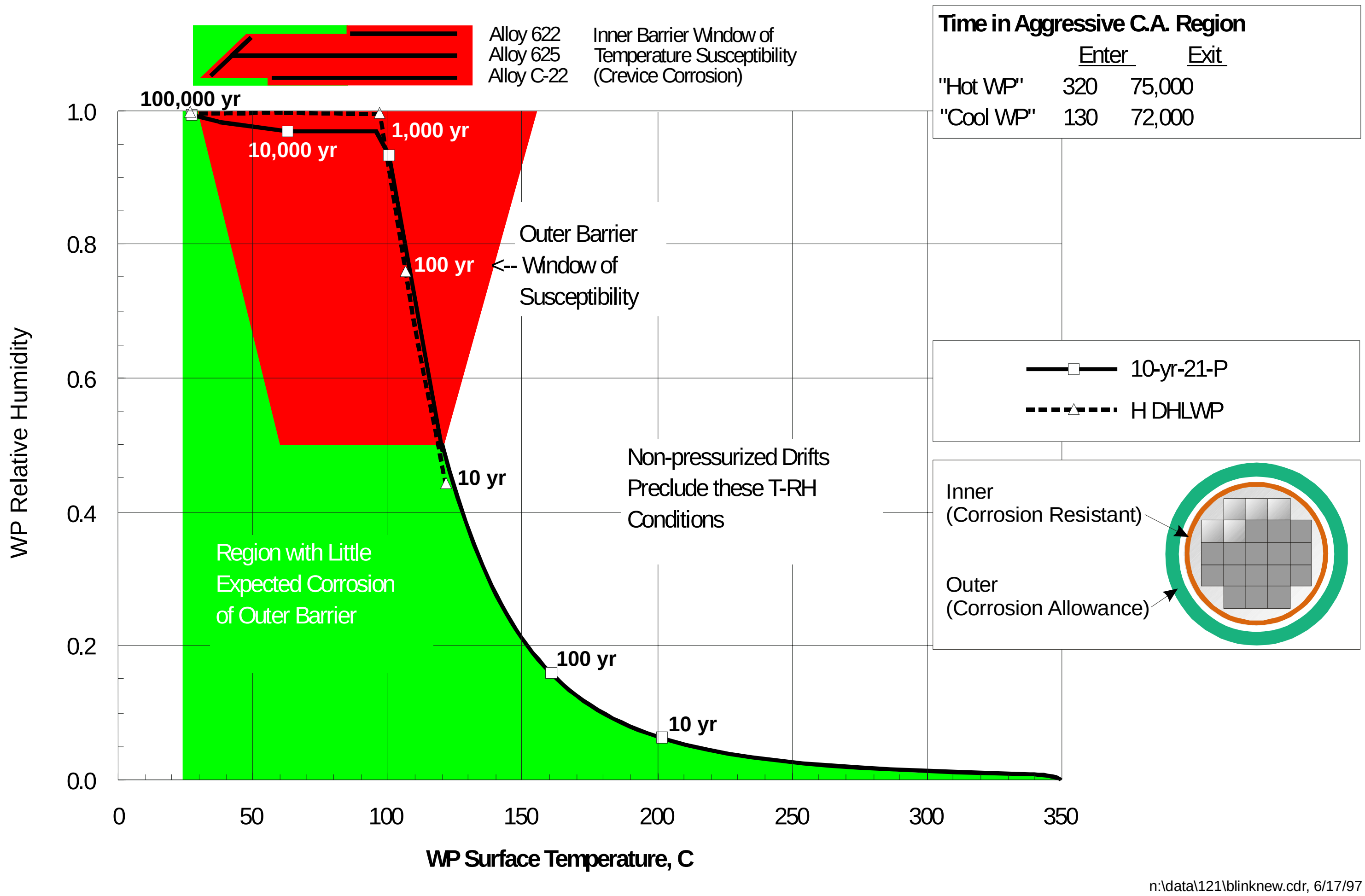
Calculated WP Surface Relative Humidity



22.5 m drift spacing

Reference Design WP Environment vs Corrosion Susceptibility

83 MTU/acre, Point Load, No Backfill, 6 mm/yr Ambient Flux



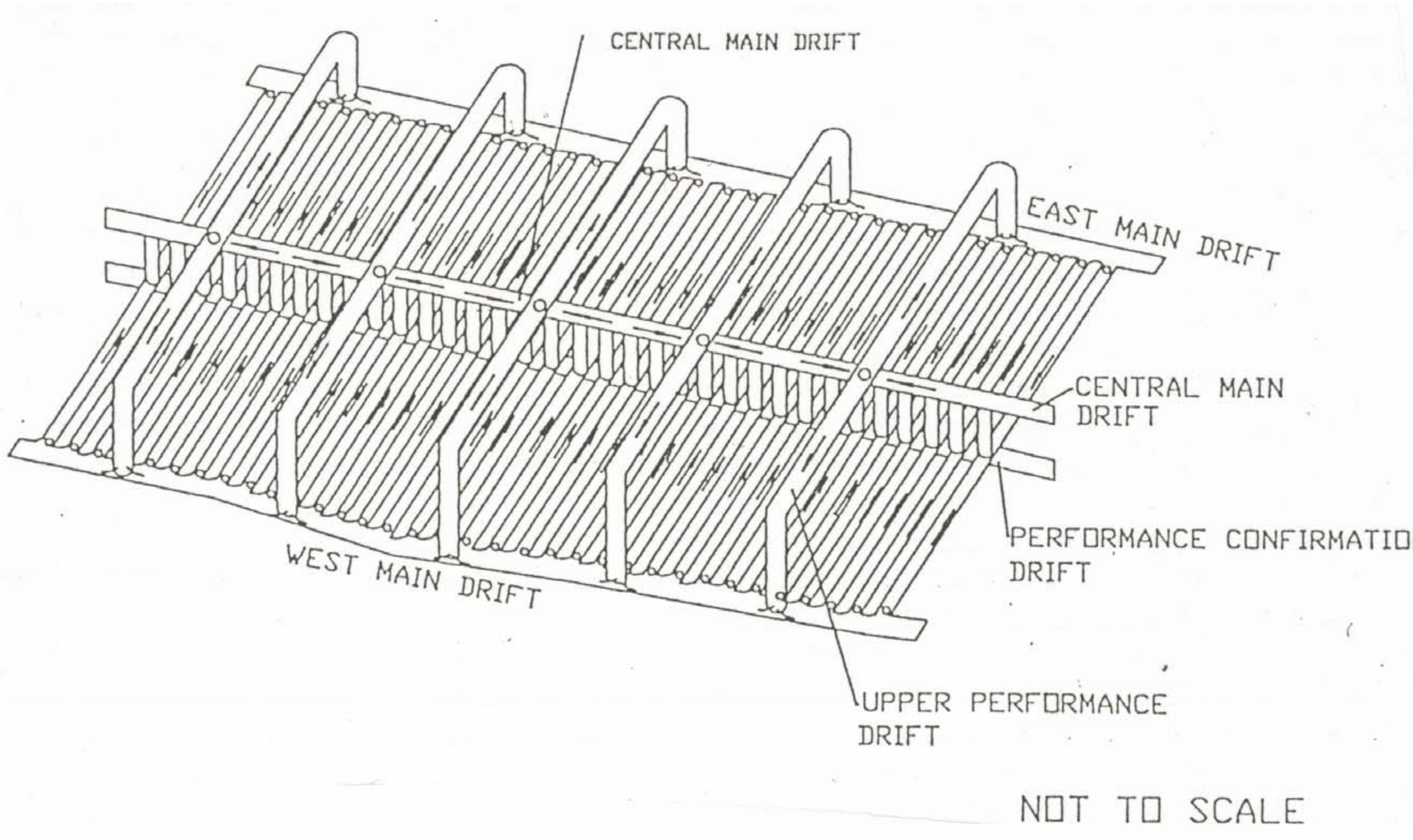
Ventilation effects on WP and Drift Wall Temperatures

- **Currently, ventilation is 0.1 m^3/s after the drift is full, as a preclosure radiological control measure. This removes some water, but does not limit the temperature**
- **The ESF ventilation system removes 200 mm/yr of flux, based on the drift surface area**
- **Repository Design has done analyses of time required to "blast cool" the drift for reentry, as a function of ventilation rate**
- **UNR recently completed an analysis for the NWTRB that included long term natural convection in both *open* and *closed* repositories**
- **Long term ventilation has two potential benefits: temperature control and moisture removal**

Preclosure Repository Ventilation

	Ventilation Rate, m^3/s					
	0.1	0.6	1.0	2.0	5.0	10
Peak Air Temperature, °C	141	120	107	83	56	43
Peak Drift Wall Temperature, °C	144	128	117	95	67	51
100 yr Heat Removed, %	8%	38%	52%	67%	79%	83%

Natural Ventilation of a Closed Repository (UNR Report to NWTRB)



Options to Decrease Clad Temperature

- Thicken the aluminum shunts in the basket
- Thermal blending in the WP (to reduce peak thermal power from the current 18 kW limit)
- Storage underground in a strongly ventilated drift until heat output falls to the desired level
- Increase WP spacing (and reduce drift spacing)
- Line load - space WPs very closely (< 1 m gaps) to use low output WPs as “fins” for high output WPs.
- Preclosure ventilation up to ten times the current design

Thermal Tradeoffs Provide Flexibility

- **The reference VA design is expected to meet DOE's guidance**
- **Design features such as ceramic coatings, backfill, and drip shields have the potential to significantly reduce peak dose rates at the accessible environment, but they tend to increase cladding temperatures**
- **Methods have been identified to compensate for increased cladding temperatures from these design features**