Repository Disposition Evaluation for INEL SNF and High-Level Waste (HLW)

"Performance Assessments and Criticality Analyses"

Presentation to the

U. S. Nuclear Waste Technical Review Board
Panel on the Engineered Barrier System

June 6, 1995

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Outline

- History and Purpose of Performance Assessment (PA) Evaluation
- FY-93 PA Scope (Initial PA Efforts)
- FY-93 PA SNF Criticality Basis
- FY-94 PA Scope (Enhanced PA Efforts)
- FY-94 PA SNF Criticality Evaluation Methodology
- FY-94 PA SNF Criticality Evaluation Results
- FY-94 PA Results
- FY-94 PA Open Issues
- Current PA Activities and Future Plans

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INEL Spent Fuel and High-Level Waste Program Interface Diagram

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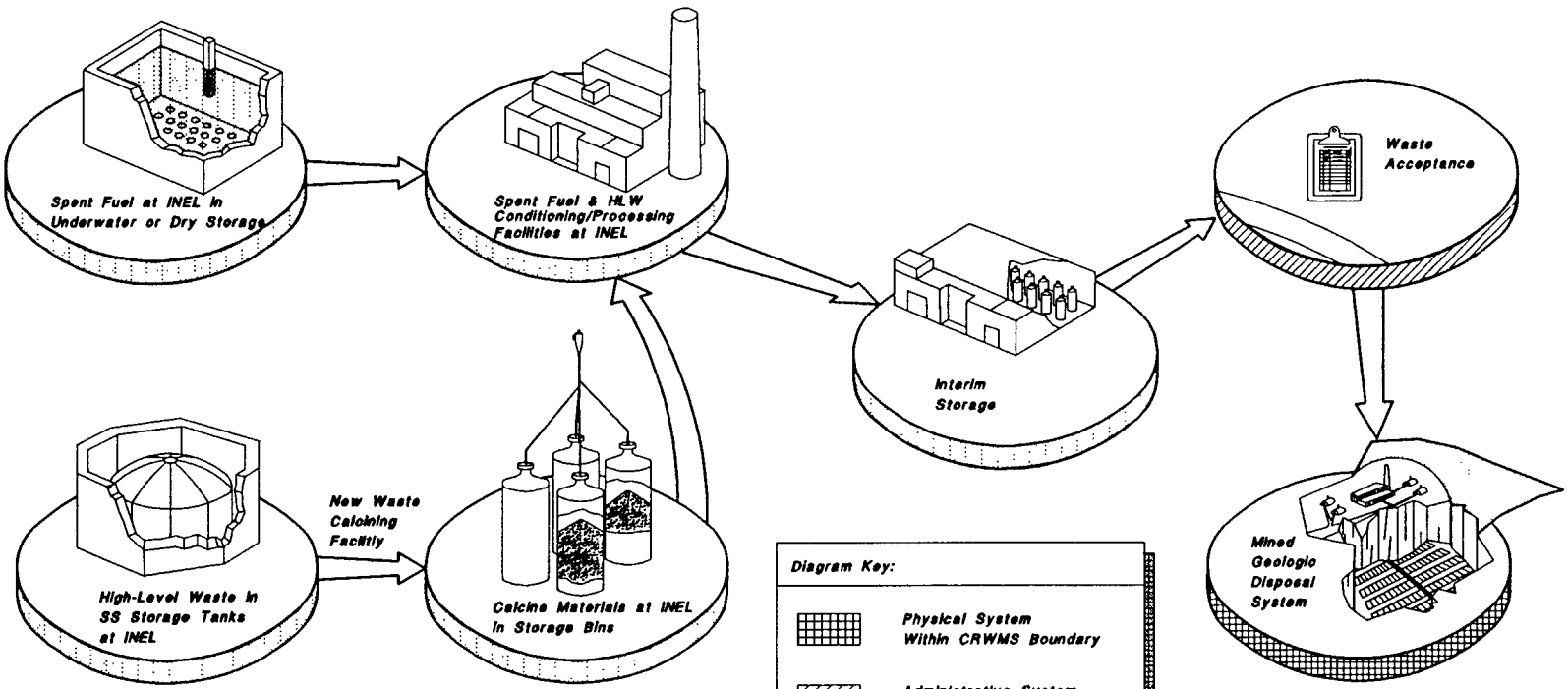

CRWMS = Civilian Radioactive Waste Management System

SF&HLWMP = Spent Fuel & High-Level Waste Program

Performance Assessment

Purpose

To initially assess the performance of potential final waste forms in hypothetical geologic repositories against the requirements of 40 CFR 191[1], and 10 CFR 60. Results will be used to help identify Waste Form Product Characteristics (WFPC) and provide guidance on the program activities and are NOT intended as support for a license application.

PA Activities Involve:

- Multi-Laboratory and organization
  - INEL led the effort
  - Contracted Sandia National Laboratory to perform the PA
  - Savannah River Site helped review criticality methodology and provided information on SRS HLW glass inventories and information
  - Hanford provided the N-reactor fuel information
  - RW M&O: B&W Fuel Company,
    TRW Environmental Safety Systems, Inc.
    Helped review criticality methodology
  - Contracted Lawrence Livermore National Laboratory to provide review support for the WFPC document
- Technical Peer Review of the PA to provide credibility
  - Five to Six member Panels consisting of experts in various PA areas

1. At this time, the NAS is in the process of developing a new EPA standard for the proposed repository at Yucca Mountain.

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FY-93 Scope
(Initial PA Efforts)

- Evaluate five potential waste forms
- Address ICPP high-level liquid and calcine wastes and INEL special and graphite fuels
- Include complex-wide glass
- Evaluate initial canister fissile loading limits for criticality safety; including
  - Processing to remove fissile materials
  - Dilution of fissile material with DU
- Evaluate two hypothetical geologic repositories
  - Igneous (granite) rock repository
  - Bedded salt repository

FY-93 PA Spent Nuclear Fuel Criticality Basis

- Mass Limit in Canister without use of neutron absorber materials
  - Bedded Salt Repository: 10 kg/canister
    (high fissile loading mainly due to exclusion of water from salt creep)
  - Igneous Rock Repository: 700 g/canister
- Migration of fissile materials from canister and assembly in the far field not considered
- Criticality event not an issue based on above assumptions

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FY-94 PA Scope

(Based on FY-93 PA Program Review Recommendations)

- Waste Forms
  - Five DOE spent fuel types
    - Advanced Test Reactor
    - Fort St. Vrain, Peach Bottom
    - Shippingport
    - PWR Commercial
    - N-Reactor fuel
  - High-Level Waste forms
    - Glass-Ceramic
    - Borosilicate Glass
    - Loose Calcine
- Tuff type repository similar to Yucca Mountain
- Evaluate the following canister designs
  - Drift emplacement 125 ton multi-purpose canister (MPC)
  - Borehole emplacement 25 ton legal-weight truck (LWT) canister
- Evaluate criticality event at post closure
  - Consequences and probability of such an event
  - Impact the criticality would have on the total system performance
- Evaluate waste forms against the 40 CFR 191 and 10 CFR 60 requirements
- Evaluate dose to the public based on the above conditions

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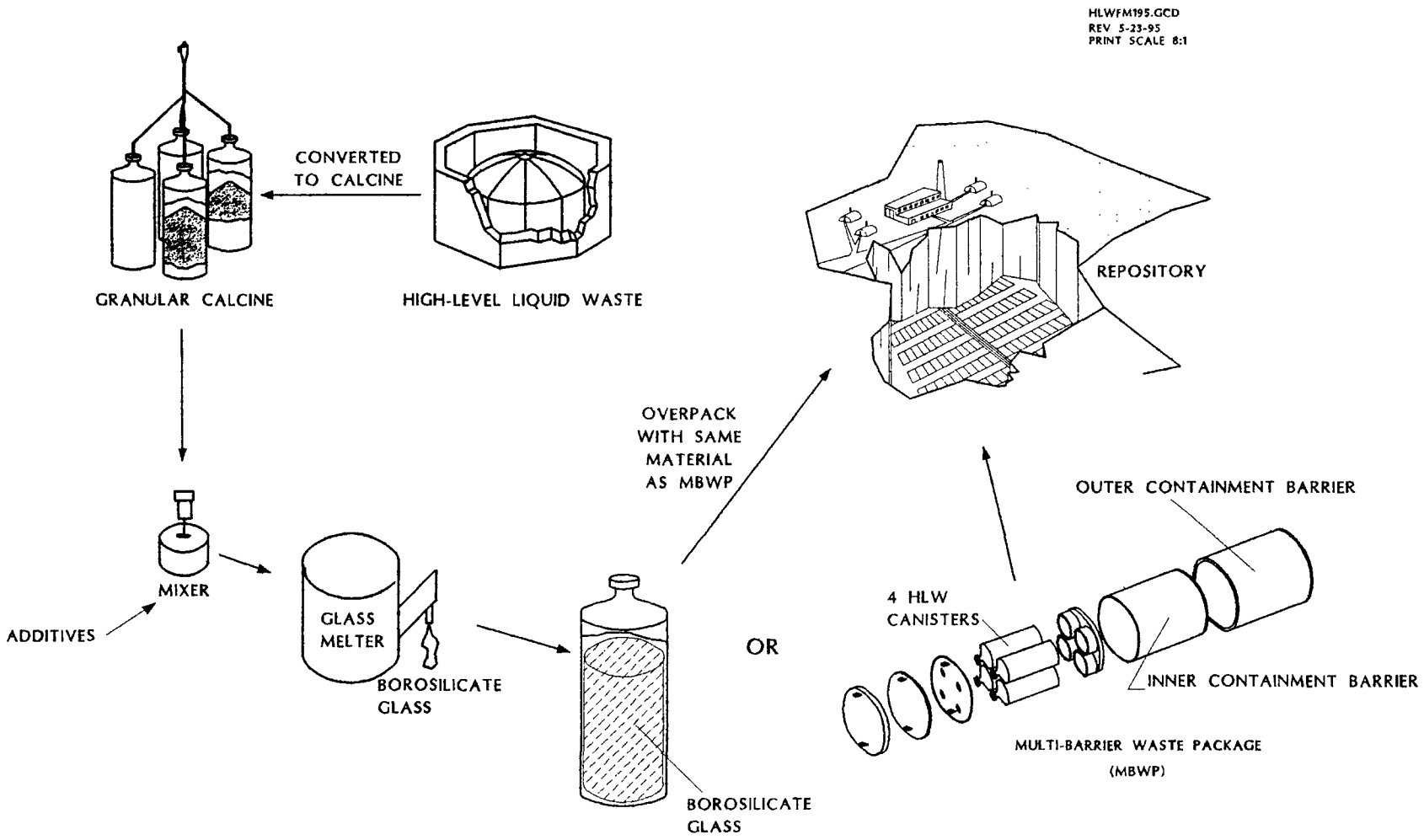
INEL HLW DISPOSAL CONFIGURATIONS

Note: Not To Scale



INEL SHIPPINGPORT SPENT FUEL DISPOSAL CONFIGURATIONS

Note: Not To Scale

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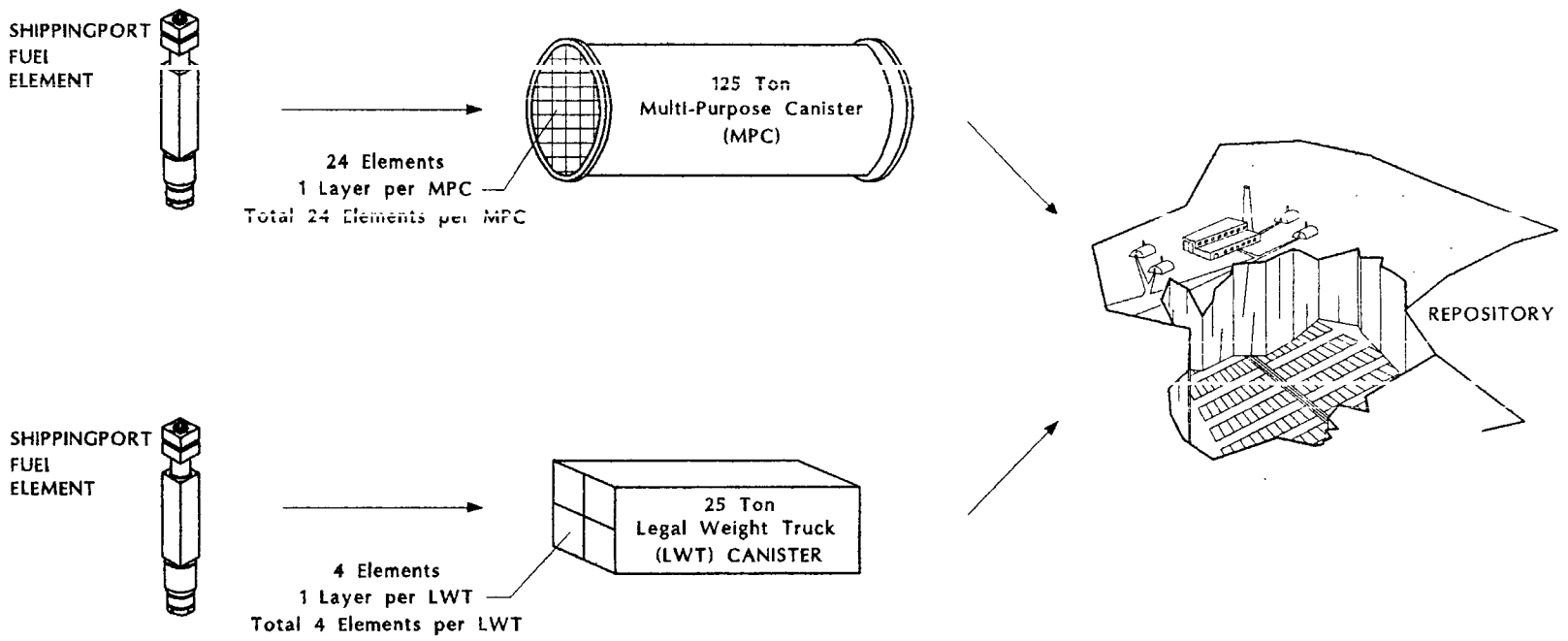
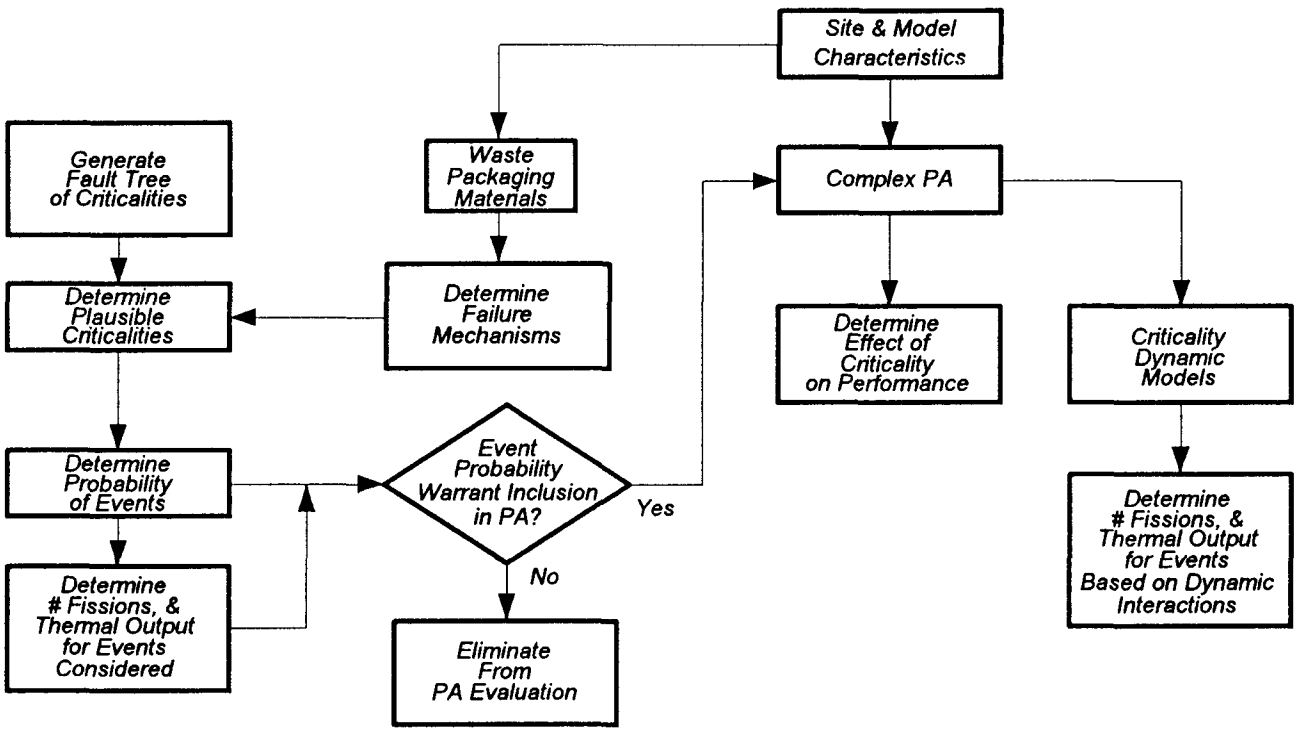
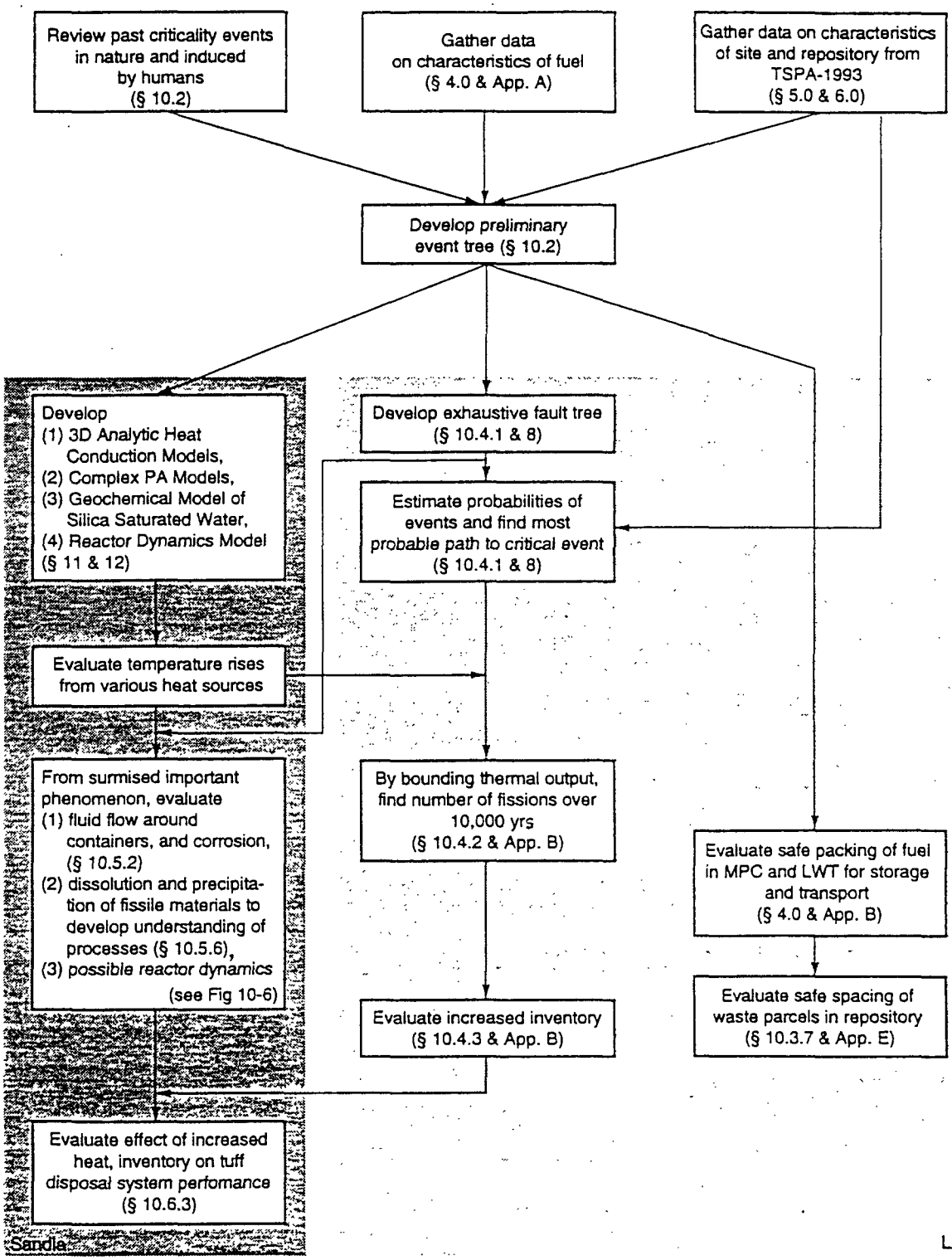


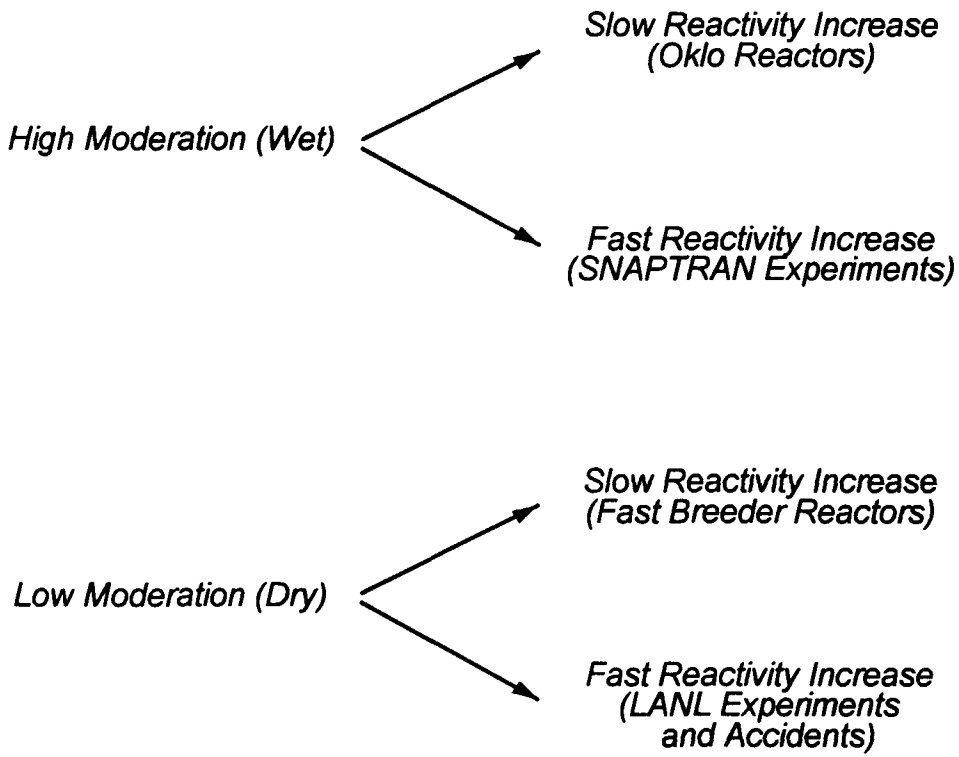
SIMPLIFIED FLOW DIAGRAM
OF FY-94 PA CRITICALITY EVALUATION



Criticality Evaluation Approaches



Criticality Events Postulated for High Enriched Uranium SNF Container



FY-94 PA Criticality Results

- Consequences of a criticality assuming high moderation and low reactivity are negligible
  - A steady-state reactor limited to 1kW to prevent boiling of water in a container would generate 10^{25} fissions over 10,000 years
  - Percent increase in total inventory due to such an event is insignificant compared to the ~10^{30} fissions represented by the 12,060 MTHM repository containing spent fuel with burnup of 40,000 MWd/MTU

- Preliminary fault tree analyses show that the possibility of a criticality could not be readily ignored as a scenario

- However, because of uncertainties of various repository processes, various conservatism has been included in these evaluations. Better understanding of these processes should significantly reduce the probability of any criticality event.

FY-94 PA Performance Results

- The proposed SNF forms (together with HLW vitrified glass from INEL, SRS, HANF, and WV) appear to be acceptable for compliance with the containment requirement of 40 CFR 191, but the waste emplacement package did not completely meet requirements of 10 CFR 60.113

- The mean release rate of ^{99}Tc and ^{14}C exceeded the allowable release rates, and the 90% quantiles of ^{129}I and ^{238}U exceeded the allowable release rates

- Radionuclides[1] contributing the most to the sum normalized activity release are

  - ^{14}C, ^{99}Tc, ^{129}I, ^{234}U, ^{237}Np

- Based on the best available information, the estimated ^{14}C inventory in DOE-owned SNF did not violate the requirement of 40 CFR 191

- The solubility of waste elements in the assumed chemical environment of the repository is an important parameter that affects release from the repository and transport to the accessible environment

1. The list of important radionuclide contributors is also sensitive to the regulatory period being considered.

FY-94 PA Evaluation Open Issues

- Verify the acceptability of using the ORIGEN2 computer code to estimate the radionuclide inventories of a slow-cooker
- Verify the ORIGEN run output data (radionuclide inventory) used in the FY-94 PA, especially the ^{14}C and other major contributor radionuclide inventories
- Validate the assumed neutron absorber material solubility in relation to the fissile materials
- Validate corrosion rates (near boiling point of ground water) of carbon steel and Incoloy 825
- Evaluate further the influence of a human intrusion on criticality scenarios
- Solubilities of radionuclides in solution saturated with and without silica

Current PA Activities

- Finalize FY-95 Performance Assessment for DOE High Level Wastes
- Evaluate the following open issues raised in FY-94 Peer and Program Reviews
  - Verify the acceptability of using the ORIGEN2 computer code to estimate the radionuclide inventories of a slow-cooker
  - Verify the ORIGEN run output data used in the FY-94 PA, especially the ^{14}C and other major contributor radionuclide inventories
- Finalize Criticality Evaluation Protocol for DOE-Owned Spent Fuels

Future PA Plans

- DOE SNF PA evaluation in FY-98 or sooner if funding is available
- Evaluate the fuel forms destined for the repository at that time
  - Further evaluate the criticality probability, scenario, and consequences of disposing DOE-Owned SNF in a geologic repository
  - Determine better radionuclide inventory data for the future PA, especially the ^{14}C and other major contributor radionuclide inventories

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