Summary of Current Research and Opportunities for Collaboration

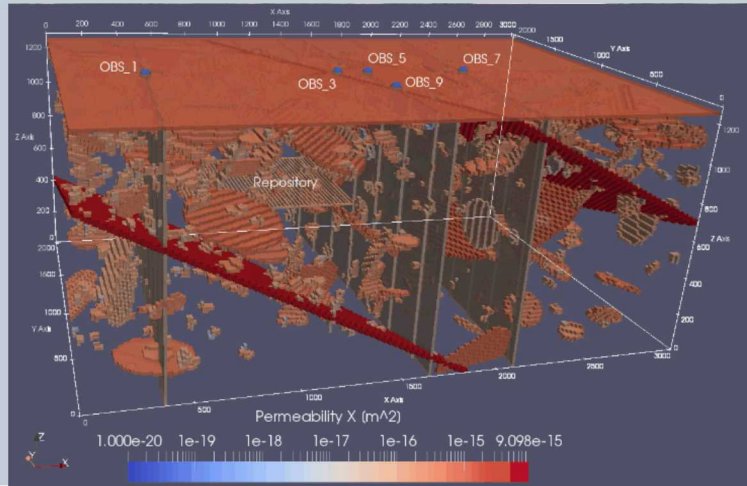
Sandia National Laboratories

SFWD

Spent Fuel & Waste Disposition

CISCC Program Meeting
March 4, 2020

SAND2020-2993PE



Program Objectives
CISCC prediction

1. **Improve prediction of timing and location of potential canister penetration by SCC**
   - Determine electrolyte (deliquescent brine) physical and chemical characteristics and how they evolve over time
     - Initial compositions
     - Evolution over time and temperature
   - Determine the relationship between surface environment and damage (pitting/SCC) distributions and rates (SNL, PNNL, SRNL)
     - Temperature and RH
     - Salt surface load and spatial distribution
   - Develop quantitative understanding of the effects of variability in material properties and mechanical environment on corrosion.
     - Weld/HAZ/base metal material properties (sensitization, texture, mineralogy)
     - Tensile stress intensity and depth profile
   - Evaluate dust and salt transport/deposition in SNF dry storage systems (PNNL)
   - *Incorporate data developed above into probabilistic model for canister SCC, evaluate model sensitivities, and modify work scope appropriately*

Overall Program Objectives

1) **Improve prediction of timing and location of potential canister penetration by SCC**
   - Experimental work and modeling to describe the chemical/physical environment on canisters, how it evolves over time, and how it impacts corrosion processes and rates
   - Characterization of the material properties of the canister weld zones and how they affect corrosion rates and processes
   - Development of a probabilistic SCC model to evaluate the importance of individual parameter uncertainties on canister penetration rates.
2) **Develop and evaluate repair and mitigation strategies for canister CISCC**
   - Development of mitigation strategies, focusing on friction stir welding and cold spray techniques, optimizing for material properties (stresses, microstructure), and corrosion resistance.
3) **Crack consequence analysis**
   - Experimental work and transport modeling to evaluate particle releases through possible SCC cracks

Program Objectives
Mitigation and Repair

2. Support work to develop and evaluate repair and mitigation strategies for canister CISCC

- Develop and optimize friction stir welding (FSW) and cold spray processes for CISCC mitigation and repair
  - Fabricate samples for corrosion testing (PNNL)
  - Corrosion testing of samples (SNL)
  - Evaluate stress redistribution in response to welds/repairs (ORNL)
- Support NEUP programs as TPOCs, collaborators (SNL, PNNL, SRNL, ORNL), providing guidance on:
  - Mitigation techniques
  - Corrosion testing methods

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NEUP Nuclear Energy University Program
U.S. Department of Energy

Ohio State · Wisconsin · Purdue · University of Cincinnati · Colorado School of Mines · University of Idaho

What to look for, and where to focus NDE
SCC crack growth rates
Site susceptibility ranking

EPRI

Corrosion testing of mitigation processes
Crack growth rates and dependence on environment
Characterization of corrosion effects
Testing environments for crack growth rates

SCC risk; mitigation strategies for SCC

Department of Energy · United States of America

PNNL

Testing environments for crack growth rates
SCC CGR data and dependence on environment
Corrosion testing of mitigation processes

Inform at-risk sites and canisters; support mitigation strategies

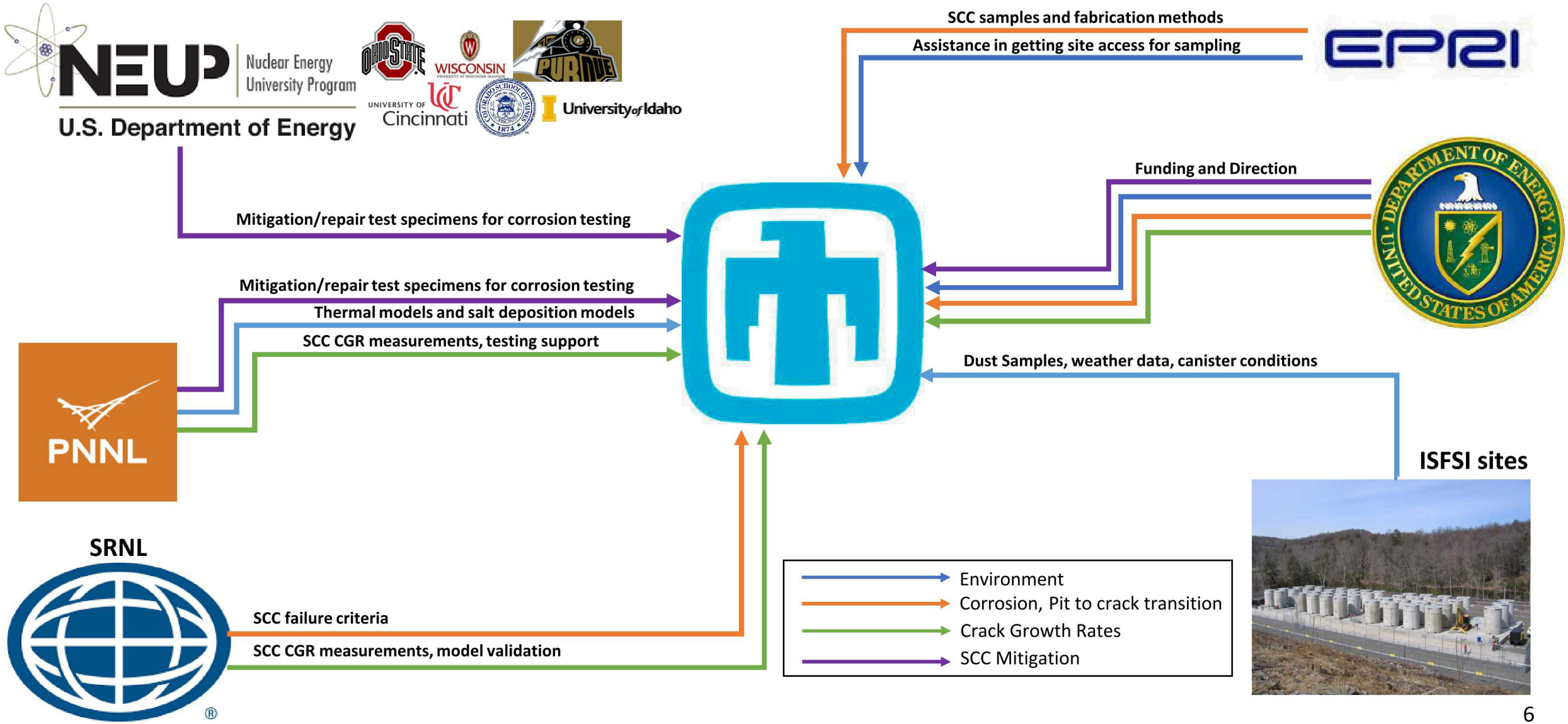
ISFSI sites

SRNL

SCC CGR data and dependence on environment
Testing environments

- Environment
- Corrosion, Pit to crack transition
- Crack Growth Rates
- SCC Mitigation

Provided to Sandia by Others



Possible Collaborative Efforts/Opportunities

Characterization of ISFSI environments

- **Defining relevant environments for risk assessment and for corrosion testing**
- *Collaboration between SNL, EPRI, and ISFSI sites for atmospheric data, dust sampling. Inland sites?*
- *Collaboration between SNL and PNNL on representative SCC testing environments (e.g., typical diurnal variations; NO_3/Cl ratios)*
- *Collaboration between SNL and PNNL on lead canister monitoring. Inland salts!*

NDE Detection

- **Determination of SCC characteristics to aid in NDE detection and development of canister inspection schedules**
  - Crack location and orientation, physical characteristics (more big plate tests?)
  - Crack growth rate for canister inspection schedules
- *Collaboration between SNL, PNNL, SRNL for CGR, SRNL (critical crack size), EPRI, ISFSIs*

Mitigation and Repair

- **Determination of material and environmental controls on corrosion and SCC to inform and improve mitigation strategies (ensure mitigation techniques do not introduce increased susceptibility for SCC; develop appropriate evaluation procedures)**
  - Determine influence of underlying microstructure on corrosion susceptibility (i.e. effect of martensite on pit morphology and micro-crack initiation)
  - Evaluate effect of mitigation strategies in SCC susceptibility
  - Expert guidance on development and optimization of mitigation technologies.
- *Collaboration between PNNL (cold spray and FSW expertise), SNL (corrosion testing), and NEUPs (OSU, Purdue, etc.)*

Crack Consequence

- **Determination of SCC characteristics can inform crack consequence modeling and testing**
  - Determine SCC size and morphology; method for production of prototypical cracks for gas and particle transport testing
  - Crack coalescence and canister “failure”?
- *Collaboration between crack consequence group, and corrosion groups (SNL, PNNL, EPRI, ORNL, SRNL?)*
- *Collaboration with SRNL on critical crack sizes*

What Others?

We will discuss additional opportunities tomorrow