Analysis of Supplemental Treatment Approaches for Low-Activity Waste at the Hanford Nuclear Reservation

Disposal Performance Evaluation

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Waste Forms Performance Evaluation for On-Site Disposal (IDF)

- **Integrated Disposal Facility RCRA Permit and Waste Acceptance Criteria**
  - Currently limits LAW waste form to glass canisters
  - Requires Performance Assessment (PA) analysis and assessment of impacts to groundwater of all wastes to be disposed
    - *Permit specifies process to propose additional wastes for disposal (including secondary wastes)*
    - *Requires mitigation if results >75% of any performance standard (e.g., drinking water standards)*

- **2017 IDF Performance Assessment**
  - Only considered ILAW glass and secondary wastes from LAW processing
  - No consideration of SLAW alternatives or their secondary wastes

- **FFRDC Team identified the need for a Performance Evaluation (PE)**
  - Assess the ability of supplemental treatment alternatives to meet the waste acceptance criteria of IDF
  - Modelled after the 2017 IDF PA methods and approach, but a more limited effort
Groundwater concentrations of Tc and I are driven by releases from solid secondary waste (SSW).

- $^{99}\text{Tc}$: 900 pCi/l
- $^{129}\text{I}$: 1 pCi/l

### SLAW Waste Form “Systems” for IDF Performance Evaluation

<table>
<thead>
<tr>
<th>Analysis Case</th>
<th>Supplemental LAW Waste Forms</th>
<th>Secondary Wastes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Glass (Vitrification)</td>
<td>Borosilicate Glass</td>
<td>LSW - ETF</td>
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<tr>
<td>2 - Grout</td>
<td>Cast Stone</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>3 - Steam Reforming (FBSR)</td>
<td>FBSR Mineral – Macro-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>encapsulated</td>
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</tbody>
</table>

FBSR=fluidized bed steam reforming; LSW=liquid secondary waste; ETF=Effluent Treatment Facility; SSW=solid secondary waste; GAC=granular activated carbon; HEPA=high efficiency particulate air filter

Three sensitivity cases (sets of waste form release parameters) were selected for each waste form:

- **Low performing case** – lower range of experimental data
- **High performing case** – upper range of experimental data
- **Projected best case** – recent enhancements to formulations and performance improvements that have been observed, but require additional studies to confirm
PE – Analysis Methodology

• Focused on groundwater pathway and impacts of key radionuclides—Tc-99 and I-129
  o Groundwater impacts from Tc and I previously shown to be key area of concern for ILAW, SLAW, and secondary wastes from LAW processing

• STOMP modeling platform applied for consistency with 2017 IDF PA analysis
  o eSTOMP (scalable version of STOMP) was used to enable more efficient modeling
  o Benchmark simulations conducted for ILAW glass and secondary wastes to assure PE was producing equivalent results to the IDF PA for the same model inputs

• Simulated a full stack of waste packages within IDF with a unit inventory of Tc-99 and I-129 in each package
  o Four stacked ILAW glass canisters, or eight stacked B-25 (secondary waste) boxes, or eight 8.3 m³ (SLAW grout or steam reforming) boxes
  o Model output provided fractional release rate (Ci released/Ci disposed/yr) from bottom of IDF as a function of time

• Translated eSTOMP-derived peak release rate to peak groundwater concentration using 2017 IDF PA algorithm based on full vadose zone and groundwater transport modeling

PRE-DECISIONAL
Performance Evaluation Results - Technetium

- All waste forms can meet Tc-99 regulatory objectives, except:
  - Low performing grout case exceeds the Tc-99 MCL of 900 pCi/L
  - Low performing FBSR case exceeds 75% of Tc-99 MCL (requiring mitigation)

- High performing and projected best cases for glass, grout, and FBSR waste form systems result in Tc-99 groundwater concentrations well below regulatory objectives

Figure F-15*. Predicted technetium-99 groundwater concentrations for 100 m downgradient compliance well for a) SLAW Glass, b) SLAW Grout, and c) SLAW Steam Reforming (FBSR) systems

Performance Evaluation Results - Iodine

- Only high performing and best cases for FBSR, and projected best cases for grout and glass met the I-129 MCL of 1 pCi/L
  - Low and high performing cases for glass and grout, and low performing case for FBSR exceeded I-129 MCL of 1 pCi/L
  - SSW GAC performance was the primary driver for the glass and FBSR cases that exceeded MCL

Figure F-17*. Predicted iodine-129 groundwater concentrations for 100 m downgradient compliance well for a) SLAW Glass; b) SLAW Grout; and c) SLAW Steam Reforming (FBSR) systems.

Outer box represents total sum of contributions of SLAW, SSW, and LSW waste forms

<table>
<thead>
<tr>
<th>NDAA CRITERIA</th>
<th>VITRIFICATION CASE: DISPOSAL ONSITE AT HANFORD</th>
<th>GROUTING CASE 1: DISPOSAL ONSITE AT HANFORD</th>
<th>GROUTING CASE 2: OFFSITE DISPOSAL</th>
<th>STEAM REFORMING CASE 1: SOLID MONOLITH PRODUCT DISPOSAL ONSITE AT HANFORD</th>
<th>STEAM REFORMING CASE 2: GRANULAR PRODUCT OFFSITE DISPOSAL</th>
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</thead>
<tbody>
<tr>
<td>RISKS/OBSTACLES</td>
<td>• Difficult to build and operate because highly complex process</td>
<td>• Requires pretreatment of organics Requires wasteform validation</td>
<td>• Requires pretreatment of organics</td>
<td>• Requires most technology maturation Requires wasteform validation</td>
<td>• Requires most technology maturation</td>
</tr>
<tr>
<td>BENEFITS</td>
<td>• Similar to technology being built for first LAW</td>
<td>• Low integrated complexity No liquid secondary waste</td>
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<tr>
<td>COST</td>
<td>~$20B to ~36B</td>
<td>~$2B to ~$3B</td>
<td>~$5B to ~$8B</td>
<td>~$6B to ~$12B</td>
<td>~$9B to ~$17B</td>
</tr>
<tr>
<td>YEARS NEEDED BEFORE STARTUP</td>
<td>10-15 years</td>
<td>8-13 years</td>
<td>8-13 years</td>
<td>10-15 years</td>
<td>10-15 years</td>
</tr>
<tr>
<td>REGULATORY COMPLIANCE</td>
<td>• Primary waste is compliant Secondary waste may require iodine mitigation</td>
<td>• Likely meets requirements after organics pretreatment May require iodine mitigation</td>
<td>• Compliant following organics pretreatment</td>
<td>• Likely meets technical requirements</td>
<td>• Compliant</td>
</tr>
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PRE-DECISIONAL