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Duration of the Period of Regulatory Concern: Technical Issues and Regulatory Policy

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Understanding performance over geologic time

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- In general, confidence in quantitative estimates of engineered systems decreases with time
- Confidence in some geologic processes may remain relatively constant with time
  - I.e., the processes of the future will look like those of today
- Site specific aspects of the system will change with time
  - Processes related to climate, hydrology, and surficial geomorphology will change over thousands or tens of thousands of years
  - Isotopic content of the waste will change over hundreds to millions of years
  - Regional tectonics may change over millions or tens of millions of years

Simplistic Insights from Safety Assessments

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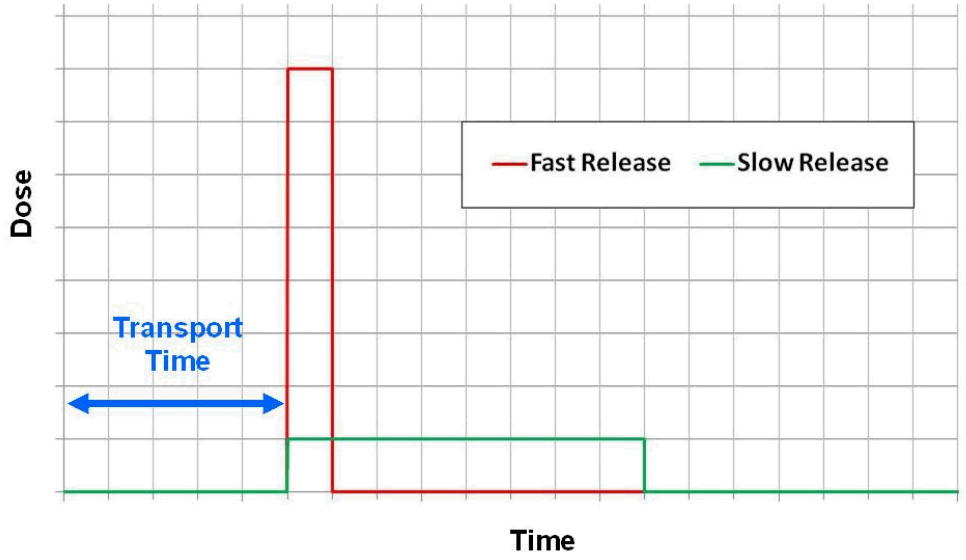
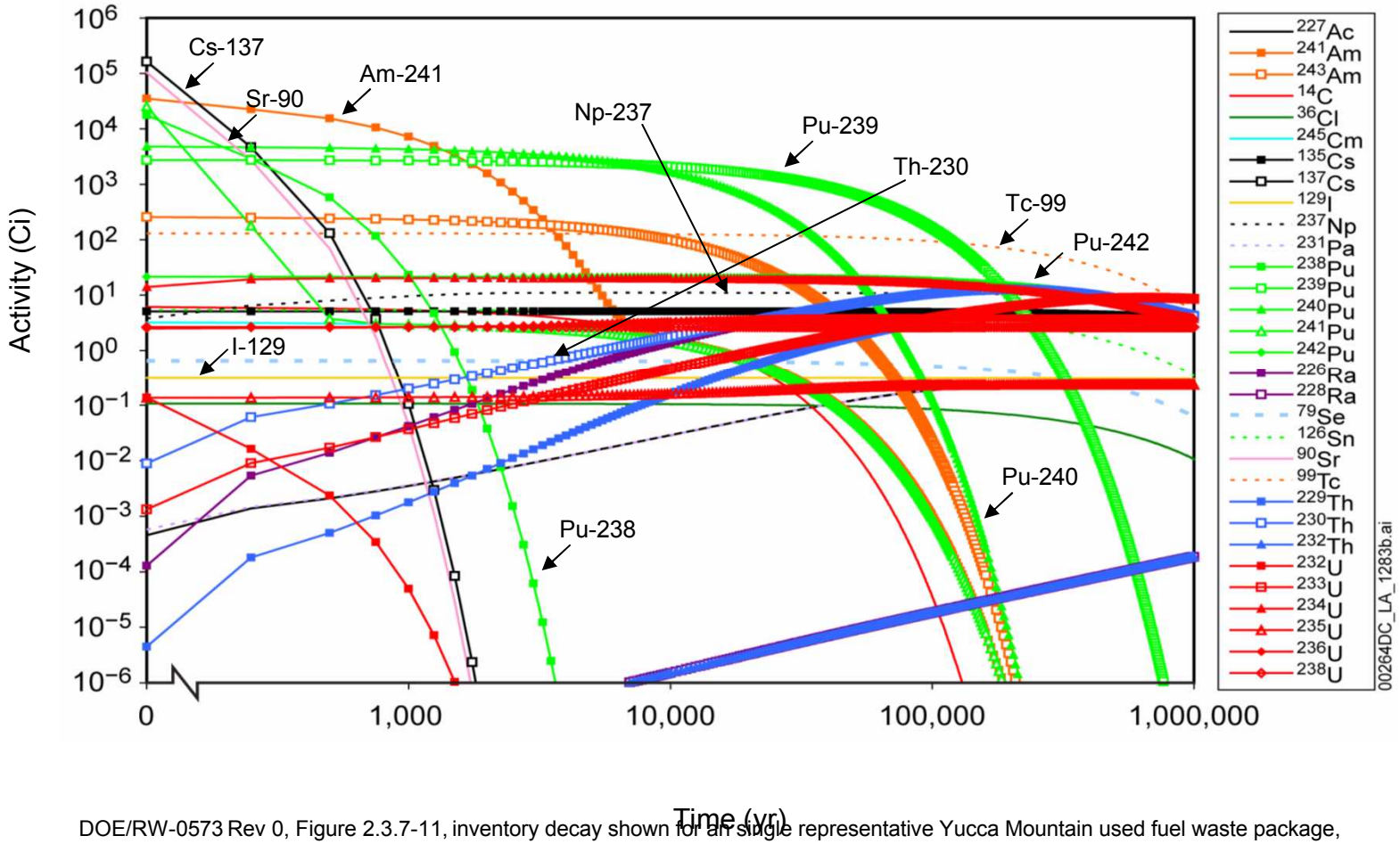
What matters for long-term performance?

- Initial mass (inventory) of dose-contributing radionuclides (or parents)
- Rate of radionuclide releases from waste packages (fast vs. slow)
  - Waste form and Waste Package degradation rates, radionuclide solubility
- Transport processes/residence time in the engineered barrier system and in the natural system / geosphere
  - Mass spreading: advection, dispersion, diffusion
  - Mass retention/loss: sorption, decay



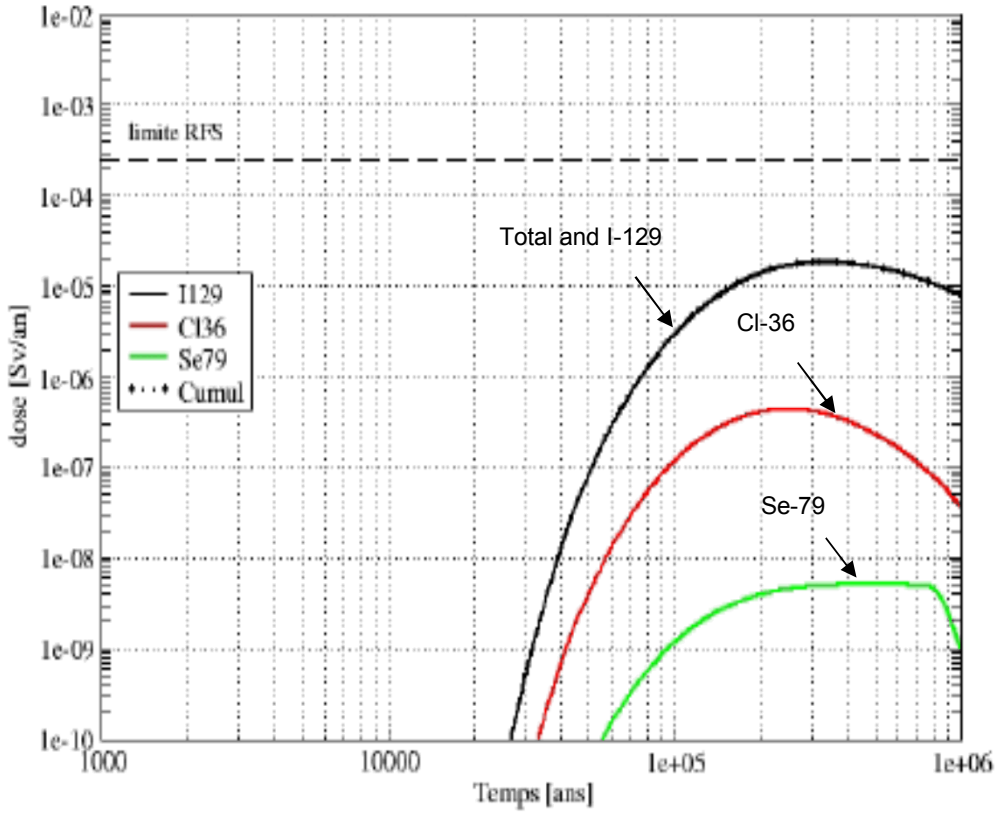
Freeze and Lee, 2011, Proceedings of the 2011 International High-Level Radioactive Waste Management Conference

Commercial Used Nuclear Fuel Decay



DOE/RW-0573 Rev 0, Figure 2.3.7-11, inventory decay shown for an single representative Yucca Mountain used fuel waste package, as used in the Yucca Mountain License Application, time shown in years after 2117.

Contributors to Total Dose: Meuse / Haute Marne Site (France)

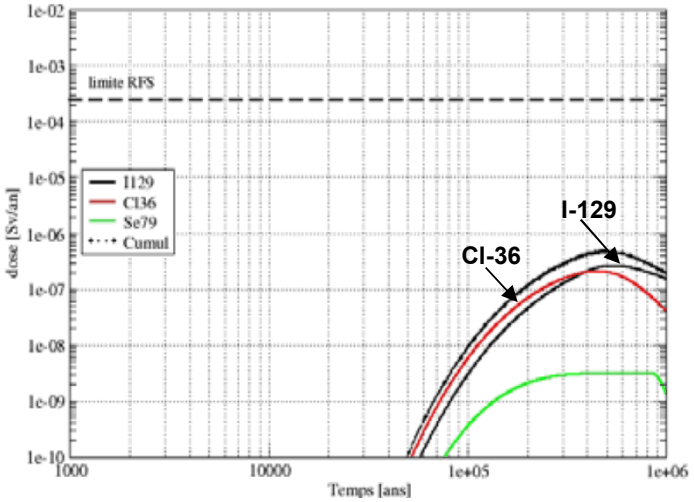


ANDRA 2005, *Dossier 2005: Argile. Tome: Evaluation of the Feasibility of a Geological Repository in an Argillaceous Formation*, Figure 5.5-18, SEN million year model, CU1 spent nuclear fuel and Figure 5.5-22, SEN million year model, C1+C2 vitrified waste

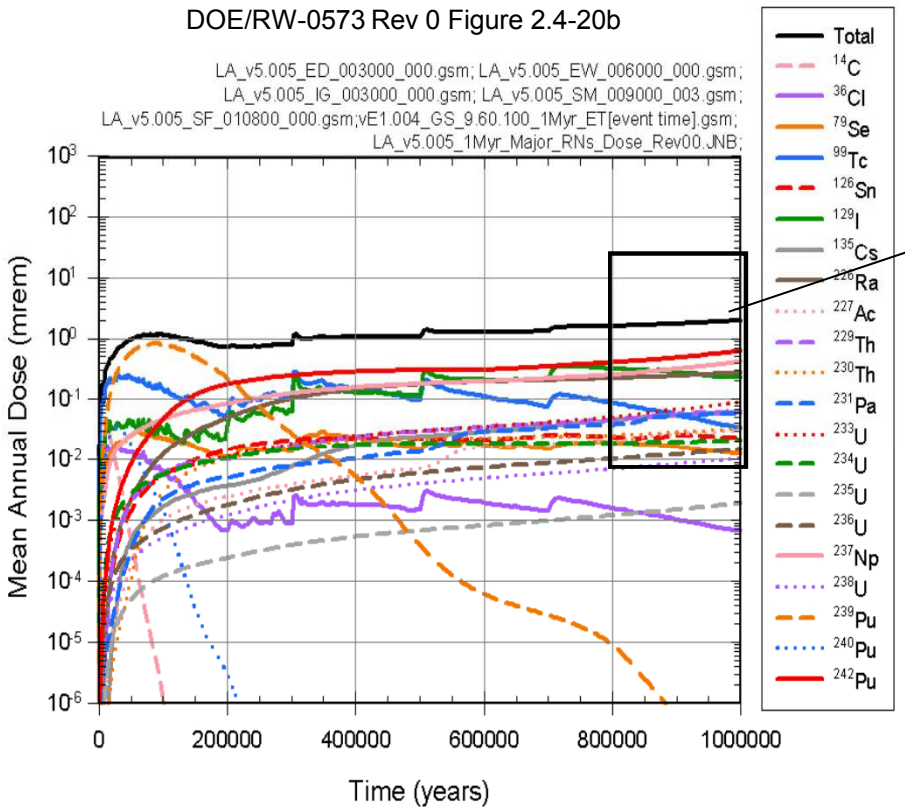
Diffusion-dominated disposal concept: Argillite

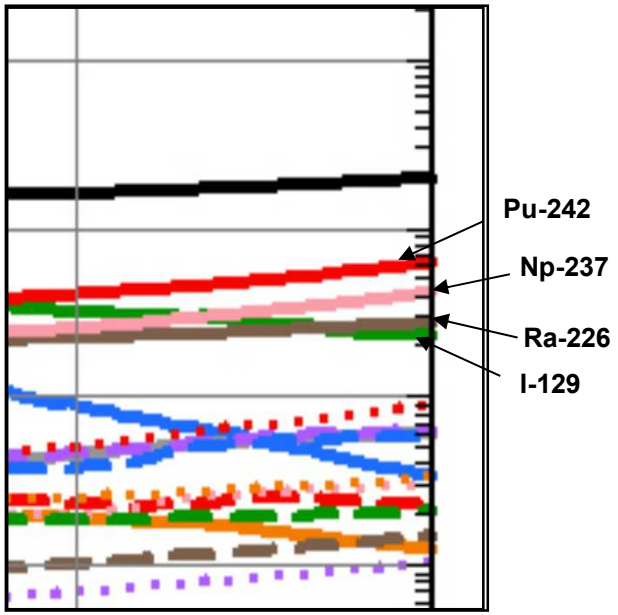
I-129 is the dominant contributor at peak dose

Examples shown for direct disposal of spent fuel (left) and vitrified waste (below)



Contributors to total dose: Yucca Mountain





Disposal concept with an oxidizing environment and advective transport in the far-field: Fractured Tuff

Actinides are significant contributors to dose; I-129 is approx. 1/10th of total

Contributors to total dose: Forsmark site (Sweden)

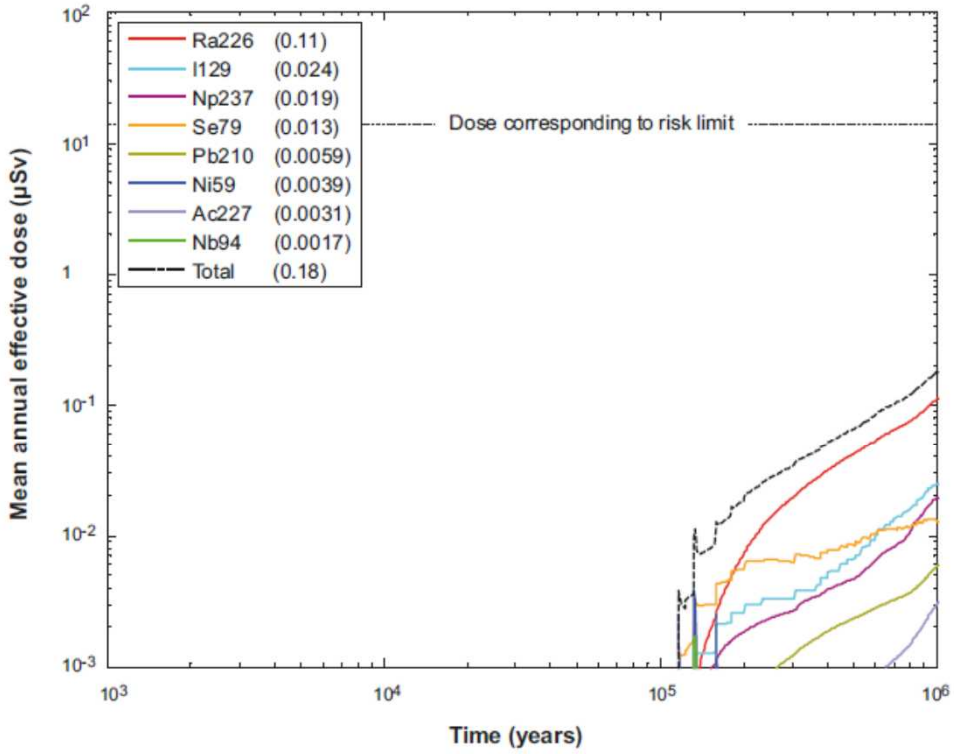


Figure 13-18. Far-field mean annual effective dose for the same case as in Figure 13-17. The legends are sorted according to descending peak mean annual effective dose over one million years (given in brackets in μSv).

SKB 2011, Long-term safety for the final repository for spent nuclear fuel at Forsmark, Technical Report TR-11-01

Disposal concept with advective transport in the far-field: Fractured Granite

Long-term peak dose dominated by Ra-226

Once corrosion failure occurs, dose is primarily controlled by fuel dissolution and diffusion through buffer rather than far-field retardation

US Regulatory Approach

- Waste Isolation Pilot Plant
  - 40 CFR part 191
    - 10,000-year cumulative release standard
- Yucca Mountain
  - 40 CFR part 191 and 10 CFR part 63
    - Million year dose standard
      - 0.15 mSv for first 10,000 years
      - 1 mSv from 10,000 to 1 million years
    - Models are developed for 10,000-year scenarios and then run for 1 million years
- Future repositories
  - Uncertain, but may be similar to Yucca Mountain

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Thank you