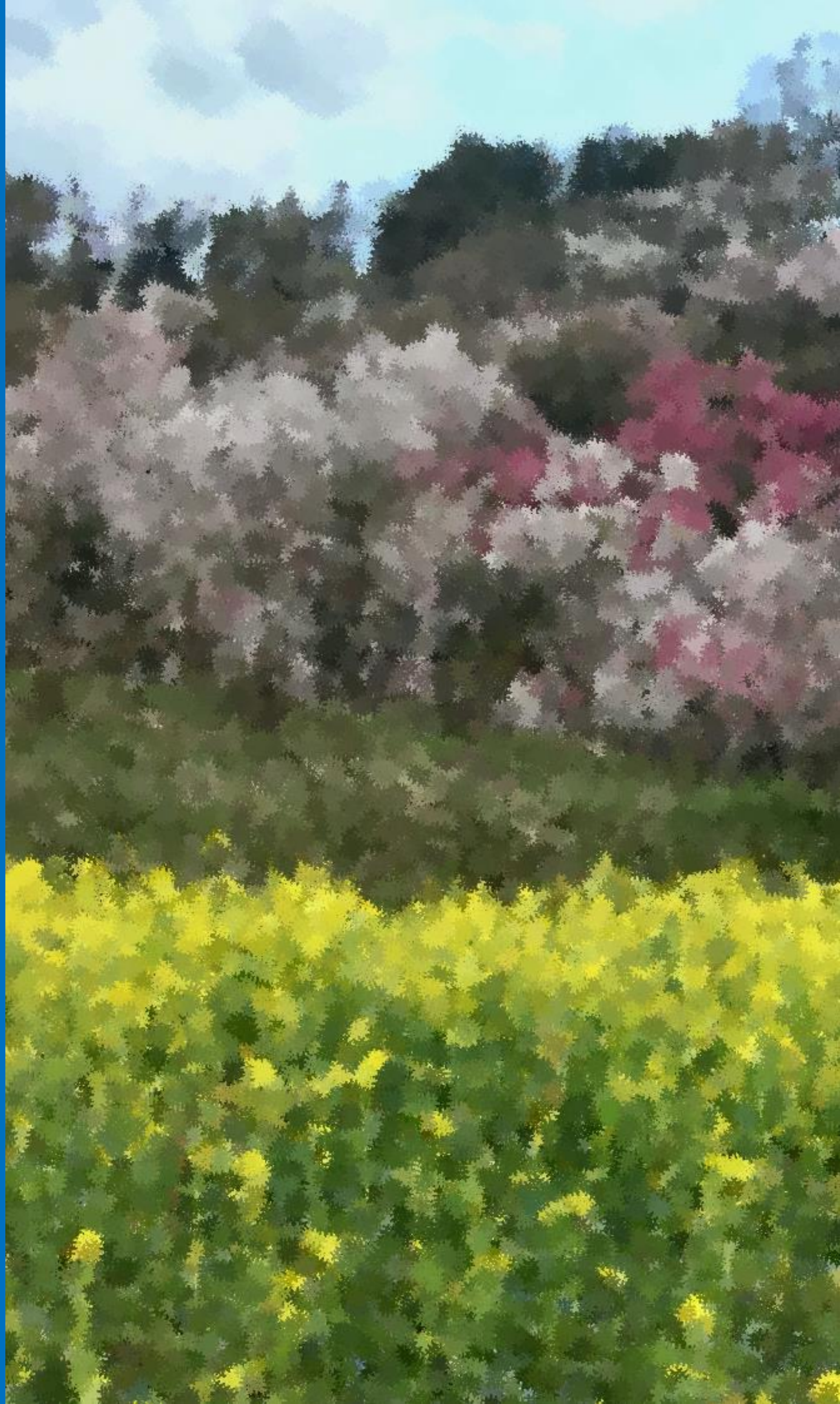
Nuclear Waste: Leading Environmental and Waste Technologies

Haruko Wainwright, MIT

NSE
Nuclear Science & Engineering at MIT
science : systems : society

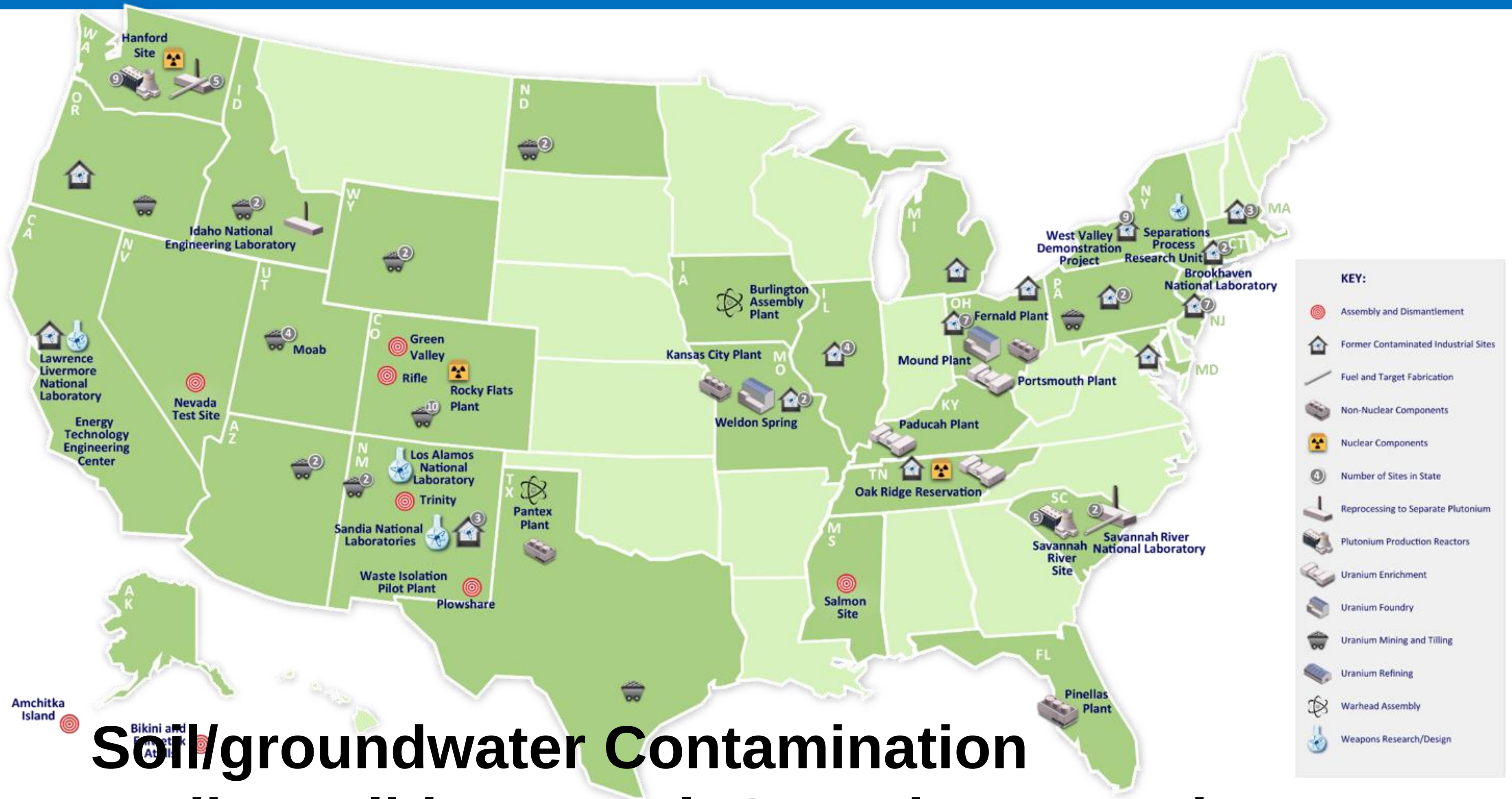
Civil and Environmental Engineering



Nuclear Waste: Key Facts

- Small/well accounted waste footprint across the life cycle
- Best managed/isolated waste
- Environmental monitoring for providing assurance
- Advancing interdisciplinary research and education

Lessons Learned from DOE's Legacy Sites

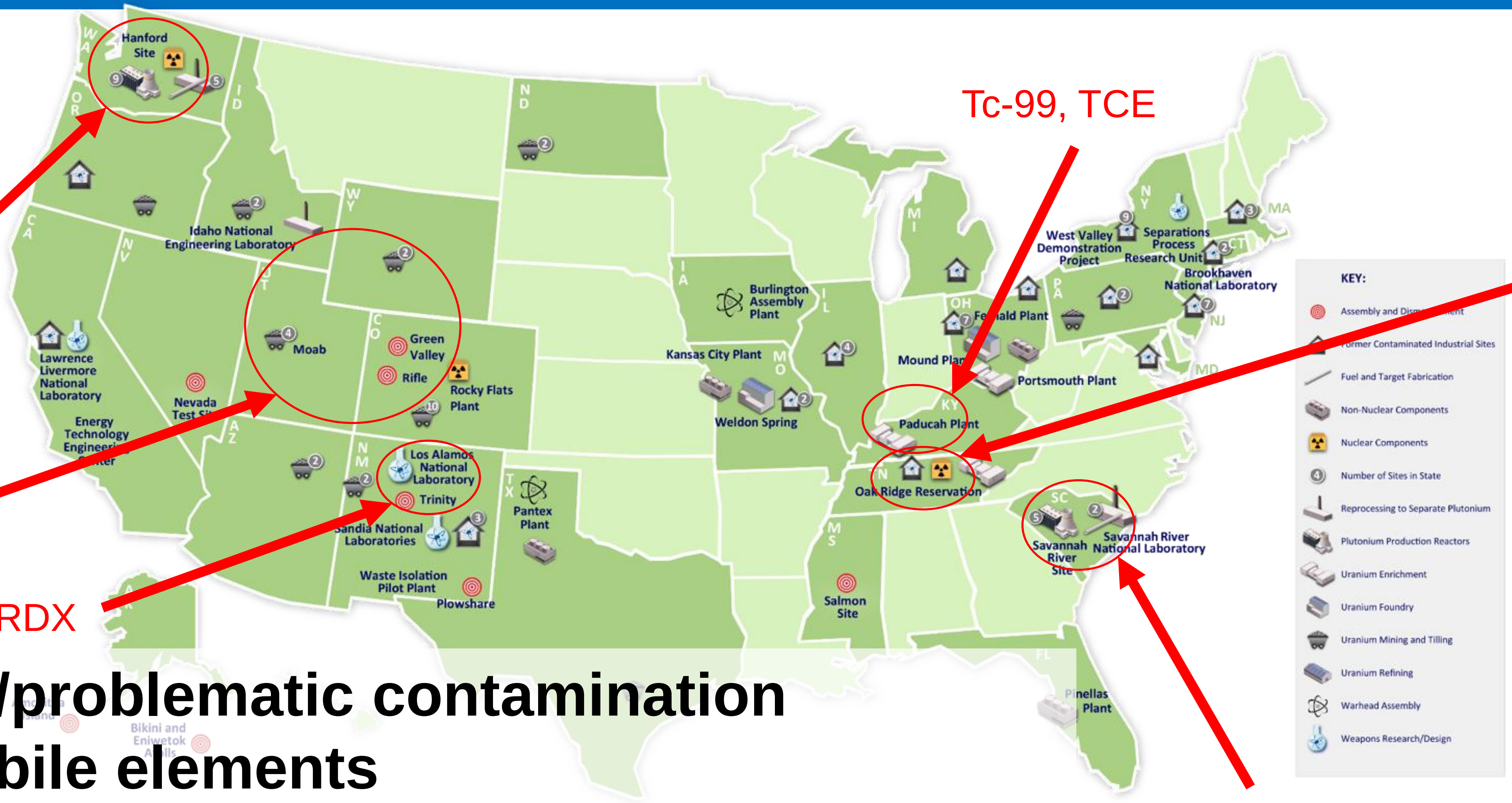


Soil/groundwater Contamination

Radionuclides, Metal, Organic contaminants

→ 30+ years of remediation

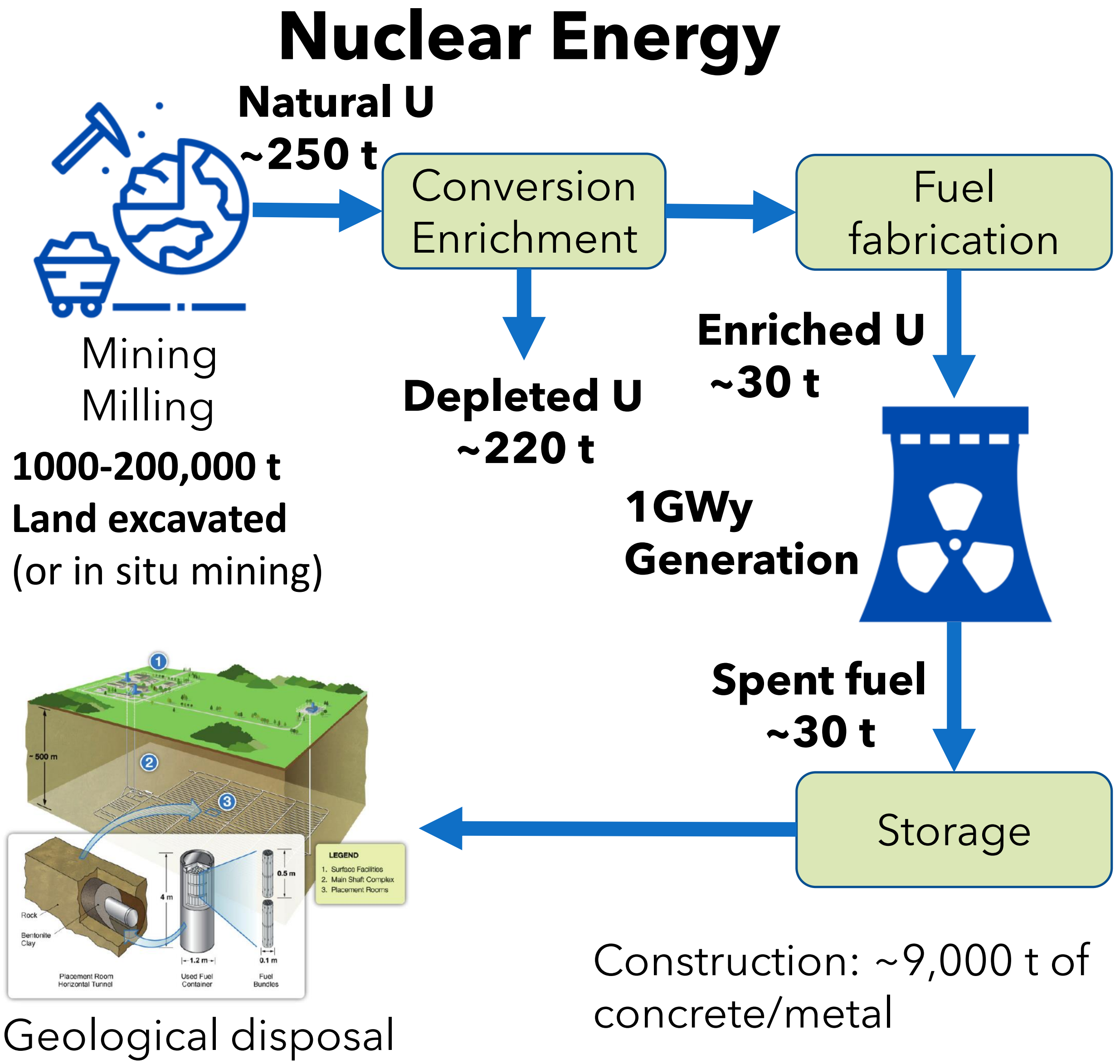
Lessons Learned from DOE's Legacy Sites

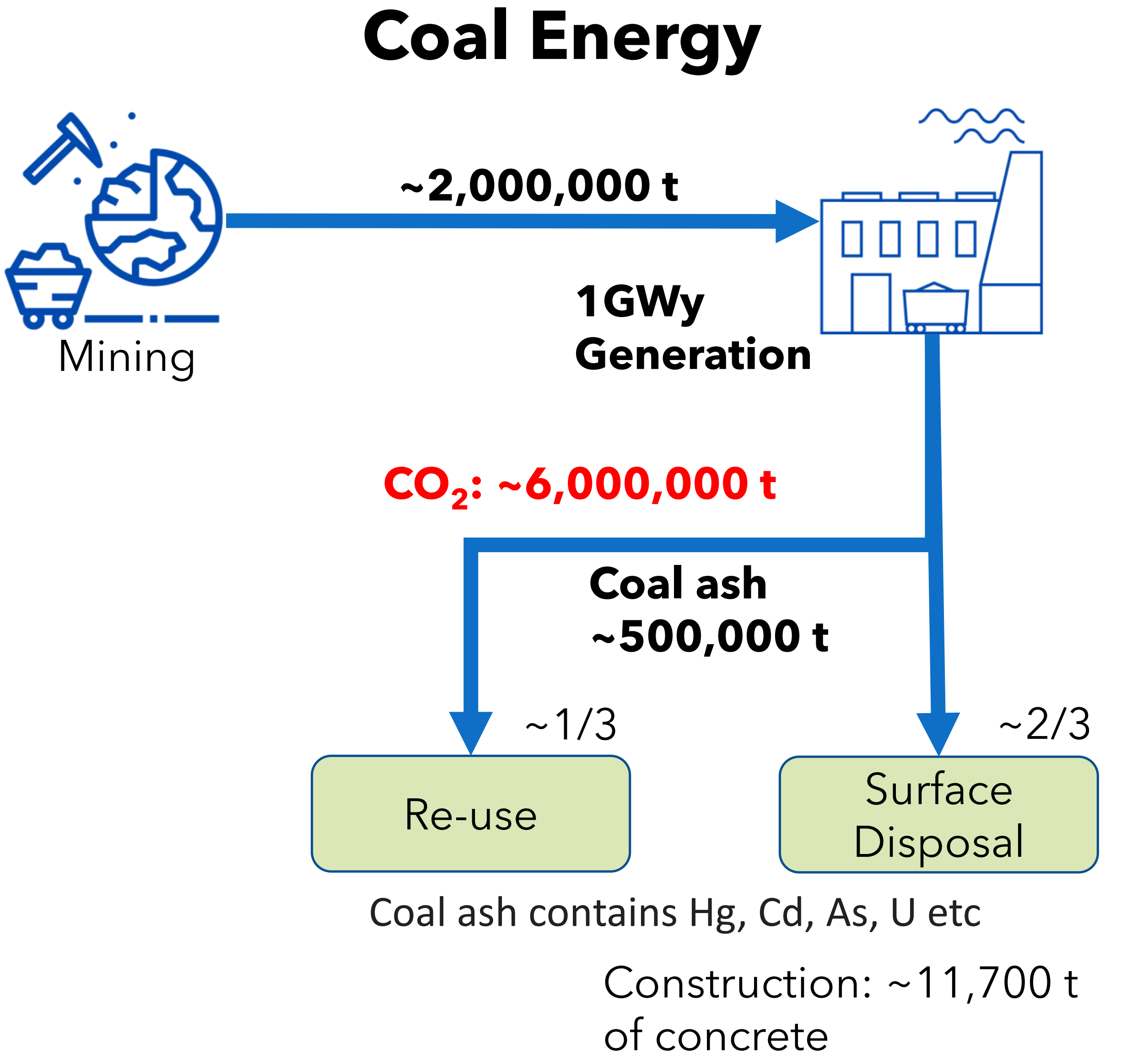


Large/problematic contamination

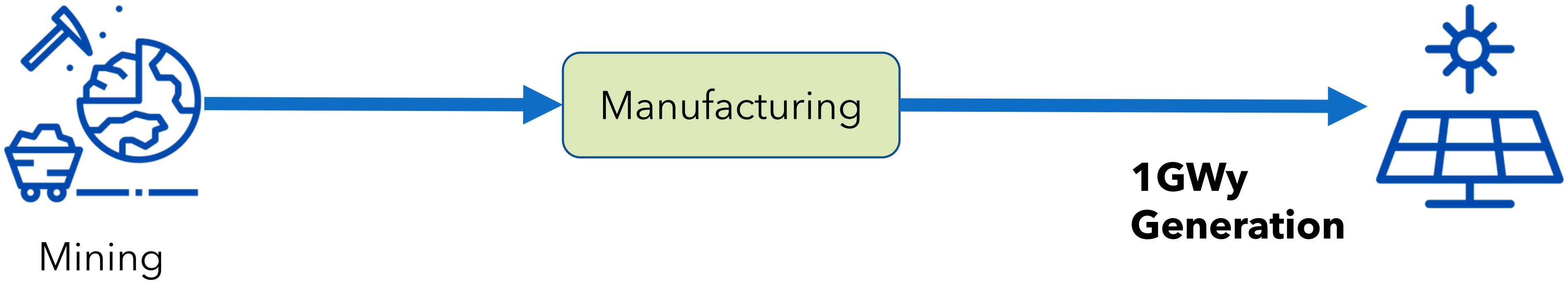
- Mobile elements
- Low-level radioactive and mining waste
- Non-rad elements (metal, organic)

Waste Across Energy Life Cycle: Nuclear/Coal





Waste Across Energy Life Cycle: Renewable?



Waste
~3,000 t/year

- Cap. factor = 0.3
- 30 year life

(IEA-PVPS 2016)

13 Al	14 Si	
29 Cu	32 Ge	49 In

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Check for updates

Metal leaching from Lithium-ion and Nickel-metal hydride batteries and photovoltaic modules in simulated landfill leachates and municipal solid waste materials

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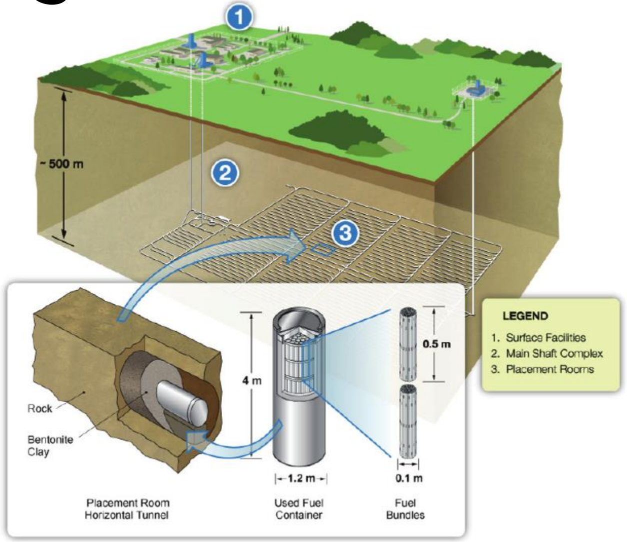
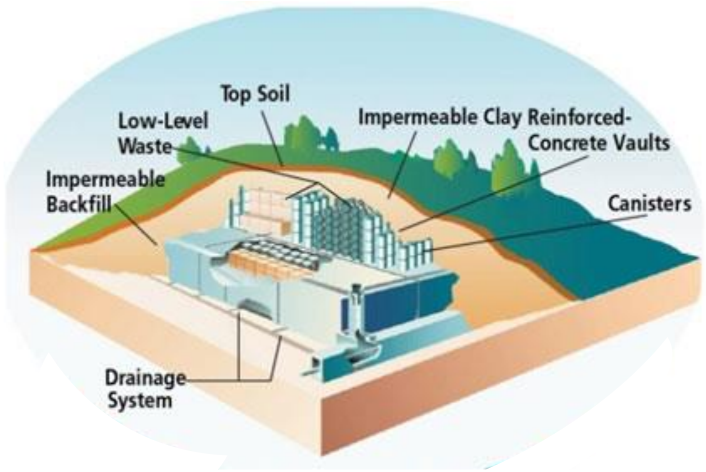
Disposal: Waste Isolation Systems

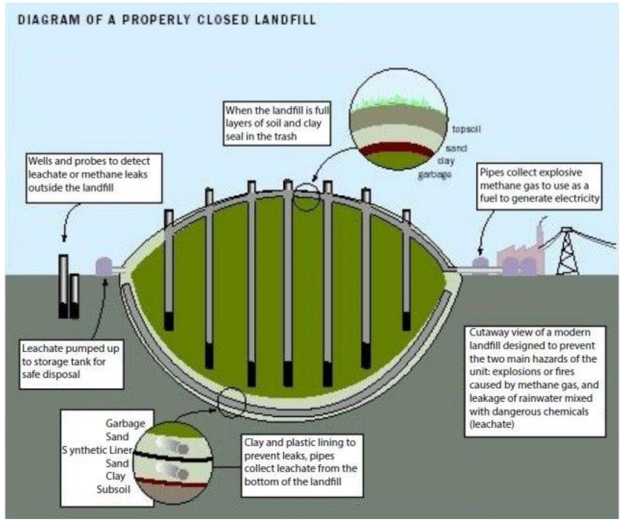
High-level rad. waste



Low-level (U mining) waste



Hazardous waste



Disposal: Waste Isolation Systems

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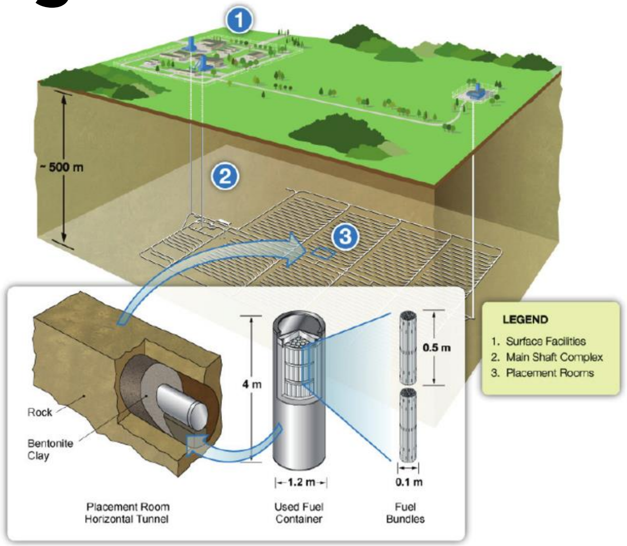

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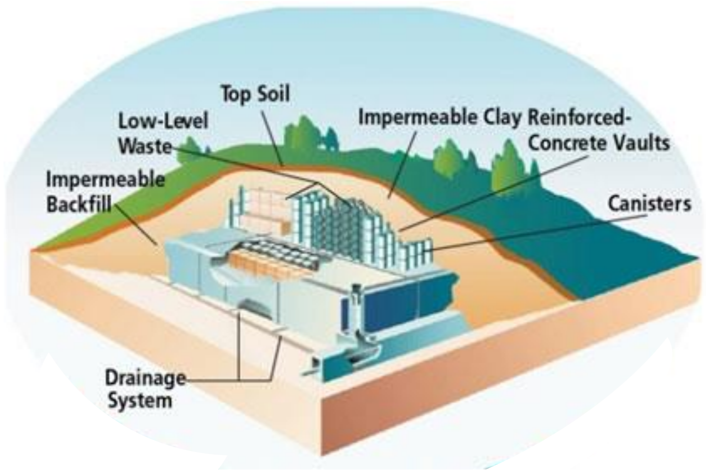

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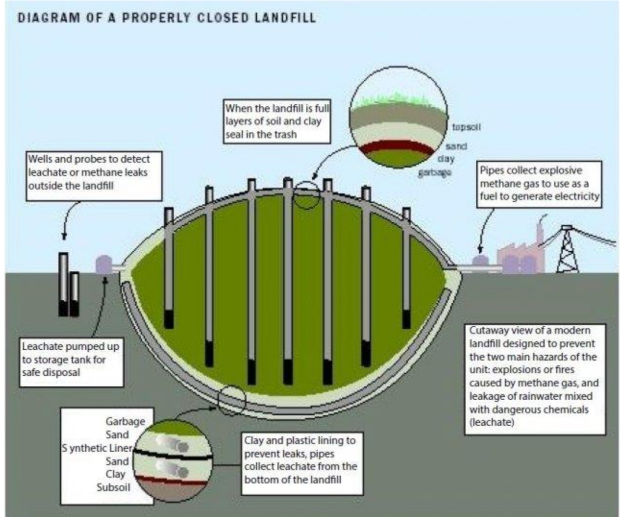

Barrier systems

- **Waste form/canister/clay**
- **Deep geology**

- **Clay cover/geomembrane**

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Disposal: Waste Isolation Systems

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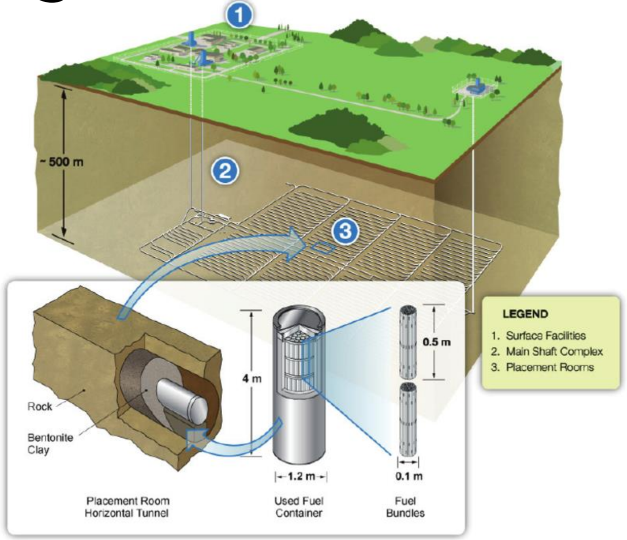

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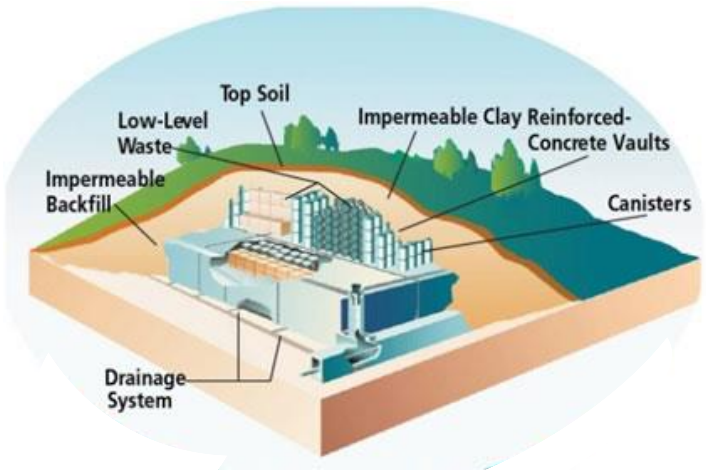

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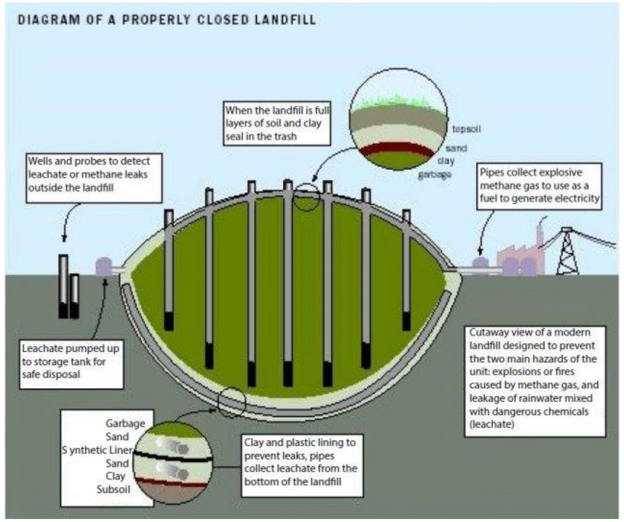

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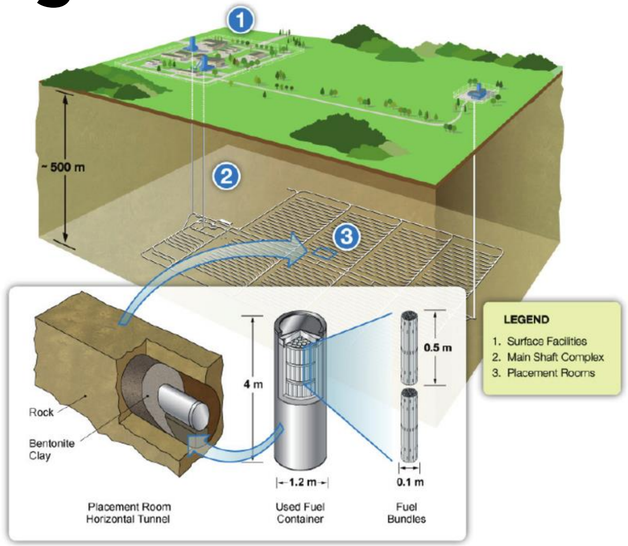
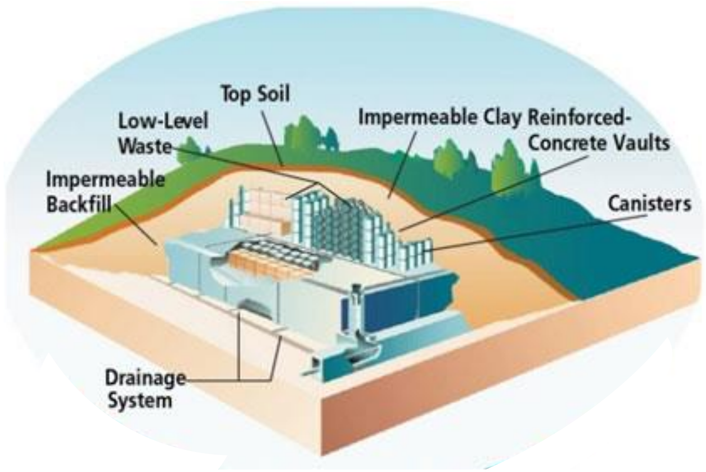
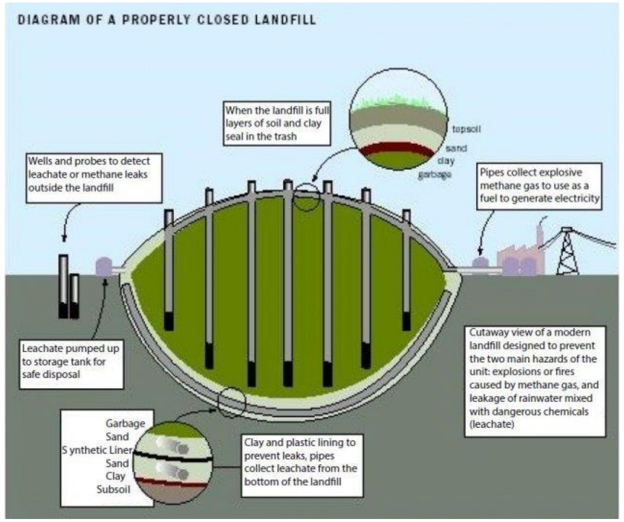
Compliance

10,000 - 1,000,000 years
- Probabilistic risk assessment

- **500 - 100,000 years**
- Probabilistic risk assessment

- **30 years + extension**
- No risk assessment required

Disposal: Waste Isolation Systems

High-level rad. waste	Low-level (U mining) waste	Hazardous waste
		

Barrier systems

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Compliance

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10,000 - 1,000,000 years • Probabilistic risk assessment	• **500 - 100,000 years** • Probabilistic risk assessment	• **30 years + extension** • No risk assessment required

Radioactive toxicity
Decays over time/Long-lived nuclides are internal exposure

Toxicity:
Some never decay: metals etc

Waste Management History

General Hazardous Waste

Times Beach


Cuyahoga River

Solid Waste Disposal Act, 1965
Clean Air Act, 1970
Clean Water Act, 1972
Resource Conservation and Recovery Act, 1976
Comprehensive Environmental Response Compensation and Liability Act, 1980

Coal ash rule, 2015

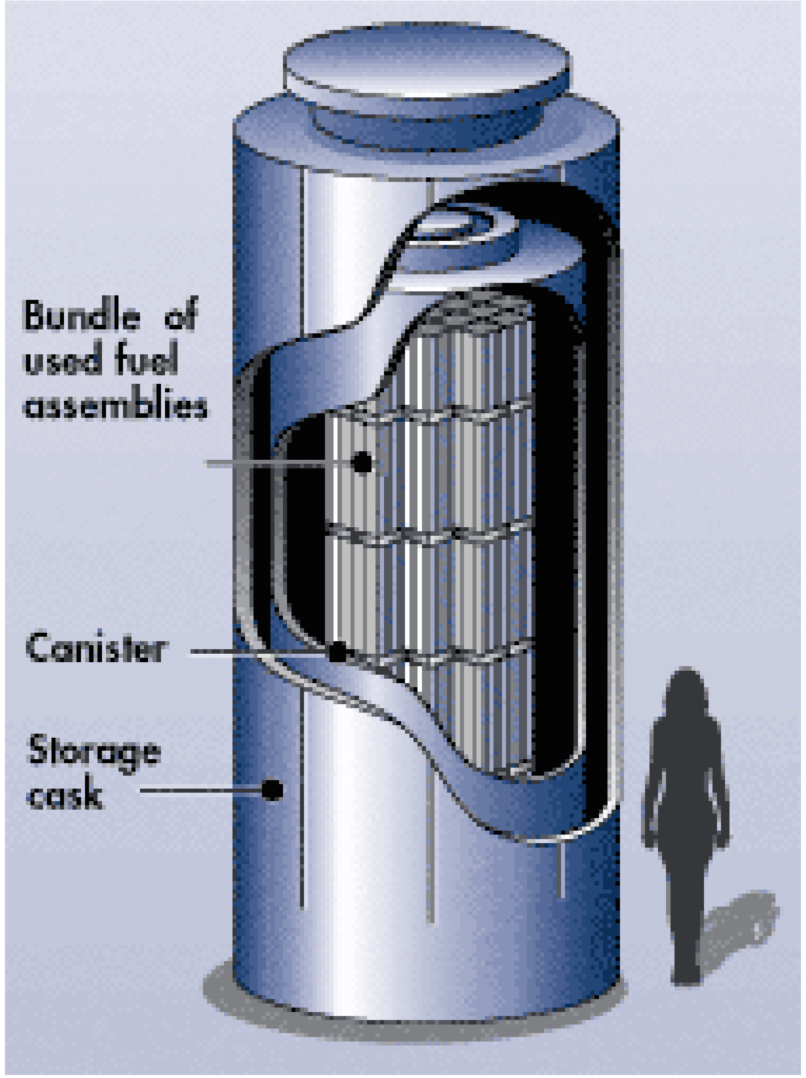
Nuclear Waste

1955 Nuclear power to generate electricity
1957 National Academy recommend geologic disposal of high-level waste
1970 U.S. begins search for sites

1980 Nuclear Waste Policy Act (NWPA)
1985 Low-level Radioactive Waste Policy Amendments Act
1987 NWPA to focus on Yucca Mountain

2015 Consent-based siting

Dry Cask Storage for Spent Fuel

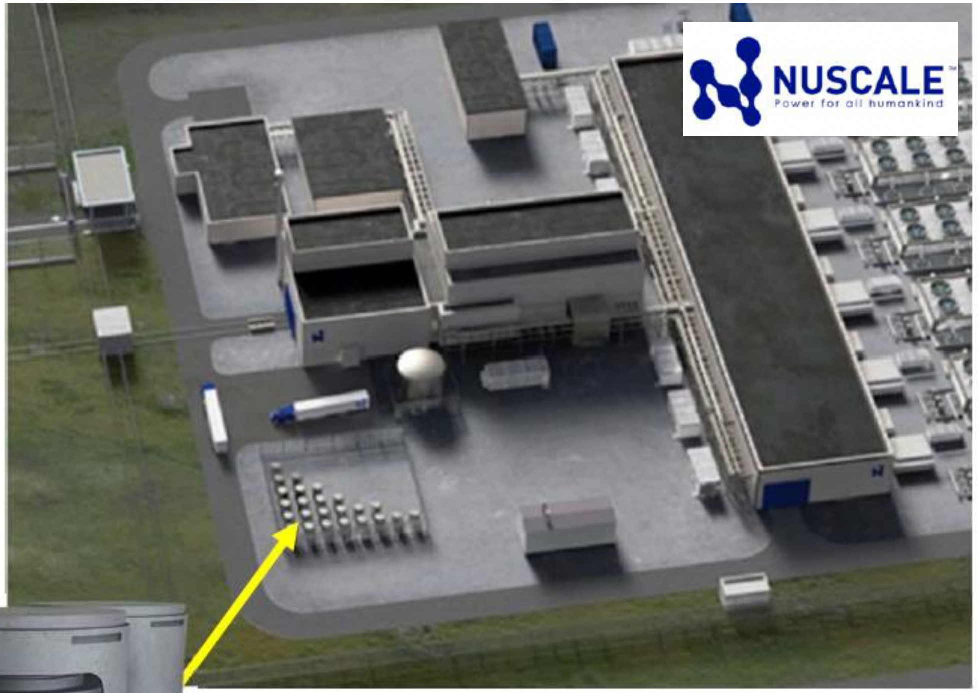


- Annual spent fuel: 2–3 casks per year
- Passive safety: no active cooling
- Probabilistic risk assessment for earthquakes, floods, high winds, lightning strikes, accidental aircraft crashes, and pipeline explosions
- No accident/leak since 1986

StoreFUEL: https://www.uxc.com/p/products/rpt_sf_stf.aspx

Advanced Reactors

Advanced reactor companies have waste management plans



Independent spent fuel storage: 0.8 acre pad for 60-yr operation

Different types of waste

- Different fuel: TRISO fuel
- Structural material: Graphite
- Coolant: Molten salt, sodium

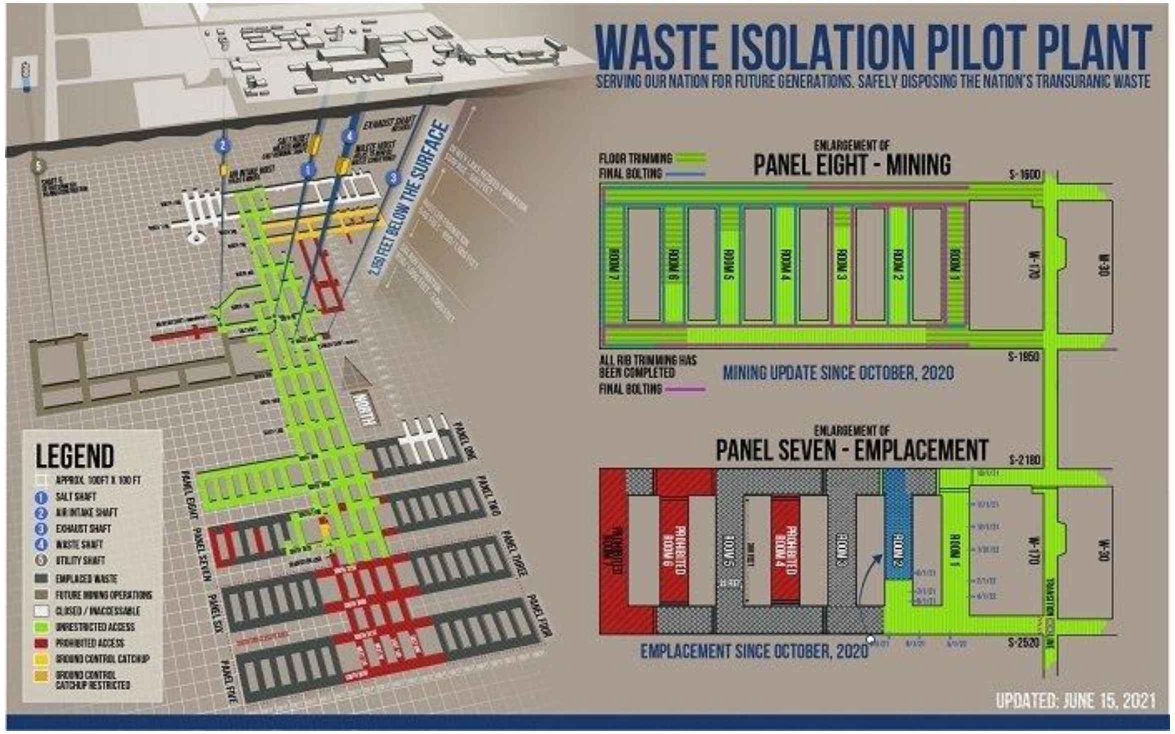
→ Many research activities on managing/disposing these wastes

Is it really safe?

Environmental Monitoring

- Data/evidence provides assurance to local communities
- Detection of anomalies if they happen
- Critical ways to keep operators accountable/responsible

Monitoring for Consent-based Siting



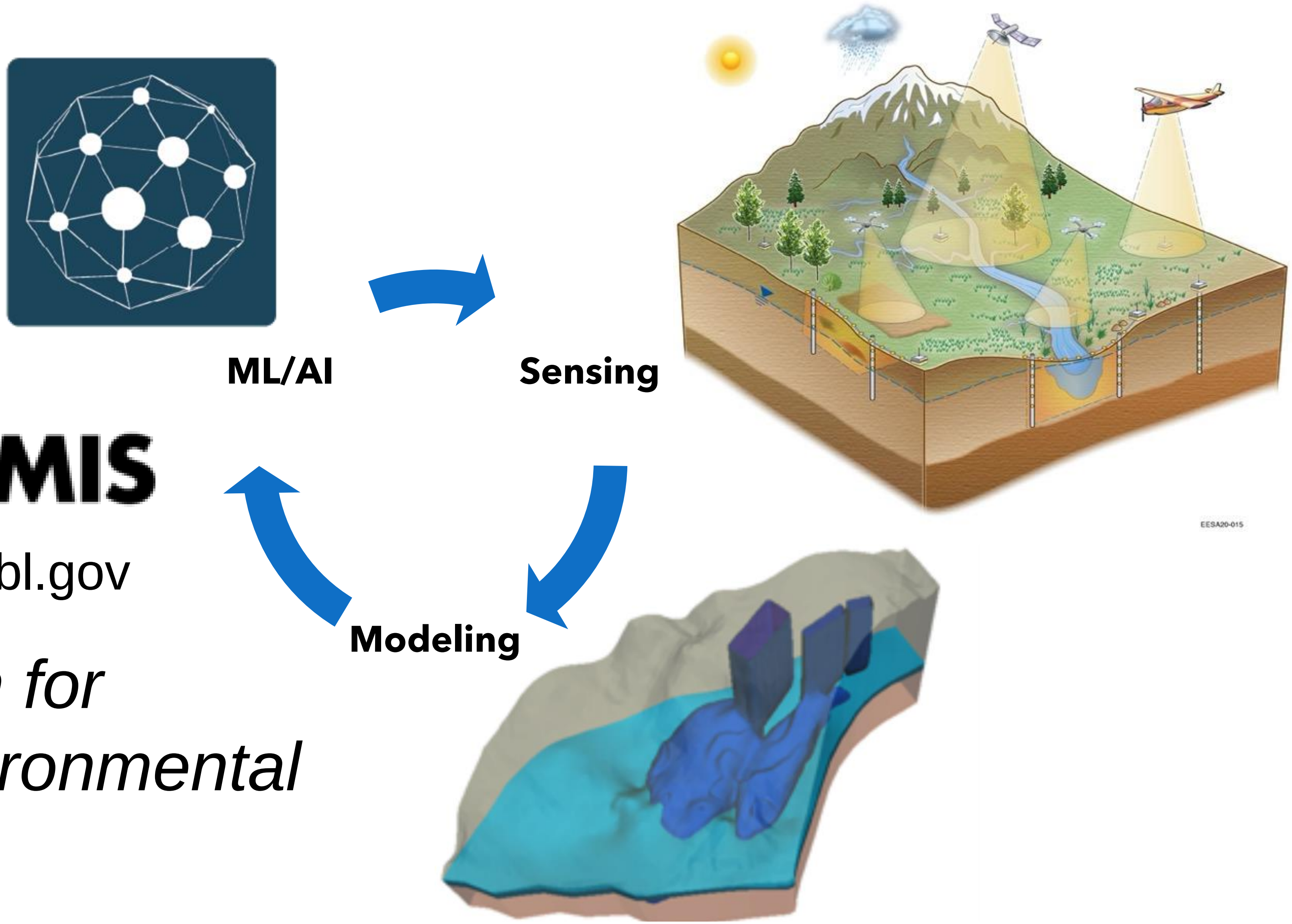
Waste Isolation Pilot Plant

- First deep geological disposal in the world for transuranic waste
- Successful consent-based siting

Carlsbad Environmental Monitoring and Research Center (CEMRC)

- Independent/state-funded center
- Characterized background radiation and its fluctuation
- Outreach and surveys to understand people's concerns
- Detected the 2014 accident first, and provided assurance

Advanced Long-term Environmental Monitoring Systems



ALTEMIS

altemis.lbl.gov

New paradigm for long-term environmental monitoring

POWER & OPERATIONS

Importance of environmental monitoring for consent-based siting of nuclear facilities

Sat, Nov 19, 2022, 6:04AM | Nuclear News | Haruko Wainwright and Carol Eddy-Dilek

Transforming Education

Changing Mindsets

- Develop a diverse and inclusive community. Antagonistic views are important for protecting the environment and improving safety
- ~~Send waste to the middle of nowhere~~
  → Engineers should design waste isolation in a way that they can have it in their “backyard”
- Engineers should design reactors and technologies from the “waste up”

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