

Appendices

Appendix A

U.S. Nuclear Waste Technical Review Board Members

B. John Garrick, Ph.D., P.E.; Chairman

Dr. B. John Garrick was appointed to the U.S. Nuclear Waste Technical Review Board as Chairman on September 10, 2004, by President George W. Bush.

Dr. Garrick is an executive consultant on the application of risk sciences to complex technological systems in the space, defense, chemical, marine, transportation, and nuclear fields. He served for 10 years (1994–2004), 4 years as chair, on the U.S. Nuclear Regulatory Commission’s Advisory Committee on Nuclear Waste. His areas of expertise include risk assessment and nuclear science and engineering. A founder of the firm PLG, Inc., Dr. Garrick retired as President, Chairman, and Chief Executive Officer in 1997. Before PLG’s acquisition and integration into a new firm, it was an international engineering, applied science, and management consulting firm.

Dr. Garrick was elected to the National Academy of Engineering in 1993, President of the Society for Risk Analysis 1989–90, and recipient of that Society’s most prestigious award, the Distinguished Achievement Award, in 1994. He has been a member and chair of several National Research Council committees, having served as vice chair of the Academies’ Board on Radioactive Waste Management and as a member of the Commission on Geosciences, Environment, and Resources. He recently chaired the National Academy of Engineering Committee on Combating Terrorism. Among other National Academy committees he has chaired are the Committee on the Waste Isolation Pilot Plant, the Committee on Technologies for Cleanup of High-Level Waste in Tanks in the DOE Weapons Complex, and the Panel on Risk Assessment Methodologies for Marine Systems. Other Academy committee memberships included space applications, automotive safety, and chemical weapons disposal. He is a member of the first class of lifetime national associates of the National Academies.

Dr. Garrick has published more than 250 papers and reports on risk, reliability, engineering, and technology, has written several book chapters, and was editor of the text, *The Analysis, Communication, and Perception of Risk*.

Dr. Garrick received his Ph.D. in engineering and applied science from the University of California, Los Angeles, in 1968. His fields of study were neutron transport, applied mathematics, and applied physics. He received an M.S. in nuclear engineering from UCLA in 1962, attended the Oak Ridge School of Reactor Technology in 1954–55, and received a B.S. in physics from Brigham Young University in 1952. He is a fellow of three professional societies: the American Nuclear Society, the Society for Risk Analysis, and the Institute for the Advancement of Engineering. He is a registered professional engineer in California.

Dr. Garrick lives in Laguna Beach, California.

Mark D. Abkowitz, Ph.D.

Dr. Mark D. Abkowitz was appointed to the Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Abkowitz is a professor of civil and environmental engineering at Vanderbilt University in Nashville, Tennessee, and is director of the Vanderbilt Center for Environmental Management Studies. He brings to the Board expertise in transportation safety and security, systems analysis, all-hazards risk management, and applications of advanced information technologies.

Dr. Abkowitz has served on several national and international committees, including as chairman of the National Academy of Sciences Transportation Research Board Committee on Hazardous Materials Transport and as a member of the National Research Council Committee on Disposal of Transuranic Waste at the Waste Isolation Pilot Plant. Dr. Abkowitz also serves on the board of Visual Risk Technologies. He is the author of more than 70 journal publications and study reports, and has appeared on National Public Radio, Fox National News, and CNBC discussing various risk management topics of national importance.

Dr. Abkowitz has been inducted into Chi Epsilon and the National Society of Sigma Xi and is a member of the World Conference on Transportation Research Society. He received the Distinguished Service Award in 1996 from the Transportation Research Board.

Dr. Abkowitz received a bachelor of science degree in civil engineering from the Massachusetts Institute of Technology (MIT) in 1974. In 1976, he received a master of science degree in civil engineering from MIT. He was awarded a Ph.D. in civil engineering–transportation by MIT in 1980. From 1976 to 1980, he worked as a project manager and a research investigator for the U.S. Department of Transportation. In 1980, he joined the civil engineering faculty of Rensselaer Polytechnic Institute. During a sabbatical in 1986–87, he served as a senior analyst to the U.S. Congress, Office of Technology Assessment. He joined Vanderbilt in 1987 as Administrative Director, Vanderbilt Engineering Center for Transportation Operations and Research.

Dr. Abkowitz lives in Nashville, Tennessee.

William Howard Arnold, Ph.D., P.E.

Dr. William Howard Arnold was appointed to the U.S. Nuclear Waste Technical Review Board on September 10, 2004, by President George W. Bush.

Dr. Arnold is a private consultant. He was president of Louisiana Energy Services until his retirement in 1996. Louisiana Energy Services was a partnership of Urenco, Duke Power, Fluor Daniel, Northern States Power, and Louisiana Power and Light, formed to build the first privately owned uranium-enrichment facility in the United States. Dr. Arnold had retired from Westinghouse Electric Corporation in 1989 after 33 years in a variety of positions.

From 1955 to 1961, Dr. Arnold was senior engineer and section manager for Westinghouse Commercial Atomic Power. He was responsible for reactor physics design of the first series of Westinghouse commercial reactors. He spent 1 year with NUS Corporation as a nuclear fuel management consultant. From 1961 to 1968, he was deputy engineering manager, operations manager, and program manager for the NERVA nuclear rocket project for Westinghouse Astronuclear Laboratory. In 1968–1970, Dr. Arnold was manager of the overseas weapons department for the Westinghouse Defense Center in Baltimore, Maryland, responsible for the Mk 48 torpedo. From 1972 to 1989, he held various positions with Westinghouse in the nuclear area, including engineering manager of the pressurized-water reactor systems division, general manager and president of the Nuclear International Division, and general manager of the Advanced Energy Systems Division. He also served as vice president of Westinghouse Hanford Company.

Dr. Arnold was elected to the National Academy of Engineering in 1974 and is a Fellow and past member of the Board of Directors of the American Nuclear Society. He has participated in several National Academy of Sciences studies, including chairing the 2003 study, titled “Improving the Scientific Basis for Managing DOE’s Excess Nuclear Materials and Spent Nuclear Fuel.”

Dr. Arnold received a bachelor’s degree in chemistry and physics from Cornell University in 1951. In 1955, he was awarded a Ph.D. in experimental physics by Princeton University. He is a registered professional engineer in Pennsylvania.

Dr. Arnold resides in Macatawa, Michigan, and Coronado, California.

Daryle H. Busch, Ph.D.

Dr. Daryle H. Busch was appointed to the U.S. Nuclear Waste Technical Review Board on September 10, 2004, by President George W. Bush. Dr. Busch resigned from the Board effective July 15, 2005.

Dr. Busch is the Roy A. Roberts Distinguished Professor of Chemistry at the University of Kansas. He also is deputy director of the NSF Engineering Research Center, which has the title Center for Environmentally Beneficial Catalysis.

Before going to the University of Kansas, Dr. Busch was a member of the faculty at The Ohio State University, eventually becoming Presidential Professor in 1987. His research in basic transition metal coordination chemistry fathered modern macrocyclic ligand chemistry and created the molecular template effect. He was one of the founders of the subject of ligand reactions and an early researcher and proponent of bioinorganic chemistry. He first described the phenomenon called "preorganization" in 1970. His research is presently focused on homogeneous catalysis, bioinorganic chemistry, and orderly molecular entanglements, a part of supramolecular and nanochemistry.

Dr. Busch served on the board of directors and in various capacities on local and regional sections and committees of the American Chemical Society (ACS). He was president of the ACS in 2000, and a member of the Board of Directors in 1999–2001.

In addition to some 400 scientific publications, Dr. Busch holds 11 patents jointly with 5 major industrial companies and 2 universities. Recognition of his research includes the ACS Award for Distinguished Service in Inorganic Chemistry (1976); the ACS Award for Research in Inorganic Chemistry (1963); the John C. Bailar Medal of his alma mater, the University of Illinois (1978); the Dwyer Medal of the Royal Society of N.S.Wales, Australia (1978); the Izatt-Christenson International Award for Macrocyclic Chemistry (1994); and the Basolo Medal of Northwestern University (2003). In 2003, Dr. Busch was an honorary inductee into the Chemical Society of Japan. His teaching has been recognized by the University of Kansas Louis Byrd Graduate Educator Award (1996) and an Ohio State University Alumni Teaching Award (1980).

He was recently chairman of the Chemistry Section of the American Association for the Advancement of Science and served the International Union for Pure and Applied Chemistry as chairman of the Commission on Inorganic Nomenclature and as secretary of the Inorganic Chemistry Division Committee.

Dr. Busch received a bachelor's degree in chemistry from Southern Illinois University in 1951 and master's and Ph.D. degrees in chemistry from the University of Illinois in 1952 and 1954 respectively.

Dr. Busch lives in Lawrence, Kansas.

Thure E. Cerling, Ph.D.

Dr. Thure E. Cerling was appointed to the U.S. Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Cerling is Distinguished Professor of Geology and Geophysics and Distinguished Professor of Biology at the University of Utah. He brings to the Board expertise in terrestrial geochemistry. His research interests are in the study of geochemistry processes occurring at or near the Earth's surface and in the geological record of ecological change.

Dr. Cerling was elected to membership in the National Academy of Sciences in 2001. He is a fellow of the American Association for the Advancement of Science and of the Geological Society of America. He has been a visiting professor at Scripps Institution of Oceanography, Yale University, the University of Lausanne in Switzerland, the California Institute of Technology, and at the University of Cape Town in South Africa.

Dr. Cerling has served on numerous boards, panels, and committees, including the National Research Council–National Academy of Sciences Board of Earth Sciences and Resources, Geochemical Society Board of Directors, and the Nuclear Waste Group of the International Union of Geological Sciences. He also served on the Governor's Nuclear Waste Task Force, State of Utah, in 1981–83. In 1998, he received the University of Utah Distinguished Research Award.

In 1972, Dr. Cerling earned a bachelor of science degree in geology and chemistry from Iowa State University. In 1973, he received a master of science degree in geology from Iowa State University. In 1977, he was awarded a Ph.D. in geology by the University of California–Berkeley. From 1977 to 1979, Dr. Cerling worked as a research scientist at Oak Ridge National Laboratory. In 1979, he joined the faculty of the University of Utah.

Dr. Cerling lives in Salt Lake City, Utah.

David J. Duquette, Ph.D.

Dr. David J. Duquette was appointed to the U.S. Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Duquette is Department Head and a professor of materials science and engineering at Rensselaer Polytechnic Institute (RPI) in Troy, New York. He brings to the Board expertise in the physical, chemical, and mechanical properties of metals and alloys, with special emphasis on environmental interactions. His current research interests include the physical, chemical, and mechanical properties of metals and alloys, with specific reference to studies of cyclic deformation behavior as affected by environment and temperatures, basic corrosion studies, and stress-corrosion cracking.

Dr. Duquette is author or co-author of more than 200 scientific publications, primarily in environmental degradation of materials and electrochemical processing of semiconductor interconnects. Among the awards that he has received are the Willis Rodney Whitney Award from the National Association of Corrosion Engineers in 1990 and the Humboldt Prize from the Alexander von Humboldt Foundation in 1983. He has been elected an Honorary Member of Alpha Sigma Mu, the national metallurgical honorary society, and has received an Outstanding Paper Award from *Acta Metallurgica*. He is a Fellow of the National Association of Corrosion Engineers and of the American Society for Metals and is also a member of the Minerals, Metals & Materials Society and of the Electrochemical Society.

Dr. Duquette spent more than 5 years as a member of a scientific review group that advised the Canadian government on disposal of high-level nuclear waste. He also has been a member of a panel that advised the United States government on container design and materials selection for disposing of nuclear waste.

Dr. Duquette received a bachelor of science degree from the U.S. Coast Guard Academy in 1961. From 1961 to 1965, he served as a commissioned officer in the U.S. Coast Guard. From 1965 to 1968, he was a research assistant in the Department of Metallurgy and Materials Science at the Massachusetts Institute of Technology (MIT). In 1968, he was awarded a Ph.D. in materials science by MIT. From 1968 to 1970, he worked as a senior research associate in the Advanced Materials Research and Development Laboratory of Pratt and Whitney Aircraft. Dr. Duquette joined the RPI faculty in 1970.

Dr. Duquette lives in Loudonville, New York.

George M. Hornberger, Ph.D.

Dr. George M. Hornberger was appointed to the U.S. Nuclear Waste Technical Review Board on September 10, 2004, by President George W. Bush.

Dr. Hornberger is Ernest H. Ern Professor of Environmental Sciences in the Department of Environmental Sciences at the University of Virginia.

Dr. Hornberger's work in catchment hydrology and hydrochemistry has centered on the coupling of field observations with mathematical modeling. The focus has been to understand how water is routed through soil and rock to streams and how hydrological processes and geochemical processes combine to produce observed stream dynamics. The modeling work allows the extension of work on individual catchments to regional scales. Dr. Hornberger's work in transport of colloids in geological media involves the processes affecting transport of inorganic colloids and biocolloids (e.g., bacteria) through porous media.

Dr. Hornberger's honors and awards include Virginia Chapter of Sigma Xi President's and Visitor's Prize (1986); Robert E. Horton Award, Hydrology Section, American Geophysical Union (1993); Fellow, American Geophysical Union (1994); Biennial Medal for Natural Systems, Modeling, and Simulation, Society of Australia (1995); John Wesley Powell Award for Citizens' Achievement, U.S. Geological Survey (1995); Fellow, Association for Women in Science (1996); member of the National Academy of Engineering (February 1996); Excellence in Geophysical Education Award, American Geophysical Union (1999); Langbein Lecturer, American Geophysical Union (2002); and Fellow, Geological Society of America (2005).

He has chaired the Board on Earth Sciences and Resources of the National Research Council (2003 to present); the Publications Committee of the American Geophysical Union (2000 to 2004); the National Research Council Commission on Geosciences, Environment, and Resources (1996 to 2000); the Advisory Committee on Nuclear Waste, Nuclear Regulatory Commission (2001 to 2003); the Board of Journal Editors, American Geophysical Union (1998 to 2000); the Committee to Prepare a Science Plan for a Water-Cycle Initiative (1999 to 2000); and the National Research Council Committee on the Review of EarthScope Science Objectives and Implementation Planning (2001).

Dr. Hornberger was associate editor of *Water Resources Research* from 1982 to 1984, North American editor of *Journal of Hydrological Processes* from 1985 to 1992, and editor of *Water Resources Research* from 1993 to 1997.

He received a bachelor's degree in civil engineering from Drexel University in 1965, a master's degree in civil engineering (hydrology) from Drexel in 1967, and a Ph.D. in hydrology from Stanford University in 1970.

Dr. Hornberger lives in Charlottesville, Virginia.

Andrew C. Kadak, Ph.D.

Dr. Andrew C. Kadak was appointed to the U.S. Nuclear Waste Technical Review Board on September 10, 2004, by President George W. Bush.

Dr. Kadak is Professor of the Practice in the Nuclear Science and Engineering Department at the Massachusetts Institute of Technology (MIT). His research interests include the development of advanced reactors, in particular the high-temperature pebble-bed gas reactor, space nuclear power systems, improved technology-neutral licensing standards for advanced reactors, and operation and management issues of existing nuclear power plants. Dr. Kadak also serves as a member of the MIT undergraduate committee working on curriculum development and recruitment. He is president of Kadak Associates, a consulting firm specializing in management, organizational, and communication strategies for the nuclear industry.

Before joining the faculty of MIT, Dr. Kadak worked for Yankee Atomic Electric Company. He held various positions there from 1979 to 1987, including president and chief executive officer. From 1975 to 1979, Dr. Kadak was manager of nuclear information at New England Power Company. He was principal physicist for pressurized-water reactor physics at Combustion Engineering Corporation from 1972 to 1975.

Dr. Kadak was president of the American Nuclear Society from 1999 to 2000. He has served as a board and executive committee member of the Nuclear Energy Institute and the industry's Advisory Committee on High-Level Waste. He also has served as a member of the National Association of Regulatory Utility Commissioners special panel on high-level nuclear waste and the Aspen Institute's Dialogue on Nuclear Waste Disposal.

In 1995, Dr. Kadak was a member of the Advisory Committee on External Regulation of DOE Nuclear Safety for the U.S. Department of Energy. He also has conducted several audits of nuclear companies to assess their management practices and has served as chairman of a panel related to the DOE's Nevada Test Site. Dr. Kadak has presented more than 50 lectures and speeches on topics related to the technical and business aspects of nuclear power.

Dr. Kadak earned a bachelor's degree in mechanical engineering from Union College in 1967, a master's degree in nuclear engineering from the Massachusetts Institute of Technology in 1970, a Ph.D. in nuclear engineering from MIT in 1972, and an MBA from Northeastern University in 1983.

Dr. Kadak lives in Barrington, Rhode Island.

Ronald M. Latanision, Ph.D.

Dr. Ronald M. Latanision was appointed to the Nuclear Waste Technical Review Board on June 26, 2002, by President George W. Bush.

Dr. Latanision is professor emeritus of materials science and engineering and nuclear engineering at the Massachusetts Institute of Technology (MIT) and a principal and Director, Mechanics and Materials, Exponent Corporation. He brings to the Board expertise in materials processing and in corrosion of metals and other materials in aqueous (ambient as well as high-temperature and high-pressure) environments.

Dr. Latanision is the author or co-author of more than 200 scientific publications. Among the awards that Dr. Latanision has received are the 2004 Henry B. Linford Award from the Electrochemical Society; the 2001 T.P. Hoar Award from the British Institute of Corrosion, and the Willis Rodney Whitney Award from the National Association of Corrosion Engineers in 1994. He was elected Distinguished Alumnus of The Ohio State University College of Engineering in 1991 and Honorary Alumnus of MIT in 1992.

Dr. Latanision is a Fellow of the American Society of Metals International and the National Association of Corrosion Engineers. He is founder and co-chairman of New England Science Teachers and is a member of the National Academy of Engineering and the American Academy of Arts and Sciences. He has been a consultant to industry and government and has been active in organizing international conferences.

In 1964, Dr. Latanision received a bachelor of science degree in metallurgy from The Pennsylvania State University. In 1968, he was awarded a Ph.D. in metallurgical engineering by The Ohio State University. In 1968 and 1969, he was a Postdoctoral Fellow at the National Bureau of Standards. From 1969 to 1974, he worked for Martin Marietta Laboratories, first as a research scientist and then as acting head of materials science. He joined MIT in 1975 as director of the H. H. Uhlig Corrosion Laboratory. During a sabbatical in 1982–83, he served as a science advisor to the U. S. House of Representatives Committee on Science and Technology. He also was a member of the National Materials Advisory Board of the National Research Council.

Dr. Latanision lives in Winchester, Massachusetts.

Ali Mosleh, Ph.D.

Dr. Ali Mosleh was appointed to the U.S. Nuclear Waste Technical Review Board on September 10, 2004, by President George W. Bush.

Dr. Mosleh is Nicole J. Kim Professor of Engineering, director of the Reliability Engineering Program, and director of the Center for Risk and Reliability at the University of Maryland. He conducts research on methods for probabilistic risk analysis (PRA) and reliability of complex systems, and he has made many contributions to diverse fields of theory and application. They include Bayesian methods for inference with uncertain evidence; analysis of data and expert judgment; treatment of model uncertainty; risk and reliability of hybrid systems of hardware, human, and software programs; methods and tools for dynamic PRA; cognitive models for human reliability analysis; and models of the influence of organizational factors on system safety.

Dr. Mosleh is the developer of the Accident Precursor Analysis methodology and many of the methods currently used for treating of common-cause failures in highly reliable systems. On these topics, he holds several patents and has edited, authored, or co-authored more than 250 publications. Dr. Mosleh has led numerous projects on risk, safety, and security assessments for the aerospace, nuclear, chemical, and information systems and telecommunication industries. He also led the design and development of more than 10 major risk and reliability analysis software programs currently used by various government agencies and the private sector.

Dr. Mosleh is a Fellow of the Society for Risk Analysis (SRA), and the recipient of several scientific achievement awards. He has been a consultant and a technical advisor to many national and international organizations on risk assessment and management. He has chaired or organized numerous international technical conferences on risk and reliability.

Dr. Mosleh received his Ph.D. in Nuclear Science and Engineering from the University of California, Los Angeles, in 1981.

He lives in Columbia, Maryland.

Henry Petroski, Ph.D., P.E.

Dr. Henry Petroski was appointed to the U.S. Technical Review Board on September 10, 2004, by President George W. Bush.

Dr. Petroski is Aleksandar S. Vesic Professor of Civil Engineering and a professor of history at Duke University. His research focuses on the interrelationship between success and failure in engineering design. He also has a strong interest in the nature of invention, as well as in the history and evolution of technology. Before joining the faculty of Duke University in 1980, he taught at the University of Illinois and the University of Texas at Austin and was a group leader at Argonne National Laboratory, where he was responsible for research and development in fracture mechanics.

Among the honors that Dr. Petroski has received are a Guggenheim Fellowship (1990–1991); honorary degrees from Clarkson University (1990), Trinity College (1997), Valparaiso University (1999), and Manhattan College (2003); the Ralph Coates Roe Medal from the American Society of Mechanical Engineers (1991); the Civil Engineering History and Heritage Award from the American Society of Civil Engineers (1993); and the Washington Award from the Western Society of Engineers (2006). He has received the Centennial Award as an Outstanding Engineering Graduate of Manhattan College (1992) and the Alumni Award for Distinguished Service from the College of Engineering of the University of Illinois at Urbana-Champaign (1994). Dr. Petroski is an honorary member of The Moles, is a fellow of the American Society of Civil Engineers, the Institution of Engineers of Ireland, the American Academy of Arts and Sciences and is a member of the National Academy of Engineering.

Dr. Petroski is the author of the book *To Engineer Is Human: the Role of Failure in Successful Design* (1985) and is the writer and presenter of the 1987 BBC television documentary “To Engineer is Human,” which has been broadcast on PBS. Among his other books are: *The Pencil: A History of Design and Circumstance* (1990); *The Evolution of Useful Things* (1992); *Design Paradigms: Case Histories of Error and Judgment in Engineering* (1994); *Engineers of Dreams: Great Bridge Builders and The Spanning of America* (1995), *Invention by Design: How Engineers Get from Thought to Thing* (1996); *Remaking the World: Adventures in Engineering* (1997); *Small Things Considered: Why There Is No Perfect Design* (2003); *Pushing the Limits: New Adventures in Engineering* (2004); and *Success through Failure: The Paradox of Design* (2006). Dr. Petroski also writes the engineering column for *American Scientist*, which is published by Sigma Xi, the scientific research society, and a column on the profession for *Prism*, the magazine of the American Society for Engineering Education. He has published more than 75 refereed journal articles in such publications as *International Journal of Fracture*, *Engineering Fracture Mechanics*, *Journal of Applied Mechanics*, and *Research in Engineering Design*.

Dr. Petroski received a bachelor’s degree in mechanical engineering from Manhattan College in 1963 and a Ph.D. in theoretical and applied mechanics from the University of Illinois at Urbana-Champaign in 1968. He is a professional engineer registered in Texas and a chartered engineer registered in Ireland.

Dr. Petroski lives in Durham, North Carolina.

Appendix B

Meeting List

- February 9–10, 2005** **Winter Board Meeting**
Las Vegas, Nevada, and Caliente, Nevada
Topics:
- Systems integration
 - Scientific studies
 - Transportation
- November 8–9, 2005** **Fall Board Meeting**
Las Vegas, Nevada
Topic:
- Scientific updates
- February 1, 2006** **Spring Board Meeting**
Las Vegas, Nevada
Topic:
- Processes Affecting Radionuclide Transport

Appendix C

Panel Organization

Panel on the Natural System

Chair: George M. Hornberger
 Members: Thure E. Cerling

Staff: David Diodato*
 John H. Pye
 Leon Reiter

Panel on the Engineered System

Chair: Ronald M. Latanision
 Members: Wm. Howard Arnold
 David J. Duquette
 Henry Petroski

Staff: Carlos A. W. Di Bella*
 John H. Pye
 Karyn D. Severson

Panel on Repository System Performance and Integration

Chair: Ali Mosleh
 Members: Mark D. Abkowitz
 Ronald M. Latanision
 Thure E. Cerling
 Henry Petroski

Staff: Leon Reiter*
 David M. Diodato
 Daniel S. Metlay
 John H. Pye

Panel on the Waste Management System

Chair: Mark D. Abkowitz
 Members: Wm. Howard Arnold
 David J. Duquette
 Andrew C. Kadak

Staff: Daniel J. Fehring*
 Carlos A. W. Di Bella
 Daniel S. Metlay
 Karyn D. Severson

*Staff Coordinator

Appendix D

U.S. Nuclear Waste Technical Review Board Publications

The following publications are available by mail from the Nuclear Waste Technical Review Board or electronically from the Board's Web site at www.nwtrb.gov.

Letter report to Congress and the Secretary of Energy. December 2005.

This letter report to Congress and the Secretary of Energy, presents the Board's views on the status of some important issues related to the technical basis for DOE activities related to the waste management system, the engineered system, the natural system, the repository system, and the assessment of the performance of the systems. The Board also outlines issues that it expects may continue to be of interest in the future.

Report to Congress and the Secretary of Energy. May 2005.

In this report, the Board summarizes its major activities from January 1, 2004, through December 31, 2004. During that period, the Board focused on the Department of Energy's efforts to develop a system for accepting, transporting, and handling high-level radioactive waste and spent nuclear fuel before disposal in the repository proposed for Yucca Mountain. Correspondence and related materials are included in the appendices to the report along with the Board's strategic plan for fiscal years 2004–2009, its performance plans for 2005, and its performance evaluation for 2004.

Letter Report to the U.S. Congress and the Secretary of Energy. December 2004.

This letter and enclosure comprise the Board's second report to Congress and the Secretary of

Energy for calendar year 2004. The letter briefly summarizes areas where the Board believes the DOE has made progress, areas requiring attention, and the Board's priorities for the coming year. The enclosure contains a more detailed discussion of these topics.

Report to the U.S. Congress and the Secretary of Energy. May 2004.

In this report, the Board summarizes its major activities from January 1, 2003, through December 31, 2003. During that period, the Board continued its evaluation and held meetings on a range of technical and scientific issues, including seismicity, DOE plans for transporting spent nuclear fuel and high-level radioactive waste, the design and operation of facilities at the proposed repository site, performance-confirmation activities, and the potential for localized corrosion. Correspondence and related materials are included in the appendices to the report along with the Board's strategic plan for fiscal years 2004–2009, its performance plans for 2004 and 2005, and its performance evaluation for 2003.

Report to the U.S. Congress and the Secretary of Energy. December 19, 2003.

This letter and attachments constitute the Board's second report to Congress and the Secretary of Energy for calendar year 2003. This report is composed of letters on localized corrosion sent to the director of the Office of Civilian Radioactive Waste Management (OCRWM) on October 21, 2003, and November 25, 2003. It also contains the Board Technical Report on Localized Corrosion.

Board Technical Report on Localized Corrosion. November 25, 2003.

This report contains information supporting the conclusions that the Board presented in its October 21, 2003, letter to the DOE concerning the potential for localized corrosion of waste packages during the thermal pulse.

Report to the U.S. Congress and the Secretary of Energy. April 2003.

This report summarizes the Board's major activities between January 1, 2002, and December 31, 2002. During this period, the Board focused on evaluating the technical basis of the DOE's work related to analyzing a planned repository site at Yucca Mountain in Nevada. Included in an appendix to the report are letters to the DOE related to technical issues identified by the Board as part of its ongoing review in 2002. Also included in the appendices are the Board's strategic plan for fiscal years 2003–2008, its performance plans for FY 2003 and FY 2004, and its performance evaluation for FY 2002.

Report to the U.S. Congress and the Secretary of Energy. April 2002.

This report summarizes the Board's major activities between February 1, 2001, and January 31, 2002. During this period, the Board focused on evaluating the technical basis of the DOE's work related to a site recommendation, including the DOE's characterization of the Yucca Mountain site, the DOE's design of the repository and waste package, and the DOE's estimates of how a repository system developed at the site might perform. The report includes a description of activities undertaken by the Board in developing its assessment of the technical basis for the DOE's current performance estimates.

Letter Report to Congress and the Secretary of Energy. January 24, 2002.

This letter report constitutes the Board's second report to Congress and the Secretary of Energy for calendar year 2001. The report summarizes the Board's evaluation of the DOE's technical

and scientific investigation of the Yucca Mountain site during the year.

Proceedings from an International Workshop on Long-Term Extrapolation of Passive Behavior, July 19–20, 2001, Arlington, Virginia. December 2001.

The Board conducted a workshop on issues related to predicting corrosion behavior for periods of unprecedented duration. The workshop was held on July 19 and 20, 2001, in Arlington, Virginia. The workshop consisted of a panel of three Board members and 14 internationally recognized corrosion scientists, 8 of whom were from outside the United States. Following the workshop, most panelists submitted brief papers giving their views on issues related to predicting very long term corrosion. This publication is a compilation of those submissions.

Report to the U.S. Congress and the Secretary of Energy. April 2001.

In this report, the Board summarizes its major activities in calendar year 2000. During 2000, the Board identified four priority areas for evaluating the potential repository at Yucca Mountain. The areas are the following:

- meaningful quantification of conservatisms and uncertainties in the DOE's performance assessments
- progress in understanding the underlying fundamental processes involved in predicting the rate of waste package corrosion
- an evaluation and a comparison of the base-case repository design with a low-temperature design
- development of multiple lines of evidence to support the safety case of the proposed repository, the lines of evidence being derived independently of performance assessment and thus not being subject to the limitations of performance assessment.

The report summarizes the Board's views on each priority area. A more detailed discussion of the priorities can be found in letters to the DOE included among the appendices to the report.

Report by letter to the Secretary of Energy and Congress. December 2000.

This report, in the form of a letter, presents a brief update of the Board's views on the status of the DOE program.

Report to the U.S. Congress and the Secretary of Energy. April 2000.

In this report, the Board summarizes its major activities in calendar year 1999. Among the activities discussed in the report is the Board's 1999 review of the DOE's viability assessment (VA) of the Yucca Mountain site. The Board's evaluation of the VA concludes that Yucca Mountain continues to warrant study as the candidate site for a permanent geologic repository and that work should proceed to support a decision on whether to recommend the site for repository development. The Board suggests that the 2001 date for a decision is very ambitious, and focused study should continue on natural and engineered barriers. The Board states that a credible technical basis does not currently exist for the above-boiling repository design included in the VA. The Board recommends evaluation of alternative repository designs, including lower-temperature designs, as a potential way to help reduce the significance of uncertainties related to predictions of repository performance.

Report to the U.S. Congress and the Secretary of Energy. April 1999.

In this report, the Board summarizes its major activities during calendar year 1998. The report discusses the research needs identified in the DOE's recently issued *Viability Assessment* of the Yucca Mountain site, including plans to gather information on the amount of water that will eventually seep into repository drifts, whether formations under the repository will retard the migration of radionuclides, the flow-and-transport properties of the groundwater that lies approximately 200 meters beneath the repository horizon, and long-term corrosion rates of materials that may be used for the waste packages. The report describes other activities undertaken by the Board in 1998, including a review

of the hypothesis that there were hydrothermal upwellings at Yucca Mountain, a workshop held to increase understanding of the range of expert opinion on waste package materials, and a review of the DOE's draft environmental impact statement for the Yucca Mountain site.

Report to the U.S. Congress and the Secretary of Energy: Moving Beyond the Viability Assessment. April 1999.

In its report, the Board offers its views on the DOE's December 1998 *Viability Assessment* of the Yucca Mountain site in Nevada. The Yucca Mountain site is being characterized to determine its suitability as the location of a permanent repository for disposing of spent nuclear fuel and high-level radioactive waste. The Board discusses the need to address key uncertainties that remain about the site, including the performance of the engineered and natural barriers. The Board addresses the DOE's plans for reducing those uncertainties and suggests that consideration be given to alternative repository designs, including ventilated low-temperature designs that have the potential to reduce uncertainties and simplify the analytical bases for determining site suitability and for licensing. The Board also comments on the DOE's total system performance assessment, the analytical tool that pulls together information on the performance of the repository system.

Report to the U.S. Congress and the Secretary of Energy. November 1998.

In its report, the Board offers its views on the direction of future scientific and technical research under way and planned by the DOE as part of its program for characterizing a site at Yucca Mountain, Nevada, as a potential repository for spent fuel and high-level radioactive waste. The Board discusses some of the remaining key scientific and technical uncertainties related to performance of a potential repository. The Board's report addresses some of these uncertainties by examining information about the proposed repository system presented to it in meetings and other technical exchanges. The Board considers and comments on some of the important connections

between the site's natural properties and the current designs for the waste package and other engineered features of the repository.

Review of Material on Hydrothermal Activity. July 24, 1998.

This series of documents concerns the Board's review of material related to Mr. Jerry Szymanski's hypothesis of ongoing, intermittent hydrothermal activity at Yucca Mountain and large earthquake-induced changes in the water table there. The series includes a cover letter, the Board's review, and the reports of the four consultants the Board contracted with to assist in the review.

Report to the U.S. Congress and the Secretary of Energy: 1997 Findings and Recommendations. April 1998.

This report details the Board's activities in 1997 and covers, among other things, the DOE's viability assessment, due later this year; underground exploration of the candidate repository site at Yucca Mountain, Nevada; thermal testing under way at the site; what happens when radioactive waste reaches the water table beneath Yucca Mountain; transportation of spent fuel; and the use of expert judgment. The Board makes four recommendations in the report concerning (1) the need for the DOE to begin now to develop alternative design concepts for a repository, (2) the need for the DOE to include estimates of the likely variation in doses for alternative candidate critical groups in its interim performance measure for Yucca Mountain, (3) the need for the DOE to evaluate whether site-specific biosphere data is needed for license application, and (4) the need for the DOE to make full and effective use of formally elicited expert judgment.

Report by letter to the Secretary of Energy and the Congress. December 23, 1997.

This report, in the form of a letter, addresses several key issues, including the DOE's viability assessment of the Yucca Mountain site, design of the potential repository and waste package, the total system performance assessment, and

the enhanced characterization of the repository block (east-west crossing).

Report to the U.S. Congress and the Secretary of Energy. March 1997.

This report summarizes Board activities during 1996. Chapter 1 provides an overview of the Department of Energy's high-level nuclear waste management program from the Board's perspective, including the viability assessment, program status, and progress in exploration and testing. The chapter ends with conclusions and recommendations. Chapter 2 examines the three technical issues—hydrology, radionuclide transport, and performance assessment—and provides conclusions and recommendations. Chapter 3 deals with design, including the concept for underground operations, repository layout and design alternatives, construction planning, thermal loading, and engineered barriers. The Board also makes conclusions and recommendations. Chapter 4 provides an overview of recent Board activities, including the international exchange of information, the Board's visit to the River Mountains tunnel, and a presentation to the NRC. Appendices include information on Board members, the organization of the Board's panels, meetings held in 1996 and scheduled for 1997, the DOE's responses to previous Board recommendations, a list of Board publications, references for the report, and a glossary of technical terms.

Nuclear Waste Management in the United States—The Board's Perspective. June 1996.

This publication was developed from remarks made by Dr. John Cantlon, Chairman of the Nuclear Waste Technical Review Board, at Topseal '96, an international conference on nuclear waste management and disposal. The meeting was sponsored by the Swedish Nuclear Fuel and Waste Management Company and the European Nuclear Society. The publication highlights the Board's views on the status of the U.S. program for management and disposal of commercial spent nuclear fuel and provides a brief overview of the program's organization. It summarizes the

DOE's efforts to characterize the Yucca Mountain site and to develop a waste isolation strategy for the site. The publication also outlines legislative and regulatory changes under consideration at that time and the Board's views on the technical implications of those possible changes.

Report to the U.S. Congress and the Secretary of Energy: 1995 Findings and Recommendations. April 1996.

This report summarizes Board activities during 1995. Chapter 1 provides an overview of the DOE's high-level waste management program, including highlights, current status, legislative issues, milestones, and recommendations. Chapter 2 reports on Board Panel activities and Chapter 3 provides information on new Board members, meetings attended, interactions with Congress and congressional staff, Board presentations to other organizations, interactions with foreign programs, and a review of the Board's report on interim storage of spent nuclear fuel. Appendices include Board testimony and statements before Congress, Board correspondence of note, and the Department of Energy's responses to recommendations in previous Board reports.

Disposal and Storage of Spent Nuclear Fuel—Finding the Right Balance. March 1996.

This special report caps more than 2 years of study and analysis by the Board into the issues surrounding the need for interim storage of commercial spent nuclear fuel and the advisability and timing of the development of a federal centralized storage facility. The Board concludes in the report that the DOE's efforts should remain focused on permanent geologic disposal and the site investigations at Yucca Mountain, Nevada; that planning for a federal centralized spent fuel storage facility and the required transportation infrastructure be begun now, but actual construction delayed until after a site-suitability decision is made about the Yucca Mountain site; that storage should be developed incrementally; that limited, emergency backup storage capacity be authorized at an existing nuclear facility; and

that, if the Yucca Mountain site proves unacceptable for repository development, other potential sites for both centralized storage and disposal be considered.

Report by letter to the Secretary of Energy and the Congress. December 13, 1995.

This report, in the form of a letter, addresses the DOE's progress in underground exploration with the tunnel boring machine, advances in the development of a waste isolation strategy, new work on engineered barriers, and progress being made in performance assessment.

Report to the U.S. Congress and the Secretary of Energy: 1994 Findings and Recommendations. March 1995.

This report summarizes Board activities during 1994. It covers aspects of the DOE's Program Approach, their emerging waste isolation strategy, and their transportation program. It also explores the Board's views on minimum exploratory requirements and thermal-loading issues. The report focuses a chapter on the lessons that have been learned in site assessment from projects around the world. Another chapter deals with volcanism and resolution of difficult issues. The Board also details its observations from its visit to Japan and the Japanese nuclear waste disposal program. Findings and recommendations in the report centered around structural geology and geoengineering, hydrogeology and geochemistry, the engineered barrier system, and risk and performance analysis.

Report to the U.S. Congress and the Secretary of Energy. May 1994.

This report summarizes Board activities primarily during 1993. It reviews the nuclear waste disposal programs of Belgium, France, and the United Kingdom; elaborates on the Board's understanding of the radiation protection standards being reviewed by the National Academy of Sciences; and, using "future climates" as an example, examines the DOE's approach to "resolving difficult issues." Recommendations center on the use of

a systems approach in all of The Office of Civilian Radioactive Waste Management's (OCRWM) programs, prioritization of site-suitability activities, appropriate use of total system performance assessment and expert judgment, and the dynamics of the Yucca Mountain ecosystem.

Letter Report to Congress and the Secretary of Energy. February 1994.

This report is issued in letter format due to impending legislative hearings on the DOE's fiscal year 1995 budget and new funding mechanisms sought by the Secretary of Energy. The 8-page report restates a recommendation made in the Board's Special Report, that an independent review of the OCRWM's management and organizational structure be initiated as soon as possible. Also, it adds two additional recommendations: ensure sufficient and reliable funding for site characterization and performance assessment, whether the program budget remains level or is increased, and build on the Secretary of Energy's new public involvement initiative by expanding current efforts to integrate the views of the various stakeholders during the decision-making process—not afterward.

Underground Exploration and Testing at Yucca Mountain: A Report to Congress and the Secretary of Energy. October 1993.

This report focuses on the exploratory studies facility (ESF) at Yucca Mountain, Nevada: the conceptual design, planned exploration and testing, and excavation plans and schedules. In addition to a number of detailed recommendations, the Board makes three general recommendations. First, the DOE should develop a comprehensive strategy that integrates exploration and testing priorities with the design and excavation approach for the exploratory facility. Second, underground thermal testing should be resumed as soon as possible. Third, the DOE should establish a geoengineering board with expertise in the engineering, construction, and management of large underground projects.

Special Report to Congress and the Secretary of Energy. March 1993.

The Board's report provides a nontechnical approach for those not familiar with the details of the DOE's high-level nuclear waste management program. It highlights three important policy issues: the program is driven by unrealistic deadlines, there is no integrated waste management plan, and program management needs improvement. The Board makes three specific recommendations: amend the current schedule to include realistic intermediate milestones; develop a comprehensive, well-integrated plan for the overall management of all spent nuclear fuel and high-level defense waste from generation to disposal; and implement an independent evaluation of the OCRWM organization and management. These recommendations should be implemented without slowing the progress of site-characterization activities at Yucca Mountain.

Sixth Report to the U.S. Congress and the U.S. Secretary of Energy. December 1992.

The Board's report begins by summarizing recent Board activities, congressional testimony, changes in Board makeup, and the Little Skull Mountain earthquake. Chapter 2 details panel activities and offers seven technical recommendations on the dangers of a schedule-driven program; the need for top-level systems studies; the impact of defense high-level waste; the use of high capacity, self-shielded waste package designs; and the need for prioritization among the numerous studies included in the site-characterization plans. In Chapter 3, the Board offers candid insights to the high-level waste management program in five countries, specifically those areas that might be applicable to the U.S. program, including program size and cost, utility responsibilities, repository construction schedules, and alternative approaches to licensing. Appendix F provides background on the Finnish and Swiss programs.

Fifth Report to the U.S. Congress and the U.S. Secretary of Energy. June 1992.

The Board's report focuses on the cross-cutting issue of thermal loading. It explores thermal-loading strategies (U.S. and others) and the technical issues and uncertainties related to thermal loading. It also details the Board's position on the implications of thermal loading for the U.S. radioactive waste management system. Also included are updates on Board and panel activities during the reporting period. The report offers 15 recommendations to the DOE on the following subjects: ESF and repository design enhancements, repository sealing, seismic vulnerabilities (vibratory ground motion and fault displacement), the DOE approach to the engineered barrier system, and transportation and systems program status.

Fourth Report to the U.S. Congress and the U.S. Secretary of Energy. December 1991.

The Board's report provides update on the Board's activities and explores in depth the following areas: ESF construction; test prioritization; rock mechanics; tectonic features and processes; volcanism; hydrogeology and geochemistry in the unsaturated zone; the engineered barrier system; regulations promulgated by the EPA, the NRC, and the DOE; the DOE performance assessment program; and quality assurance in the Yucca Mountain project. Ten recommendations are made across these diverse subject areas. Chapter 3 offers insights from the Board's visit with officials from the Canadian nuclear power and spent fuel disposal programs. Background on the Canadian program is in Appendix D.

Third Report to the U.S. Congress and the U.S. Secretary of Energy. May 1991.

The Board's report briefly describes recent Board activities and congressional testimony. Substantive chapters cover exploratory shaft facility alternatives, repository design, risk-

benefit analysis, waste package plans and funding, spent fuel corrosion performance, transportation and systems, environmental program concerns, more on the DOE task force studies on risk and performance assessment, federal quality assurance requirements for the repository program, and the measurement, modeling, and application of radionuclide sorption data. Fifteen specific recommendations are made to the DOE. Background information on the German and Swedish nuclear waste disposal programs is included in Appendix D.

Second Report to the U.S. Congress and the U.S. Secretary of Energy. November 1990.

The Board's report begins with the background and framework for repository development and then opens areas of inquiry, making 20 specific recommendations concerning tectonic features and processes, geoengineering considerations, the engineered barrier system, transportation and systems, environmental and public health issues, and risk and performance analysis. The report also offers concluding perspectives on DOE progress, the state of Nevada's role, the project's regulatory framework, the nuclear waste negotiator, other oversight agencies, and the Board's future plans.

First Report to the U.S. Congress and the U.S. Secretary of Energy. March 1990.

The Board's report sets the stage for the Board's evaluation of the DOE program to manage the disposal of the nation's spent fuel and high-level waste. The report outlines briefly the legislative history of the nation's spent fuel and high-level waste management program including its legal and regulatory requirements. The Board's evolution is described, along with its protocol, panel breakdown, and reporting requirements. The report identifies major issues based on the Board's panel breakdown, and highlights five cross-cutting issues.

