

## Haz Waste: Radioactive Waste

- Background revisited
- Types of waste
- "Treatment" methods

## Radioactive Wastes

- Human background dose of radiation ~360 mrem/yr:
  - 55% radon from natural soil; 15% medical x-rays; 15% solar radiation; 11% internal; 3% consumer products; misc
- Can't really "treat" material to reduce radioactivity, since it is nuclear decay
- Long times needed to decay to harmless material (ex: half-life U  $1.6E5$  to  $4.5E9$  yrs)
- Need to absorb released radiation ( )

## Radioactive Wastes

- Not regulated by EPA
  - Nuclear Regulatory Committee (NRC) under Atomic Energy Act, Energy Policy Act, Nuclear Waste Policy Act, etc.
- 6 categories
  - Uranium mining and milling wastes
  - High level waste (HLW)
  - Spent fuel from nuclear reactors
  - Transuranic Waste (TRU)
  - Low level waste (LLW)
  - Mixed waste

## Uranium Mining and Milling Waste

- Contains low concs of naturally occurring radioactive materials
- Large quantities usually present due to processing the ore into reactor fuel
- Includes solids and gas wastes
- No current U mines operating in U.S.
  - ~35 in 1977, 4 in Colorado

## High Level Waste (HLW)

- Wastes derived from nuclear energy reactors
- Due to reprocessing spent fuel
- Highly penetrating radiation and "short" decay time
- Liquid waste prior to treatment
- Intended for ultimate disposal in Yucca Mt.

## Spent Nuclear Reactor Fuel

- Solids
  - Pellets of enriched rad. material in tubes
  - Tubes (fuel rods) replaced every 12-18 mo
- ~111 nuclear power plants in U.S.
- Includes long-lived radioactive elements (Pu)
- Intended for ultimate disposal in Yucca Mt.

## Transuranic Waste (TRU)

- From defense reactors, solids and liquids
- Long decay times, emitting, >100 nCi/g
- Elements heavier than Uranium
- Many DOE sites contain large quantities
  - Hanford, Rocky Flats, INEL, LANL, NTS, SRS, LLNL, ANL, ORNL, Mound, +15 small
- To be disposed in WIPP

## Low Level Waste (LLW)

- <100 nCi/g
- From a variety of sources
  - 50% nuclear power plants, 30% hospitals and research, 20% commercial, defense industries
- Solids, liquids, or gases
- NOT other categories
- 2-3 current disposal sites in U.S.

## Mixed Waste

- Radioactive waste + RCRA Hazardous waste characteristics
- One incinerator in U.S. licensed to treat
- Combined properties make them difficult (and expensive \$\$) to treat

## Rad Waste “Treatment”

- Phytoaccumulation
  - Ex. Sunflowers in Russia + incineration
- Vitrification
  - “glassify”; Hanford
- Ocean Disposal
  - 1944 Hanford Columbia River Pac Ocean
  - 1946-1970 35 dump sites in Atlantic (~34,000 containers 79K Ci), Pacific (~52,000 containers 15K Ci), Gulf of Mexico
    - Rad surveys find low concs Cs & Pu in some fish
  - 1972 Marine Protection Act prohibits ocean disp.
  - UK and France dump ~1E5 Ci/yr into coastal waters from nuc. fuel reprocessing facilities

## Rad Waste “Treatment”

- Sub sea bed (SSB) disposal
  - Waste in sealed containers buried 20-50m deep
  - Seismically stable locations
  - Clays will isolate the HLW from environ.
  - Under development by multi-national consortia
- On site storage of nuclear power plant fuel
  - Steel-lined concrete pools of water
  - Dry casks of concrete &/or steel above ground
  - Used since 1950s ...running out of space!

## Rad Waste “Treatment”

- LLW disposal in below ground vaults
  - U.S. generates ~57M metric tons/yr LLW
  - 1985 LLW policy Law
    - Each state must have own LL rad waste site
    - State have made regional compacts to share sites (5 NW, 8 midwest, 11 NE, 8 SE, 5 central, 5 Rocky Mt, Ca, Tx,....)
    - No new sites yet built and active
      - Large controversy in CA (close), etc.
  - Concrete vaults, waste in 55-gal drums, modular concrete container disposal
  - Used in Japan

## Rad Waste "Treatment"

- Monitored Retrievable Storage (MRS)
  - Central storage for used nuclear fuel from power plants
  - Stored at MRS site until send to permanent underground repository (ex: Yucca Mt)
  - Alternatively find a use for the fuel (reprocessed fuel reactors) and use it
  - Concern: transportation safety
- Long term storage
  - Allow radioactive decay to harmless, stable products
  - Storage for 1000s of years needed (WIPP, Yucca)

## Yucca Mountain, Nevada

- Mandated under 1987 Nuclear Waste Policy Act for a fuel storage facility
- Repository to be built 1000' below ground w/ multiple barriers to isolate HLW and spent fuel
- Site characterization studies began in 1987
  - Rad dose limit <1/1000% of natural bkg thru 1000 yrs after closure
  - Far from population
  - GW travel time to public supply >1000 yrs
  - Waste pkg dsn life 300 yrs, safe for accidents and earthquakes
  - Waste retrievable up to 50 yrs

## WIPP

- Waste Isolation Pilot Plant
- 26 miles SE Carlsbad, New Mexico
- TRU stored underground in deep salt beds
  - Salt stable >200M yrs; 2000' formation starting 850' below ground, waste 2150' bgs
  - Salt will permanently encapsulate the waste
- First waste received Mar. 26, 1999
  - Should receive 37,000 shipments from 23 locations for 35 yrs @ \$200M/yr

## Transporting Rad Waste

- TRUPACT-II (8' Dx10' H SS)
  - Contain up to 14 55-gal drums of "contact handled" waste
  - 3 layers SS + foam/impact liner
  - 12,705 lbs empty, ~19,280 lbs loaded
  - Withstood 385G during free-drop test (~20x highway collision force)
- RH-72B (3.5' D x 12' L)
  - For "remote handled" waste
  - Double containment steel + 2" lead
  - Approved Mar. 2000; begin use ~2002

## Safety Tests for Trans. Containers

- Ignite with jet fuel; 1475F 30 min
- Freeze at -40F
- Free drop 30' onto concrete
- Free drop 40" onto 6" dia steel bar (puncture test)
- External pressure from immersion >50' water

## Dsn WIPP for communicating waste location and content for >10,000 yrs

- Surface berm 100' wide base x 33' tall around subsurface burial 2858'x2354'
  - Inc. 128 radar-reflecting metal markers + magnets
- Perimeter monuments 25'H, 20tons granite
  - 7 language warnings, around 4 sq mi area + inside berm
- Information center @ physical center 40'x32'x15'h+2 underground rooms; engraved granite
- Buried markers 2-6' deep over repository
- Archives in many locations worldwide