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Disposition of Spent Nuclear Fuel at the Savannah River Site

Thanh-Tam Truong

Scientist, Environmental & Legacy Management

SRS Citizens Advisory Board Meeting

September 23, 2025

Focus Areas for Future Processing Needs

- H-Canyon anticipated to Cease Processing in ~2034
  - Final Drops to H Tank Farm
  - Last Sludge Batch

- Key Focus Areas for Potential Options to Process
  1. Disposition of Non-Aluminum Spent Nuclear Fuel (NASNF)
     - Difficult to Dissolve
     - Challenging to Dry
     - Damaged Fuels
  2. Remaining and Incoming Aluminum Spent Nuclear Fuel (ASNF)

Overview of Processing Options

1. Aqueous Dissolution with Vitrification (all new) – Tam Truong
2. Dry Storage - Drew Fairchild
3. Melt/Dilute SNF – Chris Rasmussen
4. Direct Vitrification with no Dissolution – Jake Amoroso
5. H-Canyon Life Extension with Decoupled Vitrification (new) – Jake Amoroso

Modular Approaches

- Intent for any New Processes to be Modular
  - Not a New Large Canyon Facility
  - May use Modules or Cargo Containers similar to Mobile Pu Facility
  - May use Modular Hot Cells
- Enables Agility for Process Changes
- Improves Affordability

Mobile Melt Consolidate Process

Drying Savannah River Site (SRS) Spent Nuclear Fuel for Disposal in a HLW Repository

Citizens Advisory Board

Drew Fairchild – Project Manager

September 23, 2025

SRS SNF Facility

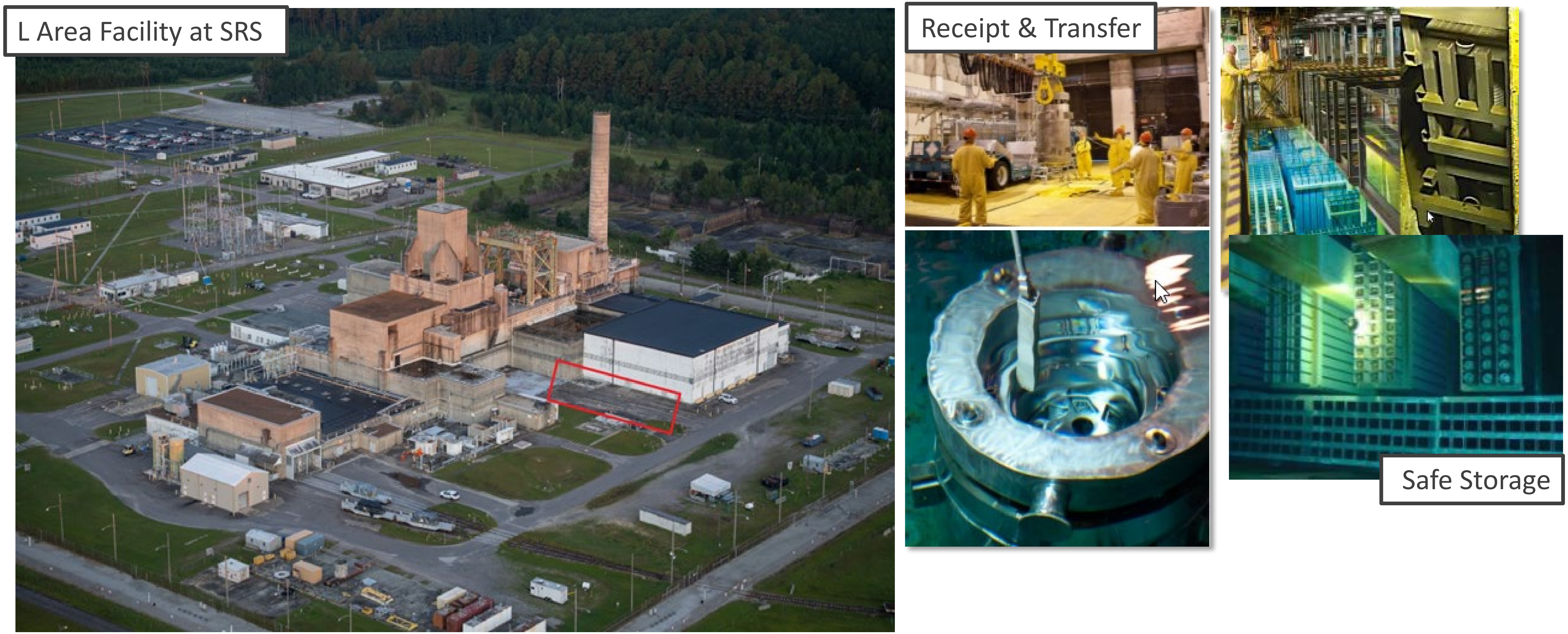
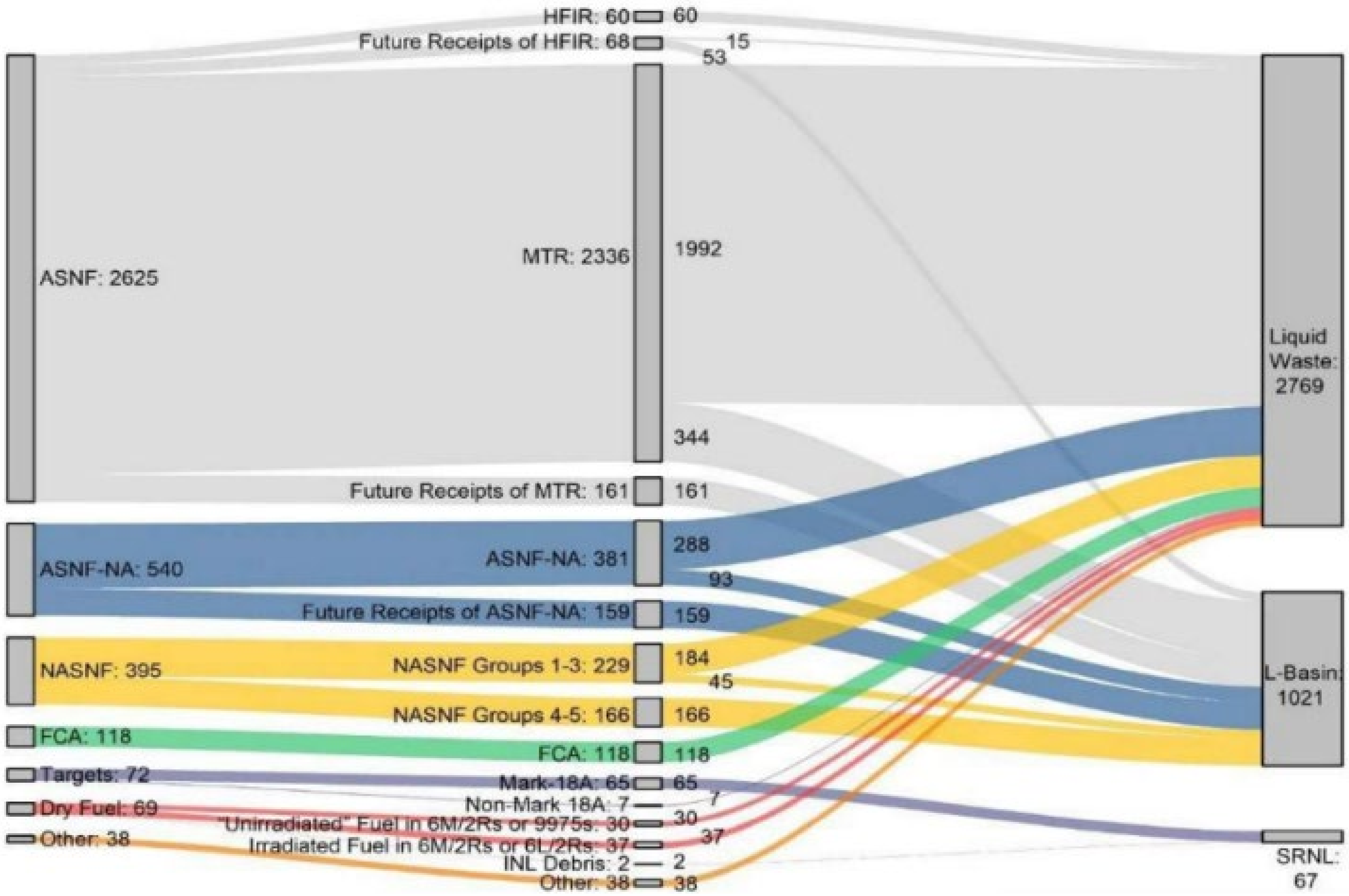
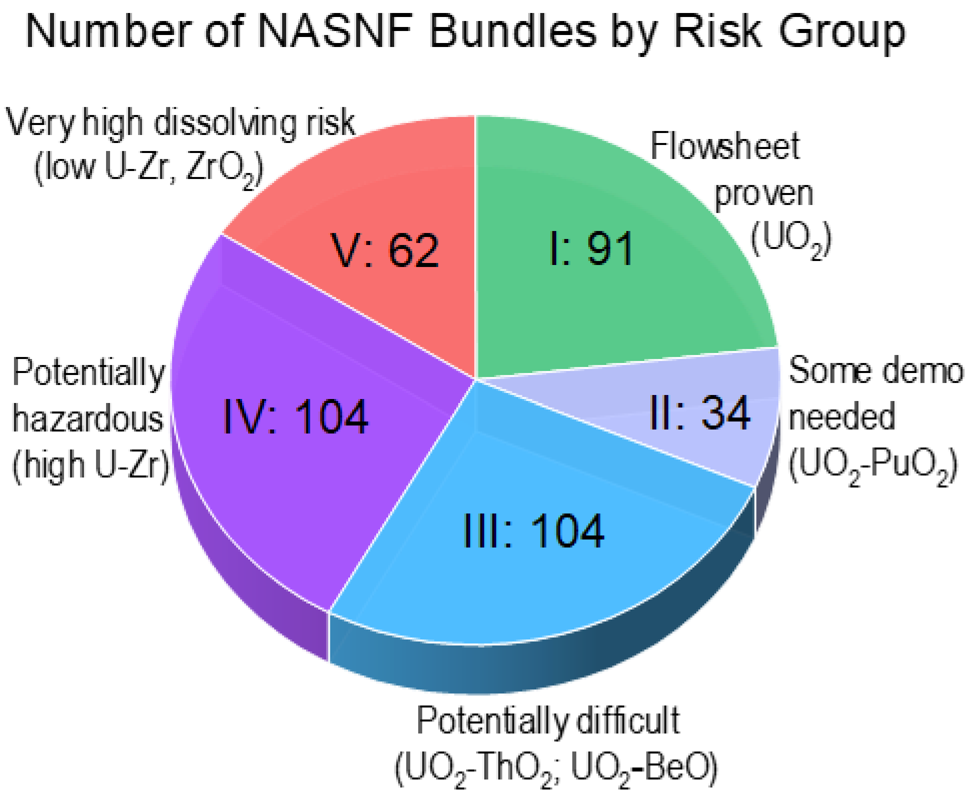


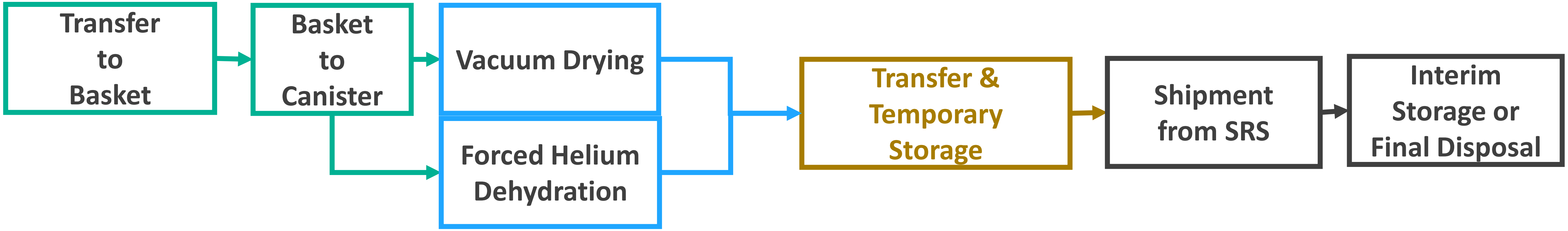
Figure 1: SRS L-Area Facility & General Operations

L Area Spent Nuclear FuelJ





Alternative for SRS Spent Nuclear Fuel (SNF)



Wet to Dry Storage Transfer

- SNF retrieved from SRS L Basin wet storage
- SNF transferred into basket
- Basket (w/ SNF) transferred into canister
- Canister transported to process area

Drying

- Vacuum
- Forced He Dehydration

Transfer & Temporary Storage

- Shielded overpack
- Shipping pre-requisites
- Surveillance

Aluminum-Clad SNF (ASNF) Pilot Test

Pilot Test Evolution

- Execute Transfer of ASNF
- Perform Drying
  - He Forced Dehydration
  - Vacuum Drying
- Monitor off-gas generation

Expand Dry Storage in-scale

Impacts of Pilot Test Evolution

- Option - Expand Dry Storage In-Scale
- Option - Extend Dry Storage to Non-Aluminum Clad SNF
- Demonstrate in L Area Facility:
  - Prevention of Flammability at Engineering Scale
  - Prevention of Explosive Condition at Engineering Scale

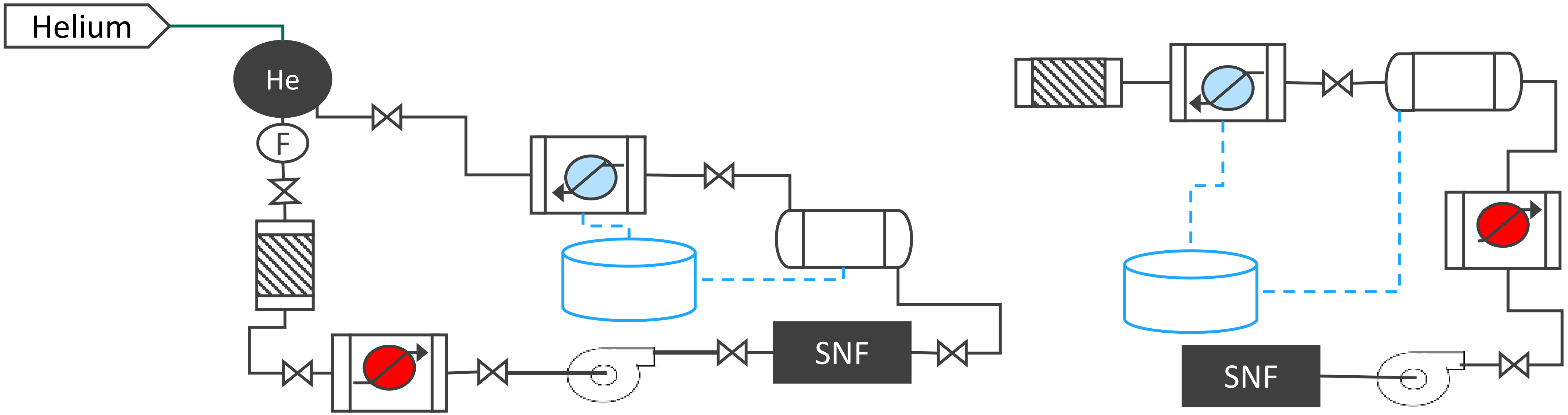


Figure 2: Conceptual Schematics - Forced Helium Drying System (Left) & Vacuum Drying System (Right)

Challenges for SNF Drying

- ASNF R&D
  - Prevent Flammable Condition
  - Prevent Explosive Concerns
- Non-Aluminum Clad Spent Nuclear Fuel
  - Altered SNF
    - SNF deviating from original condition (e.g., cut / degradation)
    - No implications upon safety or containment of fuel contents
  - Washing and slow drying needed to stabilize and prevent reactions in air
  - Underwater handling and contamination controls in the basin

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Melt Disposition of Aluminum and Non-Aluminum Spent Nuclear Fuel (ASNF and NASNF)

Chris Rasmussen

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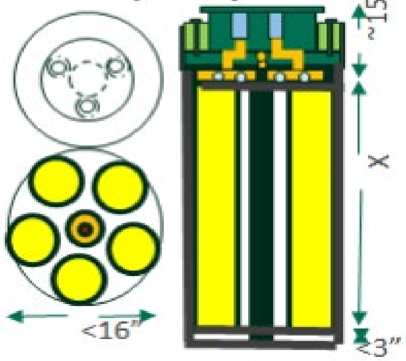
ASNF + NASNF Melt Dilute Option

The melt-dilute process for treatment of spent fuel melts and dilutes it with aluminum and/or stainless steel, making it eligible for federal repository.

Example basin with spent nuclear fuel under water

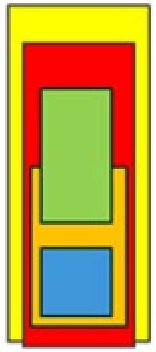
ASNF + NASNF Melt Dilute Overview

Damaged Fuel Can w/ Basket (Yellow)



DFC: Modified 18" OD MCO
Approach: Mott filter, dipleg, vent, Rup. Disk , shield, valves.; ship in shielded cask

Baskets 16" OD of various inner divisions and heights. For melt and dilute, basket H=18" or 34".



Inert Induction Furnace
Chamber 3'D
Mold
16.5"ID x 35" crucible
16" x 15" puck (50 liter)

MD Overview

Move SNF
↓
Pack/Chop
↓
Drying (Cold and Hot) (assumes Metallic risk requires both)
↓
Off-gas Collection and Treatment
↓
Feed Prep
↓
Melter
↓
Waste Loading
↓
Interim Storage, ready to ship

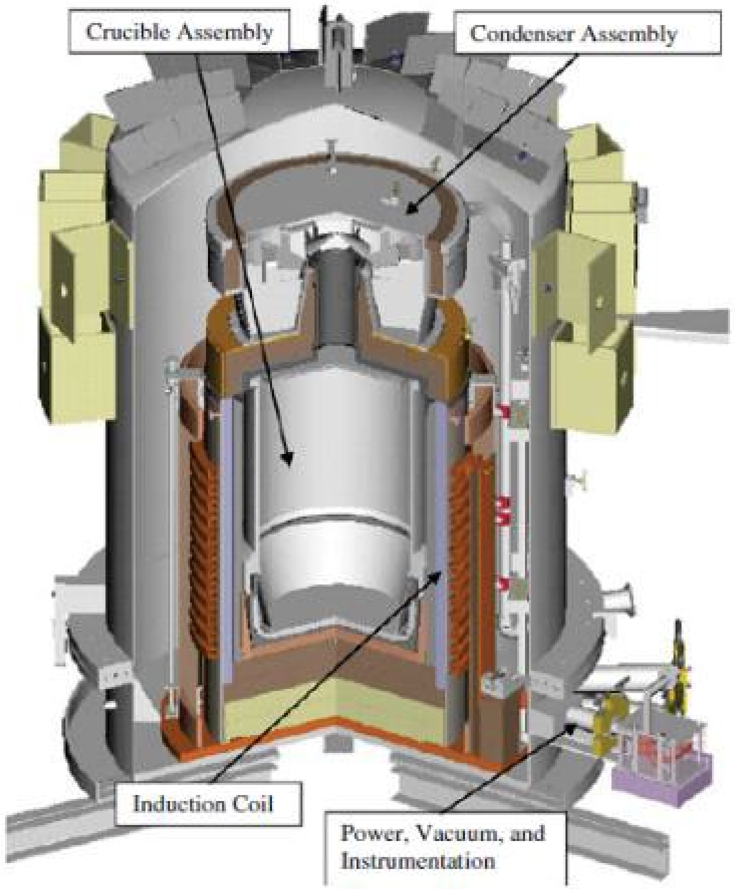


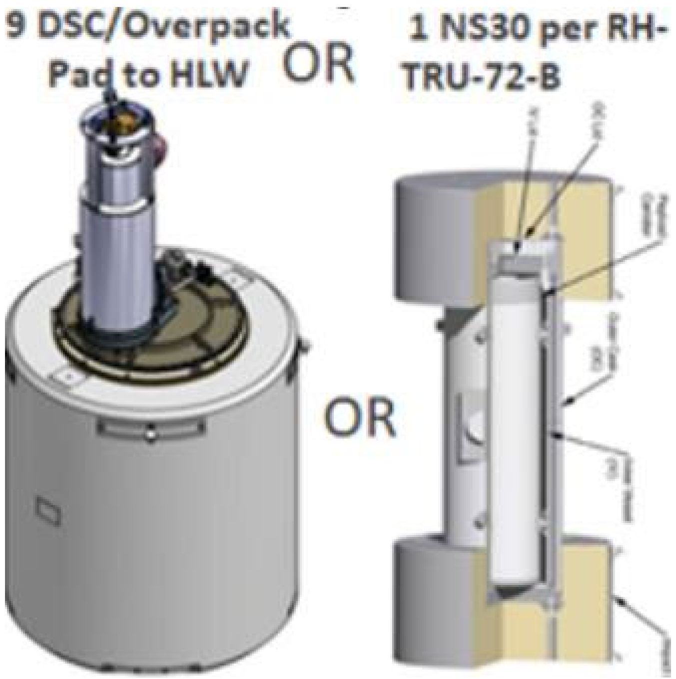
Fig. 1—Schematic of production-scale metal waste equipment.

ASNF + NASNF Melt Dilute Option

-Primarily NASNF Group 4-5 (e.g. UZr, ThU, ZrO_2, ThO_2, UO_2, BeO and some damaged) and combine with any remaining Group 1-3.
-Co-melting ASNF (Aluminum Spent Nuclear Fuel) and NASNF reduces the required temperature and off-gas risk, while decreasing the number of high-level (HLW) canisters.
-Melt Dilute was experimentally tested for L-Area Experimental Facility (LEF).
-Melt Dilute being used Mobile Melt Consolidate (MMC) in Norway.

ASNF + NASNF Melt Dilute Advantages

-Reduction of volume for storage configuration
-Lower safeguard requirements
-Consistent handling of waste forms
-Potential reduction in High-Level Waste storage vs. dry storage



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Aqueous Dissolution & Vitrification of Spent Nuclear Fuel Post H-Canyon Accelerated Basin De-inventory

Thanh-Tam Truong

SRS Citizens Advisory Board Meeting

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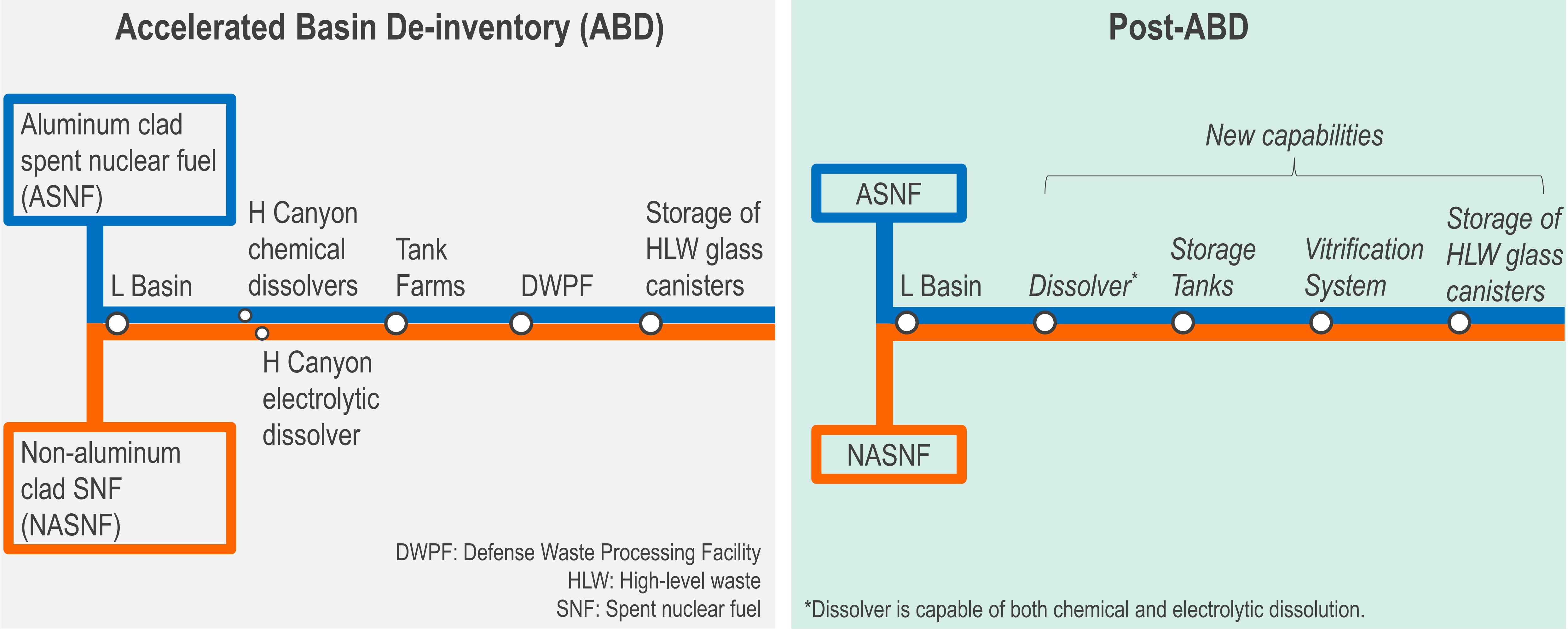
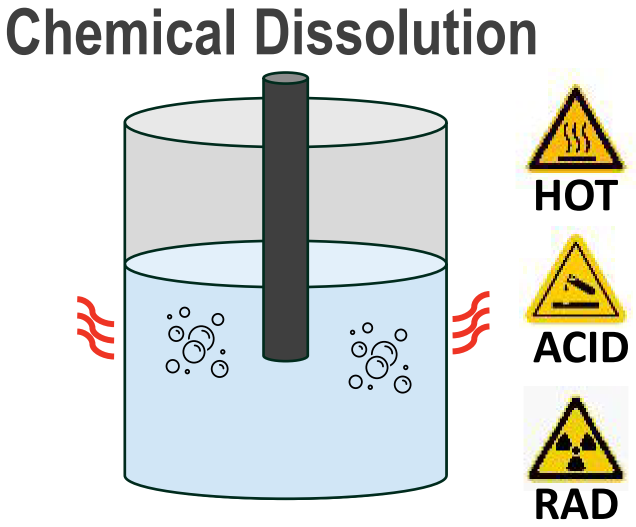
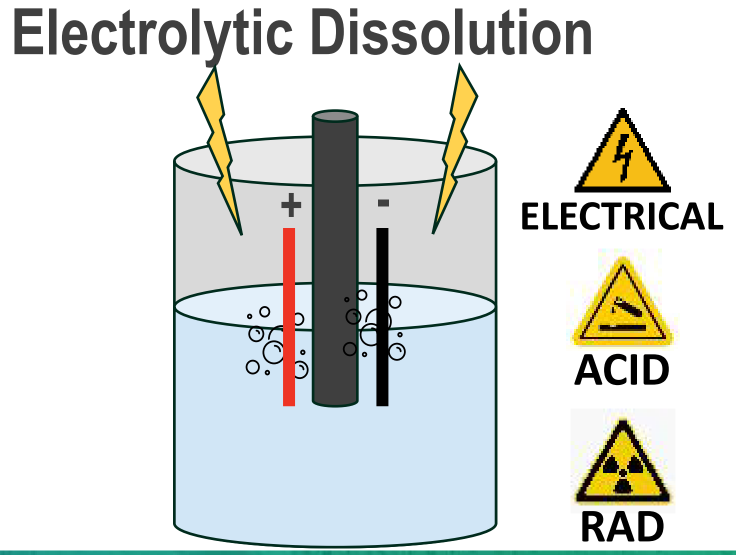
Aqueous Dissolution & Vitrification



Post-ABD Aqueous Dissolution

- New dissolver - smaller than H Canyon dissolvers
- Dissolver is capable of both chemical and electrolytic dissolution using customized inserts and electrode assemblies.
- Bundles are dissolved one at a time. Depending upon the flowsheet, additional bundle(s) can be added.
- Dissolution flowsheets (chemicals/conditions) will be developed and tailored for each SNF subgroup. Ex:
  - ASNF: nitric acid chemical dissolution (*established flowsheet*)
  - NASNF Group 1-3: nitric acid electrolytic dissolution
  - NASNF Group 4-5: AlNiflex chemical dissolution

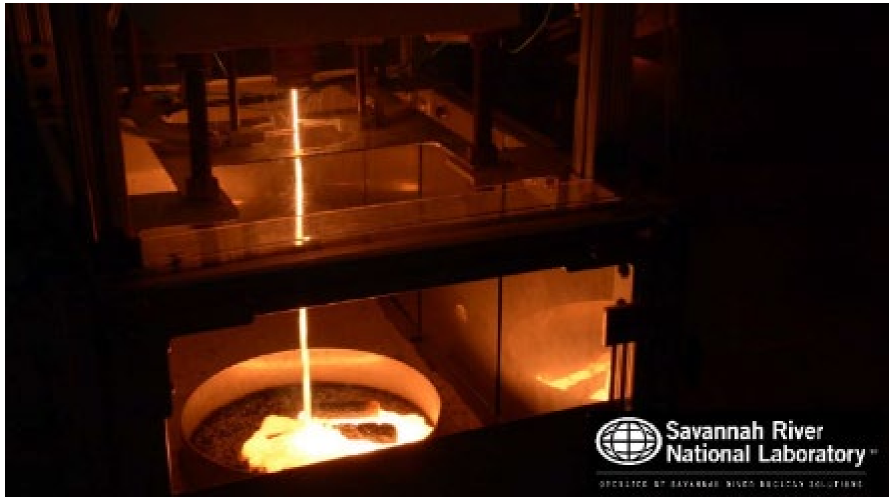




Post-ABD Vitrification and Storage

- Aqueous waste stream is characterized, prepared, and transferred to vitrification system.
  - Melt and pour high-level waste (HLW) glass into canisters.
- HLW glass canisters could be stored in shielded overpacks on a nearby Interim Storage Pad or in a facility similar to the existing Glass Waste Storage Buildings.

- Throughput can be increased with additional units (dissolvers and vitrification system).



AlNiflex Flowsheet Development

- >100 bundles of NASNF Group 4 & 5 will remain post-ABD.
  - Precautions are needed to control reactions when dissolving Group 4 uranium-zirconium (U-Zr) alloys in nitric acid.
  - Control strategy: add fluoride
- Lab-scale AlNiflex flowsheet development is in progress.
  - AlNiflex flowsheet, initially studied in the 1970s, focuses on controlling dissolution using fluoride and minimizing stainless-steel corrosion.
  - Current lab experiments aim to assess the feasibility of AlNiflex, optimize the process and understand corrosion impacts.

U-Zr and AlNiflex Flowsheet Development

- All >100 bundles of NASNF Group 4 & 5 will remain post-ABD.
  - Precautions are needed to control reactions when dissolving U-Zr alloys (Group 4) in nitric acid
  - Most common hazard control strategy is to add fluoride.
- Lab-scale AlNiflex flowsheet development is in progress.
  - AlNiflex dissolvent: hydrofluoric acid (HF) - nitric acid (HNO_3) - aluminum nitrate ($Al(NO_3)_3$) - potassium dichromate ($K_2Cr_2O_7$).
  - Simulant studies using Al, Zr, and U metal pieces have confirmed feasibility of AlNiflex flowsheet.
  - Will demonstrate flowsheet using U-fissium-Zr pieces in FY26.

Vitrification of Spent Nuclear Fuel

Jake Amoroso

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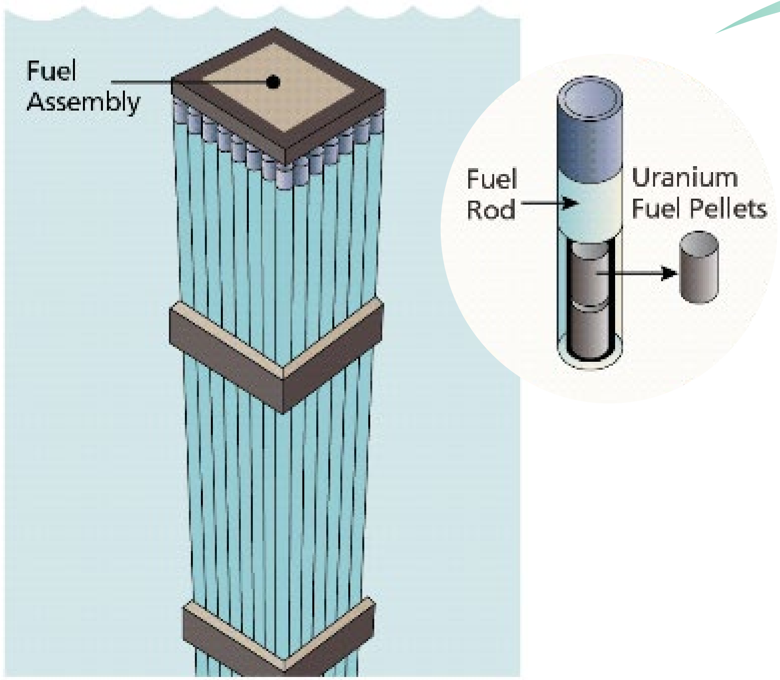
Direct Vitrification

- Direct conversion of SNF into HLW glass using proven vitrification technology.
  - No chemical/aqueous processing prior to conversion to glass.



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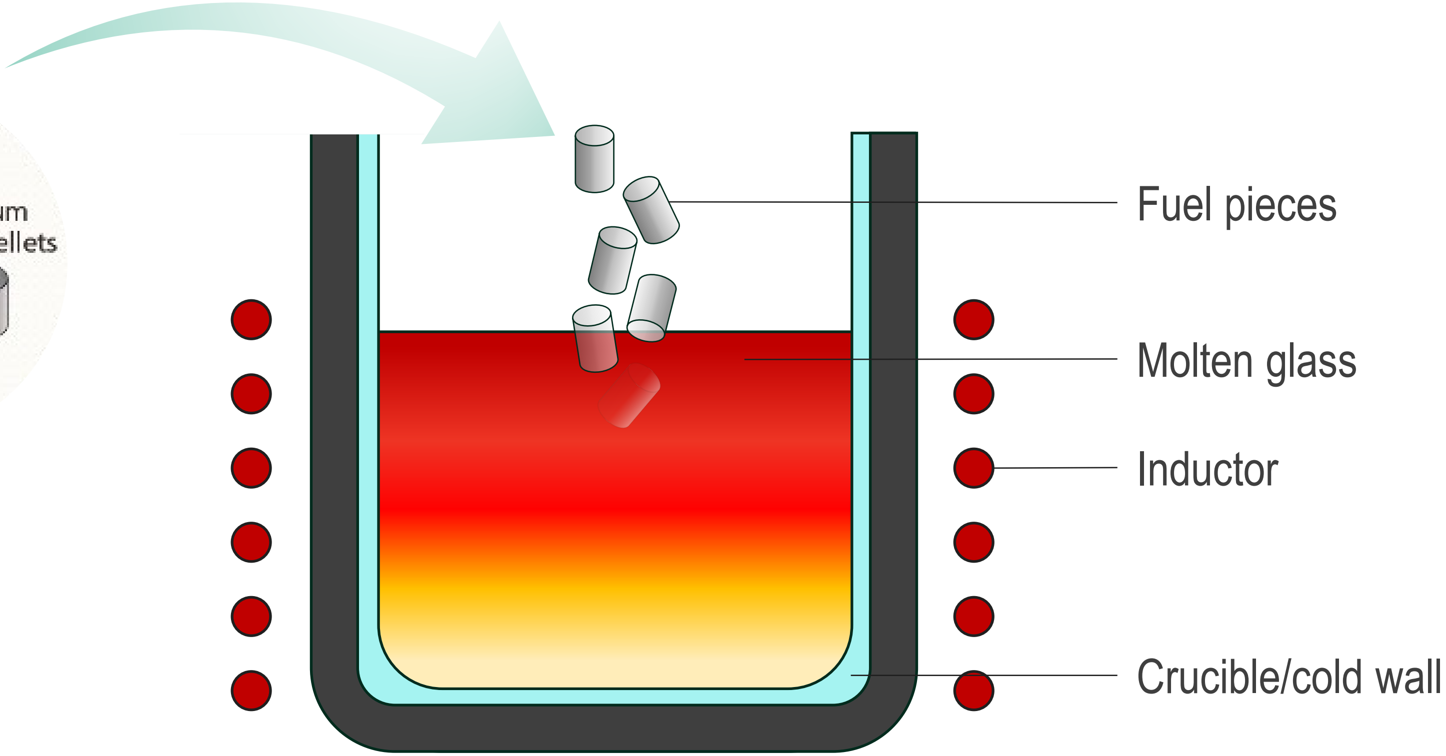


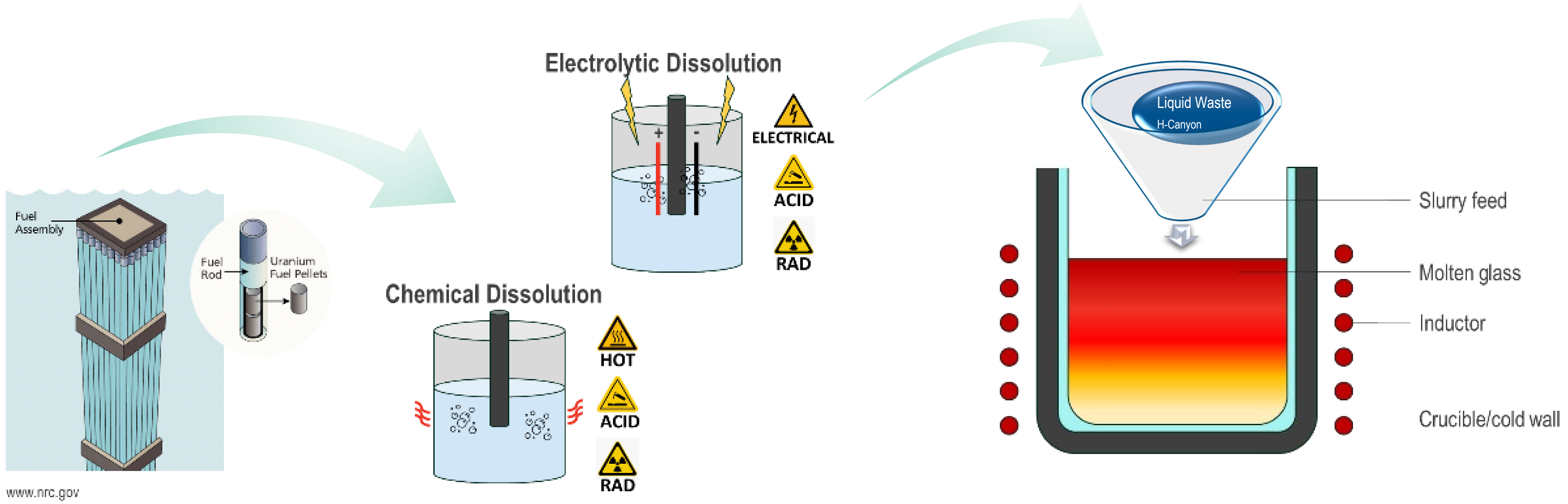
Direct Vitrification - Waste Form

- **Waste Acceptance and Product Specification (WAPS)**
  - Technical specifications the waste form producers are required to meet to ensure acceptance of HLW into the Civilian Radioactive Waste Management System (CRWMS).
  - **Vitrification** into borosilicate glass is the only approved HLW waste form in the United States for non-conforming fuel and other wastes

As poured glass after dissolution of bulk Zr (7.5 wt%) and Al (3.75 wt%) metal. Melting conditions: 1400 ^{o}C for 2 hours.

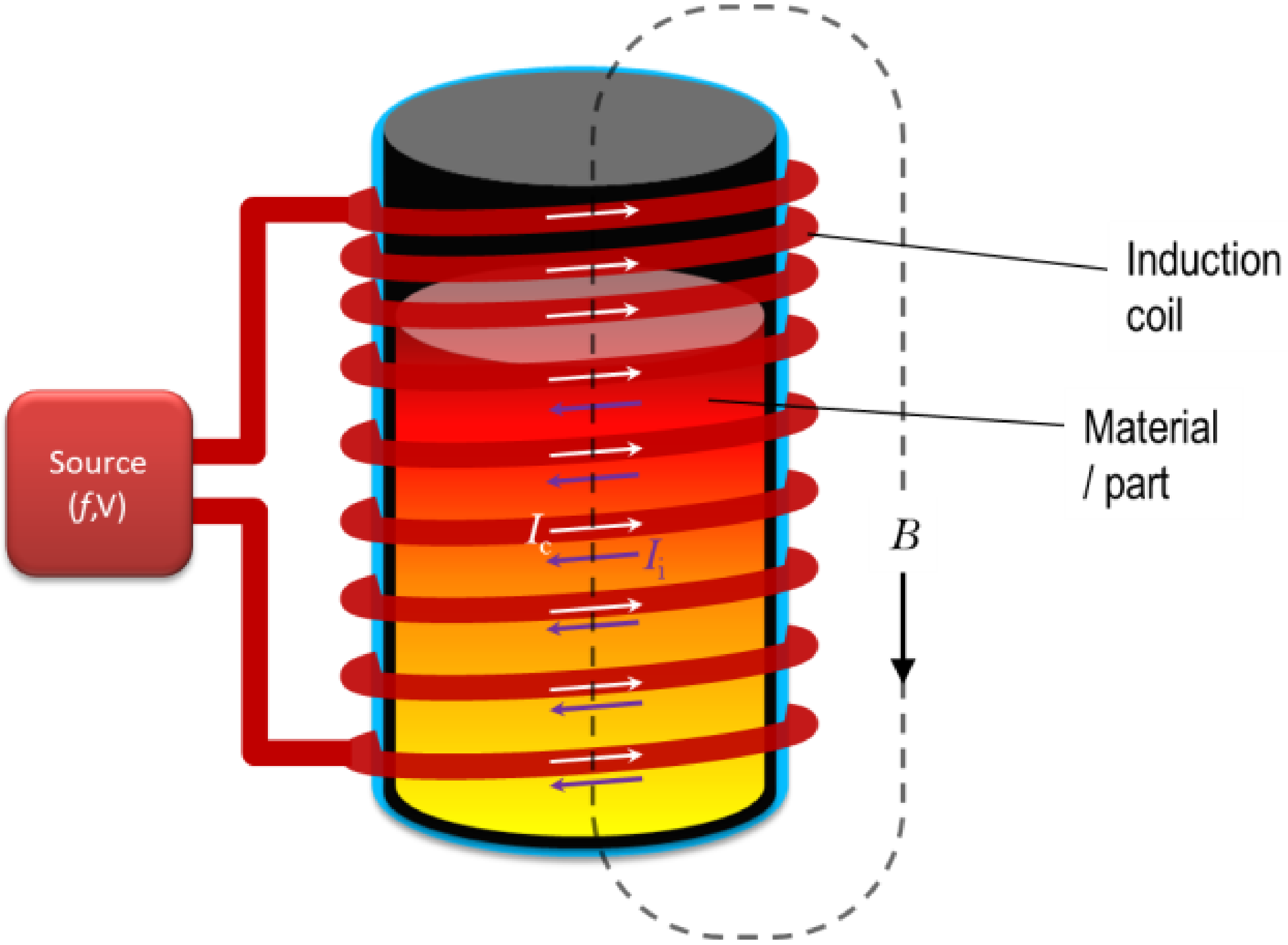
De-Coupled H-Canyon Processing (aqueous processing)

- A vitrification system for decoupling SNF processing from the existent tank waste system plan.



Induction Melter

- **Scalable**
  - Designed to work effectively across small-scale lab experiments to full-scale industry implementation
- **Modular**
  - Can be adapted or expanded to fit different sizes and complexities without the need for a complete redesign
- **Versatile**
  - Can adapt to different materials, operating conditions and other technologies



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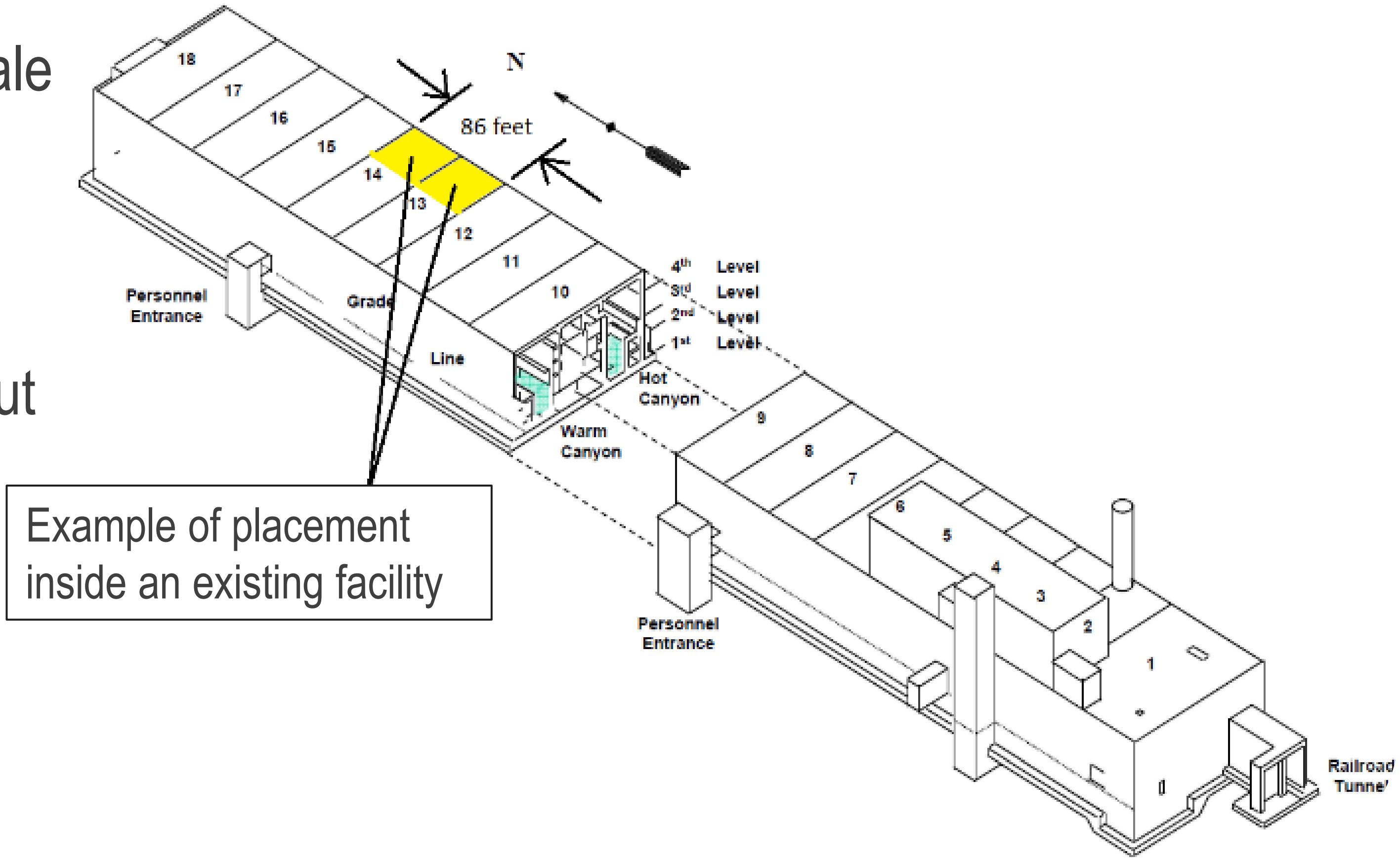
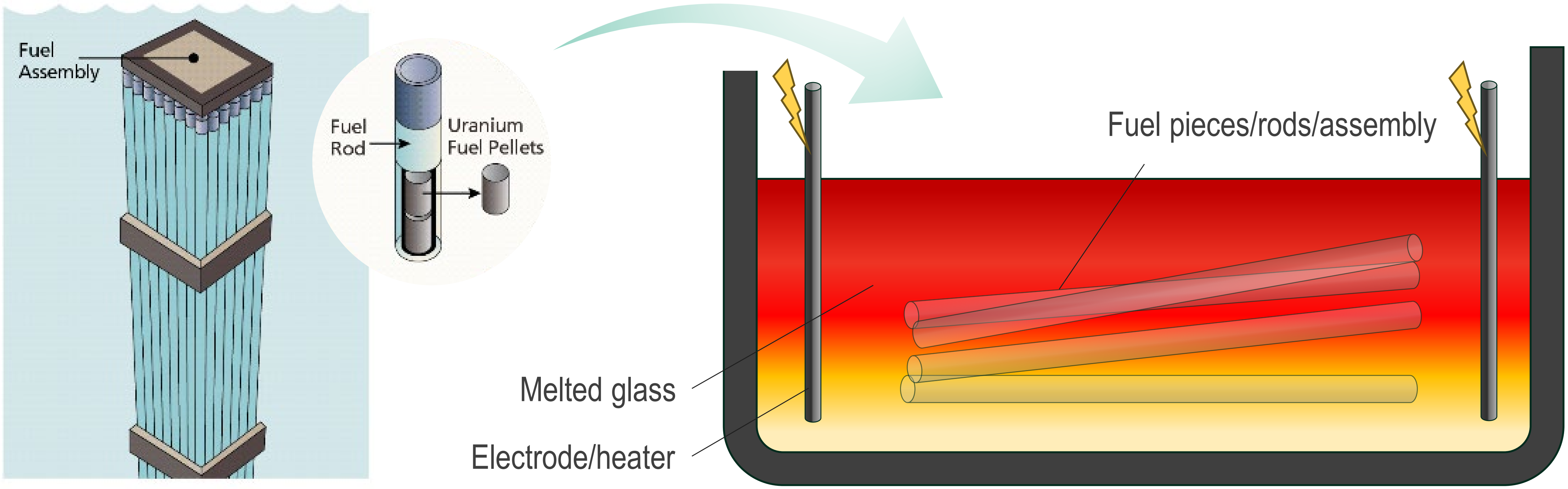


Solidification and Stabilization

- This alternative considers processes that utilize a disposable melter/container, which are distinct from traditional glass melters



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Summary

Questions?