Nuclear “Burning” of Nuclear “Waste”

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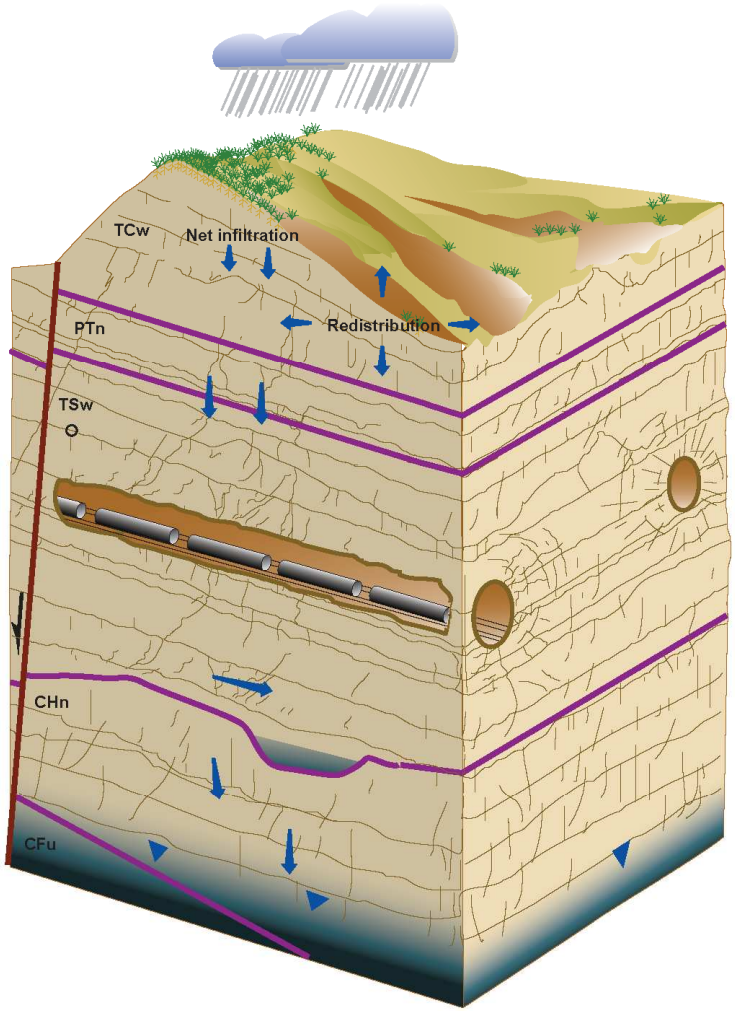
The Yucca Mountain Geologic Repository

- Civilian and defense-related activities have produced spent nuclear fuel and high-level radioactive waste that has accumulated at 72 commercial and 4 DOE sites.
- U.S. Congress adopted the Nuclear Policy Act of 1982: permanent isolation of above materials by their disposal in a deep underground repository.
- In 1987 Yucca Mountain was selected as the single site for further study.
- In 2002, the President signed into law a congressional resolution designating the Yucca Mountain site for development as a geologic repository for disposal of spent nuclear fuel and high level radioactive waste.

The Yucca Mountain Geologic Repository (cont)

- Yucca Mountain site is located in Mojave Desert about 160 kilometers from Las Vegas.
- Underground network of horizontal tunnels, total of about 66 kilometers long, to accommodate about 1100 waste packages, 70,000 tons of heavy metal of spent nuclear fuel and high-level radioactive waste.
- Tunnels about 300 meters below surface and about 300 meters above water table.
- Construction: 5 years
- Operations: 50 years
- Monitoring: 50 years
- Closure: 10 years (last 10 years of monitoring period)
- DOE assumes start of operation in 2017



CHn = Calico Hills nonwelded.
CFu = Crater Flat undifferentiated.
PTn = Paintbrush nonwelded.
TCw = Tiva Canyon welded.
TSw = Topopah Spring welded.

Note: Conversion factors are on the inside back cover of this Repository SEIS.

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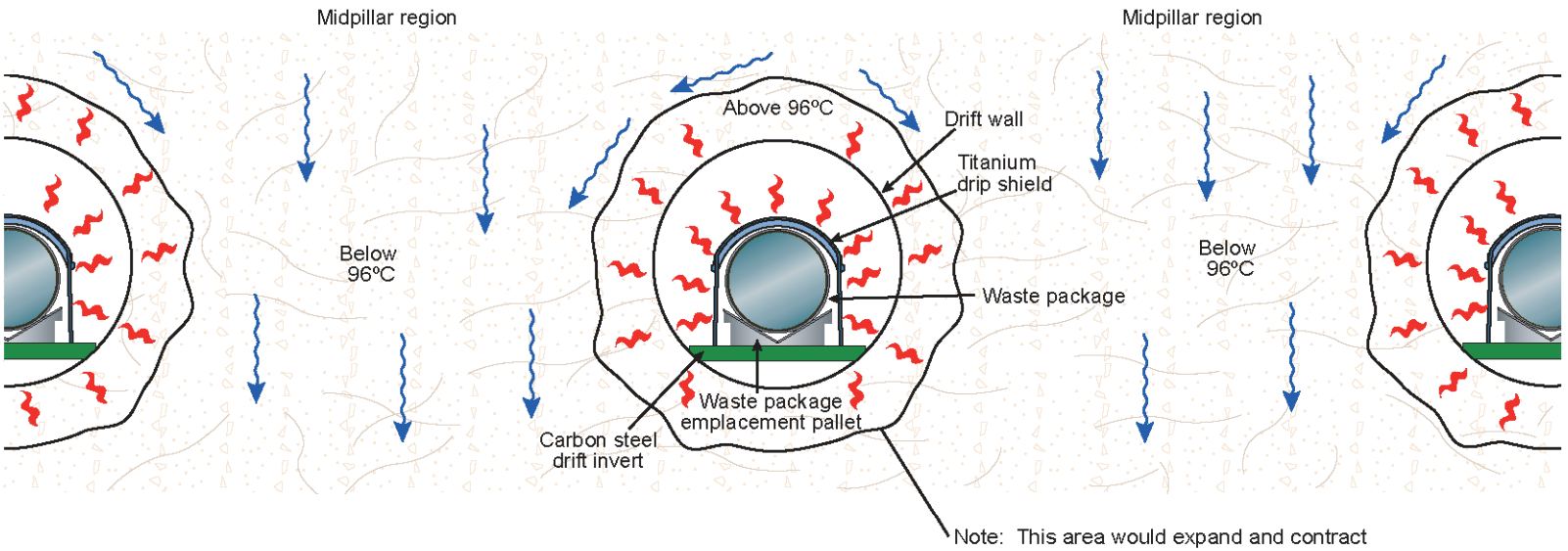

Drawing not to scale.

Legend

Water flow

Heat

°C = degree Celsius

Note: The midpillar region that would be below 96°C immediately after closure of the repository would be small but would increase over time.

Source: Modified from DIRS 155970-DOE 2002, p. 2-11.

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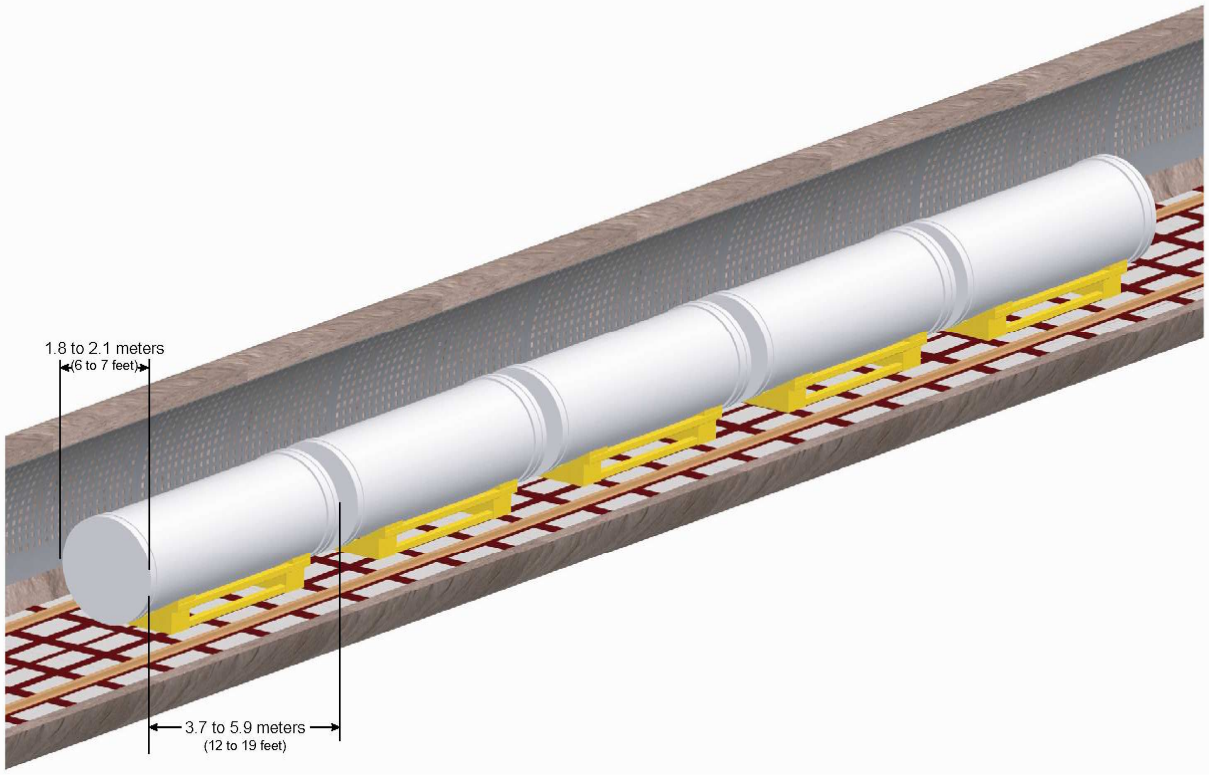

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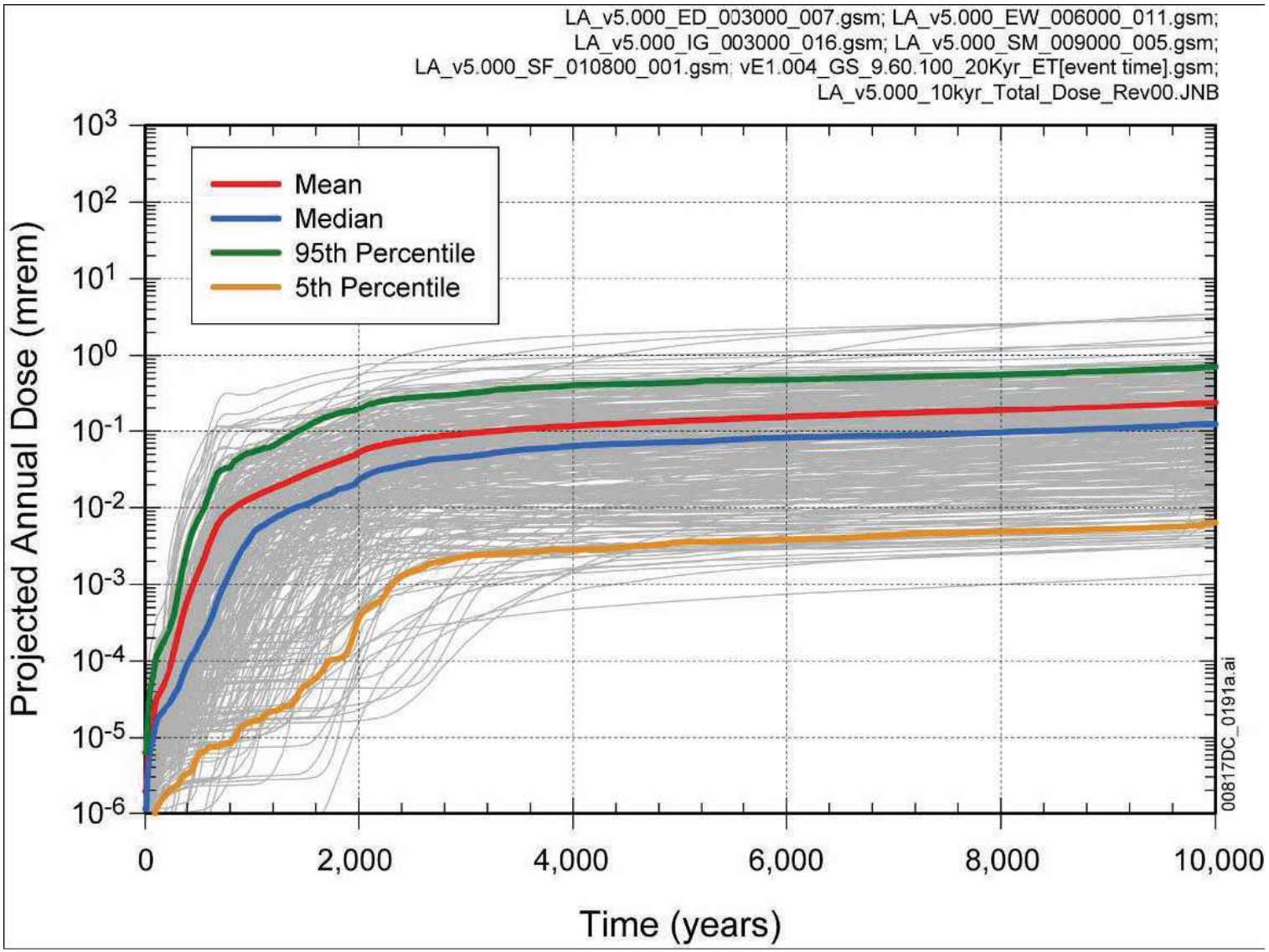
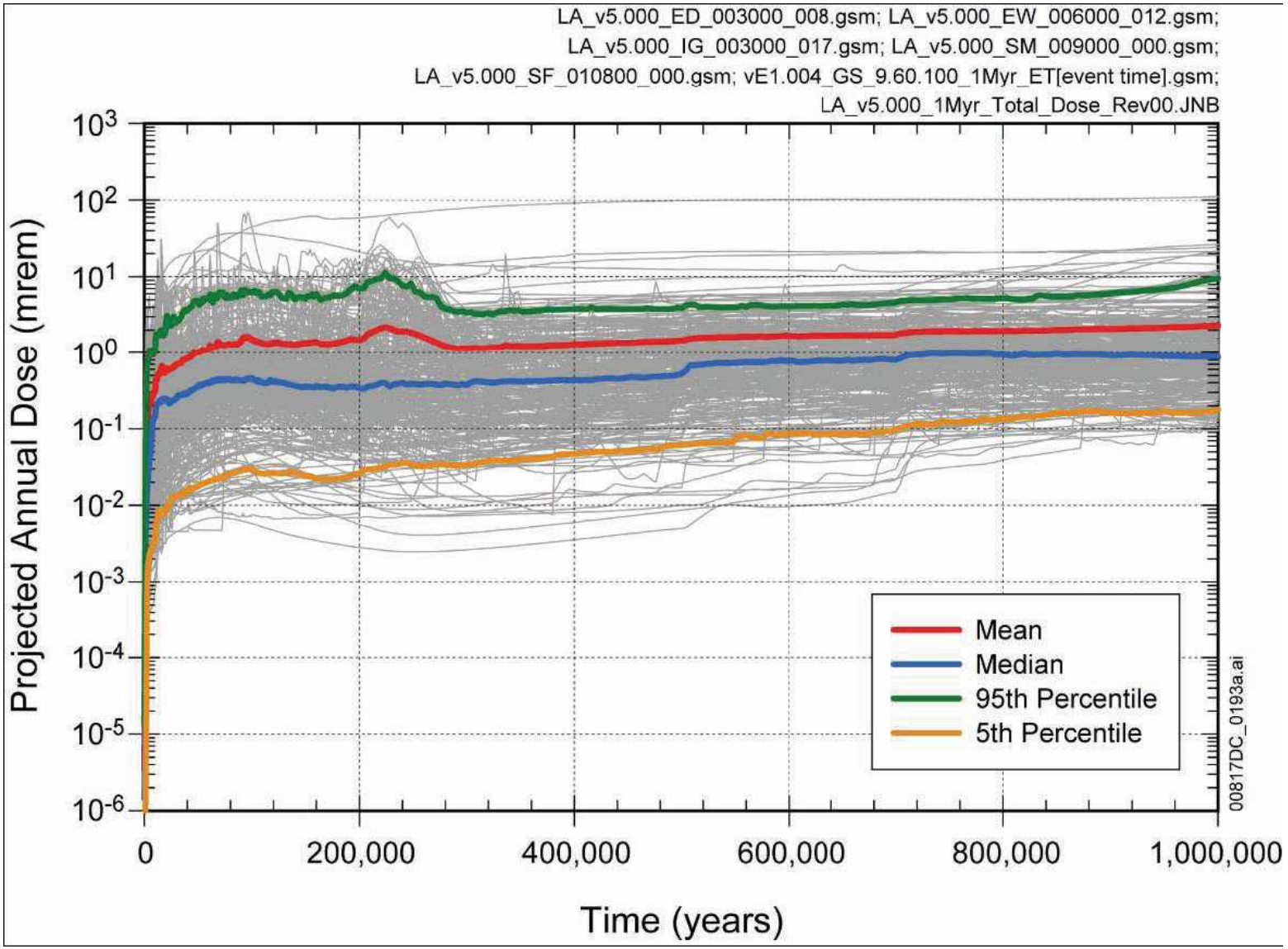
- **NRC would regulate repository construction, operation, monitoring and closure.**
- **EPA and NRC radiation protection standards:**
  - **DOSE to individual located 18 kilometers from the repository.**
    - **Mean annual dose of 15 millirem for the first 10,000 years after closure.**
    - **Median annual dose of 350 millirem for the post 10,000 year period.**

Projected total annual does for the first 10,000 years after repository closure-combined drip shield early failure, waste package early failure, igneous intrusion, volcanic eruption, seismic ground motion, and seismic fault displacement modeling cases.

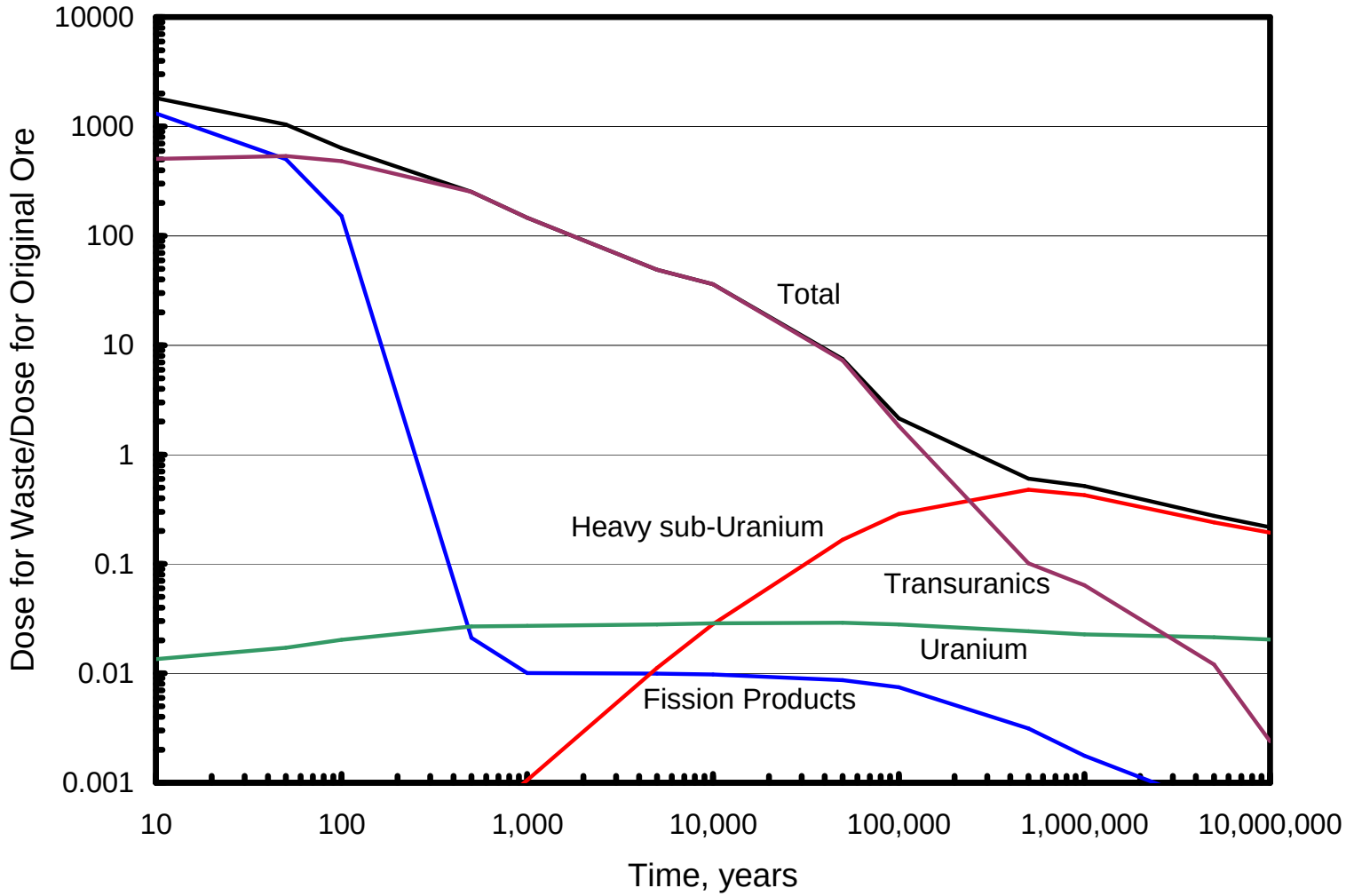


Projected total annual dose for the post-10,000-year period-combined drip shield early failure, waste package early failure, igneous intrusion, volcanic eruption, seismic ground motion, and seismic fault displacement modeling cases.

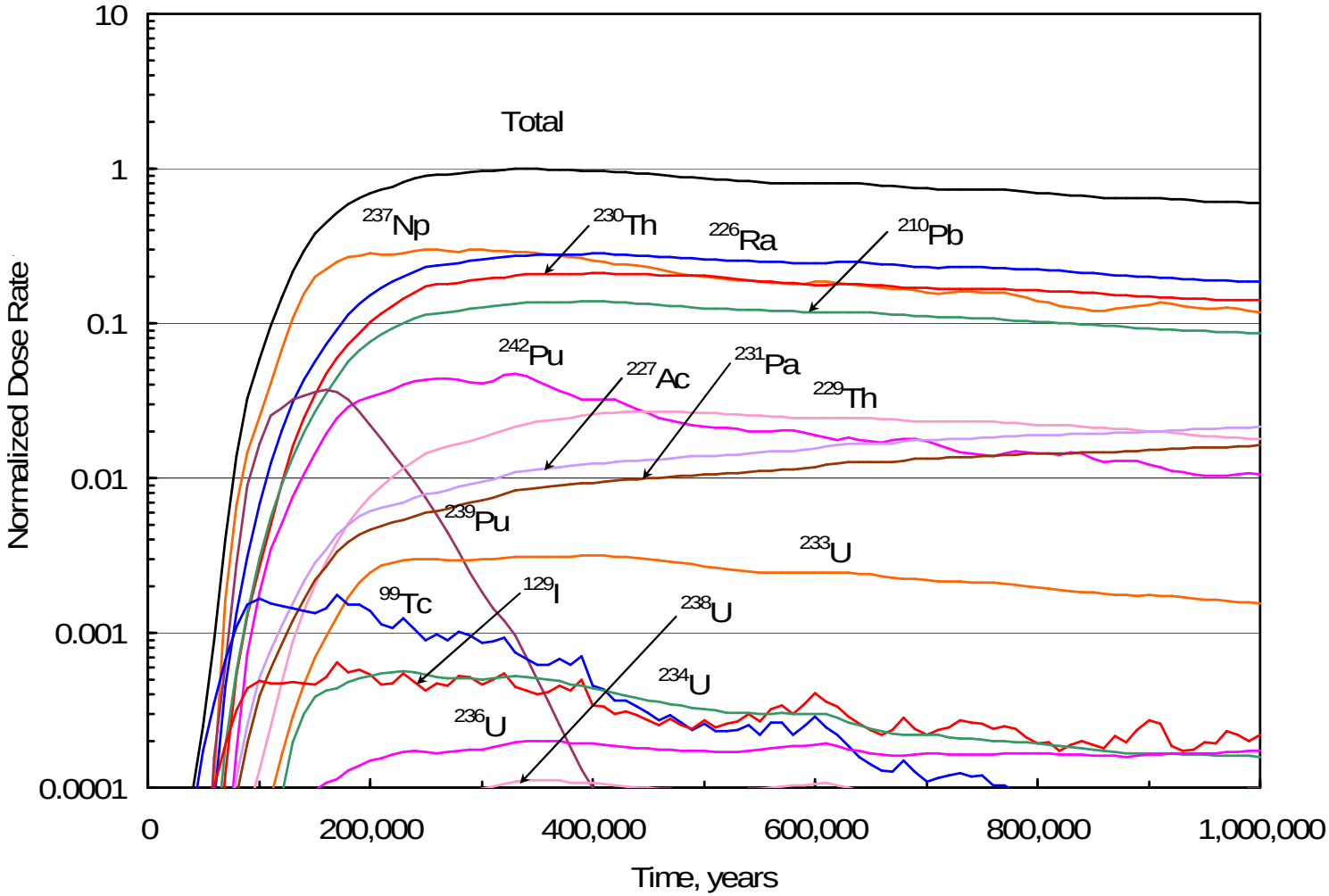


- **Transuranics: Any element with atomic number greater than 92 (Uranium)**
- **Actinides: Elements with atomic numbers 89 to 103**
- **Fission Products: Fission fragments and their decay products**

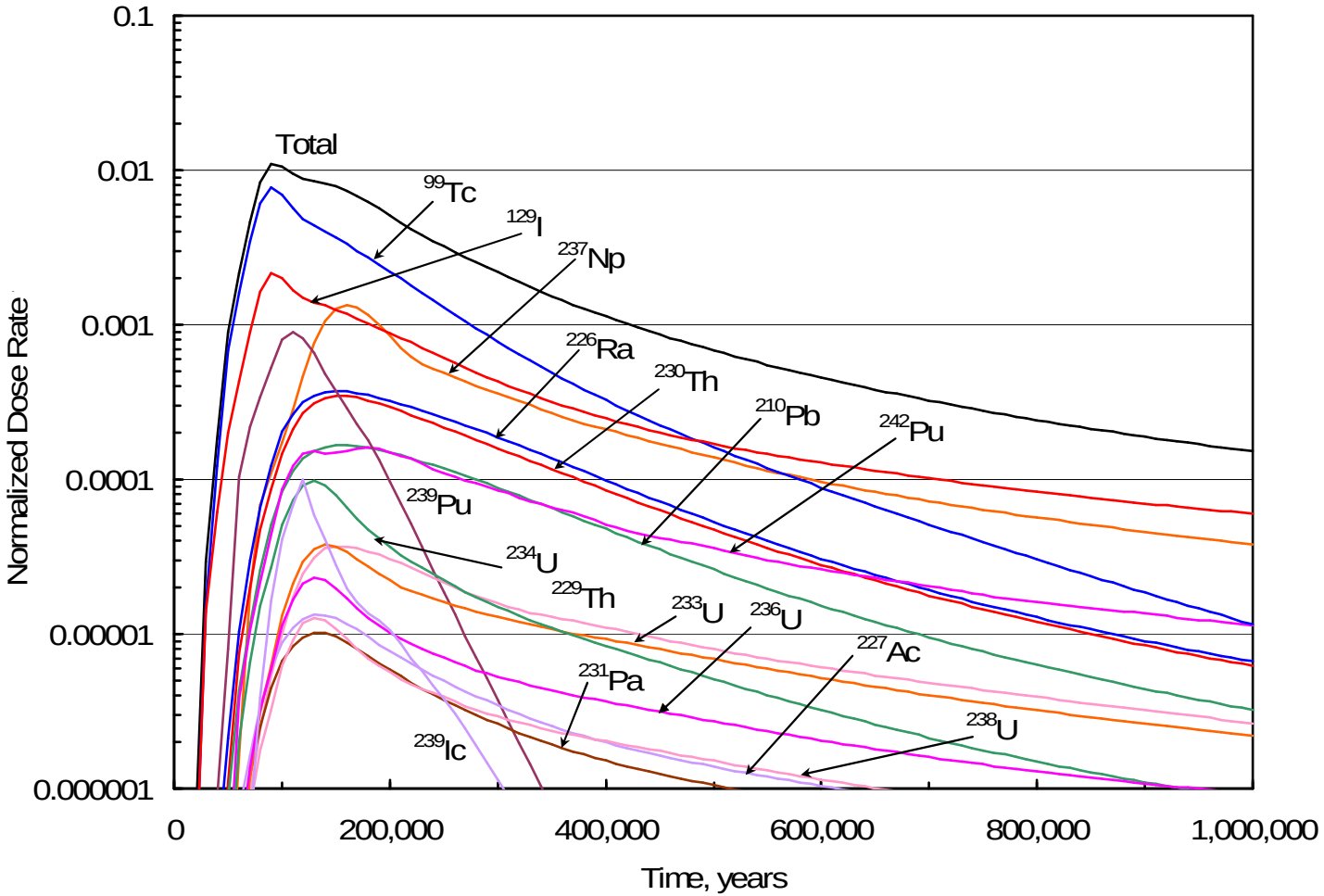
Contributors to dose: PWR fuel with 33GWd/MTHM burnup



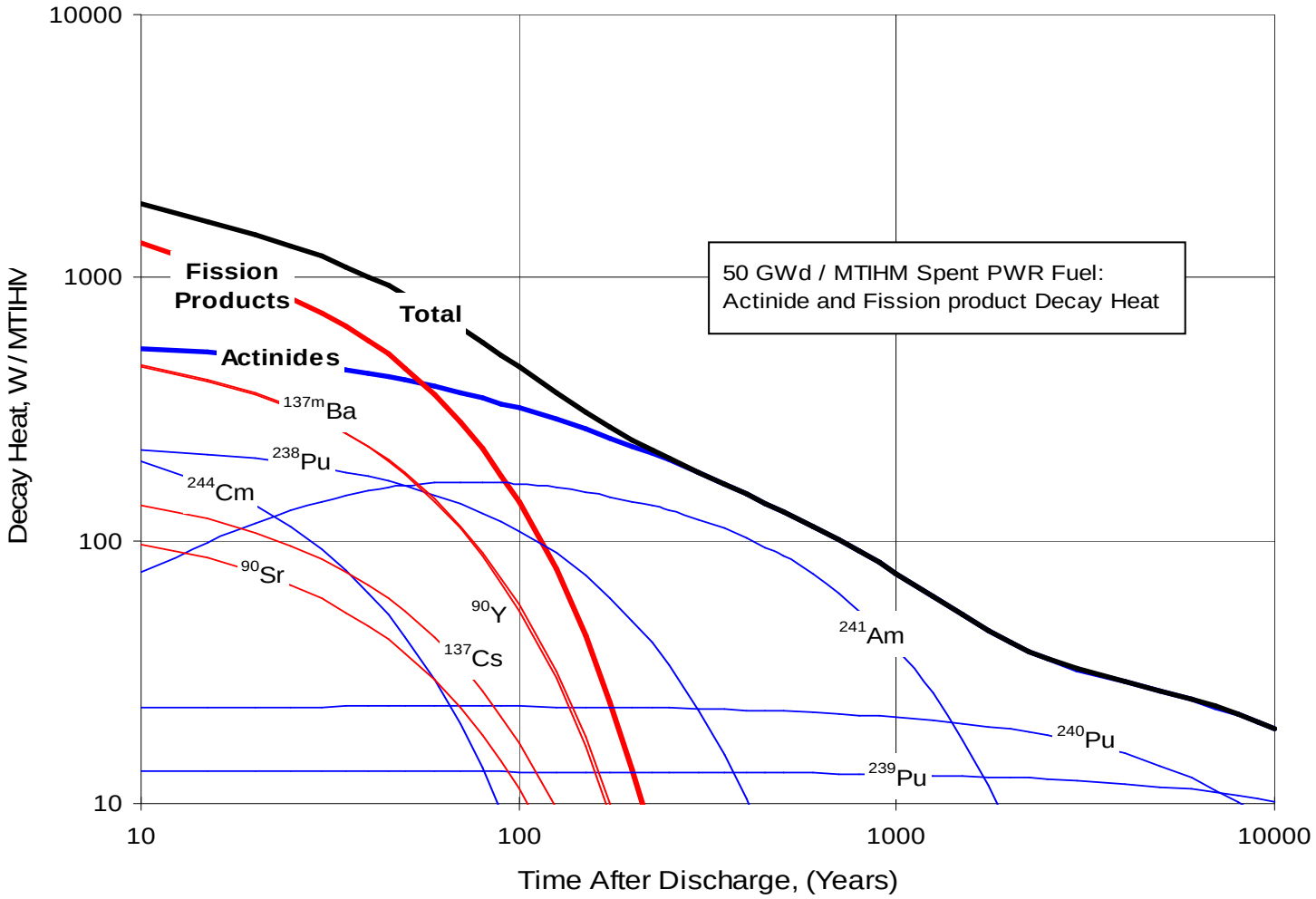
Dose Rate from Direct Disposal of 70,000 MTIHM of PWR Spent Fuel Repository, Normalized to the Peak Dose Rate



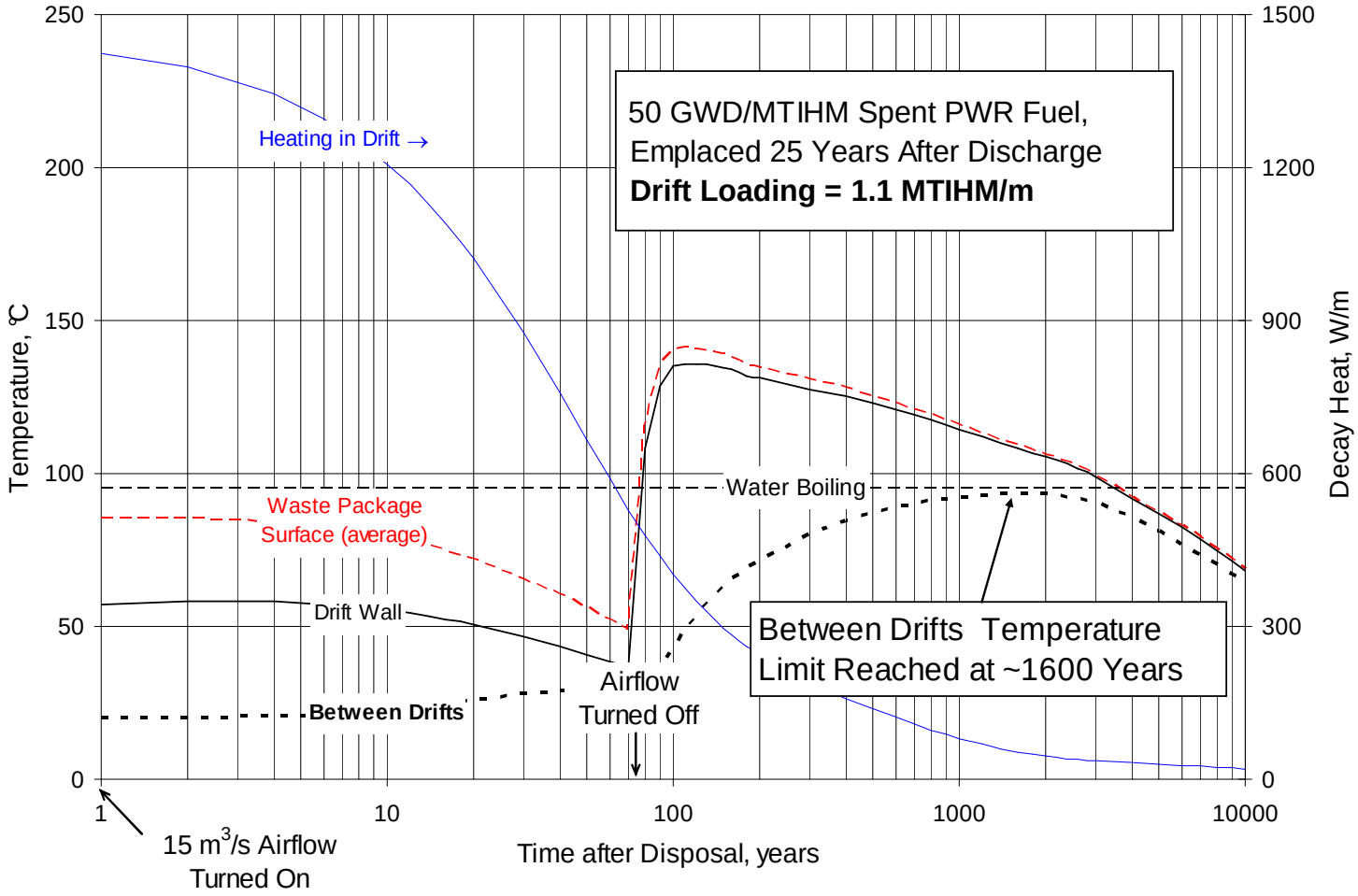
Dose Rate: 70,000 MTIHM of PWR Spent Fuel with 99.9% Removal of All Actinide Elements, Normalized to the Peak Dose Rate from Direct Disposal of 70,000 MTIHM of PWR Spent Fuel



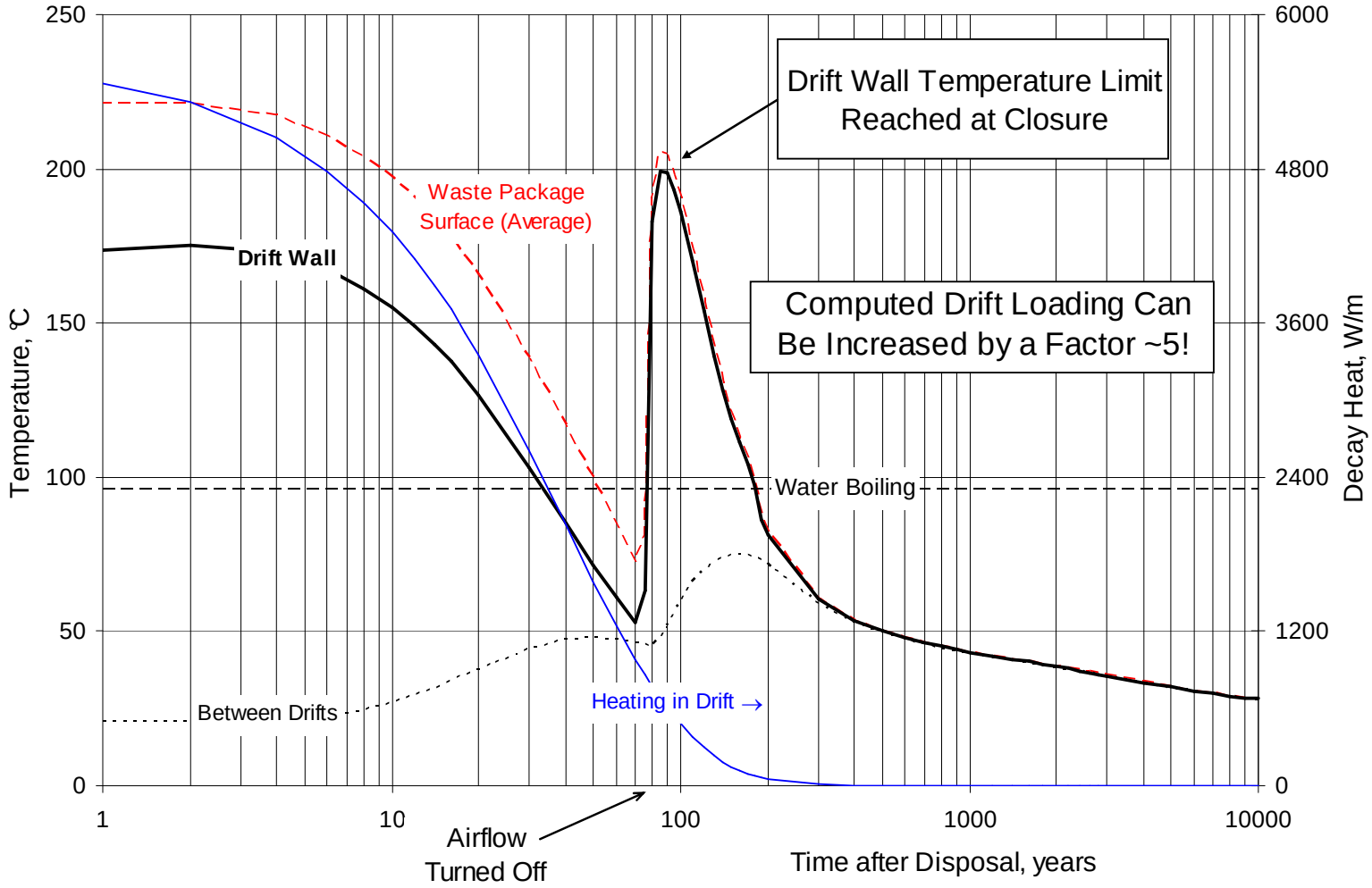
Thermal Characteristics of Spent Nuclear Fuel



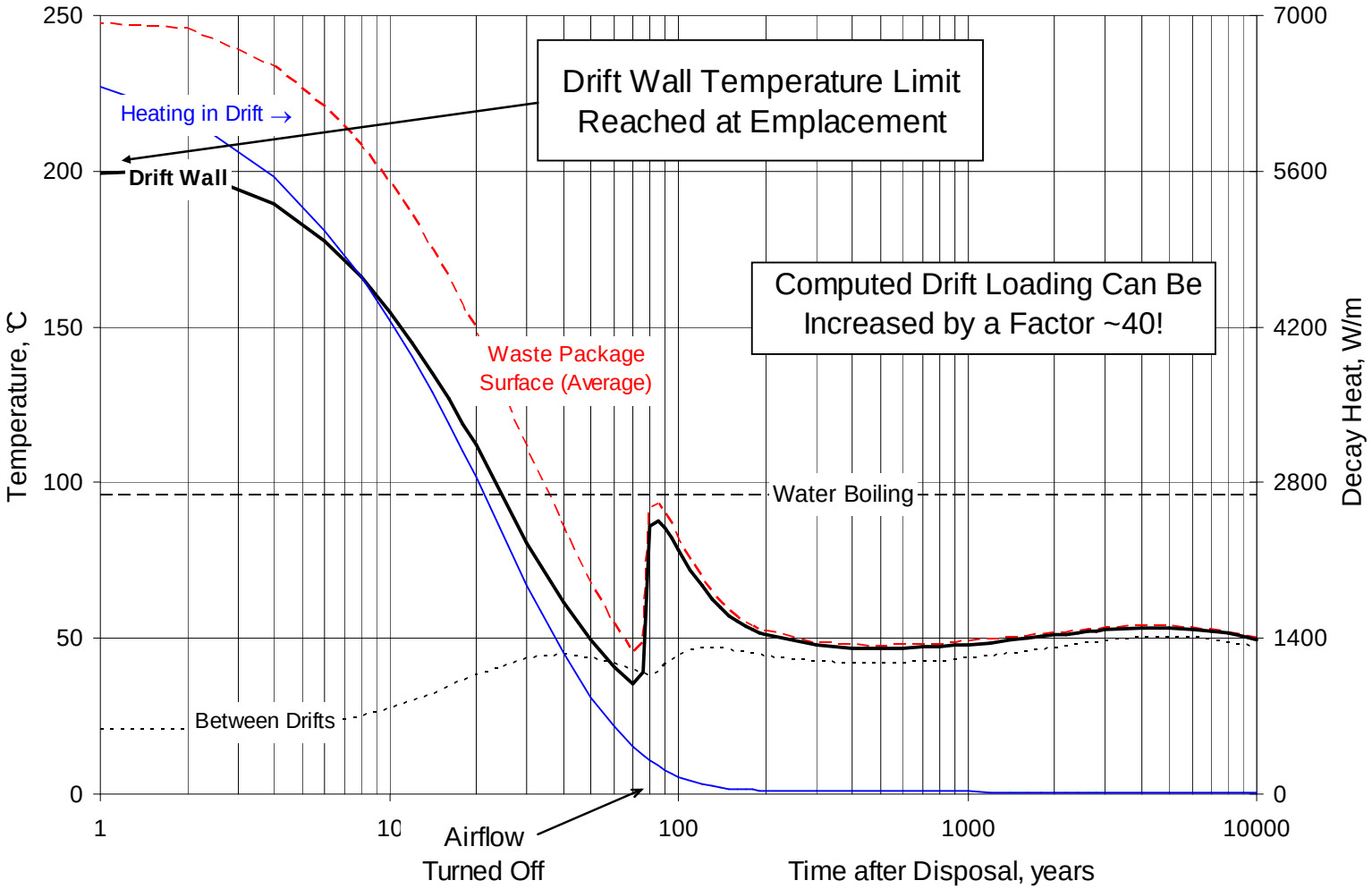
Repository Heating from Directly Disposed PWR Spent Fuel



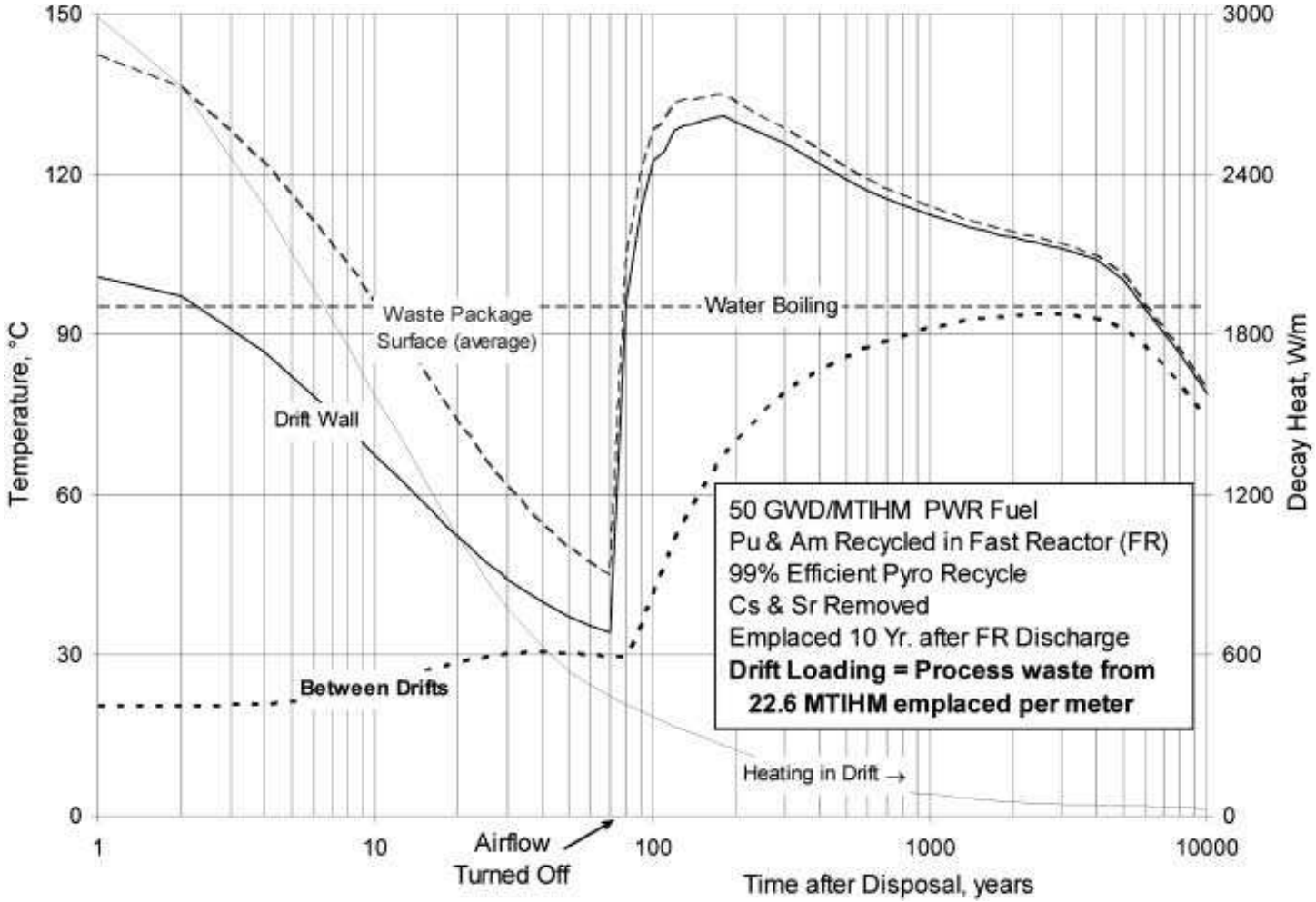
Repository Heating with 99.9% Pu & Am Removed

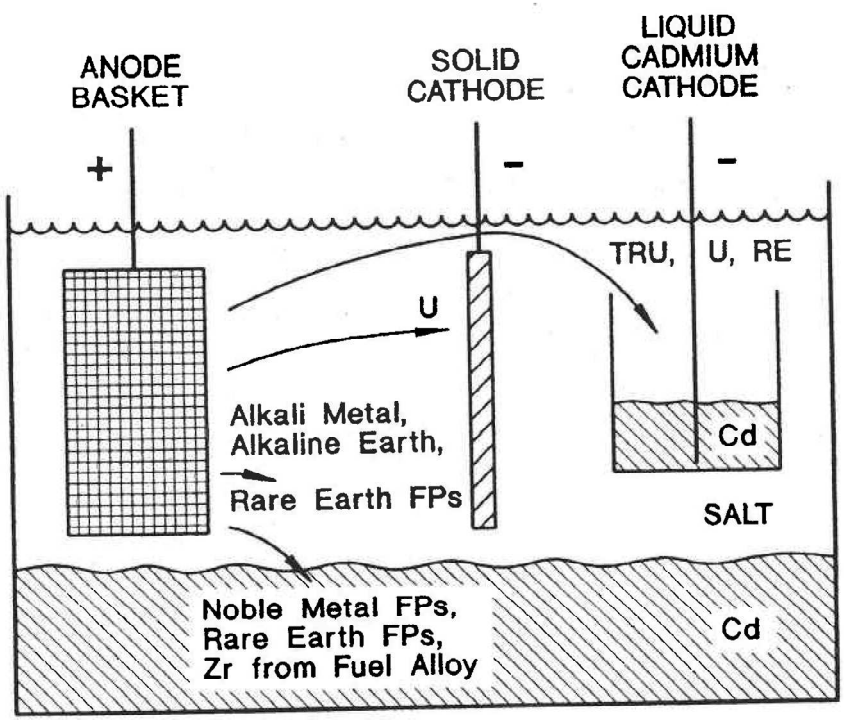


Repository Heating with 99.9% of Pu, Am, Cs & Sr Removed

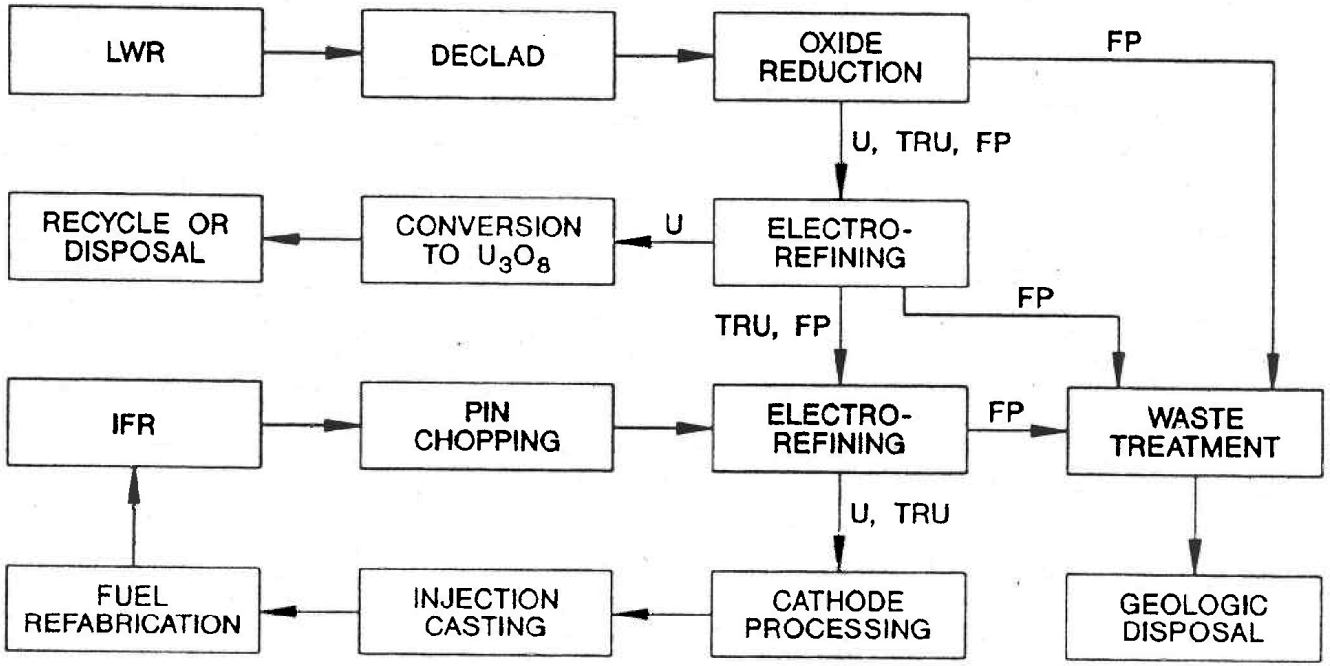


Transient thermal response: removal of plutonium, americium, cesium, and strontium from spent PWR fuel, recycling of plutonium and americium in a fast reactor, and increased drift loading.

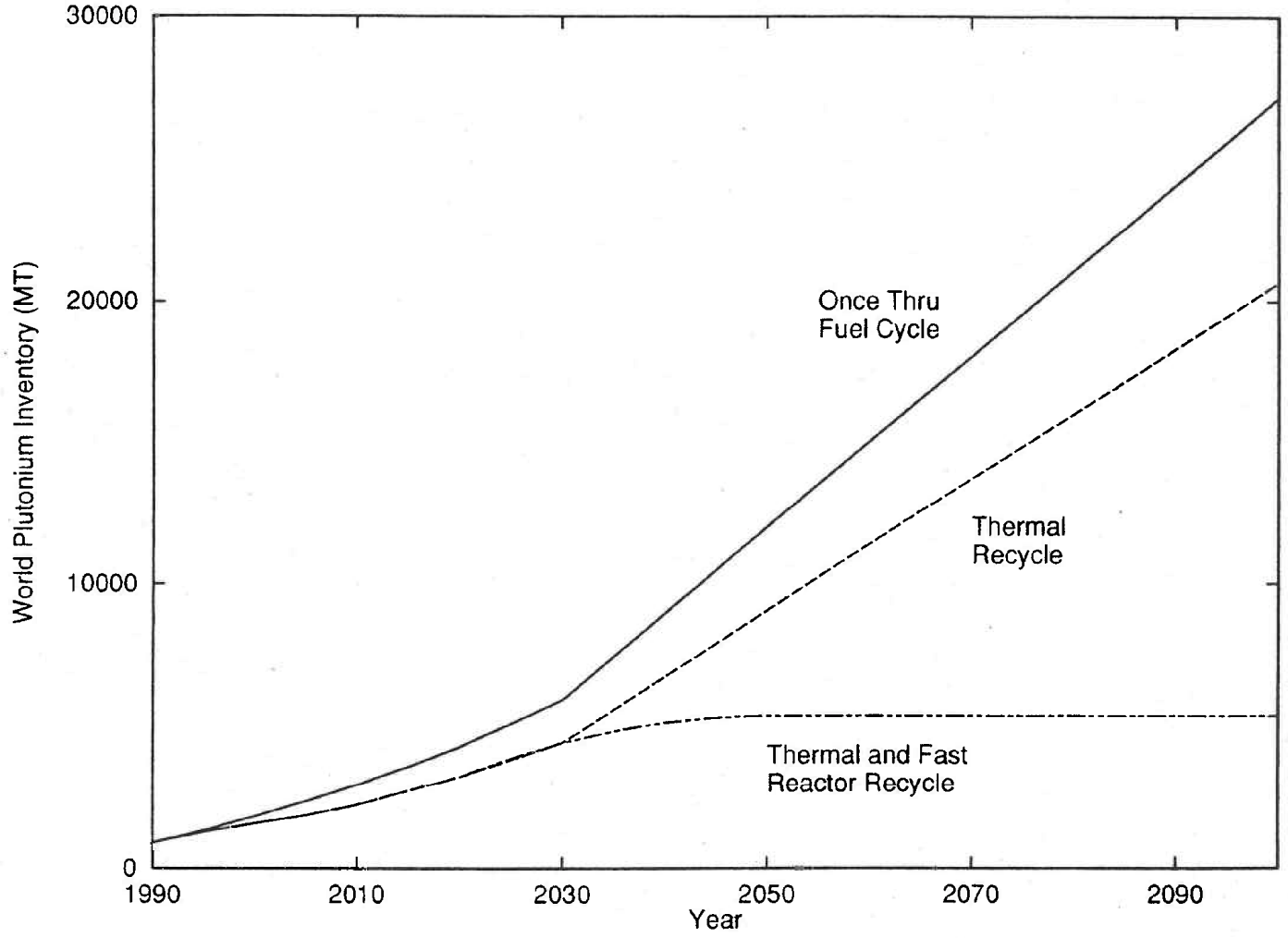




Schematic Diagram of Electrorefining Process. Spent fuel segments are placed in the anode basket and anodically dissolved. Pure uranium collects on the solid cathode, while a mixture of transuranic (TRU) elements, uranium and rare earth (RE) fission products deposit in the liquid cadmium cathode. Other fission product (FP) elements distribute between the salt and cadmium phases according to the stability of their chlorides.



The Combined Fuel Cycle for the Light-Water Reactor (LWR) and Integral Fast Reactor (IFR). (U: uranium; TRU: transuranic elements; FP: fission products.)

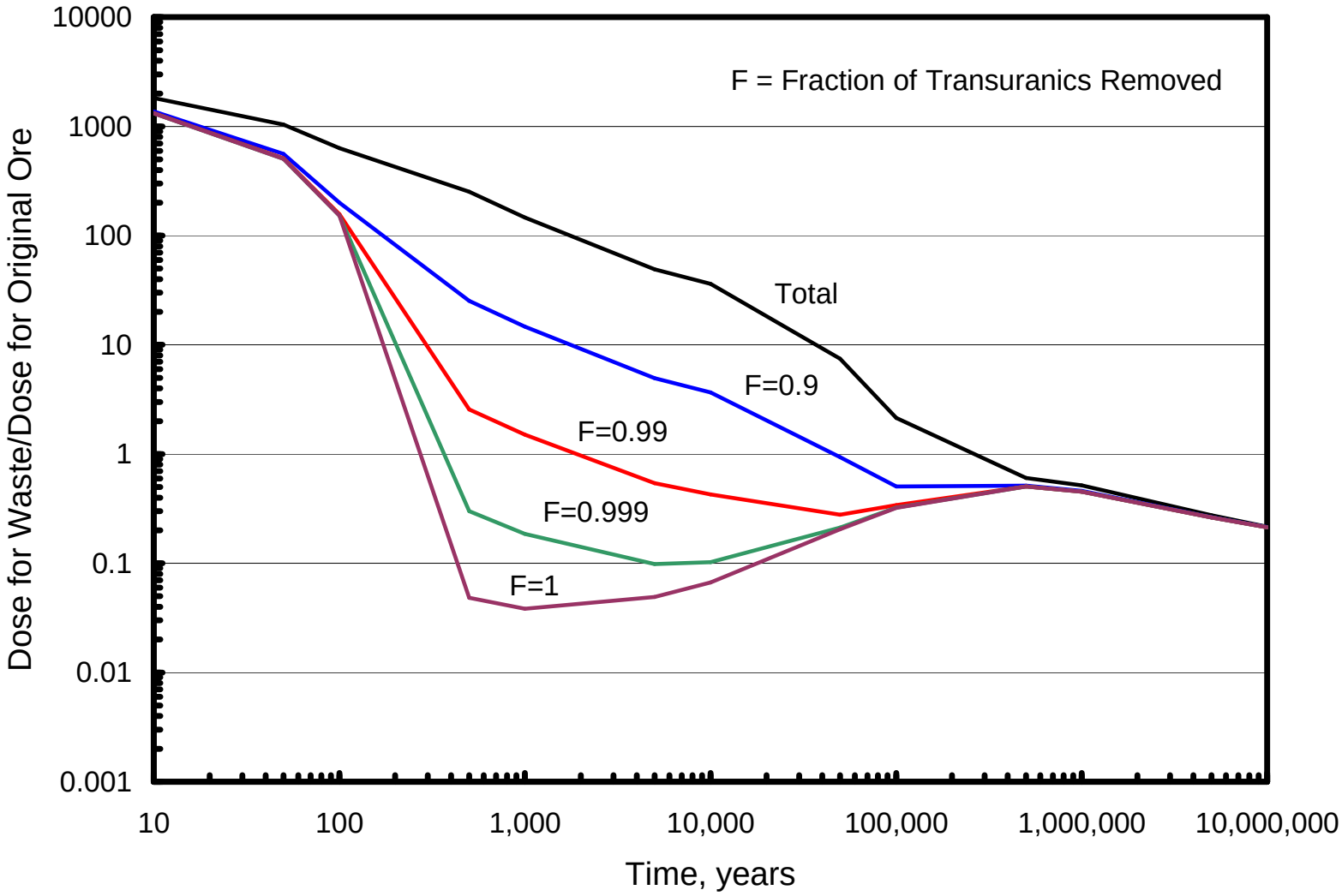


The Effect of Recycle on World Inventories of Plutonium.

Summary

- Removal of transuranics can lower the radiotoxicity of the waste to that of the original uranium ore in about 300 years.
- Removal of Plutonium and Americium can either increase the repository loading or reduce its size by a factor of 4 to 5 (depending on separation efficiency).
- Removal of Cesium and Strontium also, can further reduce the size by a factor of 40.
- Removal of Curium also, can reduce the size up to a factor of 225.
- Separation and recycling of actinides in fast neutron spectrum reactors (Burners) drastically reduces the waste to be disposed and drastically increases the nuclear fuel available for energy production.

Impact of transuranics on dose: PWR fuel with 33 GWd/MTHM burnup



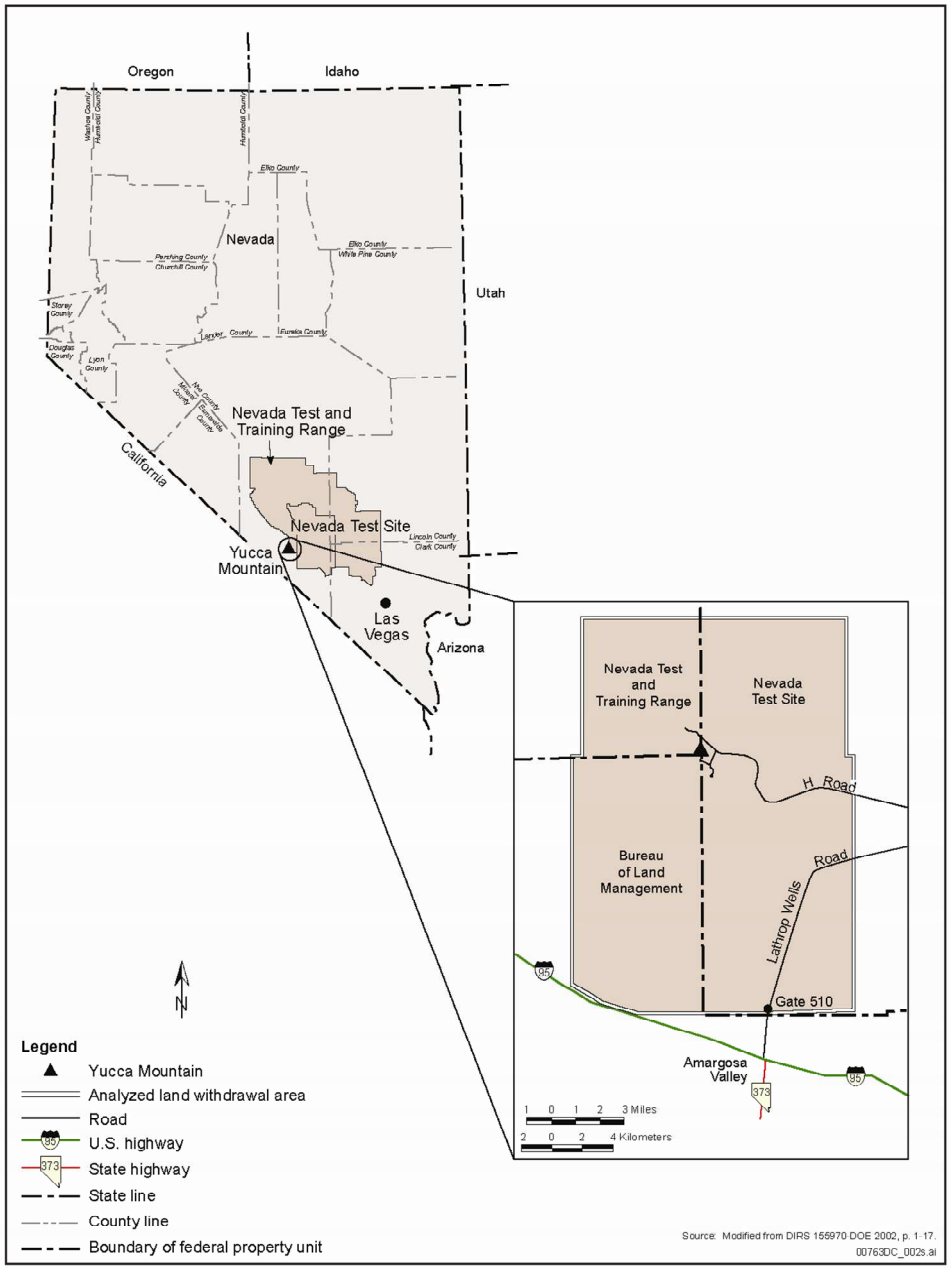


Figure S-2. Land withdrawal area used for analytical purposes.

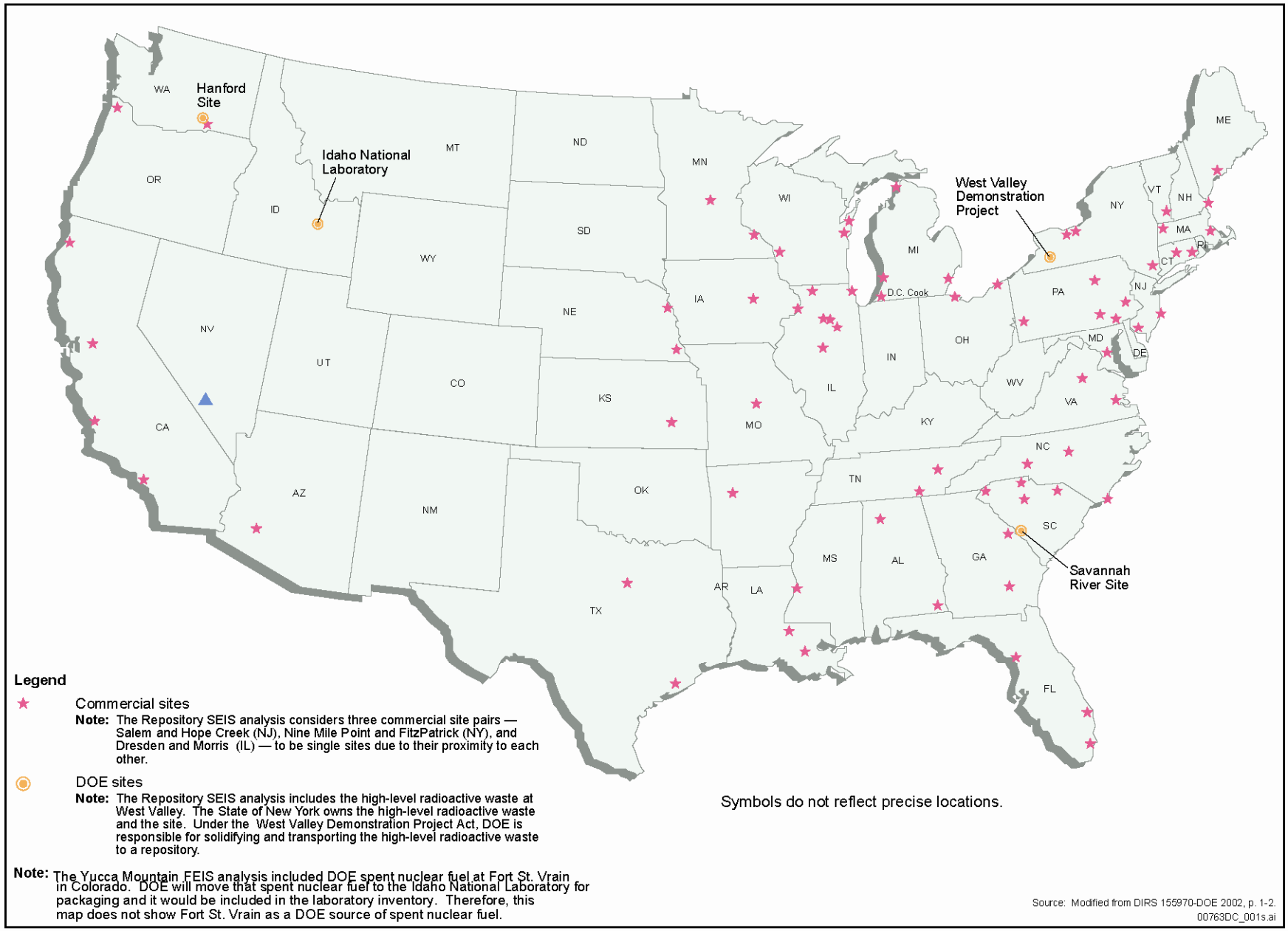


Figure S-1. Commercial and DOE sites from which DOE would ship radioactive materials to Yucca Mountain.