SAND2015-2537C

Exceptional service in the national interest

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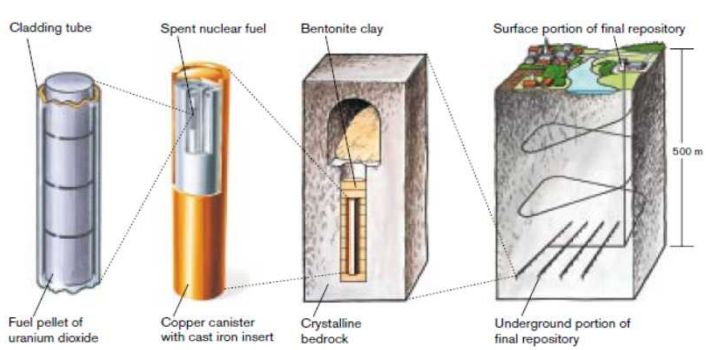

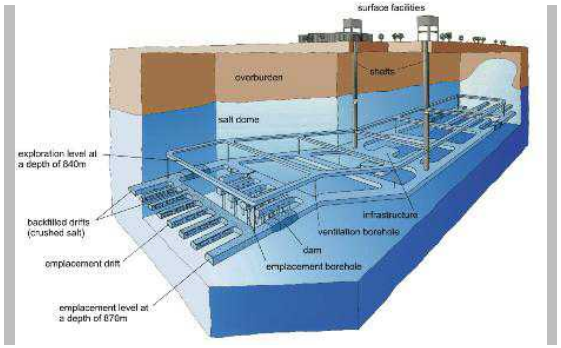

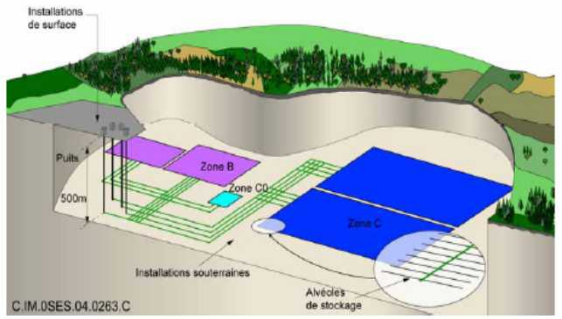

Knowledge Preservation for Repository Systems

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Charleston, South Carolina

U.S. DEPARTMENT OF ENERGY | NNSA National Nuclear Security Administration

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Outline

- Knowledge Management vs Knowledge Preservation
- Yucca Mountain Project Knowledge Preservation – case study
- Waste Isolation Pilot Plant Knowledge Preservation – case study
- Sandia National Laboratories (SNL) Knowledge Preservation for Nuclear Weapons – case study
- NEA-OECD Sponsored Records, Knowledge and Memory (RK&M) Project Overview
- NEA-OECD Sponsored Repository Metadata (RepMet) Project Overview
- Conclusion

Knowledge Management

- Knowledge Management:
  - Encompasses efforts directed at compiling, organizing, and leveraging an organization's knowledge to support organizational goals, (continuity, profitability, efficiency, etc.)
  - For repository systems, includes the following:
    - Technical, well understood, (certain) physical/chemical characteristics (waste packages materials, waste forms, corrosion, and waste locations);
    - Less well understood (uncertain) characteristics, (natural fluid flow, volcanism, other low probability events);
    - Very poorly definable characteristics, (cultural influences, societal characteristics)

Knowledge Preservation

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- For repository systems envelops both classic subdivisions of knowledge; ***explicit*** knowledge, and ***tacit*** knowledge
  - ***Explicit*** knowledge includes information that is readily codified into a tangible form, i.e., documentary material (reports, analyses, memos, videos, email, databases, etc.) that may be retained in a wide variety of media (paper, film, electronic, etc.)
  - ***Tacit*** knowledge is knowledge that we as individuals possess, but is not readily codified.
    - More difficult to codify, if possible at all
    - Examples include technical, societal, or cultural processes that pertain to substantial organized efforts (large engineering projects)

Media for Knowledge Preservation

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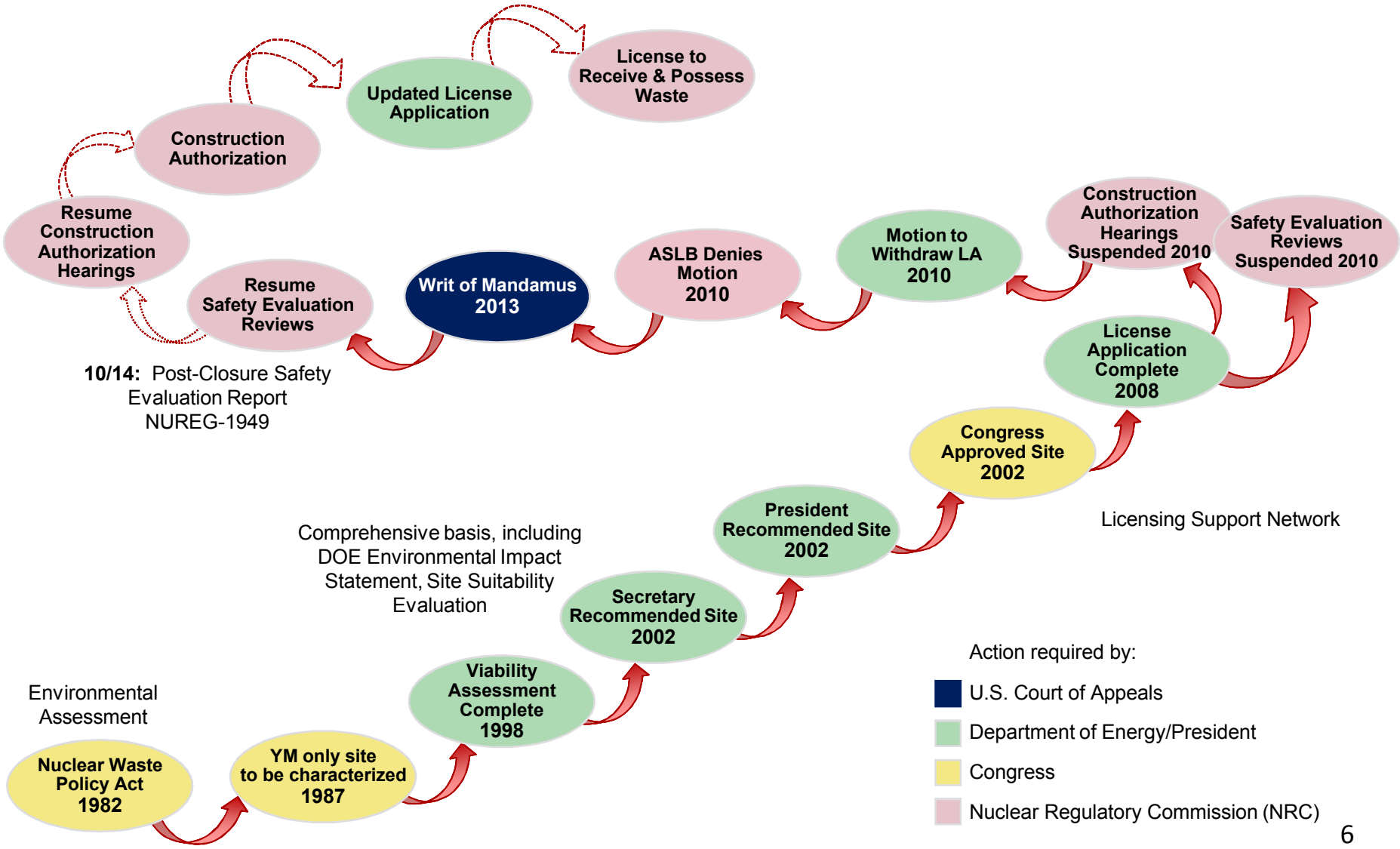
- The Preservation Media is a pervasive problem that overshadows all attempts at knowledge preservation, especially those attempting to preserve knowledge for centuries or even millennia as in the case of repository post-closure information[1]
- Paper objects have traditionally served as the media for important information.
- Technological advances are clearly directing preservation efforts to electronic forms…but these are not immune to obsolescence.
  - While ease of web-based publishing has greatly enhanced the dissemination of information, inevitable changes in the web construct lead to international efforts to secure continued access to scientific and technical literature in the nuclear field[2]

[1] Cloonan, M.V., 1993, The Preservation of Knowledge, Library Trends, Vol. 41, No. 4, Spring 1993, pp 594-605.
[2] IAEA, 2008, Web Harvesting for Nuclear Knowledge Preservation, IAEA Nuclear Energy Series No. NG-T-6.6, Vienna

Yucca Mountain (YM) Project

1982 - Now



Yucca Mountain Project

Knowledge Preservation Case Study - Continued

- NRC's rules required population of a Licensing Support Network (LSN) to facilitate legal discovery for the adjudicatory licensing hearing.
  - LSN is an electronic system, established by the NRC and operated by the NRC's Atomic Safety and Licensing Board (ASLAB) panel.
  - Purpose to provide internet access to documents that may be used as evidence in the NRC's review process and licensing proceedings.
- Information to support licensing was preserved by NRC, in addition to the DOE and support organizations.
- Rigorous records management provisions were imposed by DOE throughout the project.
  - Collection of information maintained by DOE's Legacy Management office is the most comprehensive YMP collection.

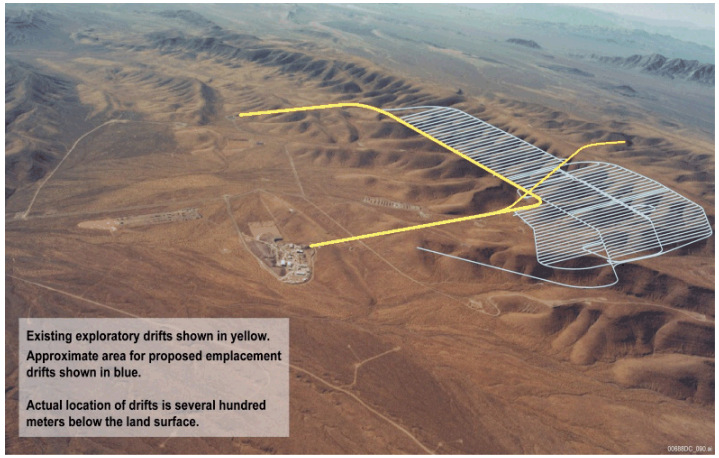
Yucca Mountain Project

Knowledge Preservation Case Study - Continued

- Knowledge Preservation Systems for the Yucca Mountain Project that preserve ***Explicit*** knowledge include:
  - NRC ADAMS (Agency Document and Management System) Collection
  - NRC ASLAB LSN (Licensing Support Network) Collection
  - DOE Legacy Management Collection
  - Sandia National Laboratories (Yucca Mountain Project Lead Laboratory for Post-Closure)

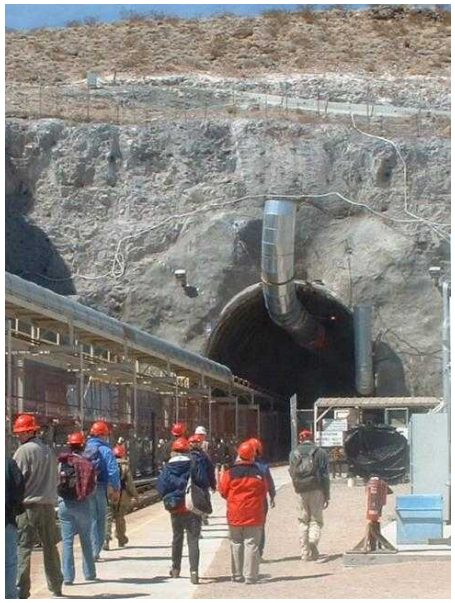
Yucca Mountain Project

Knowledge Preservation Case Study - Continued



July 2009 focus group discussions with YM technical staff

- Study to collect & preserve ***tacit*** YM knowledge
- Addressed the way policy and organizational changes affected perceptions of the:
  - Organizational environment,
  - Views of the role and nature of the technical work, and
  - Understandings of the norms and expectations for career scientific and technical professionals, over the nearly thirty year evolution of the project
- Concluded that one of the most significant concerns expressed by the YM workforce was the loss of RW management expertise, suggesting that a sustained institutional, organizational, and personnel effort to address the national radioactive waste problem was needed.

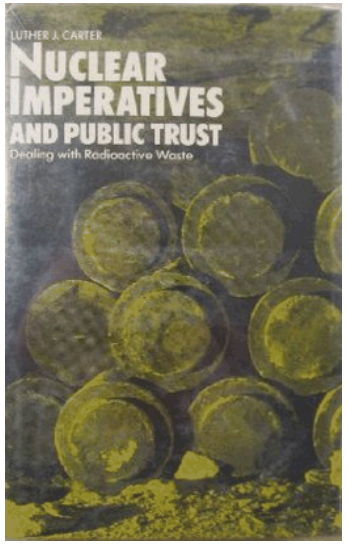


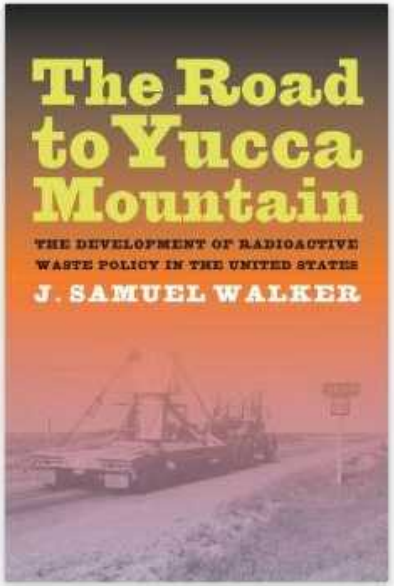
July 2010, all YM site-related technical studies were ended

Yucca Mountain Project

Key Historical References

- Luther Carter, 1987, *Nuclear Imperatives and Public Trust: Dealing with Radioactive Waste*, Resources for the Future, Inc. Baltimore, MD: John Hopkins University Press; 1987
- J. Samuel Walker, 2009, *The Road to Yucca Mountain*. Berkeley, CA: University of California Press.
- R. P. Rechard, T.A. Cotton, and M.D. Voegele, 2014, "Site Selection and Regulatory Basis for the Yucca Mountain Disposal System for Spent Nuclear Fuel and High-Level Radioactive Waste", *Reliability Engineering and System Safety* v. 122, p. 7-31 [see also other papers in the same volume]

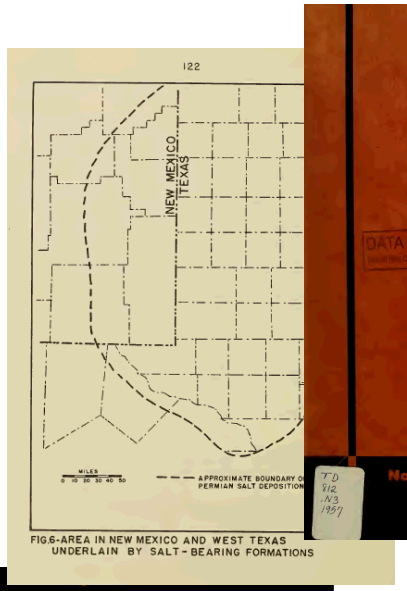


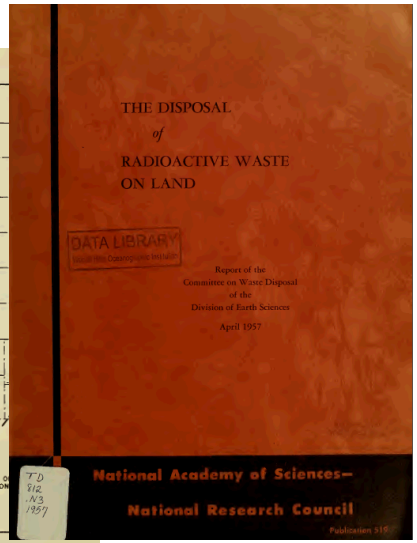


Waste Isolation Pilot Plant (WIPP)

Knowledge Preservation Case Study

- 1940s Manhattan Project generates first significant volumes of spent nuclear fuel SNF and high-level radioactive waste (HLW)
  - Waste managed on-site
- 1957 National Academy of Sciences (NAS) report *The Disposal of Radioactive Waste on Land*
  - *"Disposal in cavities mined in salt beds and salt domes is suggested as the possibility promising the most practical immediate solution of the problem." (NAS 1957, p. 1)*
- 1971 City of Carlsbad, NM approaches NM congressional delegation seeking a repository
- 1975 Sandia National Laboratories assumes lead science
  1976 Project is named Waste Isolation Pilot Plant
- 1979-1993 Site characterization
- 1996 DOE submits the WIPP Compliance Certification Application to the US EPA
- 1998 EPA certifies the WIPP for disposal operations
- 1999 First waste arrives at WIPP
  - 11,894 shipments to date, all by truck
    http://www.wipp.energy.gov/shipments.htm

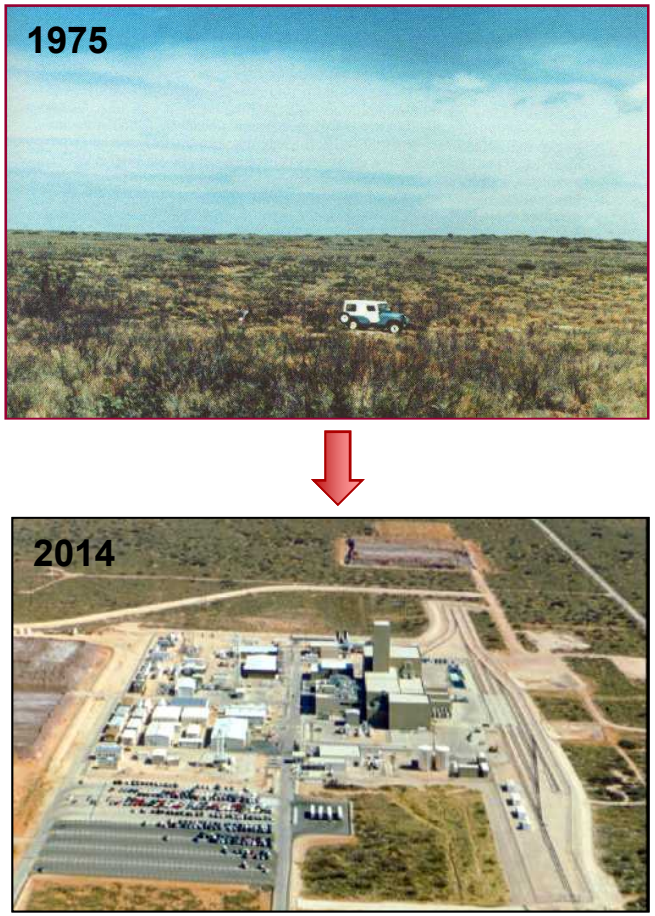




Waste Isolation Pilot Plant (WIPP)

Knowledge Preservation Case Study

- Several layers of requirements prescribe what ***explicit*** records are to be kept for how long
- Hierarchy of messages is to be created, with the most detailed message level proposed to be stored at a number of U.S. state archives, the U.S. federal archives, and if possible in international archives[3]
- Archival quality paper and buffered inks are mandated by federal and other archiving institutions, but work is in progress to also, or perhaps instead, create electronic archives that are and will remain searchable and adaptable as hardware platforms and software technologies change
- Length of time over which archives (as well as markers on the site to inform the future) to be maintained is not specified. *As long as practicable* is assumed to be the timeframe, and not longer than 10,000 years



[3] Wagner, R.L. Beauheim, T.W. Pfeifle, A. Bethel, G. Sosa-Yates, C.V. Williams, M. Milligan and M. Fox. 2002. WIPP Case Study: Compliance Monitoring, Passive Institutional Controls, and Record Keeping, SAND 2002-2010, Albuquerque, NM, July 2002.

Waste Isolation Pilot Plant (WIPP)

Knowledge Preservation Case Study

Open issues remain concerning ethical and physical dimensions to warn the future through maintaining records

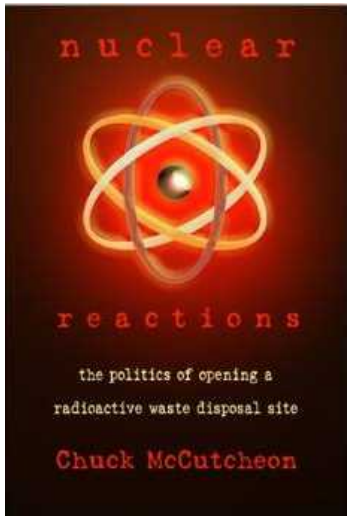
1. Balance must be struck between the investment pulled out of the resources available to current generations and the prevention of an unknown degree of harm to an unknown and hypothetical human in the far-future.
2. Assessment should be made of the quantity and nature of the information proposed to be archived:
   - Purpose for the archived materials is limited,
   - Trusting in archives and the national and international institutions that maintain them to exist for longer periods than a thousand years may be foolhardy and not contribute to future safety at all.

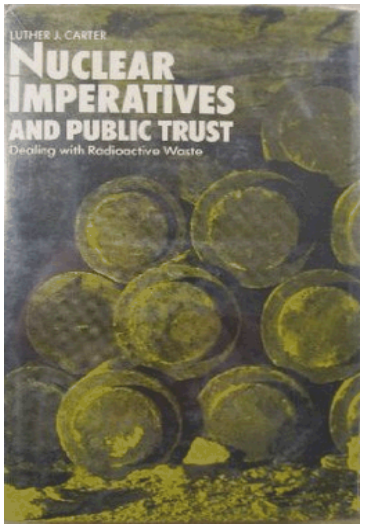
Images from http://www.wipp.energy.gov/Photo_Gallery_Images

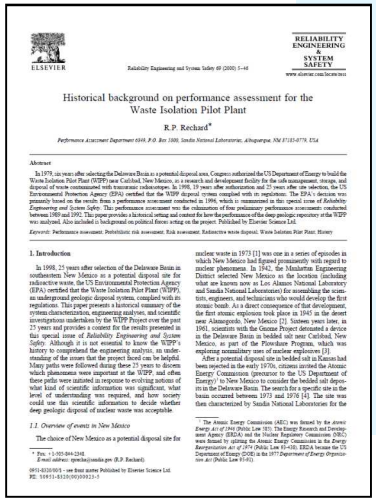
Waste Isolation Pilot Plant

Key Historical References

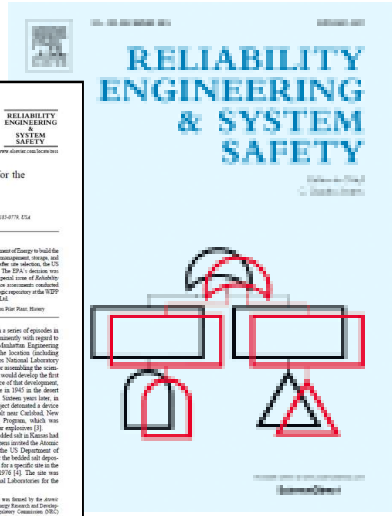
- Luther Carter, 1987, *Nuclear Imperatives and Public Trust: Dealing with Radioactive Waste*, Resources for the Future, Inc. Baltimore, MD: John Hopkins University Press
- Chuck McCutcheon, 2002, *Nuclear Reactions: The Politics of Opening a Radioactive Waste Disposal Site,* University of New Mexico Press.
- R.P. Rechard, 2000, "Historical Background on Performance Assessment for the Waste Isolation Pilot Plant," *Reliability Engineering and System Safety* v. 69, p. 5-46 (See also other papers in this volume).






Historical background on performance assessment for the Waste Isolation Pilot Plant

R.P. Rechard*



SNL Nuclear Weapons

Knowledge Preservation Case Study

- SNL emerged from World War II's Manhattan project4
- Through the 1940's, nuclear stockpile was small, consisting of a few hand-crafted devices modeled on the Fat Man design used in World War II.
  - As cold war progressed from the 1950's through the end of the 20th century, the US developed a larger stockpile of nuclear weapons of multiple designs
  - SNL primary mission continues to be to provide the science and technology to maintain and certify the nuclear stockpile
- Ability to certify safety, security and operational capabilities of the stockpile are made even more difficult since the banning of nuclear weapon testing in 1996

4 Johnson, L. 1997, Sandia National Laboratories, A History of Exceptional Service in the National Interest, SAND97-1029.

SNL Nuclear Weapons

Knowledge Preservation Case Study - Continued

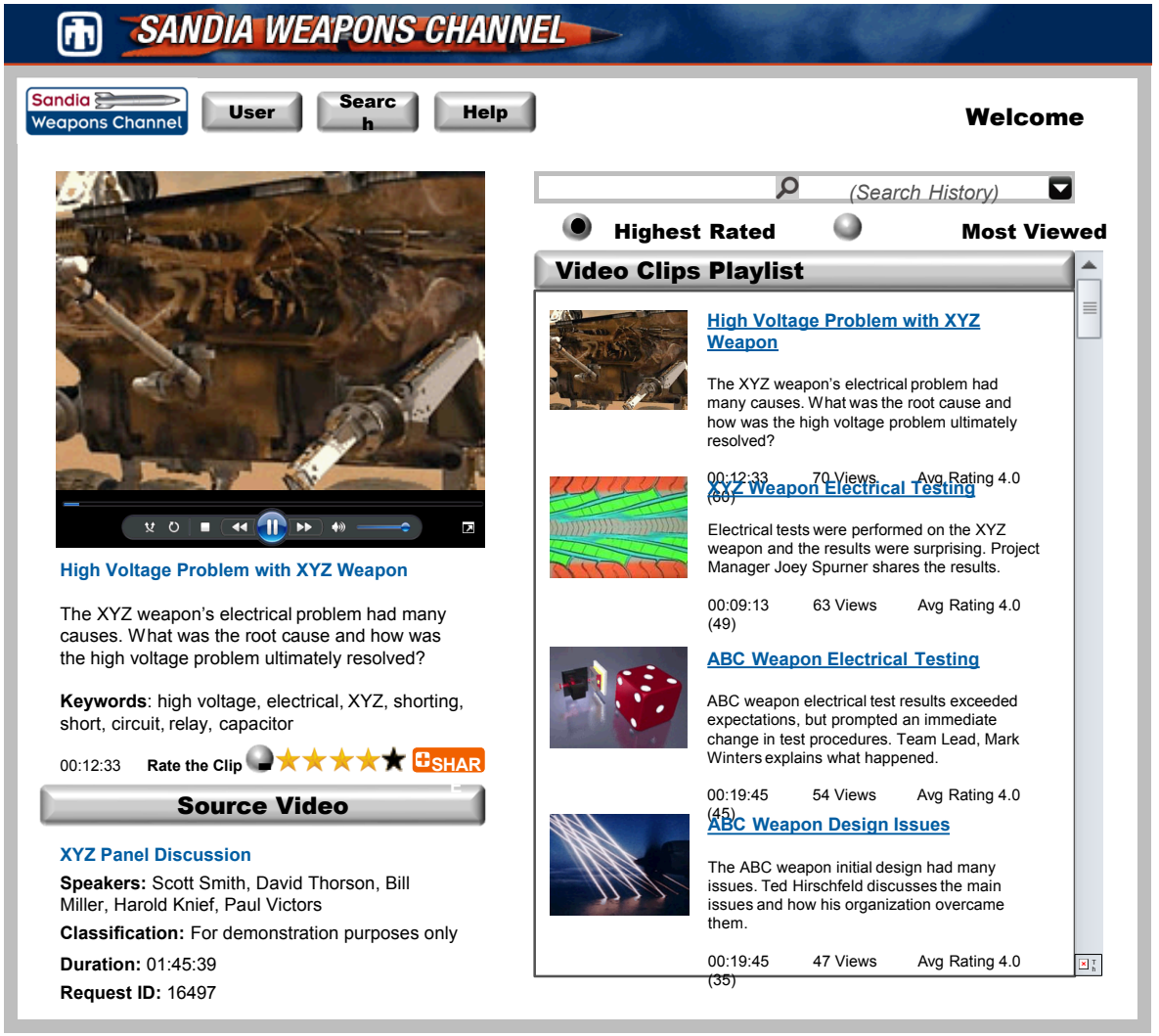
- 1990's, SNL recognized there were no new weapons designs on the horizon and designers of the weapons over the prior 40+ years were leaving SNL and entering retirement [5]
  - Challenge to maintain expertise to sustain the nuclear stockpile and the capability to respond to changes in the threat environment
  - SNL and DOE require storage and maintenance of all design and test drawings and documents (***Explicit*** knowledge), but SNL had no way of capturing and preserving ***Tacit*** knowledge of the weapons designers
  - In the 1990's and early 2000's, much of this ***Tacit*** knowledge of retiring weaponeers >1,500 hours of video was gathered and placed on the Sandia Classified Network
  - For over a decade, this captured ***Tacit*** knowledge resided on servers, available but unused

[5] Sandia Lab News, July 8, 1994.

SNL Nuclear Weapons

Knowledge Preservation Case Study - Continued

- In 2012, retirees reviewed the lengthy tapes, identifying and categorizing short (5-10 minute) synopses (video clips) for inclusion into a web based “YouTube” like application
- Sandia Weapons Channel created



SNL Nuclear Weapons

Knowledge Preservation Case Study - Continued

Sandia Weapons Channel

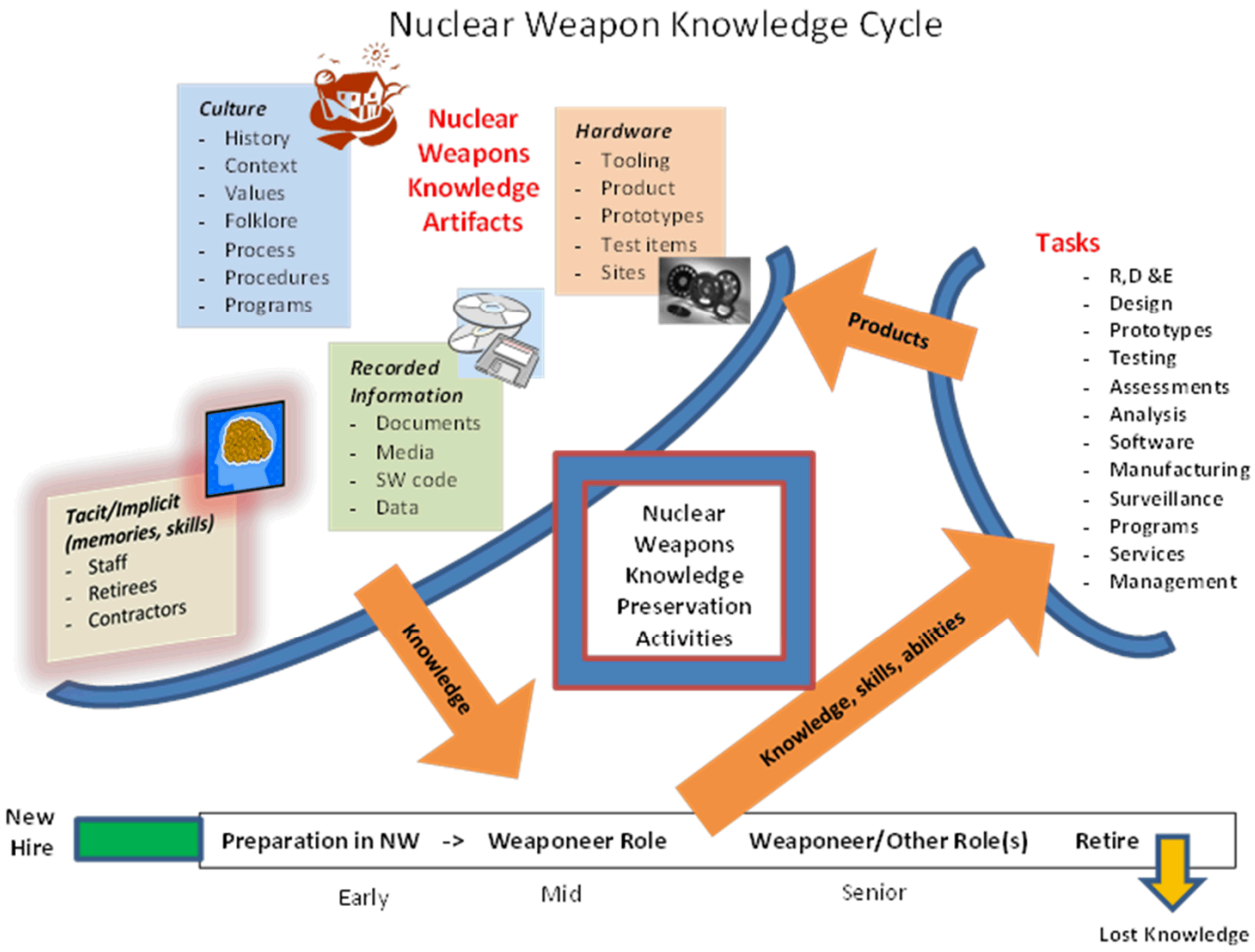
SNL Nuclear Weapons

Knowledge Preservation Case Study - Continued

- Sandia Weapons Channel, while an important component of the knowledge preservation at SNL, is not the only component of the Knowledge Preservation Project
- All phases of the Nuclear Weapon Knowledge Cycle are currently being addressed in SNL's knowledge preservation activities
- As a weaponeer passes through early, middle and senior stages of their career, the Nuclear Weapon Knowledge Cycle repeats itself.
  - Goal to minimize lost knowledge that would be leaving the organization
  - Nuclear Weapon Knowledge Cycle shown in next slide

SNL Nuclear Weapons

Knowledge Preservation Case Study - Continued



Records, Knowledge & Memories

NEA-OECD RK&M Sponsored Project

- International consensus that geologic repositories represent the best known method for permanently disposing of used nuclear fuel and high-level radioactive waste, without putting a burden of continued care on future generations [6]
- Repositories are conceived to be intrinsically safe, there should be no intention to forgo, at any time, knowledge and awareness of the repository or waste that it contains [7]
- The OECD sponsored "*Project on Preservation of RK&M Across Generations*," initiated in 2010, identified specific products and actions over the years 2010-2014

[6] USDOE, January 2013, Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Waste http://energy.gov/downloads/strategy-management-and-disposal-used-nuclear-fuel-and-high-level-radioactive-waste

[7] NEA-OECD , October 2011, Vision for the RWMC Project on Preservation of RK&M Across Generations, NEA/RWM(2011)6/REV2, http://www.oecd-nea.org/rwm/docs/2011/rwm2011-6.pdf.

Records, Knowledge & Memories

NEA-OECD RK&M Sponsored Project (Continued)

- Preservation of records, knowledge and memory (RK&M) need to be integral parts of the phases of repository development process from pre-siting all the way through site characterization, licensing, operations of waste emplacement and post-closure monitoring and management
- Challenge to knowledge preservation for repository development phases is exacerbated by the time frames from start to finish, which may extend over hundreds of years

Repository Metadata Project

NEA-OECD Sponsored RepMet Project

- October 2012, Integration Group for the Safety Case of Radioactive Waste (IGSC) 14th Annual Meeting in Paris:
  - Proposal for data management was made.
  - Identified usefulness of a review of the data types and preservation methods that different national programs are currently using.
  - DaMa project initiated.
- September 2013, Data Management (DaMa) project held first meeting:
  - Participation included Belgium, France, Germany, Hungary, Japan, Spain, Sweden, the United Kingdom and the United States
  - *"…Aim of this project is to create a metadata registry that can be used by national programmes to manage their repository data and records in a way that is harmonized internationally and is suitable for long-term management…"*

Repository Metadata Project

NEA-OECD Sponsored RepMet Project (Continued)

- January of 2014, the first RepMet meeting was held in Paris
- The scope of the RepMet project includes:
  - Identification of methods and protocols for repository data and metadata
  - Justification of sufficiency of metadata
  - Relationship to safety assessment models
  - The role of metadata in 'handshake' between data providers and data users
  - Identification of methods, protocols to guarantee persistence of procedures in time
  - Guideline for proposed data/metadata management
  - Data auditability, verification methods

Conclusion

- Knowledge Preservation related to an eventually successful nuclear repository project will be of inestimable value
- Projects like this require a historian or knowledge management entity that is explicitly responsible for Knowledge Management and Knowledge Preservation, as well as, a defined process for capturing not only ***Explicit***, but also ***Tacit*** knowledge from participants
- We should not leave future generations wondering: '*How did they move those enormous stones into place to build the pyramids*?'