Disposal of large volume of radioactive waste

What we heard, what we learnt

- Some ad hoc reflections -

P. ORMAI
Waste Technology Section
Topics you indicated worth discussing

- **Addressing the issue (disposal of large volume of waste) at national policy, strategy level**
  - Optimised management of large volume wastes
  - Advance planning for nuclear / radiological accident situation

- **Disposal aspects:**
  - Specific aspects of disposal of large volume of waste
  - Waste characterisation of large volume of waste
  - WAC – mixed waste

- **NORM waste disposal**

- Managing of large volume of decommissioning waste

- Transportation of large volume of waste

- **Societal aspects** (public communication and involvement)

- **Practical examples, lessons learnt**
Meeting structure

1. Accident-related WM issues (disposal)
2. Advance planning
3. Remediation experience, creative solution on waste characterisation and disposal
4. Lessons from NORM waste management
5. Lessons from VLLW disposal
6. Other significant references
   - Lessons from large non–nuclear/ radiological disasters
   - Public communication, stakeholder involvement
Lessons learnt from the major accidents (1)

Chernobyl:
Main problems were

- lack of information and forecast (inventory)
- lack of detailed plan
- lack of proper technical capabilities
- absence of storage/disposal routes
- lack of experience

Problems still are (focus on current efforts)

- safety concern about storage/disposal facilities
- safety reassessment (difficult due to lack of information)
- lack of funds
- necessity for recover and reburial of waste
Lessons learnt from the major accidents (2)

**Fukushima**

Too early to discuss of lessons learnt (disposal aspects)

Temporary storage, interim storage (30-yr) – disposal

- *total storage volume ranges between 15-28 million m³*
- *storage concepts (temporary storage of contaminated soil, interim storage)*
- *no decision on disposal (location, concept)*
- *public sensitivity*

- Systematic approach: zoning, segregation, volume reduction (incineration, soil washing, etc.)
- Early waste characterisation
- Allocation of responsibilities (national, local government, operator)
- Several IAEA missions assist Japan to make proper early decisions and measures with due consideration of long term waste management aspects
Disposal considerations (1)

- Major proportion of the very large volumes of generated material that is to be collected will in the aftermath of an accident likely be **only slightly contaminated**.

- **Early segregation** is essential
  - Separating hazardous from non-hazardous debris difficult & slow (US)

- At the outset, it is imperative to have **clear criteria** for what constitutes **radioactive waste** and which kind of waste can be **cleared** (either conditionally or unconditionally) from the regulatory control.
Disposal considerations (2)

- Disposal decisions should be based on a robust decision making process involving regulation and input from stakeholders – apply for accident/legacy related waste

- Decisions made in the early period can significantly influence the waste management activities for the long-term period.
  - rapid response is needed, no time for time consuming considerations, actions are rather ad hoc

- Early mistakes may result situations to difficult rectify
  - Chernobyl temporary storage/ disposal sites
  - Waste was bulldozed into shallow pits, quantities and composition unknown (Maralinga, Australia)
Optimisation:

- **Graded disposal** approach, different levels of barriers depending on waste
- **avoid over-design** of disposal options
- Japanese plan: highly engineered facility for slightly contaminated shorter-lived waste
The adequate characterization of collected material will allow the distinction between material that can be unconditionally cleared, conditionally cleared and material that has to be managed as nuclear waste.

- The pathways for management of these three categories are significantly different depending on the results of SA for each case.

- Excellent summary: Characterisation of large volume of waste, large components, soils
  - State-of the-art methods, new techniques, solutions tailored to the needs

- Advance planning aspect: keep track of the development on characterisation
The **determination of disposal routes** for RWs arising from accidents can be a challenge because

- their characteristics are different from those of conventional waste, and

- **criteria for acceptance of accident-derived wastes** at existing disposal facilities are not something that would have been foreseen.
The *unconditionally cleared* material can be considered for *recycling* and *reuse* or conveniently managed as *municipal solid waste* utilizing existing infrastructure for transportation, handling and disposal in municipal solid waste landfills.

The management of *conditionally cleared* material would require certain arrangements for handling and disposal in *designated municipal landfills*.

Only the *fraction designated as radioactive waste* would be required to meet the corresponding requirements for transportation, adequate processing, packaging, facilities for storage and disposal.
National policy and strategy

**Optimization:** for achieving an **efficient management of large volumes** of LLW-VLLW (UK, France, USA, Slovakia)

- A very large amount of LLW will arise from decommissioning
- Encourage volume reduction (sorting, decontamination)
- driver: reduce costs

- **UK:** diversion of VLLW to landfills and exemption
  - Complex approach: explore alternative routes
    - *metal treatment*
    - *metal melting*
    - *landfills have permits for VLLW*
    - *several hazardous waste incinerators*
    - *improve scope for disposal to landfill*
    - *future opportunities: reduction, recycling (metal, concrete) and reuse*

- Proximity principle: onsite disposal
Waste minimization, volume reduction

• Volume reduction: **part of the optimization**
  - **cost-effectiveness**
  - **management of secondary wastes**

• **Soil waste minimization** an extremely important cost driver and waste management issue – US experience
  - *soil segregation methods achieve cost savings due to significantly less soil requiring transport and disposal*
    - **soil washing**
    - soils determined to be clean can be used as **backfill** minimizing the expense of off-site backfill materials (reuse vs. transportation and off-site disposal cost)

• The cost for disposal, depending on whether the waste can be sent to a **municipal solid waste landfill, to VLLW repository** or to a **low level radiological waste repository**.
Advance planning

Being prepared may significantly contribute to a sound management of post-accident conditions, including those implemented later on.

• Preparedness and planning:
  – identification of temporary and permanent storage sites
  – anticipated disposal routes (identification of potential sites for disposal of large quantities of VLLW and LLW)
  – monitoring and sampling strategy
  – development of ‘generic’ design and’ generic’ safety cases for the different types of facilities
Other potential advance planning issues

• To what extent municipal solid waste landfills can accommodate additional quantities from clean-up campaigns

• How many existing landfills could be designated to receive conditionally cleared material, or

• To what extent municipal solid waste management infrastructure is available to handle additional volumes.
Example: France

**CODIRPA:** to establish the framework, define, prepare and implement the steps necessary to deal with a post-accident situation

One of the thematic working groups: waste management

- **Doctrine for waste management**
- **Waste characterization**
- **Waste management technical options**
- **Waste types of waste and waste management options**
- **Recommendations of an operational waste management**
Several designs

- Concept adapted from the VLLW disposal facility
- Simple design
- Ready to implement within very short time
- Some aspects are case-specific (WAC, institutional control period) subject to licensing (based on SA)
Example: USA


• A **tool to support radiological incident planning** and response activities by **assessing waste quantities and characteristics** as a function of potential mitigation strategies and targeted cleanup levels.

• For **emergency planners** to scope out the WM issues resulting from a radiological response and recovery effort.

• Objective: understand not only the quantity, characteristics, and level of contamination of the waste, but also the **implications of response and cleanup approaches regarding waste generation**.
Lessons (1): from NORM residue / waste management

Dilution, blending

- clear residue mixed with contaminated one (dilution)
- mix slightly contaminated material with higher concentration material (blending) - compliance to WAC
- ploughing (blending) avoidance of contamination
- nuclear waste disposal ??

- UK ’dilution’ practice: part of optimisation
  - turn VLLW into exempt waste
  - use of hazardous waste incinerator for VLLW (dilute radioactive waste into hazardous waste)
  - safety justification, regulatory approval
Lessons (2): from VLLW disposal - French example -

- Technical/economical optimisation of disposal
- Reduction of the total volume required LLW repository capacity
- VLLW repository reasonable for large waste volume and large items (size limited by transport/handling only)
- Single purpose facilities (VLLW-LLW disposal), might be co-located
- Disposal package optionally not needed, but transport package necessary;
- Clear safety restrictions on long lived RN;
- Safety analyses needed => WAC and limits for each RN to be established
Lessons (3): from disasters

- Hurricane Katrina: disaster waste management
  - Message: advance planning is crucial

- Oil spill accident
  - Strong regulatory oversight
  - Multiple disposition pathways
  - Stakeholder involvement program

- World Trade Center
Lessons (4): from environmental restoration disposal facilities

- Australian case studies
  - Waste from Maralinga Remediation
  - Hunters Hill
  - Mineral Sands Mines

US examples
USA experience: strategy, planning, decisions

- For most **USDOE-EM sites** with large cleanup efforts involving waste posing radioactive and non-radioactive hazards: **on-site disposal** has been selected as the preferred alternative.

- **Effective approaches** to support these decisions have included several common elements:
  - Robust and meaningful *engagement with regulators and stakeholders*
  - *Formal regulatory decision-making process* using quantitative and qualitative information
  - *Standardized designs* based on US EPA specifications for hazardous waste disposal
  - *Multiple independent reviews* of modeling and supporting activities through the USDOE and State/US EPA processes, respectively
  - Commitment to *regular reporting, monitoring and long-term oversight*
On-Site Disposal of Cleanup Waste in USA

Photos Courtesy USDOE
USDOE On-Site Disposal (Hanford Site)

Multiple Cells; about 21 meters deep
Cells 1 – 8 are 152 meters by 152 meters at base
SuperCells 9 & 10 are 152 m by 305 m at base

Environmental Restoration Disposal Facility
Largest DOE Disposal Cell (~16 million tons)

IAEA
On-Site Disposal of Cleanup Waste in USA

Hanford

Idaho Site

Fernald Site

Nevada Site (accepts off-site waste)

Photos Courtesy USDOE

SRNL

Em Office of Environmental Management

Oak Ridge Site
Environmental Restoration Disposal Facility
Largest DOE Disposal Cell (~16 million tons)
### Waste volumes

<table>
<thead>
<tr>
<th>Location</th>
<th>Type of Waste</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chernobyl</td>
<td>exclusion zone waste</td>
<td>2.9-4.2 million m³</td>
</tr>
<tr>
<td>Fukushima</td>
<td>contaminated material from clean-up</td>
<td>5 - 29 million m³</td>
</tr>
<tr>
<td>Canada</td>
<td>historic waste (Port Hope, Port Granby, Welcome)</td>
<td>1.7 million m³</td>
</tr>
<tr>
<td>UK</td>
<td>LLW to be disposed of</td>
<td>≥ 4 million m³</td>
</tr>
<tr>
<td>USA</td>
<td>Legacy clean-up waste</td>
<td>X million m³</td>
</tr>
</tbody>
</table>
## Disposal volumes

<table>
<thead>
<tr>
<th>Country</th>
<th>Facility Details</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chernobyl</td>
<td>“Buryakivka”</td>
<td>700 000 m$^3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(120 000 m$^3$ expansion)</td>
</tr>
<tr>
<td>USA</td>
<td>Hanford Environmental Restoration Disposal Facility</td>
<td>~16 million tons</td>
</tr>
<tr>
<td>USA</td>
<td>Waste Control Specialist, Andrews (90-acre)</td>
<td>700 000 m$^3$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(26 million ft$^3$)</td>
</tr>
<tr>
<td>France</td>
<td>CIRE S VLL waste disposal facility</td>
<td>650 000 m$^3$</td>
</tr>
<tr>
<td>Australia</td>
<td>(Maralinga)</td>
<td>~ 500 000 m$^3$</td>
</tr>
</tbody>
</table>
Countries seeking disposal options may consider references, matured facilities.
Waste Control Specialist

Andrews, Texas, USA
90-acre federal dump
Opened: June 6, 2013
Societal aspects

- Technically sound, viable solutions vs. **publicly acceptable solutions**

- Public acceptance:
  - communication is important: to improve understanding, build confidence
    - communication tools (internet based communication platforms)
  - involvement is crucial (community involvement improves decision quality)
  - several success stories on disposal and remediation projects
  - not one size fits all

- Emergency situation
  - enhanced public sensitivity
  - difficult to build confidence, easy to lose
  - early information vs. verified information

- Special concerns:
  - Land use & future value is sometimes difficult to predict
  - proximity to residential areas
My personal evaluation
performance indicator 1.: participation

- 16 countries (Africa, America, Asia, Australia, Europe)
- Nuclear, non nuclear countries
- Advanced programme, small programme
- Accident-stricken countries
- Countries with large volume of waste of not accident origin (NORM or decommissioning)
- regulator, implementer, TSO, researcher
- Retired, senior, young (representing future generation)
- Proper gender ratio: 5 ladies
• To **collect the experience and lessons learnt so far** from RW disposal subsequent to a nuclear or radiological accident, as well as from RWM strategies and disposal aspects that need to considered when managing large volumes of waste.

• To identify and develop those **aspects specific to a post-accident situation** and needing special consideration and further developments.
Have I missed something out?
(for sure, yes….)