

Exceptional service in the national interest



Disposal of Used Nuclear Fuel in United States

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Outline

- Need for Geologic Disposal
- Implementation of Nuclear Waste Policy Act
- U.S. Repository Program Today
- U.S. Repository Program Moving Forward
 - Generic R&D
 - Consent-Based Siting
- Concluding Remarks

Why Geologic Disposal?

- Geologic Disposal options have been proposed and evaluated for 50+ years.
 - **“The Disposal of Radioactive Waste in Land”**, U.S. National Academy of Sciences, 1957. This study focused on disposal of liquid HLW from commercial reprocessing and concluded that disposal on bedded or domed salts “possibly promising the most practical immediate solution to the problem”
- Consensus for at least thirty years, both in US and internationally, that deep geologic disposal is the preferred option
 - Multiple in-depth reviews have noted the need for geologic disposal
 - **“Geological disposal remains the only-long-term solution available”**, National Research Council Board on Radioactive Waste Management, 2001, p. 3
 - **“One or more geologic repositories eventually will be needed in the United States”**, Nuclear Waste Technical Review Board, June 2011, p.1.
 - **“Every nation that is developing disposal capacity plans to use a deep, mined geologic repository for this purpose. Other disposal options (e.g., deep boreholes) have been considered and may hold promise in the long-term but are at a much earlier stage of development.”** Blue Ribbon Commission on America’s Nuclear Future, 2012, p. 11.

Why Geologic Disposal? (continued)

- Definitive US work on disposal options dates from the 1970s, summarized in the 1980 *Final Environmental Impact Statement, Management of Commercially Generated Radioactive Waste*, DOE/EIS-0046F.
- International Experience
 - Consensus on deep geologic disposal is world-wide
 - International Atomic Energy Agency (IAEA)
 - OECD's Nuclear Energy Agency (NEA)
 - Several nations have advanced repository programs
 - Sweden, Finland (mined repositories planned in crystalline rock)
 - France, Switzerland, Belgium (mined repositories in clay/shale rock at various stages of planning)
 - Germany (mined repository in salt under evaluation)
 - Other nations with active repository research programs
 - Canada, United Kingdom, Japan, Korea, China, Taiwan, Czech Republic
- The US experience is not unique

Nuclear Waste Policy Act

- The United States began the first federal program for potential repository in 1976, focusing on salt deposits and federal nuclear facilities and building on previous studies started in 1955
- In 1980 the U.S. Department of Energy (DOE) confirmed geologic disposal as the preferred alternative in an Environmental Impact Statement that considered various modes of disposal
 - Subsea bed, island, ice sheets, deep hole, rock melt, deep well injection, outer space, and long-term storage on site
- In 1982, the U.S. Congress passed the Nuclear Waste Policy Act (NWPA)
 - Established a repository siting process requiring 2 geologic repositories in different geologic media
 - U.S. Environmental Protection Agency (EPA) to develop health standards for a geologic repository
 - U.S. Nuclear Regulatory Commission (NRC) to license the geologic repository, based on the EPA Standards
 - DOE to develop and manage the repository program, and prepare and submit license application to NRC

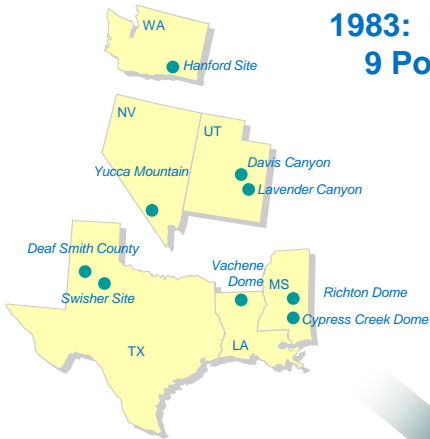
Nuclear Waste Policy Act

(continued)

- EPA, NRC, and DOE developed generic standards and regulations for geologic repositories per the NWPA in the 1980's:
 - EPA - 40 CFR 191, *Environmental Radiation Standards for Management and disposal of Spent Nuclear Fuel, High-Level Waste, and Transuranic Radioactive Wastes*
 - NRC - 10 CFR Part 60, *Disposal of High-Level Radioactive Wastes in Geologic Repositories*
 - DOE - 10 CFR 960, *General Guidelines for the Preliminary Screening of Potential Sites for a Nuclear Waste Repository*

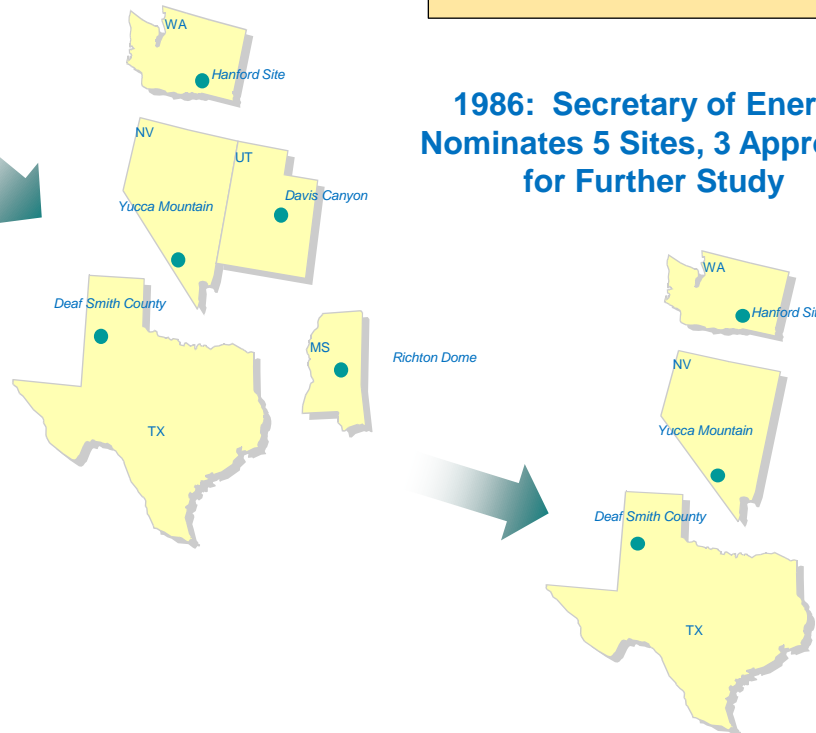
Siting of First Repository

**1983: DOE identifies
9 Potential Sites**

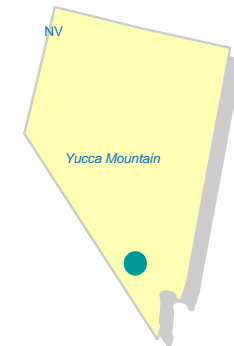


*The NWPA of 1982 (sec. 112) requires DOE to consult with affected governors and issue siting guidelines
The Secretary to nominate at least five sites
The Secretary to recommend 3 sites for characterization*

**1986: Secretary of Energy
Nominates 5 Sites, 3 Approved
for Further Study**



**1987: NWPA Amended to Mandate
One Site for Characterization**



Second Repository

- DOE also evaluated three candidate areas for a second repository in crystalline rock

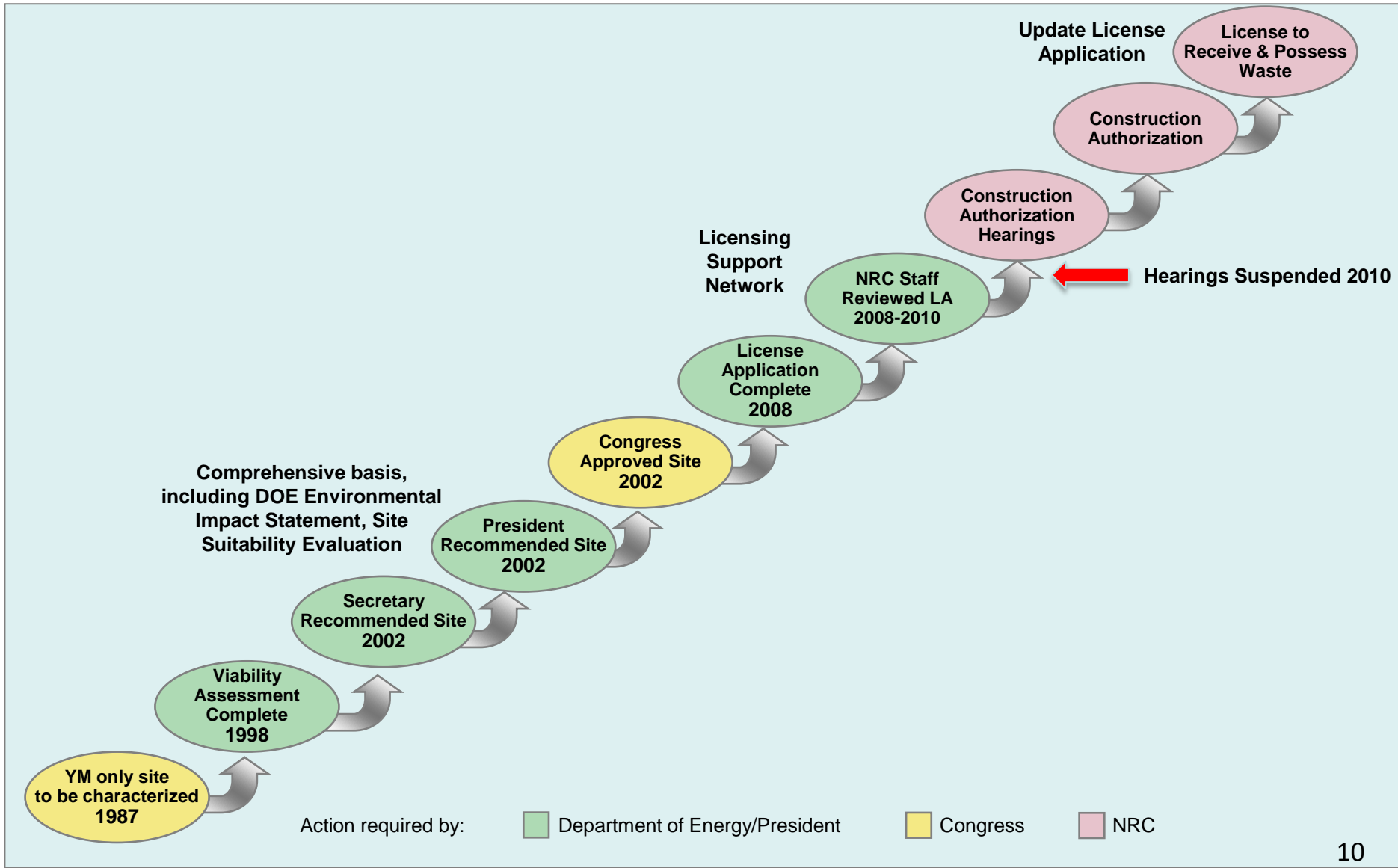


Preliminary Candidate Areas in Crystalline Rock
for the Second Repository

Yucca Mountain

- In 2000's EPA, NRC and DOE developed site-specific standards and regulations for Yucca Mountain per the NWPA, as Amended in 1987
 - EPA: 40 CFR 197, *Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada*
 - Individual Protection, Groundwater Protection, Human Intrusion Protection, and post 10,000 year dose standards
 - NRC: 10 CFR Part 63, *Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada*
 - Individual Protection, Groundwater Protection, Human Intrusion and Post-10,000 year Dose Standards
 - DOE: 10 CFR 963, *Yucca Mountain Site Suitability Guidelines*
 - Siting Criteria, consistent with EPA standards and NRC Regulation
- Regulations took long time to develop and finalize

A Short History of Yucca Mountain



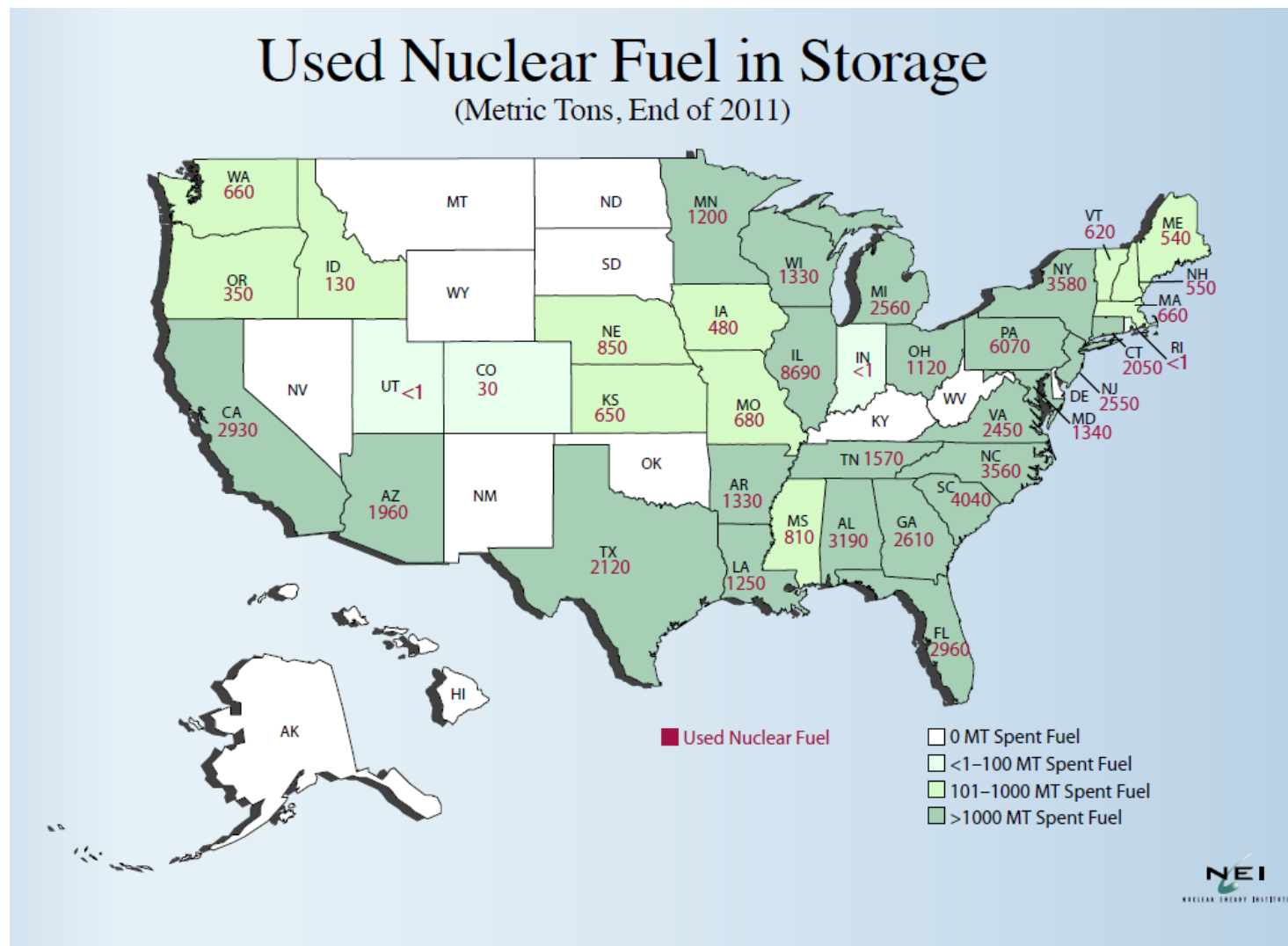
Status of Yucca Mountain License Application

- DOE submitted LA in June 2008 and NRC docketed it in September 2008
- NRC published a notice of opportunity to request a hearing on the licensing action in October of 2008
- NRC initiated requests for additional information on the technical content of the LA in December of 2008
- Interveners submitted 329 contentions to NRC's Atomic Safety Licensing Board (ASLB)
- ASLB admitted 299 contentions to be adjudicated in the NRC Licensing Proceedings in May of 2009
- DOE completed responses to 686 NRC staff requests for additional information (RAIs) on the LA and responses to the 299 contentions in 2010
- ALSB dismissed a handful of contentions prior to suspension of hearings

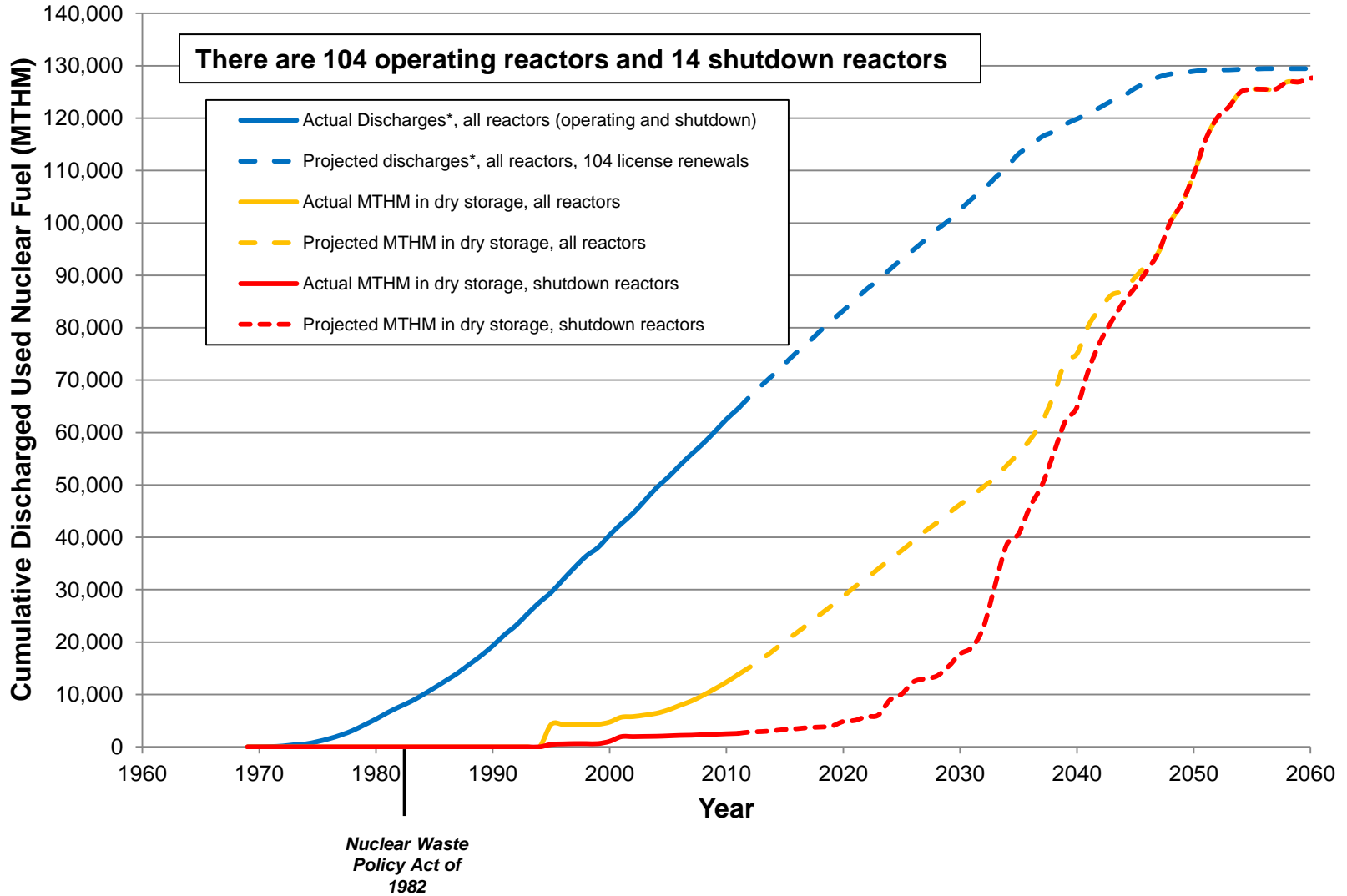
The U.S. Repository Program Today

- “Yucca Mountain is not a workable option” (DOE licensing motion, March 3, 2010)
 - “the Secretary’s judgment ... is not that Yucca Mountain is unsafe or that there are flaws in the [License Application], but rather that it is not a workable option and that alternatives will better serve the public interest.” (DOE filing to NRC Licensing Board, May 27, 2010, footnote 102)
- Yucca Mountain licensing hearings remain suspended pending court action
 - August 3, 2012 ruling by the US Court of Appeals for the District of Columbia delays a decision until after December 14, 2012, pending Congressional action
- All current DOE activities related to disposal of spent nuclear fuel and high-level radioactive waste have moved to the DOE Office of Nuclear Energy and are limited to generic R&D
- The Nuclear Waste Policy Act remains in effect

Where Spent Nuclear Fuel is Today



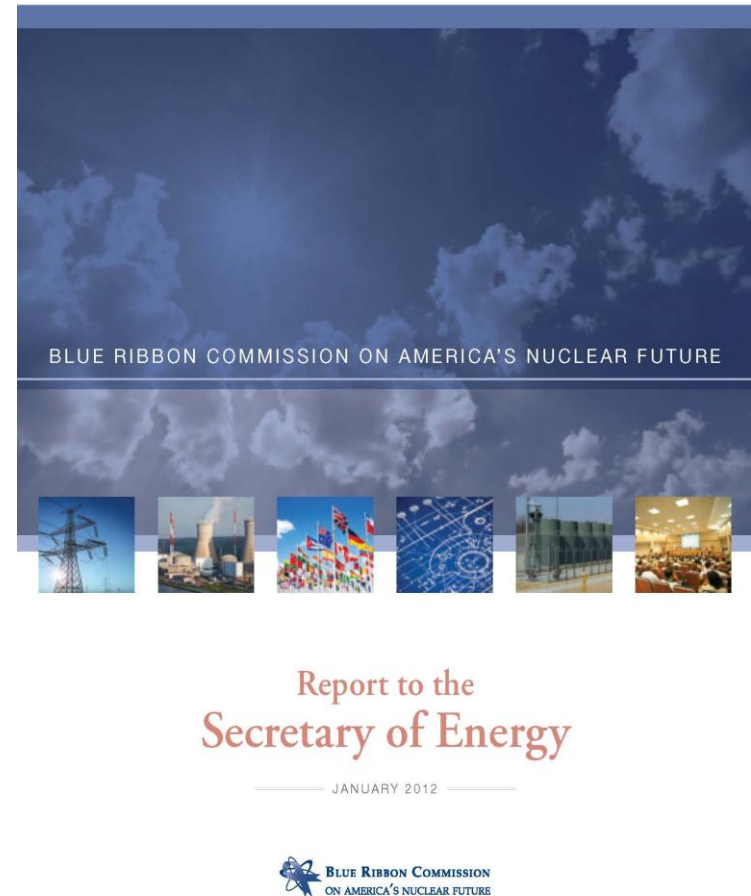
Historical and Projected Commercial Spent Nuclear Fuel Discharges in the United States



Source: Based on actual discharge data as reported through 12/31/02, and projected discharges, in this case for 104 license renewals

Repository Program Moving Forward

- The President directed the Secretary of Energy to establish a Blue Ribbon Commission (BRC) to re-evaluate the back end of the Nuclear Fuel Cycle
- The BRC was established to provide recommendations on a path forward for America's Nuclear Future in January of 2010
- In January of 2012, the BRC issued a report confirming the need for geologic disposal and recommended prompt development of one or more geologic repositories and interim storage facilities, using a consent-based siting process



Repository Program Moving Forward

(continued)

- Key Elements of BRC Recommendations
 - **A new, consent-based approach to siting future nuclear waste management facilities**
 - A new organization dedicated solely to implementing the waste management program and empowered with the authority and resources to succeed
 - Access to the funds nuclear utility ratepayers are providing for the purpose of nuclear waste management
 - **Prompt efforts to develop one or more geologic disposal facilities**
 - Prompt efforts to develop one or more consolidated storage facilities
 - Prompt efforts to prepare for the eventual large-scale transport of spent nuclear fuel and high-level waste to consolidated storage and disposal facilities when such facilities become available.
 - Support for continued U.S. innovation in nuclear energy technology and for workforce development.
 - Active U.S. leadership in international efforts to address safety, waste management, non-proliferation, and security concerns.

Used Fuel Disposition Campaign

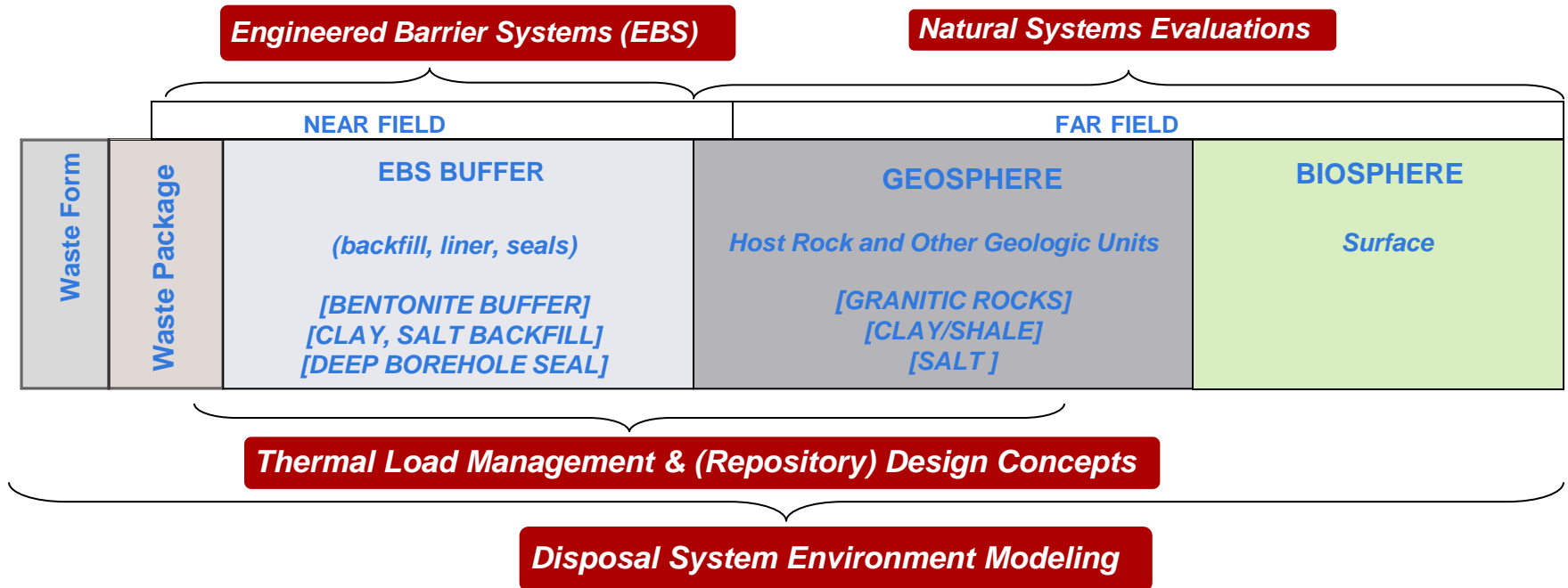
- With the suspension of the Yucca Mountain Project, the national mission has moved to the DOE Office of Nuclear Energy, Office of Used Fuel Disposition (NE-53)
 - R&D within NE-53 is performed by the “Used Fuel Disposition Campaign” (UFDC)
 - The UFDC mission is to identify alternatives and conduct scientific research and technology development to enable storage, transportation and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles.

Used Fuel Disposition Campaign (continued)

Nine national laboratories participate in the DOE Office of Nuclear Energy's "Used Fuel Disposition Campaign" (UFDC)



UFDC Disposal Research Activities



SUPPORT, ANALYSIS & EXPERIMENTAL ACTIVITIES

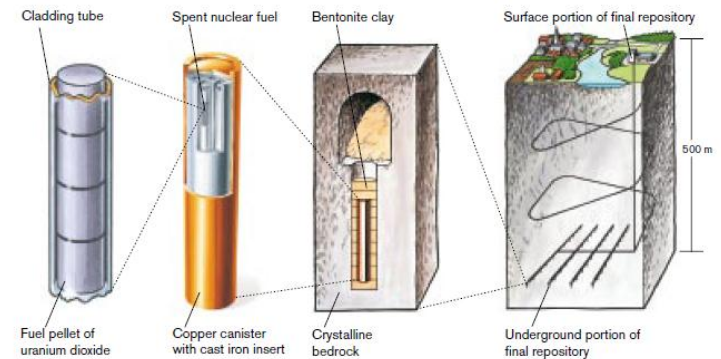
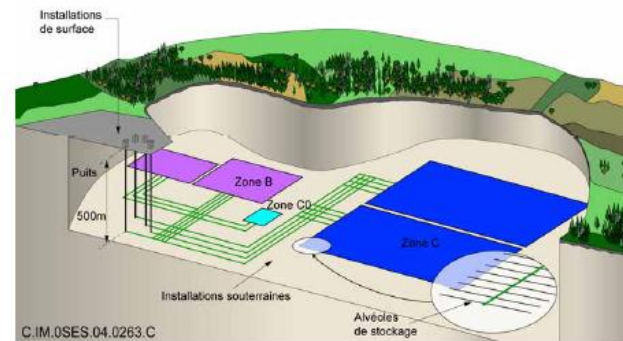
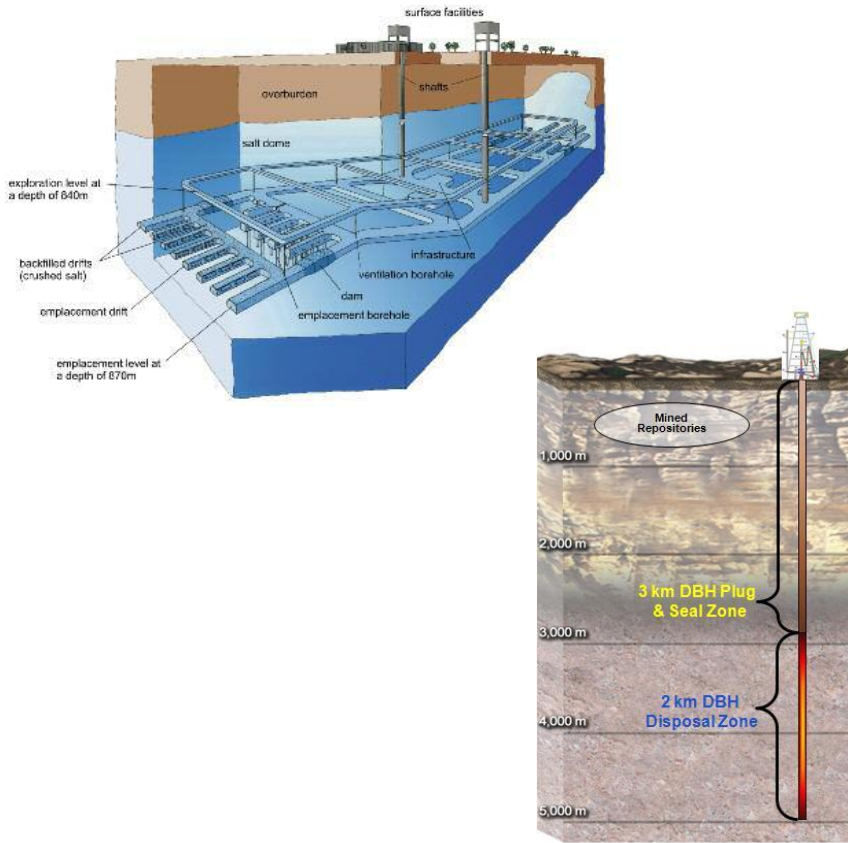
<i>Engineered Materials Performance</i>	<i>(corrosion, degradation studies)</i>
<i>Features, Events & Processes</i>	<i>(how R&D is organized and prioritized)</i>
<i>Low Level Waste Disposition Issues</i>	<i>(part of total nuclear waste consideration)</i>
<i>Inventory Projections</i>	<i>(LLW/HLW, used fuel, open → closed fuel cycles)</i>

Generic Disposal R&D

- The NWPA, as amended, precludes any and all site-specific repository investigations at locations other than Yucca Mountain
 - All disposal research must be generic at this stage
 - New site selection presumably will require a Record of Decision under the US National Environmental Policy Act (NEPA)
- What can generic R&D accomplish?
 - Provide a sound technical basis for the assertion that the US has multiple viable disposal options that will be available when national policy is ready
 - Identify and research the generic sources of uncertainty that will challenge the viability of disposal concepts
 - Increase confidence in the robustness of generic disposal concepts to reduce the impact of unavoidable site-specific complexity
 - Develop the science and engineering tools required to address the goals above, through collaborations within NE and DOE, and with universities, industry, and international repository programs

Generic Disposal R&D - Four Options

- Three mined repository options (granitic rocks, clay/shale, and salt)
- One geologic disposal alternative: deep boreholes in crystalline rocks



Standards Can Affect the Consideration of Disposal Options

Dose Standards

- Emphasis on low annual dose or risk
- Can be open-ended in time (or to peak dose)
- Uncertainty in human behavior (e.g., water use and diet) is large
- Encourages dilution and gradual release as well as isolation
- Encourages smaller initial inventories

Cumulative Release Standards

- Emphasis on isolation
- Meaningful only for a specified time period
- Allowable limit is a function of time
- Focuses on uncertainty in barrier system performance
- No benefit for dilution
- Normalization to initial inventory (as in 40 CFR part 191) removes incentive for smaller repositories

What Regulations Apply to Disposal?

- Yucca Mountain regulations (EPA 40 CFR part 197 and NRC 10 CFR part 63) apply only to Yucca Mountain
 - Limits on estimated mean annual dose for 1 million years
- Existing regulations that predate the 1987 NWPA still apply at all other sites
 - EPA 40 CFR part 191 (implemented for the WIPP)
 - Cumulative normalized release standard (rather than annual dose)
 - 10,000 years (rather than 1 million years)
 - Emphasis on human intrusion
 - Additional requirements in NRC 10 CFR part 60 (never implemented)
 - Substantially complete containment in waste packages for 300 years
 - Release rate from the engineered barrier system shall not exceed one part in 100,000 per year of the inventory of that nuclide at 1000 years
 - 1000-year travel path

What Might Siting Criteria Look Like?

- Criteria in the NWPA Section 112(a) remain in effect
 - Consult: CEQ, EPA, USGS, and interested Governors
 - Concurrence of NRC
 - “...shall specify detailed geologic considerations that shall be primary criteria for the selection of sites in various geologic media.”
 - “...shall specify factors that qualify or disqualify any site...” [including] “... factors pertaining to the location of valuable natural resources, hydrology, geophysics, seismic activity, and atomic energy defense activities, proximity to water supplies, proximity to populations, ...”
 - “... take into consideration the proximity to ... waste ...”
 - “... shall specify population factors that will disqualify any site ...”
 - “... consider the cost and impact of transporting”
 - “... consider the various geologic media”
 - “... use guidelines ... in considering candidate sites for recommendation”
- DOE’s 10 CFR Part 60 guidelines issued in 1984 remain in effect
 - Detailed specification of the siting process
 - Emphasis on qualifying and disqualifying conditions at the subsystem level

Consent-Based Siting

- BRC Recommendation (BRC 2012):
 - A new consent-based approach should be developed and implemented for siting UNF storage and disposal facilities, but the design of the consent process should not be specified and the definition of “consent should be part of the negotiation process”
- Public Perceptions on Siting of UNF Facilities *
 - Joint University of Oklahoma-Sandia National Laboratories study which has resumed public perceptions and beliefs about nuclear energy annually since 2006.
 - About 16,000 respondents to date via internet (primarily) and comparative phone subsets.
 - 2012 Survey Key Issues:
 - Perceptions of energy policies and adequacy of future supplies
 - Comparative perceptions/preferences on energy sources
 - Evolving beliefs about nuclear energy
 - **Knowledge and preferences about managing UNF**

* Source: Jenkins-Smith, H.C., et al., “Designing a Process for Consent-Based Siting of Used Fuel Nuclear Fuel Facilities: analysis of Public Support, “*The Bridge*, Vol. 42, No.3, U.S. National Academy of Sciences, 2012.

Knowledge and Preferences about Managing UNF Siting

- Current Practices
- Preference for Disposable Options
- Implications of Facility Design
- Consent-Based Siting
- Institutional Trust and Perceived Bias of Risk Assessments

Future UNF Disposition

Concept	% Oppose	% Unsure	% Support	Mean (1–7)	Statistical Significance
Continued on-site storage ^(e46)	35	32	33	3.92	<i>p</i> < .0001 (each paring)
Several interim facilities ^(e47)	28	29	43	4.17	
Two permanent repositories ^(e48)	25	24	51	4.50	

Implications of Repository Design

Design Factors	% Oppose	% Unsure	% Support	Means (1–7)	Change from Base Mean
Two Mine-Like Repositories	17	26	57	4.65 (Base)	N/A
With Research Lab	9	18	73	5.21	+12.0%
With Reprocessing	14	24	62	4.84	+4.1%
With Compensation	16	23	61	4.81	+3.4%

Implications of Assumed Future Proximity

Mean Support (1= Strongly Oppose— 7 = Strongly Support)	No Proximity Specified	300 Miles from Residence	100 Miles from Residence	50 Miles from Residence
Permanent Repository	4.65	4.35	4.00	3.60
Interim Storage Facility	4.29	4.25	3.87	3.74

HOWEVER: WIPP experience indicates that proximity can exert positive local effects as jobs and economic development become more apparent.

Understanding “Consent”

Who should be allowed to block/veto a siting decision?

	Permanent %	Interim %
A majority of citizens residing within 50 miles of the facilities	67	69
A majority of voters in the host state	58	56
The governor of the host state	56	54
Host state environmental protection agency or equivalent	47	49
U.S. Environmental Protection Agency	40	41
U.S. Nuclear Regulatory Commission	39	38
U.S. Department of Energy	36	36
U.S. Congressperson representing the host district	34	35
Either of the two U.S. Senators representing the host state	35	33
Leaders of the host state’s legislature	29	28
Nongovernmental environmental groups in the host state	21	18

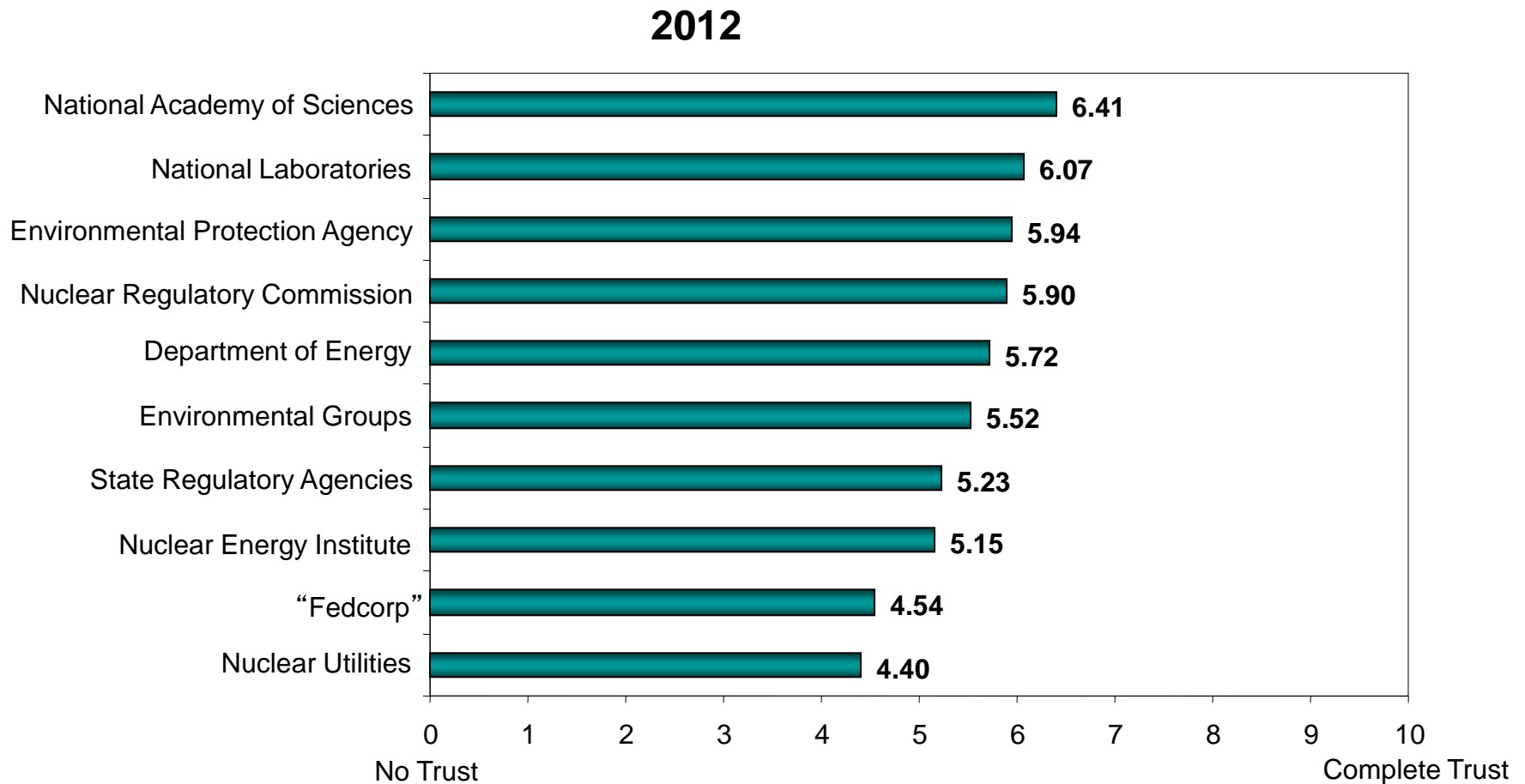
Withdrawing “Consent”

When should host communities be allowed to withdraw consent?

	% Yes	
	Permanent	Interim
Host community/state volunteers; site assessment is initiated	74	75
Scientific evaluation of site suitability is completed	74	73
License to construct a UNF facility is submitted to agencies	62	66
License is obtained; facility construction is initiated	40	46
Construction is completed; facility is prepared to receive UNF	30	34

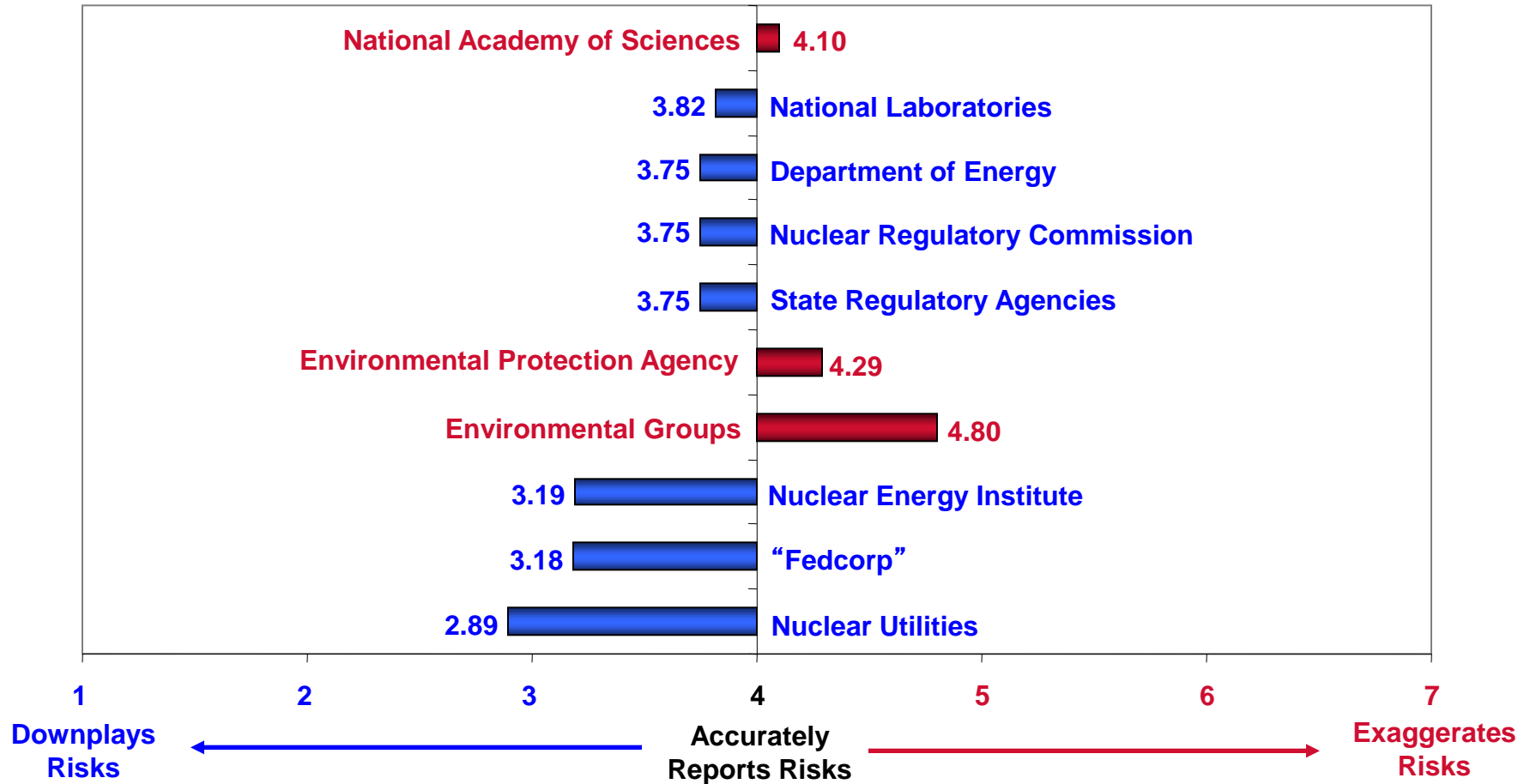
Relative Institutional Trust

Mean trust in information about UNF from each of the following sources



Perceived Institutional Risk Bias

2012



Concluding Remarks

- Future path of US Disposal Program depends on:
 - Outcome of on-going litigation related to YMP
 - Congressional and Administration actions regarding implementation BRC recommendations
- Current Generic Disposal R&D laying good foundation for future disposal mission
 - Have maintained repository sciences technical capabilities
- Consent-based siting will likely be needed and will be complex.
 - Annual survey provides data on evolving public preferences regarding NE, in general, and nuclear waste management facility siting, in particular.