# Nuclear Waste Management Strategies

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**Yucca Mountain Education Program**
**Town Hall Meeting**
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# Overview

- What is High Level Radioactive Waste?
- Where does it come from?
- Waste Management Strategies
  - Short Term Strategies
  - Intermediate Strategies
  - Long Term Strategies
- Current Waste Disposal Strategies
- Summary


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# High Level Radioactive Waste

- US Definition (10 CFR 60.2)
  - Irradiated reactor fuel,
  - liquid wastes resulting from the operation of the first cycle solvent extraction system, or equivalent, and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuel, and
  - solids into which such liquid wastes have been converted.

# Sources of High Level Waste

- Spent Nuclear Fuel
  - Commercial Reactors
  - Defense Reactors
  - Research Reactors
- High Level Waste
  - Defense Activities
  - Reprocessing

# Characteristics of Radioactive Waste: How is it different that other waste?

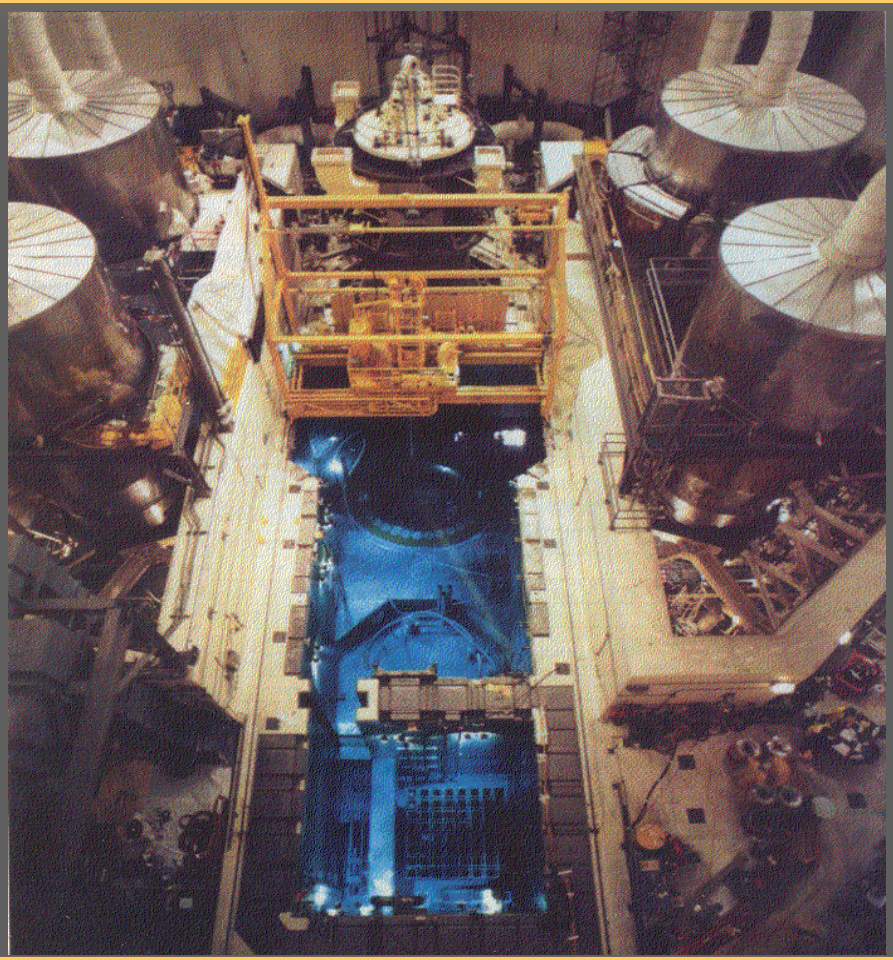
- Waste Emits Ionizing Radiation
  - Additional protection (i.e. shielding) may be needed
- Waste Generates Heat
  - Heat must be considered in designing strategies
- Waste undergoes Nuclear Transmutation
  - Chemical behavior changes over time
  - Environmental behavior of waste changes over time
  - Limited “lifetime” of waste

# Waste Disposal Strategy

- Time Frames
  - Short:  a.k.a. Temporary (less than 10 to 20 years)
    - Active Maintenance and/or security acceptable
    - Retrievability Required
  - Intermediate:  a.k.a. Storage (less than 50 to 100 years)
    - Minimal Maintenance and/or security
    - Retrievability Required
  - Long:  a.k.a. permanent or disposal (indefinite)
    - No Active Controls required
    - Retrievability/Reversibility desired, not required

# Short Term Strategies

- Spent Fuel Pools
  - Fuel stored underwater
- Tank Farms
  - Large tanks for storing liquid wastes
- Secure Storage Facility
  - Material stored in small, engineered facilities under guard



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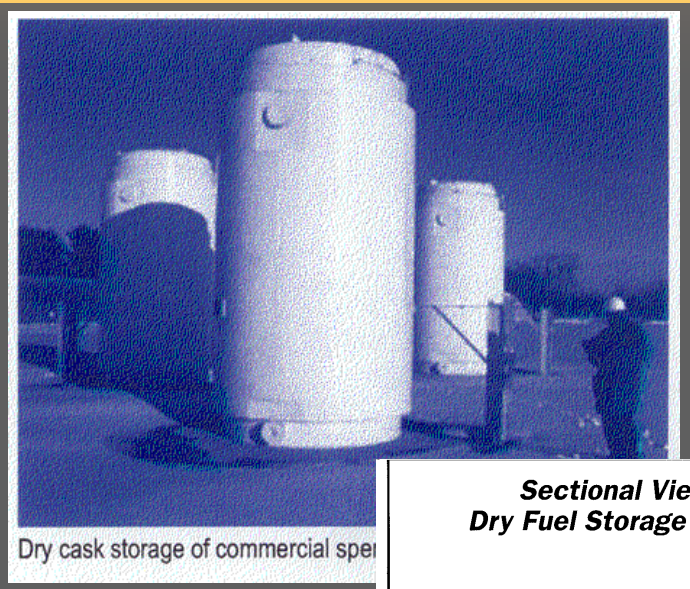
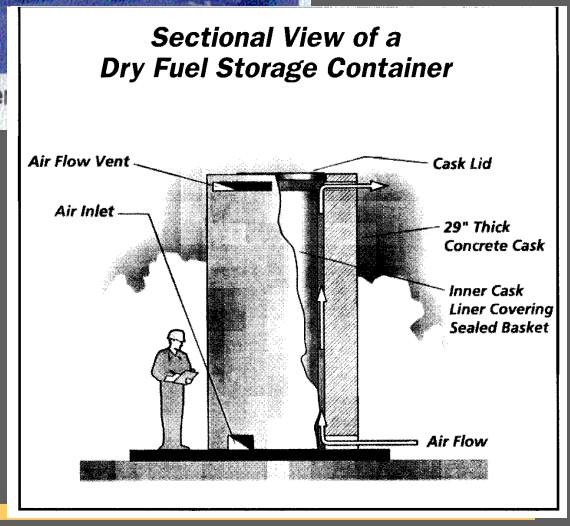
# Intermediate Term Strategies

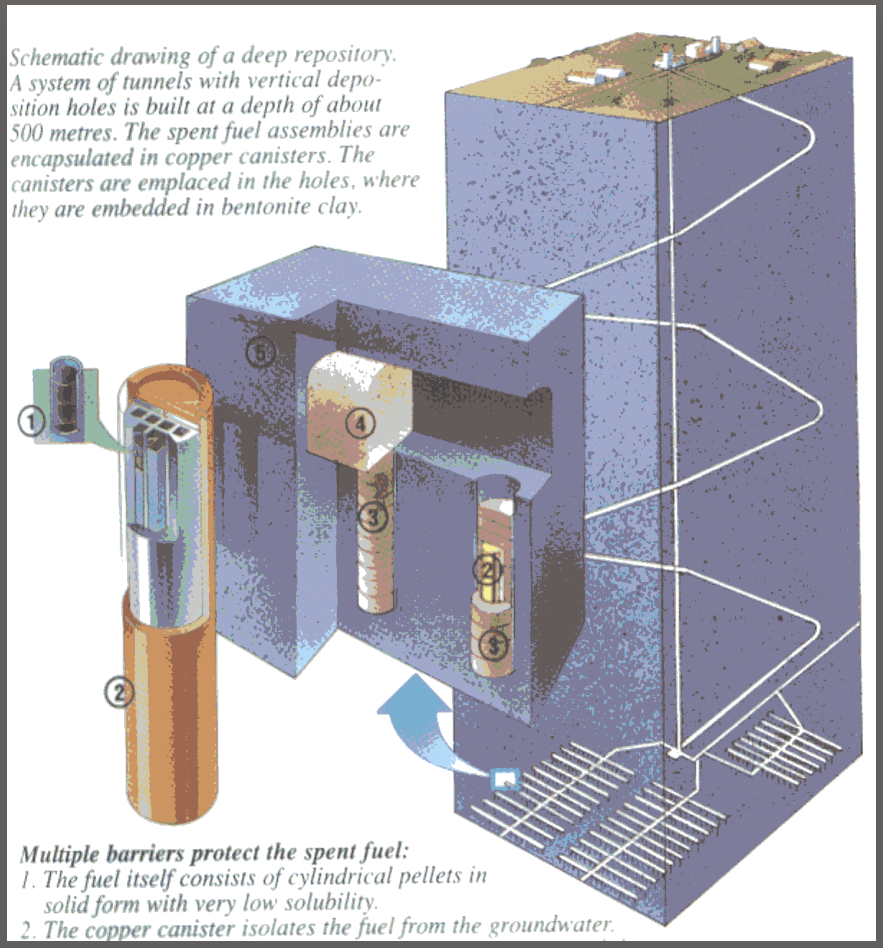
- Dry Cask Storage
- Monitored Retrievable Storage (MRS)
  - Strategies Available
    - **Centralized Storage**
      (1 central facility)
    - **Regional Storage**
      (1 facility per region)
    - **On Site Storage**
      (1 facility at each reactor site)


Dry cask storage of commercial spe



# Long Term Strategies

- Isolation
  - Ice Sheet Disposal
  - Sub-Seabed Disposal
  - Extraterrestrial Disposal
- Engineered Isolation
  - Mined Geological Disposal
  - Surface Engineered Facility
- Transmutation
  - Transmutation
  - Accelerator-driven Transmutation of Waste (ATW) strategy



*Schematic drawing of a deep repository. A system of tunnels with vertical deposition holes is built at a depth of about 500 metres. The spent fuel assemblies are encapsulated in copper canisters. The canisters are emplaced in the holes, where they are embedded in bentonite clay.*

***Multiple barriers protect the spent fuel:***
*1. The fuel itself consists of cylindrical pellets in solid form with very low solubility.*
*2. The copper canister isolates the fuel from the groundwater.*

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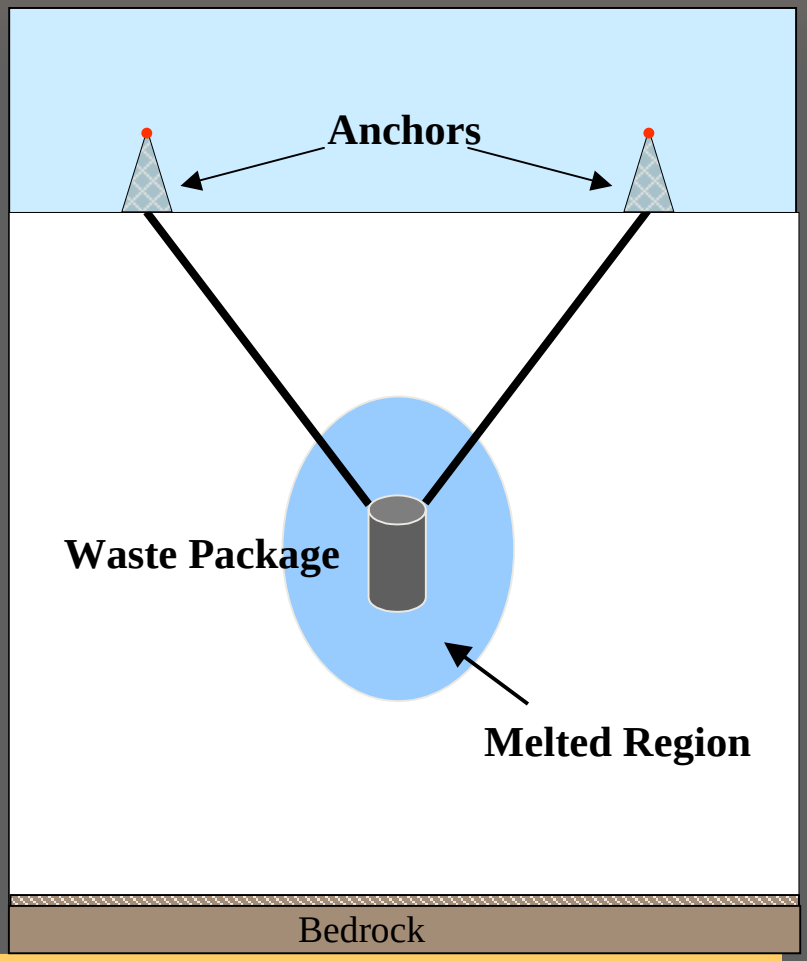
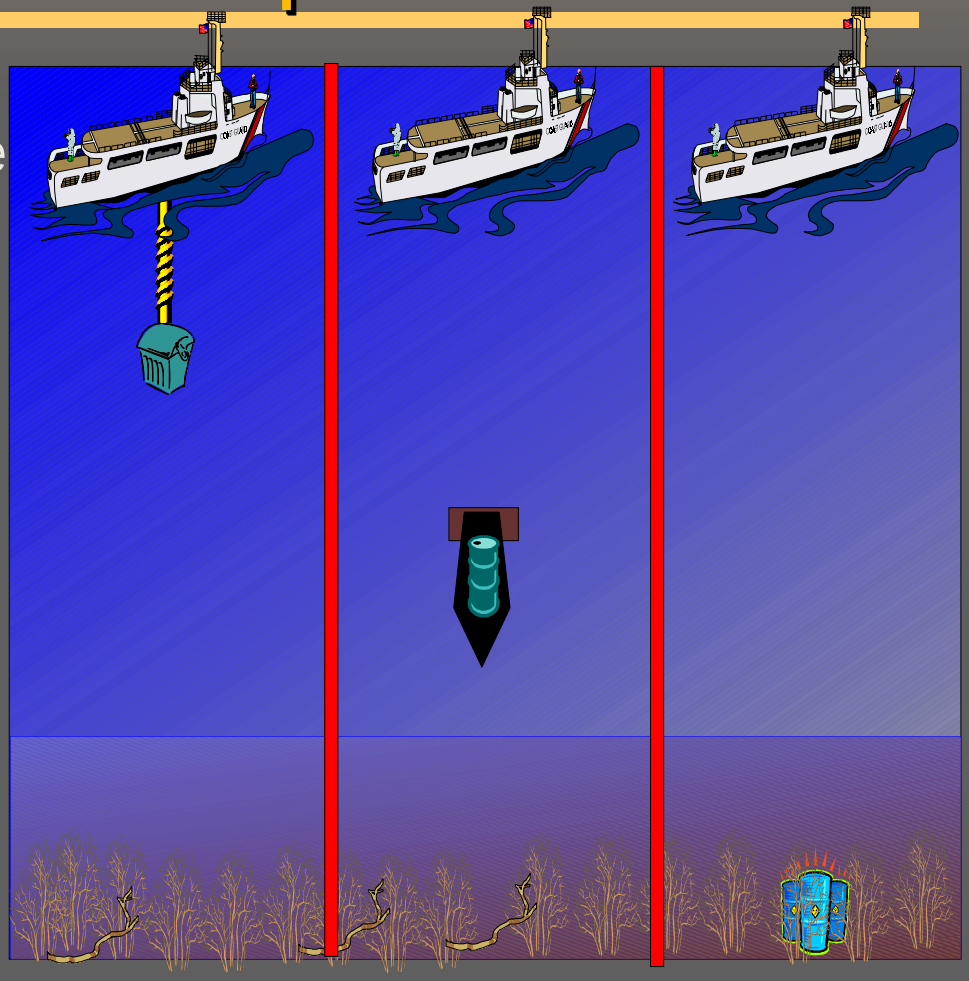
# Ice Sheet Disposal

- Summary
  - Bury waste in large ice sheets
- Pro
  - Remote Disposal Location
  - Waste Isolated from Biosphere
  - Excellent heat sink
  - Low temperatures = slower corrosion
  - Retrievable
- Cons
  - International Law prohibits waste disposal in international land/water
  - Requires operations in environmentally sensitive areas
  - Remote Location increases disposal costs



# Sub-Seabed Disposal

- Summary
  - Bury waste in deep trenches in the ocean floor
- Pro
  - Remote Disposal Location
  - Waste Removed from Biosphere
  - Minimal corrosion at sea bottom
- Con
  - International Law prohibits waste disposal in international waters
  - Waste Retrieval is not practical
  - Remote Location increases disposal costs



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# Extraterrestrial Disposal

- Summary
  - Shoot waste into outer space
- Pros
  - Waste is permanently removed from biosphere
- Cons
  - Extremely high cost
  - Significant risk to population during launches
  - Waste is not retrievable

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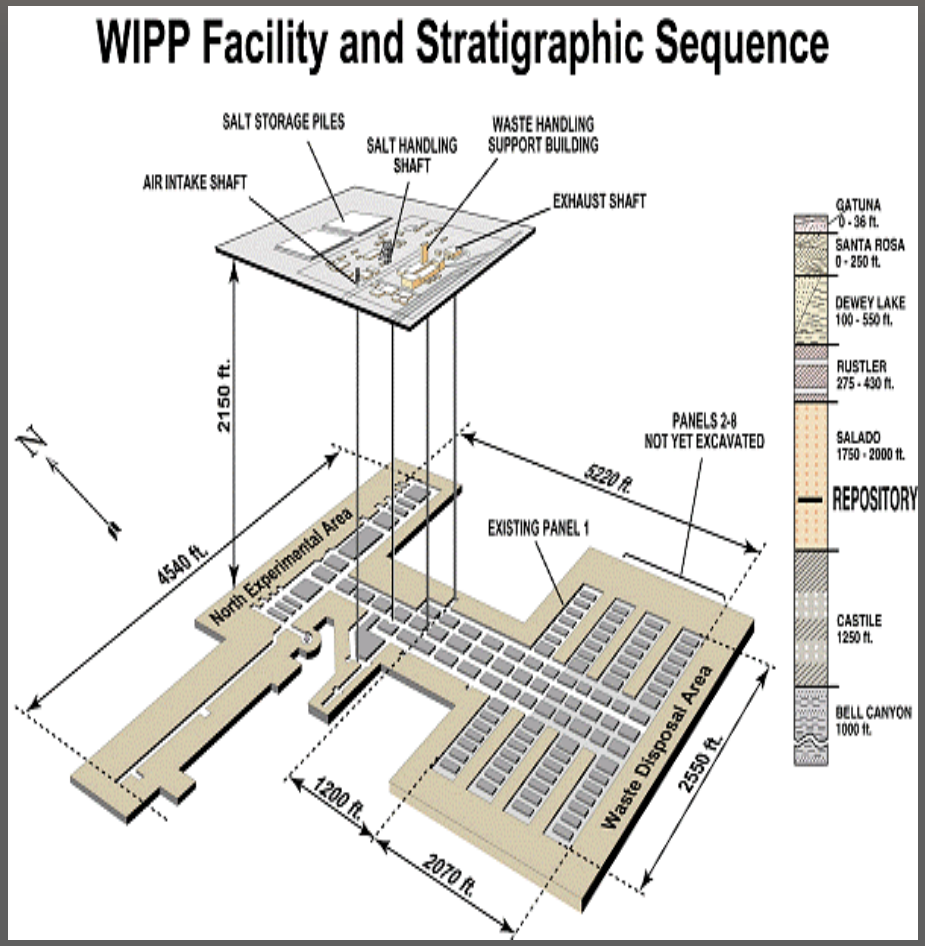
# Mined Geological Repository

- Summary
  - Bury waste deep underground
- Pro
  - Relatively low cost
  - Waste Removed from Accessible Environment
  - Sites available within U.S.
  - Waste is Retrievable
- Cons
  - Waste not removed from biosphere

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# Surface/Near Surface Facility

## Summary

- Build a facility to store waste indefinitely

**Pro**

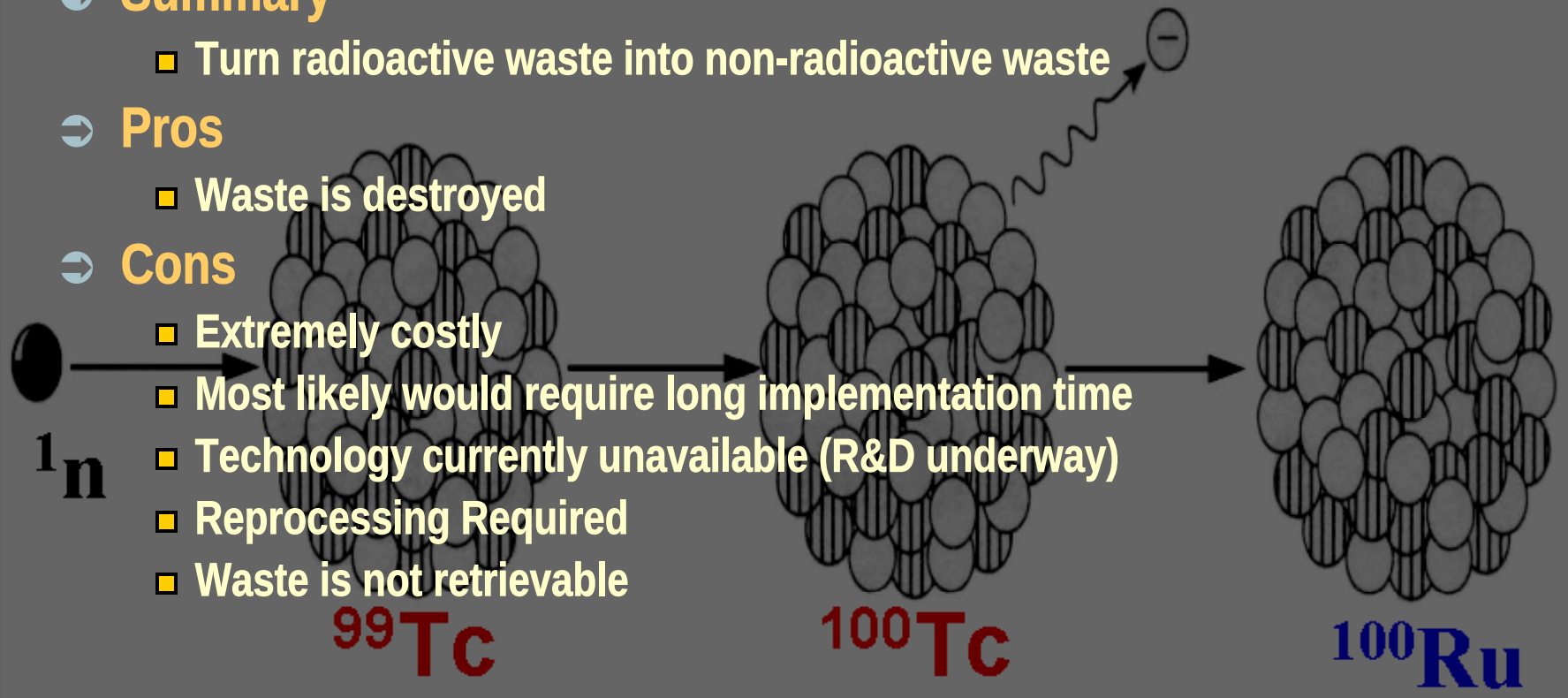
- Low Capitol Cost
- Simple to Design and Implement
- Site Available within Country
- Waste is Retrievable

**Con**

- Isolation Dependant entirely on Engineered Barriers
- Requires Active controls (maintenance and security)
- Very high cost for disposal
- Waste not removed from biosphere

# Transmutation

- **Summary**
  - Turn radioactive waste into non-radioactive waste
- **Pros**
  - Waste is destroyed
- **Cons**
  - Extremely costly
  - Most likely would require long implementation time
  - Technology currently unavailable (R&D underway)
  - Reprocessing Required
  - Waste is not retrievable



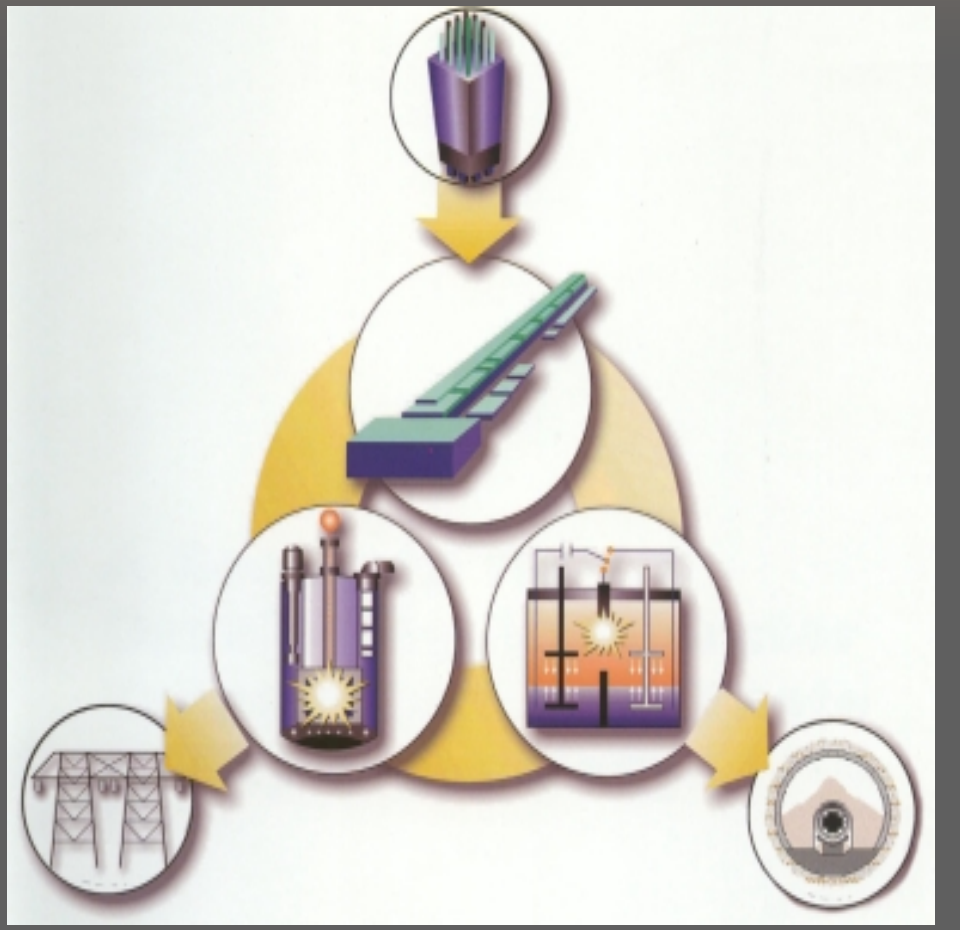
# ATW

- Summary

  Convert long-lived waste into short-lived waste, then bury all waste underground

- Pros (ATW)
  - Shorter Isolation required
  - Allows Waste Form Engineering
- Cons (ATW)
  - High Cost
  - Technology not ready

    (R&D currently underway)
  - Waste is not retrievable



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# Current Disposal Strategies

- United States
  - Short Term:  Spent Fuel Pools, Tank Farms, Secure Storage
  - Intermediate:  No Policy
    - Dry Cask (On Site Storage) on case-by-case basis
    - Monitored Retrievable Storage under investigation
  - Long Term:  Mined Geological Repository
- England, France, Japan, Germany
  - Short Term:  Secured Storage/MRS
  - Intermediate: Secured Storage/MRS
  - Long Term:  Mined Geological Repository

# Summary / Conclusions

- The Mined Geological Repository Strategy for indefinite storage/disposal is consensus long term disposal strategy in the waste management community
- Fuel cycles, short term, and intermediate waste disposal strategies vary around world
- Radioactive Waste Management is a unique techno-socio-political problem with no “correct” answer
  - Any “answer” will require trade-offs between technology and social and political agendas to be successful


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# Thank You for Your Attention

Please submit questions for the panel discussion in writing at the table in the foyer

Further questions can be directed to the panelists using the contact information provided on the YMEP website

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