EPRI Research Summary: Very Low Level Waste

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2 Reports – Publicly Available

- Report ID 1024844, published 2012
  - Investigates international and US application of the concept of VLLW
  - Compares international disposal requirements for VLLW to RCRA landfill requirements in the US

- Report ID 3002000587, published 2013
  - Provides generic technical basis for defining VLLW in the US
  - Compares results to international definitions of VLLW

VLLW - IAEA
Global Radwaste Management Practices

<table>
<thead>
<tr>
<th>Country</th>
<th>US</th>
<th>ROK</th>
<th>Spain</th>
<th>Canada</th>
<th>Sweden</th>
<th>France</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearance</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VLLW</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Waste Zoning</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>VLLW Disposal</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Recycling</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Stabilization</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>


Key Take-Aways From EPRI Report 1024844

- VLLW is part of IAEA waste categories
- Successfully used in France, Spain, and Sweden
- Concept is applied in US
  - 20.2002 exemption process
  - Agreement states
- RCRA subtitle C disposal facilities compare favorably to disposal requirements for VLLW used abroad
- Significant industry O&M and decommissioning savings can be realized with RCRA VLLW disposal path
- Could play an important role in addressing disposal needs associated with radiological dispersal devices (RDD)

VLLW Cost Savings Projection

![VLLW Cost Savings Projection Graph]

Projected Decommissioning & Operating Plant LLW Volume & Cost

- Total LLW Volume Per Year (ft³)
- Total LLW Volume Without VLLW (ft³)
- Cumulative Disposal Cost for All Waste ($ Billion)
- Cumulative Cost With VLLW Disposal ($ Billion)

~$6 Billion Gap NPV
VLLW Overview Report Number 3002000537

- Generic Technical Basis for Implementing a Very Low Level Waste Category for Disposal of Low Activity Radioactive Wastes; Low Level Waste; 3002000587

- To provide a generic basis for increasing the use of VLLW disposal.
  - VLLW represents a significant fraction of LLW
  - Continuation of work performed in 2012 for VLLW disposal (1024844)
  - Used extensively in France, Spain and Sweden on a routine basis.

Key Takeaways 3002000587

Generic Very Low Level Waste Basis (VLLW)

- VLLW can be safely disposed in properly designed generic hazardous waste disposal facilities.
  - Provides a generic approach based on reasonable yet conservative assumptions for disposal of VLLW.
  - Global applicability for lined, monitored, and capped hazardous waste disposal facilities.
  - Substantial cost savings to utilities, preservation of limited LLW disposal resources, LLW disposal relief afforded to universities and hospitals.
  - A pathway for generic disposal of VLLW is of benefit to public.

Generic VLLW Analysis Methodology

- Using reasonable yet conservative assumptions for disposal of VLLW in lined, monitored, and capped hazardous waste disposal facilities.
- Establish parameters based on global guidance and experience and sound scientific reasoning.
- The challenges:
  - Some requirements vary by country
  - What performance objective (dose limits) should apply?
  - Some factors are relatively constant such as minimum hazardous waste disposal facility design requirements for lining, capping, monitoring, etc. conforming to:
    - Annex 1 of EU council directive 1999/31/EC
    - US EPA RCRA subtitle C
VLLW Facility Design & Waste Streams

Other Inputs

- Humid and Semi-arid site parameters from Part 61 Basis
- Representative radionuclide mix is important to performing proper dose evaluations, evaluated both:
  - Operational waste stream taken from 2007 four year EPRI database (1016120)
  - Decommissioning waste stream derived from Connecticut Yankee, Yankee Rowe and Humboldt Bay approved alternate disposal applications (similar to VLLW)

![Operational Dry Solid Waste](image)

VLLW: What dose limits to apply and to whom?

Various Limits in use Globally

<table>
<thead>
<tr>
<th>Source</th>
<th>Non-Occupationally Exposed Worker and Member of the Public (mrem/yr)</th>
<th>Future Human Activities or Inhulation (mrem/yr/µSv/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Rad Protection</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>10 CFR Part 20.2000</td>
<td>No more than a few millirem</td>
<td>No more than a few millirem</td>
</tr>
<tr>
<td>EPA (residual limits for remediated facilities)</td>
<td>15 (150)</td>
<td>15 (150)</td>
</tr>
<tr>
<td>IAEA VLLW</td>
<td>15 (150)</td>
<td>15 (150)</td>
</tr>
<tr>
<td>Spanish VLLW</td>
<td>25 (250)</td>
<td>25 (250)</td>
</tr>
<tr>
<td>IAEA VLLW (Note 1)</td>
<td>Not Defined - activity up to ~100x exempt waste</td>
<td>Not Defined - activity up to ~100x exempt waste</td>
</tr>
<tr>
<td>/Landfill Process (Note 2)</td>
<td>1 (10)</td>
<td>1 (10)</td>
</tr>
</tbody>
</table>

Notes:
- IAEA Exempt Waste Limits <1 mrem/yr (<10 µSv/yr) and 100X higher for low probability events
- Process more comparable to IAEA Exempt Waste
- 5 mrem/yr (50 µSv/yr) Selected as Generic Limit

Generic VLLW Scenario Development

- Used conservative global guidance and experience to define exposure scenarios
- Determine the maximally exposed individual (MEI) from both workers and post closure intruders:
  - Bulldozer (compactor) Operator
  - Landfill Driver (truck driver or worker)
  - Resident Farmer (lives on site after closure)
  - Post Closure Worker (factory or other industry built over closed facility)
- Conservative as all worker doses are calculated w/o site inventory decay
- Peak intruder factors used, but all assumed at T=30 years regardless of when individual radionuclide dose peaks occur (several at 600 – 700 years)
Generic VLLW Derived Limits
Select values from report

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Limit ρCi/gm (Bq/gm)</th>
</tr>
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<tbody>
<tr>
<td>Co-60</td>
<td>33 (1.24)</td>
</tr>
<tr>
<td>Cs-137</td>
<td>235 (8.7)</td>
</tr>
<tr>
<td>H-3</td>
<td>164 (6.07)</td>
</tr>
<tr>
<td>C-14</td>
<td>2,700 (100)</td>
</tr>
<tr>
<td>Ni-63</td>
<td>10,300 (383)</td>
</tr>
</tbody>
</table>

- Initial derived limits for some radionuclides were higher but were adjusted down to align with other global guidance.
- For mixes of radionuclides, the sum of fractions of the waste activity divided by its limit cannot exceed unity (1).

What Waste is Eligible for VLLW?

- Estimated waste eligible for VLLW disposal under this generic process:
  - Minimum 10% of Operational Waste from both dry solid waste and PWR secondary resins
  - Minimum 60% of Decommissioning Waste
  - Eligible volumes can be increased with modest additional segregation efforts
- Potential cost savings decommissioning value at ~$6 billion for US fleet alone in 2011 dollars through 2056 (1024844)
- Operational waste averted per reactor year estimated at 12,000 lbs (5,500 kg) or 2,200 ft³ (62 m³)