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

Update of the System Implications of the Repository Thermal Loading Study

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July 8, 1992

Presentation Outline

- Reasons for Study
- Study Objectives
- Coordination
- Study Approach
- Alternative Thermal Loading Strategies
- Assumptions
- Analysis Methodology
- Waste Stream Management
- Scenario Development
- Potential Scenarios
- Current Observations
- Future Work

Reasons for Study

- Several CRWMS repository thermal management strategies for enhancing containment have been independently proposed.

- Implementation of any of those strategies may impact design and operational functions of each of the other components of the CRWMS, particularly near-term decisions needed by MRS and transportation design.

- Selection of a thermal management strategy should reflect the evaluation of these system impacts, as well as the MGDS issues of performance assessment and licensability.

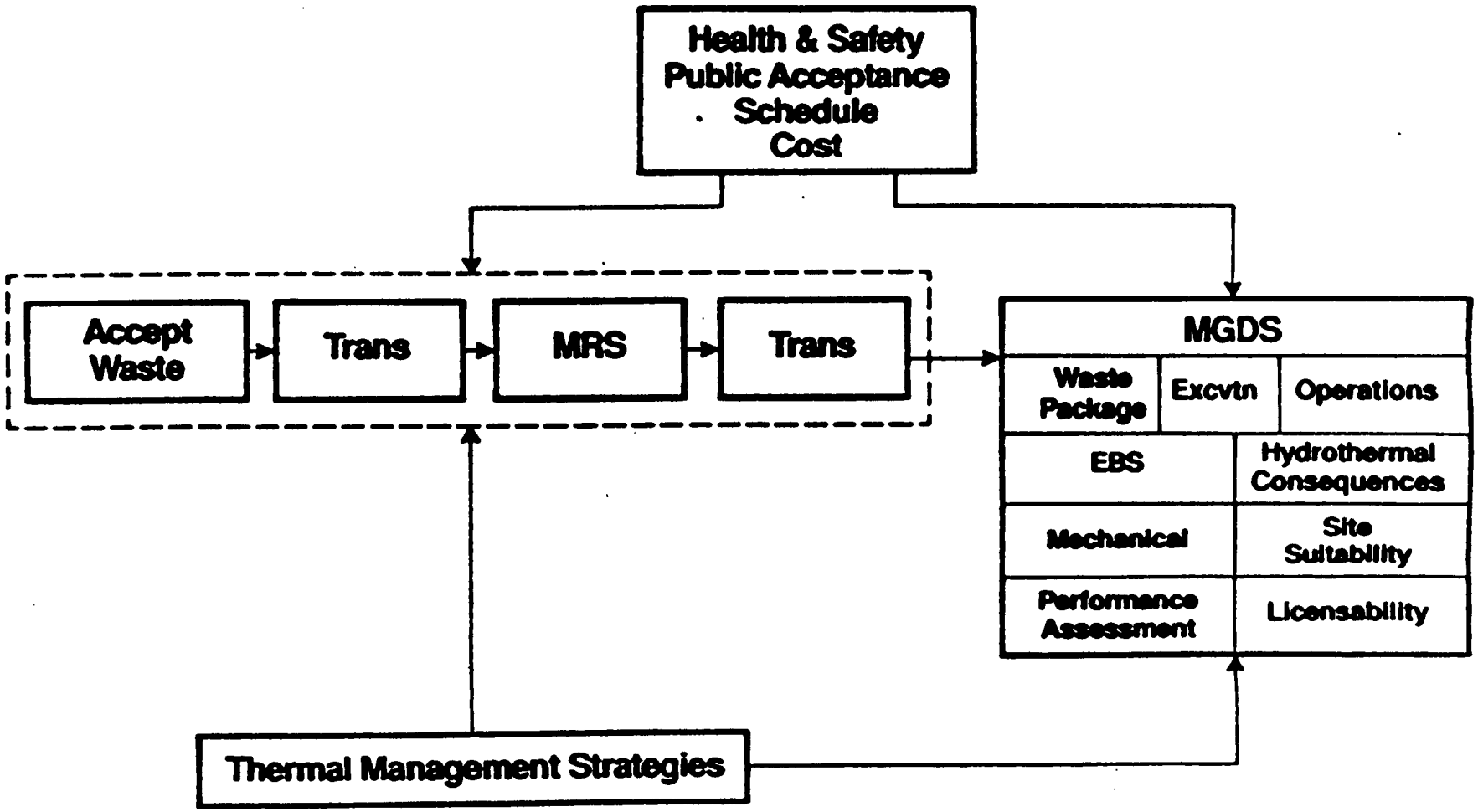
Near Term CRWMS Needs

- Design guidance for some system element design work, especially for MRS:
  - MRS storage technology
  - Transportation/storage cask concepts
  - Transportation cask design (e.g., de-rating)
  - MGDS Advanced Conceptual Design
- Early assessment of system Implications of repository thermal loading for CRWMS concept of operations planning:
  - Waste acceptance issues
  - MRS operations (e.g., passthrough/flowthrough vs. selective withdrawal, extended inventory/storage)
  - MGDS operations (e.g., lag storage, infilling, variable spacing, relocation)

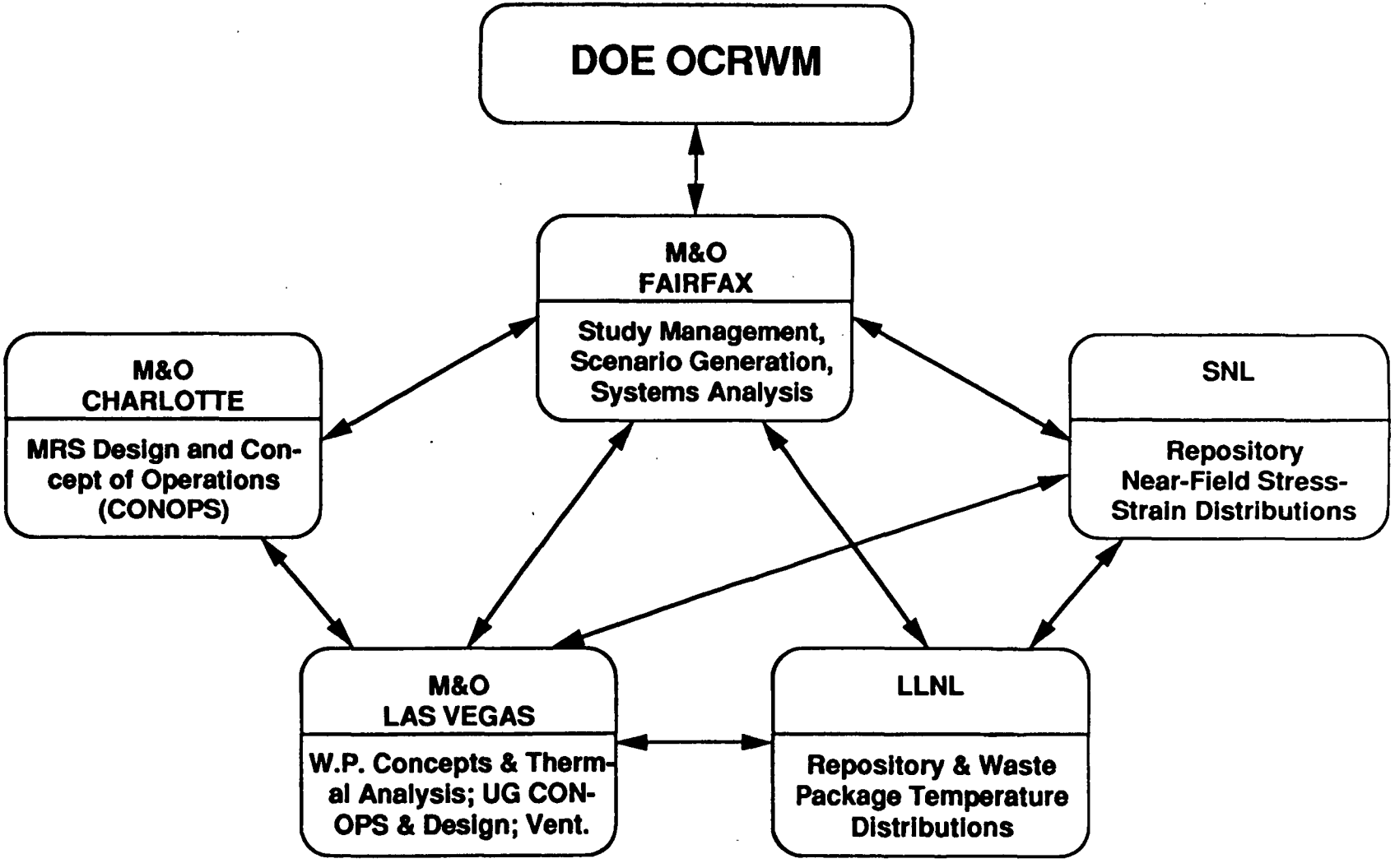
Study Objectives

- Identify potential system scenarios which can support each repository thermal loading strategy
- Analyze the system level impacts of the proposed range of repository thermal loading strategies
- Identify potential program-critical milestones which may be impacted by selection of a repository thermal loading strategy
- Provide system information for design basis guidance and trade-offs for CRWMS requirements specification and design activities

Study Context



Coordination Among Principal Study Participants



Study Approach

Study is being conducted in two phases:

Phase I:

- Define potential repository thermal loading alternatives and waste stream scenarios
- Develop analysis methodology to evaluate scenarios
- Determine scenario feasibility with respect to waste stream management
- Identify potential system implications of repository thermal loading on the CRWMS elements (waste acceptance, transportation, MRS, and MGDS

Phase II:

- Refine thermal strategies/scenarios from Phase I
- Refine evaluation criteria
- Reassess systems impacts incorporating considerations of design, operations, geology, licensability, etc.
- Propose options to decision makers

Thermal Loading Alternatives Selected

- Alternatives selected to encompass a range of potential repository thermal loading goals, while keeping the number of cases to analyze to a manageable size
- Thermal loading depends on: MTU/waste package, waste characteristics, area over which packages are emplaced (APD, LAPD).
- Thermal loading alternative selected:
  - Hot:
    - 30 and 60 year old SNF; 45 BWR or 21 PWR size waste package; target APD = 114 kW/acre; 5000 - 10,000 years above boiling temperatures
  - Similar to SCP:
    - 30 year old SNF; 3 PWR + 4 BWR mixed waste package; design APD = 57 kW/acre; less than 1000 years above boiling temperature
  - Cold
    - 30 and 60 year old SNF; 4 BWR or 2 PWR/(10 BWR or 4 PWR) small size robust waste package; target APD = 20 kW/acre; below boiling temperatures

Phase 1 Assumptions

- No schedule delays for acceptance or MRS start-up
- OFF allocation rights preserved
- 3000 MTU/yr steady state throughput
- Levelize thermal loading
- APD/LAPD used as a surrogate for long-term thermal/dryout repository performance
- Three conceptual robust waste packages
  - 45 BWR or 21 PWR
  - 10 BWR or 4 PWR
  - 4 BWR or 2 PWR
- Drift spacing = 100 ft.
- Repository emplacement area = 1250 acres

Phase I Assumptions (continued)

Potential Benefits of Levelizing:

- **Reduce thermal stress which can arise from spatial temperature inhomogenieties**
- **Simplify MGDS design/emplacement operations**
  - **Uniform environment for workers and machines**
  - **Ventilation and other maintenance simplified**
- **Control/assure achievement of repository thermal performance targets**
  - **Prevent leakage through the boiling front "umbrella" at localized cold spots**
  - **Guide returning water to waste-free areas (at perimeter or between widely spaced drifts)**

Analysis Methodology

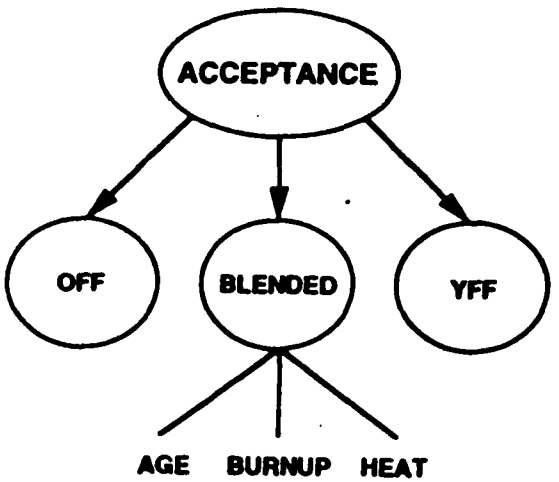
- Identify waste stream management alternatives
- Construct candidate scenarios from waste stream management alternatives (number of assemblies and where they move)
- Select alternatives for levelizing (to achieve uniform heat loading) (age and burnup where they are emplaced)
- Computations
  - Heat per package (blended and not-blended)
  - LAPD and APDs for each scenario
- Describe complete scenarios and their system impacts

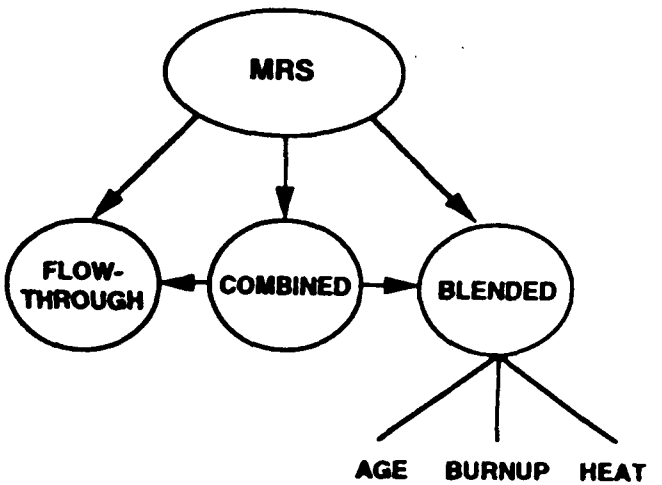
Waste Stream Management

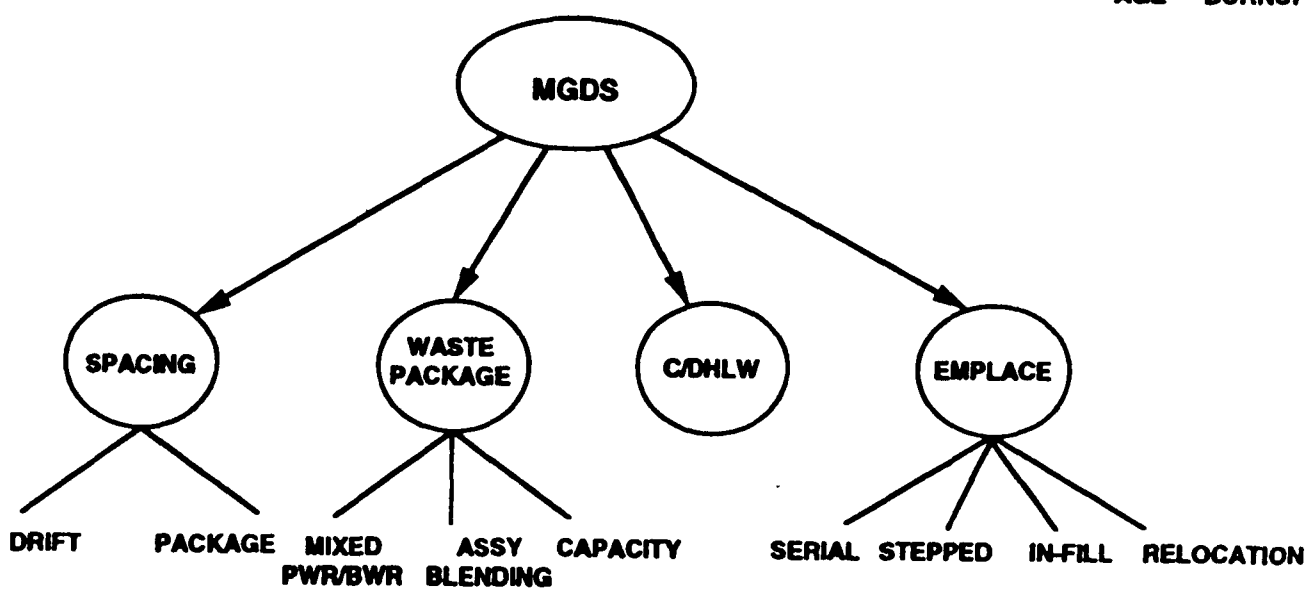
Alternative Methodologies for Levelizing

- Pair hottest and coldest assemblies for pickup from reactors
- Pair hottest and coldest assemblies for retrieval from MRS inventory
- Pair hottest and coldest assemblies for packaging at the repository
- Emplacement schemes
  - Infill within year
  - Infill from subsequent years
  - Vary package spacing
  - Vary drift spacing

Waste Stream Management Alternatives

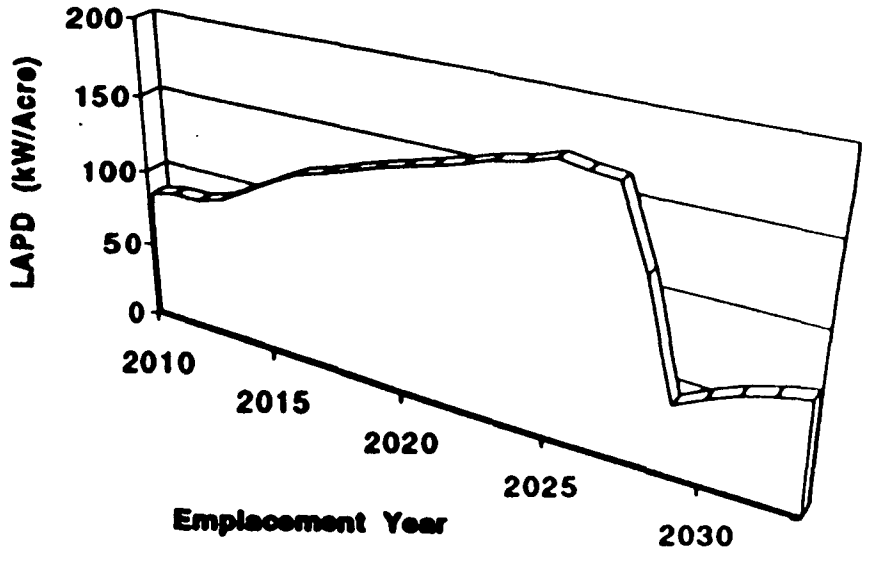




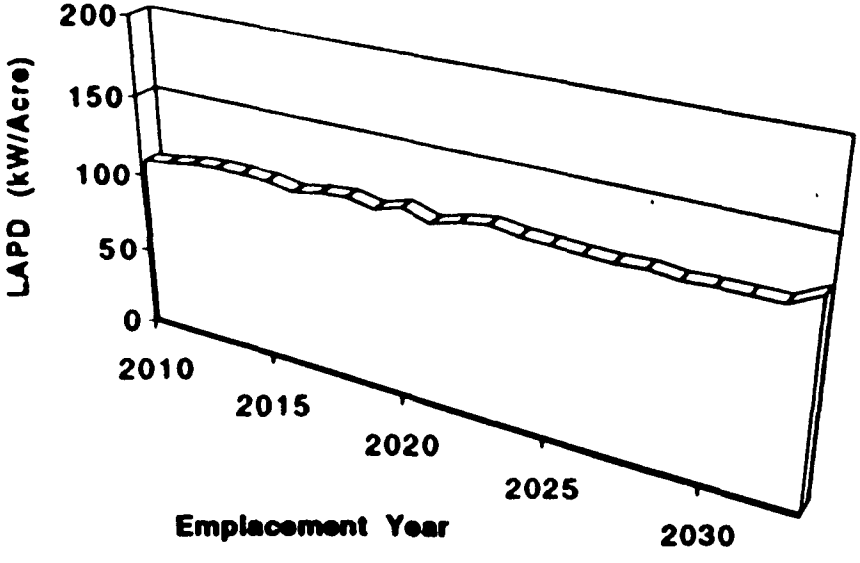


Illustrations of Effects of Blending

No Blending



Blending at Reactors and MRS



Package Size:	**17 ft**
Package Spacing:	**33 ft**
Drift Spacing:	**100 ft**
% Usable Area Used:	**48%**
Overall APD @ 2033:	**114 kW/Acre**

Sample Scenario Data Sheet

Scenario Number	1
Thermal Management Strategy Target	Hot
Acceptance	
Allocation rights (OFF)	yes
Selection Criteria	OFF
Transportation Cask Fleet	
Existing	no
Initiative 1, Phase 1	no
Initiative 1, Phase 2	yes
MESC	no
Dual Purpose	no
Universal	no
MRS	
Number of MRSs	1
MRS location	generic eastern
First acceptance at MRS, year	1998
MRS capacity	
Before repository years, MTU	10,000
After repository years, MTU	15,000
MRS operational period, years	40
Withdrawal strategy	Flowthrough

Repository	
Number of Repositories	1
Repository Location	Yucca Mountain
Initial Receipt & Emplacement, year	2010
Repository Capacity	
SNF, MTU	63,000
HLW, MTU equiv.	7,000
Waste Package	
Packaging location	repository
Type	21 PWR or 45 BWR, robust
Emplacement	in-drift
Spacing	33 ft.
Inter-Drift Spacing	100 ft.
C/DHLW Emplacement	tbd
Throughput rate, steady state, MTU/yr	3,000
Consolidation	
At reactor	no
At MRS	no
At repository	no

Baseline Scenarios, Key Data

Scenario No.	Thermal Target		Avg Age at Empl (yr)	Acceptance	MRS	MGDS	Package Capacity	Package Spacing (ft)
1	1.a.	Hot	26	OFF	CDR Ref.	Reference	45/21	33
2	1.a.	Hot	26	OFF	CDR Ref.	No Blend	45/21	33
3	1.a.	Hot	26	Blended	Blended	Reference	45/21	33
4	1.a.	Hot	26	Blended	Blended	No Blend	45/21	33
5	1.b	Hot	56	OFF	CDR Ref.	Reference	45/21	18
6	1.b	Hot	56	Blended	Blended	Reference	45/21	19.8
7	2.a	Cold	26	OFF	CDR Ref.	Reference	4/2	20.4
8	2.a	Cold	26	Blended	Blended	Reference	4/2	20.4
9	2.b	Cold	56	OFF	CDR Ref.	Reference	10/4	20.7
10	2.b	Cold	56	Blended	Blended	Reference	10/4	26.8
11	3.	SCP	26	OFF	CDR Ref.	SCP	4B+3P	17.7

Notes:

(1) MGDS = "Reference" means In-Drift Emplacement, Constant W.P. Spacing, and blending at the waste package level.

(2) MRS CDR Ref. means reference storage concept (dry vertical concrete storage); Blended implies use of vault or wet storage

(3) W.P. Capacity of 45/21 means uniform waste packages of either 45 BWRs or 21 PWRs; 4B + 3P means mixed waste packages

Baseline Scenario Data Relevant to Performance

Scenario No.	Thermal	Target	Avg APD at Emplacement kw/Acre	Fraction of Repository Used (63,000 MTU SNF; 7000 MTU HLW)
1	1.a.	Hot	113.8	.48
2	1.a.	Hot	113.7	.48
3	1.a.	Hot	114.2	.48
4	1.a.	Hot	114.2	.48
5	1.b	Hot	114.6	.27
6	1.b	Hot	114.2	.29
7	2.a	Cold	20.0	2.75
8	2.a	Cold	20.0	2.75
9	2.b	Cold	20.0	1.51
10	2.b	Cold	20.0	1.67
11	3.	SCP	56.8	.97

Current Observations: Hot Repository

Representative scenarios which satisfy initial screen for a levelized hot repository:

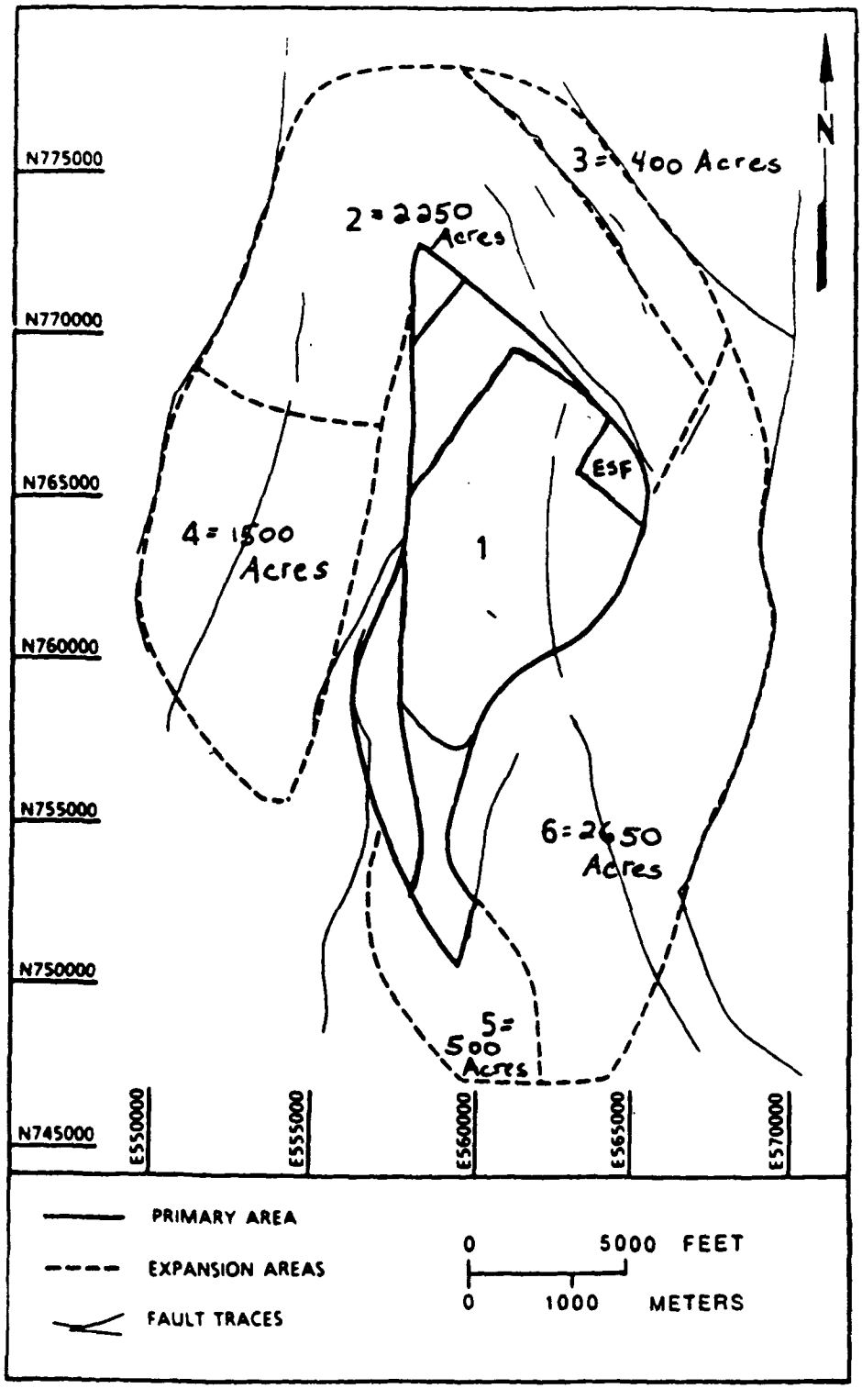
1. • Blending at MRS (implies requirement for vault or wet storage at MRS)
   • No infilling/relocation/extended lag storage required at MGDS
   • OFF acceptance
   • 86,000 MTU* emplaceable**
2. • No selection/blending at MRS (CDR Reference Design acceptable)
   • Levelized emplacement at repository with infilling and/or variable package/drift spacing
   • OFF acceptance
   • 86,000 MTU* emplaceable**

Assumptions/Qualifications

- Underground operations environmental constraints can be met
- No unpleasant surprises from site characterization
- Licensability of large waste package/EBS

* Total projected SNF from presently licensed reactors with no life extensions beyond 40 years

** SCP CDR repository design, without extensions (which may be available, according to the following map)



Area 1

- Perimeter drift minus ESF ≅ 1250 acres
- Area 1 (North and South extensions) ≅ 2200 acres
- Area 1 minus North triangle (less 200m overburden) = 1850 acres

Current Observations: Cold Repository

Representative scenarios which satisfy initial screen for a cold repository:

1. • No extended storage of SNF (26 years average emplacement age)
   • Levelized emplacement at repository without infilling
   • 24,000 MTU emplaceable**
2. • Extended storage of SNF for 30 years (e.g., 15,000 at MRS, balance in MGDS lag storage)
   • Levelized emplacement at repository without infilling/relocation
   • 50,000 MTU emplaceable**
   • OFF acceptance

** SCP CDR repository design, without extensions (which may be available, according to the following map)

Systems Studies Summary

- **Throughput Rate Study**
  - **Provides system design requirements information**
  - **Shows throughput rates in the range 3000-5000 MTU/yr are acceptable**
- **Alternative Cask/Canister Concepts**
  - **Investigated approaches for MESC's and reductions in handlings**
  - **More general scoping study underway**
- **System Implications of Repository Thermal Loading**
  - **Identified waste management scenarios supporting a range of repository thermal loads**
  - **Provides information to aid in selection of a thermal loading strategy**