U.S. Department of Energy

OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

Project Operational Thermal Management Strategy

Presented to:
Nuclear Waste Technical Review Board

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PREDECISIONAL DRAFT

Introduction

- **Thermal management approach**
  - **Integrated waste stream management**
  - **Thermal design requirements and criteria**
  - **Design features**
  - **Concept of operations**
  - **Ongoing evaluations**

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Integrated Waste Stream Management

- **Waste stream management**
  - **Starts at utility and DOE sites**
    - **Use waste generator records to derive thermal content**
  - **Continues throughout repository preclosure period**
  - **Waste form thermal content**
    - **Commercial spent nuclear fuel (CSNF) heat load is key variable**
    - **Age young CSNF to meet thermal goals**
    - **Blend CSNF to meet thermal goals**

Integrated Waste Stream Management

- **Waste stream management**
  - **DOE Design Basis Waste Stream report used for planning**
    - **YFF5 or YFF10: Youngest Fuel First, minimum age out of reactor**
  - **Average waste stream (YFF10)**
    - **CSNF - 17 yrs out of reactor, 4 percent enrichment,**
    - **44 GWd/MTHM burnup**
  - **WP emplacement follows nominal pattern, interspersing CSNF waste packages (WPs) with cooler DOE SNF and high-level waste (HLW) WPs**
  - **Actual emplacement pattern may vary, but thermal criteria must be met**
  - **Will require alternating emplacement of hotter and cooler WPs**

Integrated Waste Stream Management

(Continued)

- **Waste stream management tools**
  - **Total System Model evaluates entire OCRWM system, including throughput**
  - **Throughput modeling evaluates facilities and emplacement operations**
    - **Includes waste receipt, SNF assembly management, aging needs, WP loading and emplacement**
  - **TSPA evaluates postclosure performance**

Thermal Design Requirements and Criteria

- **Waste forms**
  - **CSNF- maintain cladding below allowable temperature limits**
    - **Surface operations 400°C normal**
    - **Surface operations off-normal limits under development**
    - **Subsurface operations and postclosure 350°C**
  - **DOE SNF and HLW- maintain canisters below allowable temperature limits**
    - **Surface and subsurface operations- various SNF and canister temperatures**

Thermal Design Requirements and Criteria
(continued)

- **Natural and engineered barriers**
  - **Emplacement drift wall temperature 200°C max**
  - **Emplacement drift rock pillar- center portion below 96°C**
  - **Waste package surface temperature 300°C max**
  - **Waste package thermal power 11.8 kW max at emplacement**
  - **Initial maximum average thermal line load 1.45 kW/m**

Thermal Design Requirements and Criteria
(continued)

- **Repository closure**
  - **Thermal pulse after closure does not exceed**
    - **Emplacement drift wall 200°C**
    - **Waste package surface 300°C**
    - **CSNF cladding 350°C**
    - **HLW 400°C**
  - **Thermal conditions important for closure**
    - **Repository temperature at closure**
    - **Repository thermal power at closure**
    - **Repository thermal power rate of change**
  - **Performance Confirmation to confirm thermal calculations**

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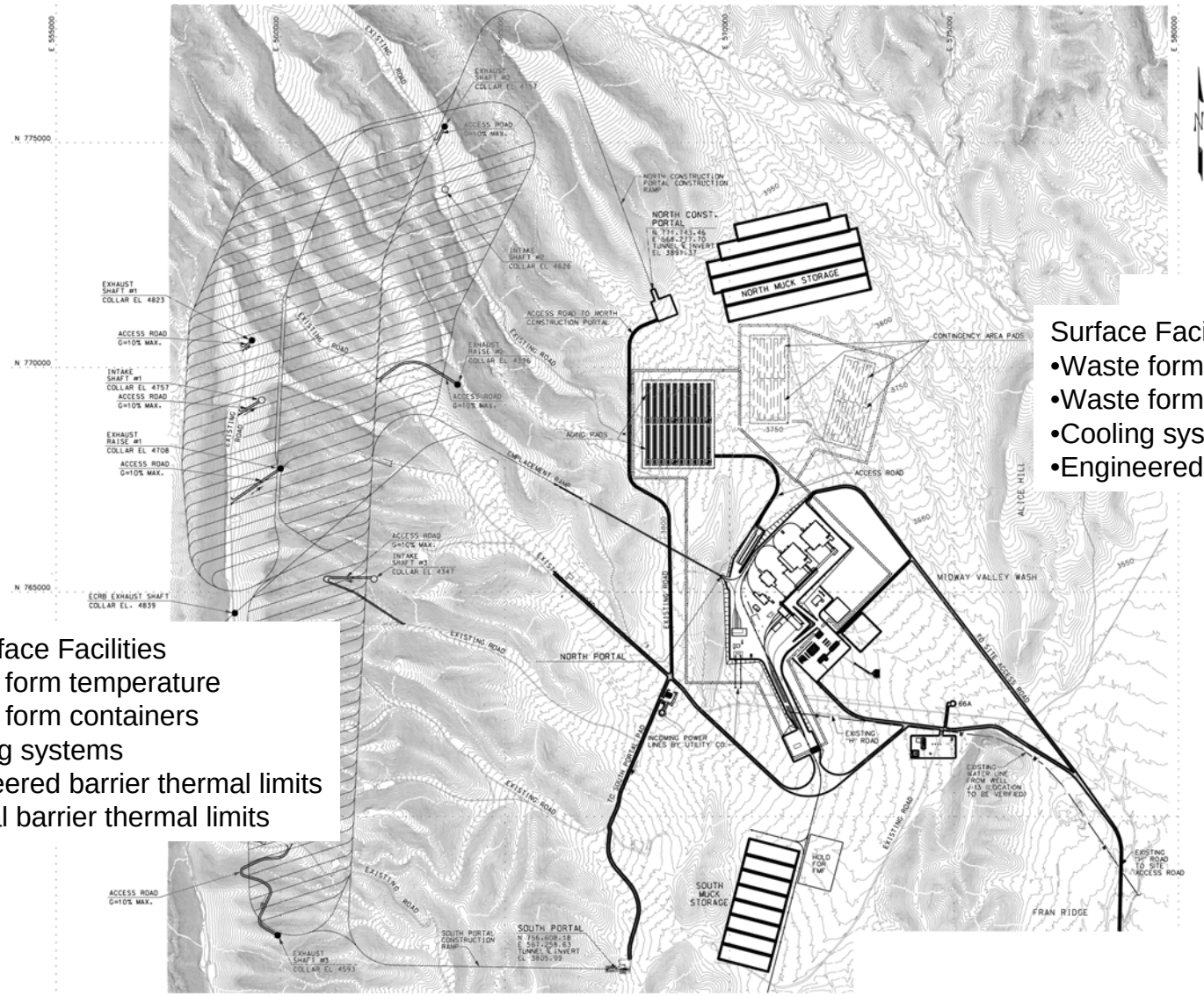
Thermal Management



Surface Facilities
- Waste form temperature
- Waste form containers
- Cooling systems
- Engineered barrier thermal limits

Subsurface Facilities
- Waste form temperature
- Waste form containers
- Cooling systems
- Engineered barrier thermal limits
- Natural barrier thermal limits

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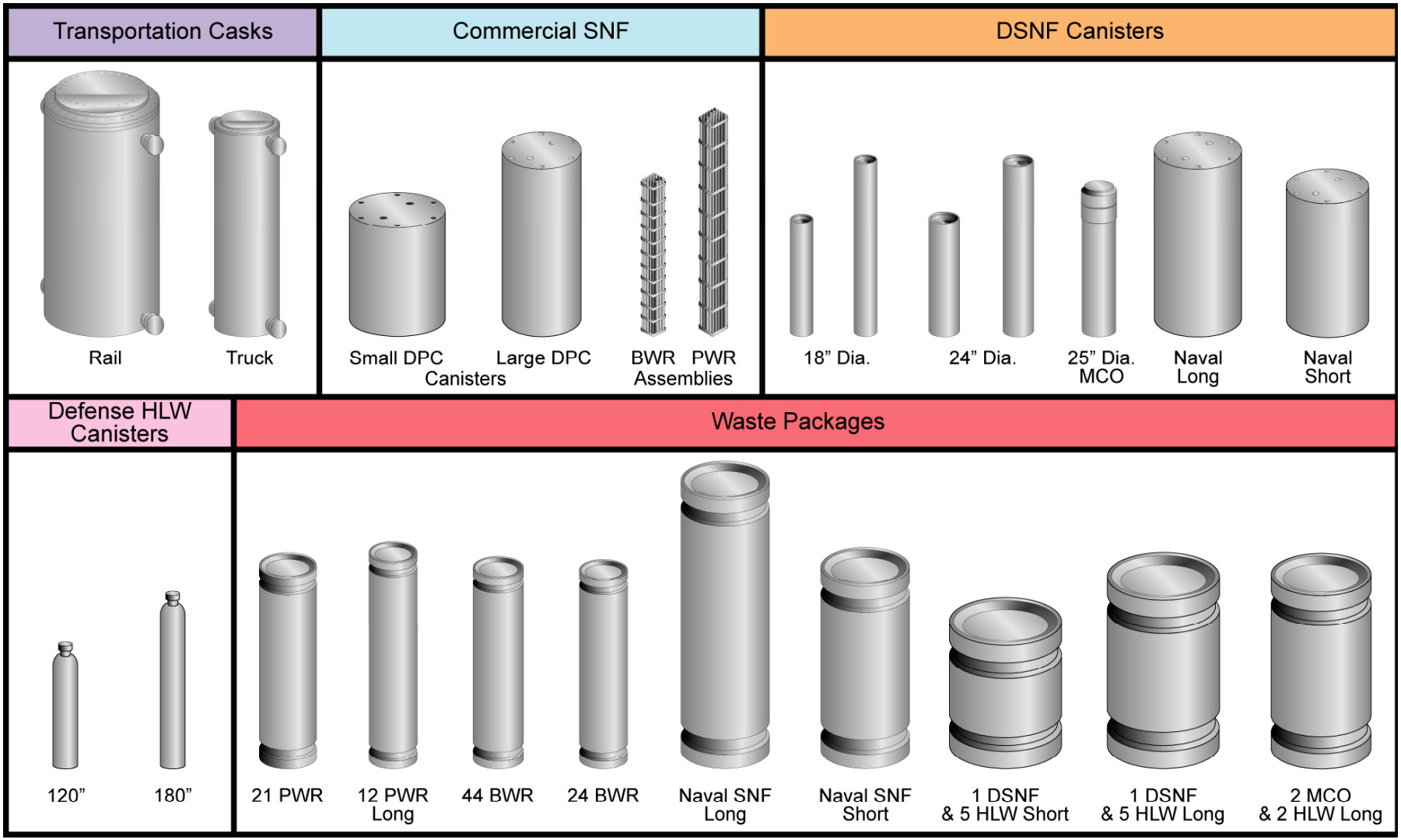
Waste Forms and Waste Packages



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Thermal Management Design Features

- **Repository systems, structures and components performing thermal management functions**
  - **Transportation casks**
  - **Waste package systems**
  - **Spent nuclear fuel aging system**
  - **Surface waste processing facilities**
  - **Surface HVAC systems**
  - **Emplacement and retrieval system**
  - **Subsurface facility**
  - **Subsurface ventilation system**

Thermal Management Concept of Operations

- **Surface facilities**
  - **Generator records evaluated prior to waste shipment to determine waste disposition upon arrival at repository**
    - **Into WPs for emplacement or into aging casks to aging pad**
    - **Will possess wide range of waste characteristics, depending upon inventory of waste shipper**
  - **Waste processed through waste transfer facilities**
  - **CSNF exceeding emplacement criteria sent to aging**
  - **Buffer areas and aging pads support limited campaigning of like waste forms**
    - **Interspersed emplacement of WPs affects extent of campaigning**

Thermal Management Concept of Operations (continued)

- **Surface facilities** (continued)
  - Facilities and systems designed to maintain thermal limits
    - Dry Transfer Facility (DTF) includes staging for 48 PWR and 72 BWR SNF assemblies and 10 DOE SNF or HLW canisters
    - Canister Handling Facility (CHF) includes staging for 10 DOE SNF or HLW canisters
    - Fuel Handling Facility (FHF) includes cell for aging cask in lieu of staging area
    - Transfer cells not inerted
  - Thermal analyses for bounding waste form heat loads
  - Thermal analyses for off normal conditions (e.g., loss of HVAC)

Thermal Management Concept of Operations (continued)

- **Aging pads**
  - **Aging casks allow assemblies to thermally cool until CSNF meets emplacement criteria**
  - **Up to 21,000 MTHM capacity**
  - **Potentially utilizes various types of casks to accommodate various types of CSNF**
  - **Potentially includes capability for aging existing dual-purpose canisters (DPCs)**

Thermal Management Concept of Operations
(continued)

- **Waste packages**
  - **WP loading controls to be developed**
    - **Address thermal, criticality, shielding criteria**
    - **May be similar to controls on loading existing dry casks**
  - **Primary CSNF WPs have capacity of 21 PWR or 44 BWR assemblies**
  - **A 12 PWR WP is available for longer SNF, but can also be used for particularly hot SNF assemblies to maintain overall WP thermal output limit**
  - **21 PWR and 44 BWR WPs could be short loaded to meet thermal limits, but would result in inefficient use of WPs and drift length**

Thermal Management Concept of Operations (continued)

- **Subsurface facilities**
  - **Facilities and systems designed to maintain thermal limits**
    - **Duration and flow rates for preclosure ventilation are established to meet thermal limits**
    - **Approximately 50 years preclosure ventilation planned from start of emplacement**
    - **Waste packages and cladding can withstand extended interruptions in ventilation**
    - **Initial postclosure conditions must be met prior to closure**

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Typical Aging Facility

Thermal Management Ongoing Evaluations

- **Throughput modeling**
  - **Throughput capability of waste handling facilities**
  - **System optimization**
  - **Safety and operational evaluations (operator dose, minimize waste form handling operations, safety analysis input)**
  - **Waste package and aging cask loading**
  - **Emplacement drift loading**
- **Thermal evaluations**
- **Handling CSNF in air**
  - **Effects of air on CSNF during handling operations**

Thermal Management Ongoing Evaluations (continued)

- **Total System Model**
  - Effects of varying waste stream on facility operations
  - Durations of facility operations
  - Optimization of operations
- **TSPA**
  - Evaluation of postclosure performance
- **Preclosure Safety Analysis**
  - Effects of thermal management on compliance with preclosure performance objectives

Summary

- Thermal content of CSNF requires aging
- Aging systems will be similar to existing dry cask storage facilities
- Ventilation is required to meet thermal limits in both surface and subsurface facilities
- Thermal goals must be satisfied before repository closure
- Continuing work to confirm current analyses regarding facility throughputs and thermal-related effects of air on CSNF