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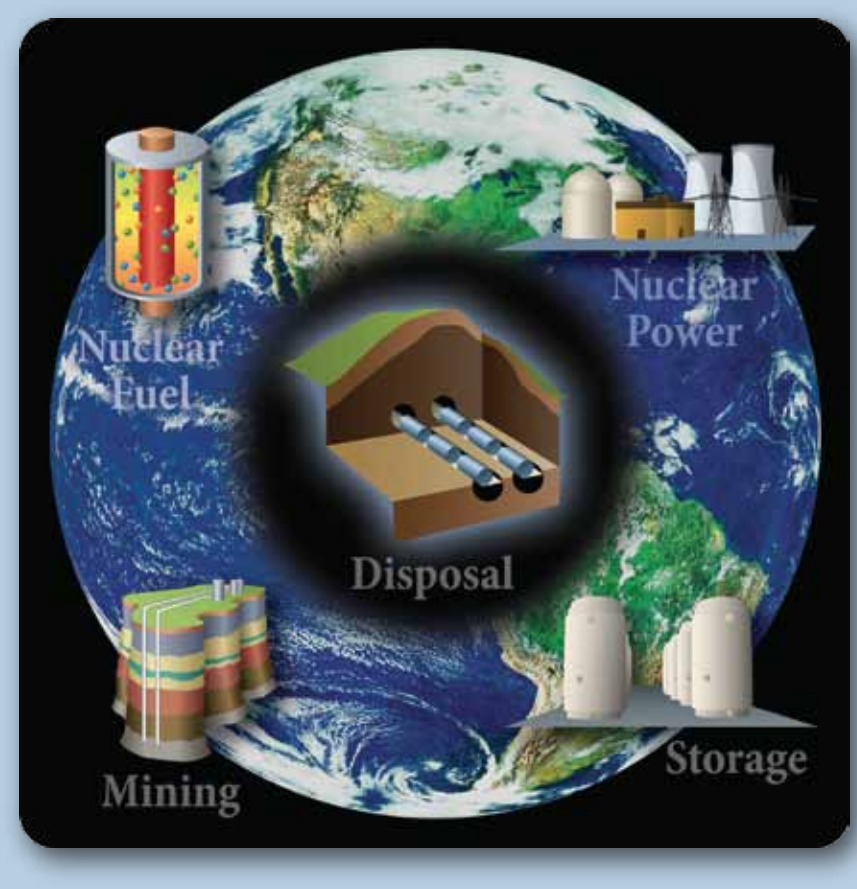
SwRI® Proposal No. 20-64989
April 4, 2012

A proposal for

URANIUM STUDY

In Response to RFP #1200001-999



Prepared for:

Commonwealth of Virginia
Department of Health
Office of Purchasing & General Services
Attn: Daniel Wilborn, Contract Officer
109 Governor Street, Room 1214
Richmond, VA 23219

Prepared by:

Center for Nuclear Waste
Regulatory Analyses
Geosciences and Engineering Division
Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78238

SOUTHWEST RESEARCH INSTITUTE®

SwRI® Proposal No. 20-64989

Proposal for

Uranium Study

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Commonwealth of Virginia
Department of Health
RFP 120000-999

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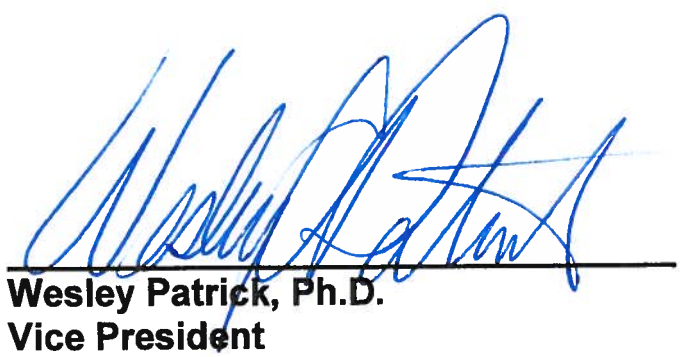
Center for Nuclear Waste Regulatory Analyses
Geosciences and Engineering Division
Southwest Research Institute®
San Antonio, Texas

April 2012



Wesley Patrick, Ph.D.
Vice President
Geosciences and Engineering Division

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FIGURES

TABLES

1 REQUEST FOR PROPOSAL COVER SHEET

REQUEST FOR PROPOSALS (RFP)

RFP # 1200001-999

Issue Date:	March 5, 2012
Title:	Uranium Study
Commodity Code:	91843
Issuing Agency:	Commonwealth of Virginia Department of Health Office of Purchasing & General Services Attn: Daniel Wilborn, Contract Officer 109 Governor Street, Room 1214 Richmond, VA 23219
Using Agency And/Or Location Where Work Will Be Performed:	Department of Health

Initial Period of Contract: From Date of Award through **November 30, 2012**.

Sealed Proposals Will Be Received Until 2:00 p.m. on April 4, 2012 For Furnishing The Services Described Herein.

All Inquiries for Information Should Be Directed To: Daniel Wilborn, Contract Officer, Phone: (804) 864-7519 or E-mail: daniel.wilborn@vdh.virginia.gov. **Questions will be accepted until close of business on March 14, 2012.**

IF PROPOSALS ARE MAILED, SEND DIRECTLY TO THE ISSUING AGENCY SHOWN ABOVE. IF PROPOSALS ARE DELIVERED BY COURIER OR HAND DELIVERED, DELIVER TO: THE ISSUING AGENCY SHOWN ABOVE, Attn: Daniel Wilborn, Contract Officer.

In Compliance With This Request For Proposals And To All The Conditions Imposed Therein And Hereby Incorporated By Reference, The Undersigned Offers And Agrees To Furnish The Services In Accordance With The Attached Signed Proposal Or As Mutually Agreed Upon By Subsequent Negotiation.

State Corporation Commission ID Number: F1431420
(See Special Terms and Conditions)

Name and Address Of Firm:
Southwest Research Institute®
6220 Culebra Road
San Antonio, Texas Zip Code: 78238-5166

Date: April 3, 2012
By: (Signature in Ink)
Name: R. B. Kalmbach (Please Print)
Title: Executive Director, Contracts

eVA Vendor ID or DUNS # 00-793-6482
Phone: (210) 522-2261
E-mail: contract@swri.org
Fax: (210) 522-3559

PREPROPOSAL CONFERENCE: A mandatory pre-proposal conference will be held at 2:00 p.m. on March 16, 2012 at the Department of Health, 109 Governor Street Room 1218, Richmond, VA, 23219. Reference: Section VII herein. NO ONE WILL BE ADMITTED AFTER 2:10 p.m. If special ADA accommodations are needed, please contact Daniel Wilborn at 804-864-7519 by March 13, 2012.

Note: This public body does not discriminate against faith-based organizations in accordance with the *Code of Virginia*, § 2.2-4343.1 or against an offeror because of race, religion, color, sex, national origin, age, disability, or any other basis prohibited by state law relating to discrimination in employment.

2 ATTACHMENT A: OFFEROR DATA SHEET

ATTACHMENT A

OFFEROR DATA SHEET

Note: The following information is required as part of your response to this solicitation. Failure to complete and provide this sheet may result in your proposal being scored lower.

1. Qualification: The vendor must have the capability and capacity in all respects to satisfy fully all of the contractual requirements.

2. Vendor's Primary Contact:

   Name: Joseph H. Marshall Phone: (210) 522-6510

3. Years in Business: Indicate the length of time you have been in business providing this type of good or service:

   65 Years _____ Months

4. Vendor Information:

   eVA Vendor ID or DUNS Number: 00-793-6842

5. Indicate below a listing of at least four (4) current or recent accounts, either commercial or governmental, that your company is servicing, has serviced, or has provided similar goods. Include the length of service and the name, address, and telephone number of the point of contact.

   A. Company:_____ Contact: _____
   Phone:(____)_____ Fax: (____)_____
   Project:_____
   Dates of Service: _____ $ Value: _____

   B. Company_____ Contact: _____
   Phone:(____)_____ Fax: (____)_____
   Project:_____
   Dates of Service: _____ $ Value: _____

   C. Company:_____ Contact: _____
   Phone:(____)_____ Fax:(____)_____
   Project:_____
   Dates of Service: _____ $ Value: _____

   D. Company:_____ Contact: _____
   Phone:(____)_____ Fax:(____)_____
   Project:_____
   Dates of Service: _____ $ Value: _____

SEE ATTACHED CREDIT REFERENCES

I certify the accuracy of this information.

Signed: Robert L. Wolfe Jr. Title: Procurement Specialist Date: March 28, 2012

SOUTHWEST RESEARCH INSTITUTE®

6220 CULEBRA RD. 78238-5166 • P.O. DRAWER 28510 78228-0510 • SAN ANTONIO, TEXAS, USA • (210) 684-5111 • WWW.SWRI.ORG

Date:

To:

BUSINESS AND CREDIT INFORMATION

DUNS: 00-793-6842

Location: San Antonio, TX
Houston, TX
Washington, DC
Detroit, MI

Officers: J.D. Bates, President
Beth Ann Rafferty, Chief Financial Officer, Vice President-Finance
Jack Fernandi, Treasurer

Accounts Payable: Karen A. Crow (210) 522-2911

A Not For Profit Texas Corporation
Texas Sales Tax Exemption Certificate is attached.
Federal Tax ID No. 74-1070544

CREDIT REFERENCES

Trade:

Wittigs Office Interiors
2013 Broadway
San Antonio, TX 78215
Accounts Receivable
Department
Attention: Eunice Myrick
Phone: 210-488-9621
Fax: 210-270-0118
eunice.myrick@wittigs.com

Fisher Scientific Company
2000 Park Lane
Pittsburgh, PA 15275
Phone: (412) 490-8308
Fax: (412) 490-5721
Attn: Kim Trauterman
Account No. 784214

W.W. Grainger, Inc.
4924 NW Loop 410
San Antonio, TX 78229
Phone: (847) 647-2060
Account No. 809690456

Matera Paper Company Inc
PO Box 200184
San Antonio, TX 78220-0184
Phone: (800) 580-8350
Fax: (210) 892-5162
Attn: Jenny Strunk/Steve Marshall

Arthur Fluid System Technologies
8341 Cross Park Drive
Austin, TX 78754
Fax: (512) 832-0063
Attn: Credit Department

Bank: Bank of America, N.A.
General credit inquiries should be faxed to 415-343-9301 and reference our name and account (001390004879).

Sincerely,

Joseph H. Marshall

Joseph H. Marshall
Purchasing Manager

HOUSTON, TEXAS (713) 977-1377 • WASHINGTON, DC (301) 881-0226

A. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Development of Supplemental EIS for Dewey Burdock In-situ Recovery Project-Task Order No. 1
Dates of Service: 10/1/09—9/28/12 $Value 589,976.00

B. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: TA for the Development of a Standard Review Plan for Conventional Mill and Hap Leach Facilities Task Order No. 5
Dates of Service: 12/24/09—9/30/12 $Value 387,029.00

C. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Development of the Technical Basis for Revision of Regulatory Guide 8.30, "Health Physics Surveys in Uranium Recovery Facilities," Task Order No. 13
Dates of Service: 4/30/10—9/30/12 $Value 147,989.00

D. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Engineered Cover Support for Decommissioning and Uranium Recovery-Task Order No. 21
Dates of Service: 9/30/10—9/28/12 $Value 312,842.00

E. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Hydrogeologist/Hydrologist to support Decommissioning and Uranium Recovery Activities—Phase 1
Dates of Service: 9/29/10—9/28/10 $Value 203,482.60

F. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437\
Project: Technical Assistance for the NRC/FSME Safety and Environmental Reviews of UR, Fuel, Cycle Facilities, Decommissioning Licensing and other NRC Licensing Support Activities
Dates of Service: $Value

G. Company: U.S. Nuclear Regulatory Commissio n Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: TA for the Development of a Supplemental EIS for the Ludeman In-Situ Recovery Project – Task Order No. 3
Dates of Service: 10/1/09—4/30/11 $Value 8,656.00

H. Company: U.S. Nuclear Regulatory Commissio n Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: "TA for the Developmental of a Final Supplemental Impact Statement for the Nichols Ranch I-Situ Uranium Recovery Project – Task Order No. 7"
Dates of Service: 10/1/09—2/11/11 $Value 374,322.00

I. Company: U.S. Nuclear Regulatory Commissio n Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: "TA for the Developmental of a Final Supplemental Impact Statement for the Lost Creek In-Situ Uranium Recovery Project – Task Order No. 8"
Dates of Service: 10/1/09—7/31/11 $Value 480,015.00

J. Company: U.S. Nuclear Regulatory Commissio n Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: TA for the Development of a Final Supplemental Environmental Impact Statement for the Moore Ranch In-Situ Uranium Recovery Project – Task Order No. 9
Dates of Service: 10/1/09—10/1/10 $Value 265,394.00

K. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Revision of Statistical Methods for Evaluation of Water Quality in the Standard Review Plan for In Situ Recovery Uranium Extraction Applications, NUREG 1568 - Task Order No. 11
Dates of Service: 4/12/10—10/11/10 $Value 31,171.80

L. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Development of Fact Sheets for Uranium Recovery Facilities - Task Order No. 12
Dates of Service: 3/22/10—10/31/10 $Value 112,710.00

M. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: "Evaluation of Land Application as Appropriate Method for Disposal of Liquid Wastes at Uranium In-Situ Recovery Facilities – Task Order No. 15"
Dates of Service: 4/8/10—9/15/10 $Value 69,953.00

N. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Hydrogeologist/Hydrologist to Support Decommissioning and Uranium Recovery Activities - Task Order No. 22
Dates of Service: 9/29/10—9/28/12 $Value 65.40

O. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Technical Assistance in Support of Engineered Systems Working Session in Hanford, WA -Task Order No. 18
Dates of Service: 7/9/10—9/30/10 $Value 40,000.00

P. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Technical Assistance for the Identification of References and Development of an Outline for an Environmental Topical Report on Reprocessing Facilities-Task Order No. 19
Dates of Service: 7/16/10—1/15/11 $Value 272,598.00

Q. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: "Technical Safety Review of Crow Butte Resources, Inc. License Amendment Application for the Three Crow Project Task Order No. 20"
Dates of Service: 9/9/10—9/30/11 $Value 60,000

R. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Hydrogeologist/Hydrologist to Support Decommissioning and Uranium Recovery Activities - Phase 003
Dates of Service: 9/29/10—9/28/12 $Value 6,101.45

S. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Development of Fact Sheets for Reactor and Complex Materials Facilities Undergoing Decommissioning
Dates of Service: 9/23/11—9/28/12 $Value 236,735.00

T. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Titan Uranium Heap Leach Safety Review
Dates of Service: 9/23/11—3/31/12 $Value 84,000

U. Company: U.S. Nuclear Regulatory Commission Contact: Valerie Whipple, Contracts Officer
Phone: (301) 492-3628 Fax (301) 492-3437
Project: Titan Heap Leach Environmental Review
Dates of Service: 9/23/11—3/31/12 $Value 45,000.00

V. Company: _____ Contact: _____
Phone: ( ) _____ Fax ( ) _____
Project: _____
Dates of Service: _____ $Value _____

W. Company:_____Contact:_____
Phone: ( )_____Fax ( )_____
Project:_____
Dates of Service:_____$Value _____

X. Company:_____Contact:_____
Phone: ( )_____Fax ( )_____
Project:_____
Dates of Service:_____$Value _____

Y. Company:_____Contact:_____
Phone: ( )_____Fax ( )_____
Project:_____
Dates of Service:_____$Value _____

Z.

3.a EXPERIENCE

Southwest Research Institute® (SwRI®) has been performing work related to the nuclear fuel cycle, including uranium mining, milling, and waste management since 1987 through the Center for Nuclear Waste Regulatory Analyses (CNWRA®). CNWRA is a federally funded research and development center (FFRDC) chartered by the U.S. Nuclear Regulatory Commission (NRC) and is part of the Geosciences and Engineering Division (GED) at SwRI. In addition to assisting NRC, CNWRA conducts research and development for non-Federal governmental organizations and commercial clients throughout the United States and abroad. Our professional staff of 61 scientists and engineers covers the following disciplines:

Figure 3-1. The Center for Nuclear Waste Regulatory Analyses Offices in San Antonio, Texas

- Hydrology and Hydrogeology
- Geochemistry
- Health Physics / Nuclear Engineering
- Geology and Geophysics
- Corrosion Science and Process Engineering
- Mining, Geotechnical, and Facility Engineering
- Performance and Risk Assessment
- Environmental Assessment
- Regulatory Analysis

Although CNWRA's main office (Figure 3-1) is in San Antonio, Texas, CNWRA also maintains an office in Rockville, Maryland to support NRC and our other clients on the East Coast.

CNWRA is particularly strong in the area of risk assessment related to the nuclear fuel cycle including probabilistic assessment of natural hazards to engineered structures, and fate and transport of radioactive and chemical contaminants in air, soil, and water (Figure 3-2).

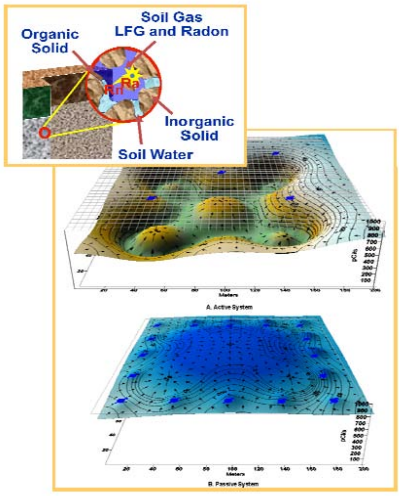

Figure 3-2. Processes Controlling Radon Emissions in a Landfill and Simulated Radon Surface Fluxes

Assisting CNWRA in the Department of Health Uranium Study will be Exponent Engineering and Scientific Consulting (Exponent) and Clear Creek Associates (Clear Creek), a small business enterprise certified with the State of Virginia. Exponent has extensive experience and expertise in toxicology and epidemiology, and has applied this expertise to matters related to environmental releases from mining projects. Exponent will focus its efforts on the non-radiological health issues related to uranium mining in Virgina, while CNWRA will focus on the nature of potential releases of contaminants from uranium mining and radiologic health effects. Clear Creek has extensive experience in hydrology and hydrogeology related to hard rock mine development, operation, and management of environmental impacts. Clear Creek will also provide local support on matters concerning impacts to local water supplies and regulations concerning these water supplies.

Coordination between the project team members and the Commonwealth of Virginia staff will be maintained through on-site meetings, teleconferences, and CNWRA in-house video conferencing facilities.

Experience of the Center for Nuclear Waste Regulatory Analyses in Risk Assessment Related to Uranium Mining, Milling, and Waste Management

CNWRA has provided support to NRC related to the uranium fuel cycle through scientific research and development of assistance in developing regulations and regulatory guidance for uranium milling and waste disposal. This expertise includes assessment of radiological human health effects from uranium mining and radioactive waste management. Although NRC does not have regulatory authority for uranium mining per se, NRC does regulate uranium extraction in the form of *in-situ* leaching as well as conventional milling, and disposal of residuals from these processes in the form of tailings impoundments and ponds. CNWRA has also provided extensive support to NRC for environmental assessments of uranium recovery projects. Specific projects that CNRWA has performed related to uranium mining, milling, and waste management are listed in our offeror's data sheet, RFP Attachment A.

Independence of Southwest Research Institute®

Since it was established in 1947, SwRI has been a source of independent research and development benefiting government, industry, and the public. This independence extends to CNWRA, a federally funded research and development center operated by SwRI under sponsorship from NRC. As explained more fully in the following discussion, the demonstrated independence of SwRI and CNWRA has a solid foundation in regulation, policy, organization, operational considerations, and practice.

SwRI is organized and operated in accordance with section 501(c)3 of the U.S. Internal Revenue Code. This establishes SwRI and each of its operating units as non-profit entities. Because it lacks any profit motive, SwRI can withstand—and for decades has demonstrated its ability to resist—undue outside influences and render sound and unbiased technical advice. The executive and division management of SwRI reports to an independent Board of Directors. The statement of purpose in the SwRI corporate by-laws reinforces the independence of the organization, stating that it is "to provide charitable, scientific testing for public safety, literary, or educational benefits in the public interest…" Operationally and practically, independence of SwRI is ensured by the fact that it works for such a broad spectrum of public and private entities on such a large number of projects (several thousands in any given year) that it does not depend on any one or a few organizations for financial support.

Within SwRI, CNWRA is organized as a FFRDC. The regulations (see 48 CFR 35.017) are clear that any FFRDC must be established and operated in a manner that fosters and assures that independent advice and counsel are provided to the sponsoring agency. Specifically, it must "…conduct its business in a manner befitting its special relationship with the Government, to operate in the public interest with objectivity and independence, to be free from organizational conflicts of interest, and to have full disclosure of its affairs…" To fulfill these requirements, an FFRDC must be a non-profit entity and, even if it is operated by a non-profit (which is the case for CNWRA) another level of independence is required by regulation, which mandates that the FFRDC be operated as "an identifiably separate operating unit…" within the parent organization.

CNWRA provides technical assistance and research support to NRC on matters related to uranium extraction, within the above framework of independence. Over the years, CNWRA has

provided assistance in developing standard review plans for guiding reviews of uranium extraction license applications, reviewing safety aspects of license renewals and amendments, evaluating mine/mill tailings impoundments, analyzing proposed alternative concentration limits, and assessing and reviewing environmental impacts related to uranium extraction operations. Regulatory guidance documents serve the dual purposes of providing instructions to staff conducting the reviews and informing potential applicants about what is needed in license applications to meet regulatory requirements. The charter and contract for operation of CNWRA explicitly speak to its responsibility to provide independent advice and counsel, including in areas where it is not currently tasked. In addition, under this award-fee contract, one of the evaluation criteria deals with the degree to which CNWRA provides independent products and services. Furthermore, CNWRA conducts a large number of projects for various clients, which further ensures its independence from outside influence.

Finally, both SwRI and CNWRA have formal processes for evaluating potential for organizational and individual conflicts of interest (COI) to ensure the independence of its work. At the corporate level, the SwRI Central Proposal Office evaluates potential for COI before any proposal is developed and submitted. This evaluation is led by the SwRI Executive Vice President, and participated in by the Chief Financial Officer, Vice President Legal and General Counsel, and Executive Director Contracts. At the division level, CNWRA evaluates and documents the independence and freedom from COI of each staff member, consultant, and subcontractor used on each project it conducts. These policies, procedures, and practices have been effective for decades, and will be applied to the proposed program. Our analysis concludes that CNWRA undertaking the proposed work for the State of Virginia will not give rise to any organizational or individual conflict of interest.

Background for Southwest Research Institute®

SwRI, headquartered in San Antonio, Texas, is one of the oldest and largest independent, nonprofit, applied research and development (R&D) organizations in the United States. Founded in 1947, SwRI provides contract research and development services to industrial and government clients in the United States and abroad.

SwRI offers multidisciplinary, problem-solving services in a variety of areas in engineering and the physical sciences. Historically, more than 4,000 projects are open at the Institute at any one time. These projects are funded almost equally between the government and commercial sectors. SwRI's total revenue for fiscal year 2011 was $581 million. In 2011, SwRI funded $6.1 million to its internally sponsored R&D program, which is designed to encourage new ideas and innovative technologies.

SwRI's headquarters occupies more than 2 million square feet of office and laboratory space on more than 1,200 acres in San Antonio. The Institute has business offices in Houston and Washington and technical offices and (Figure 3-3) laboratories in

Figure 3-3. Southwest Research Institute® Campus in San Antonio, Texas

Ann Arbor, MI	Layton, UT
Atlanta, GA	Lorton, VA
Beijing, China	Minneapolis, MN
Boulder, CO	Oklahoma City, OK
Hill Air Force Base, UT	Rockville, MD
Hanover, MD	Warner Robins, GA

In addition, SwRI provides environmental monitoring expertise at munitions disposal sites at the Umatilla Army Depot in Hermiston, Oregon and the Pine Bluff Chemical Depot in Pine Bluff, Arkansas.

At the close of fiscal year 2011, SwRI staff numbered 3,046, including 275 professionals with doctorate-level degrees and 499 with master's level degrees. In 2011, staff members published 507 papers in the technical literature; made 500 presentations at technical conferences, seminars and symposia around the world; submitted 66 invention disclosures; filed 65 patent applications; and received 34 U.S. patent awards.

Background for Exponent Engineering and Scientific Consulting

Exponent Engineering and Scientific Consulting is a leading scientific and engineering consulting firm that conducts research to provide solutions to complex technical problems. Exponent's multi-disciplinary team of scientists, physicians, engineers, and business consultants performs in-depth research, rapid-response evaluations, and analysis in more than 90 technical disciplines. Its staff totals more than 800 located in 19 U.S. (including an office in Alexandria, VA, and in the District of Columbia) and 5 international locations, and includes more than 350 Ph.D.s and M.D.s who collaborate across scientific and engineering fields to assist our clients in strategic decision making.

Exponent is nationally and internationally recognized as a leader in the development and implementation of approaches for assessing and managing human health and ecological risks. Exponent's Health Sciences staff members specialize in investigation of human health and environmental issues. Exponent's health scientists apply a multi-disciplinary approach to successfully address health questions and provide novel perspectives, insights, and innovative solutions in today's rapidly evolving world, both technologically and socially. Major divisions within the health sciences practice include exposure assessment, toxicology, public health and industrial hygiene, epidemiology and biostatistics, and food and chemical regulation. Exponent's rigorous internal quality control programs, experienced project management, and technical expertise ensure accuracy in Exponent's research methods and results. Exponent's quality management system is continuously assessed independently against the most recognized and comprehensive international standard for quality management, the International Standards Organization (ISO) 9001.

Background for Clear Creek Associates

Clear Creek Associates is a groundwater consulting firm that specializes in hydrogeologic studies, environmental investigations, and groundwater modeling. Clear Creek supports both municipal and industrial clients, and has a particular expertise in understanding the hydrologic effects of large-scale mining operations and managing groundwater resource and hydrogeologic investigations in fractured bedrock settings.

Founded in Scottsdale, Arizona in 1999, Clear Creek has expanded to include offices in Tucson, Arizona; Claremont, California; and, in 2009, Leesburg, Virginia. Clear Creek is a growing business and plans to continue to develop and grow in Virginia. In fiscal year 2011, the company's total revenue was $5.5M. Clear Creek is certified as a Virginia Small Business (#697428) under the categories of Environmental Consulting and Groundwater Consulting.

At present, Clear Creek has 32 staff members consisting of highly-qualified geologists, hydrologists, engineers, and legal and business-management professionals, with most individuals having at least fifteen years of professional experience. Clear Creek's staff is highly

regarded and includes the National Groundwater Association's (NGWA) 2012 McEllhiney Lecturer (Mr. Marvin Glotfelty), the 2012 national president of the American Institute of Professional Geologists (AIPG)(Ms. Barbara Murphy), as well as 16 staff members who are professionally licensed, and are active in national or regional professional societies.

Team Experience to Address the Statement of Needs

The CNWRA team experience and qualifications to address each of the components of the Statement of Needs are described in the following section.

III. A. Statement of Needs—Initial Literature Analysis and Recommendations

To conduct research and provide a report that:

1. Virginia & Other Relevant Studies: Utilizing summary information prepared by the Uranium Working Group agencies from the existing Virginia uranium mining studies (that is, National Academy of Sciences/National Academies Press [NAS/NAP], Virginia Beach, Roanoke River Basin, Chmura, as well as other relevant studies), and make recommendations relevant to the Board of Health's mission to protect public health and the environment. The summary should include, but not be limited to: uranium milling and mining, public drinking water systems, private wells, cisterns, springs, and recreational water issues, human and animal health (including occupational and reproductive health; teratogenesis; mutagenesis; carcinogenesis; unintentional injury; chronic disease; and toxic exposures (both acute and chronic), silicosis, and other unusual occurrences of diseases of public health concern with special attention to vulnerable populations such as infants and children).

a) Review available scientific literature on: 1) epidemiologic studies measuring long-term effects of exposures to radioactive materials and toxic substances as might be encountered in mining operations of the type proposed for Virginia; 2) limitations of available studies and recommendations of public health experts on design of relevant studies.

b) Assist VDH with development of surveillance and epidemiologic studies to evaluate short and long term health effects associated with mining. Studies must include consideration of sources for accurate, valid baseline levels of materials of concern in the environment and in animals and humans.

2. Existing Regulatory Programs: Compares existing uranium mining and milling regulatory programs including Nuclear Regulatory Commission (NRC), any agreement state programs, and international programs (such as Canada and France) and recommends provisions from within those regulatory programs that are relevant to the Board of Health's mission as described above. Identify where additional requirements may be appropriate to accommodate Virginia-specific population density, rainfall, climate, water table levels, and unique geography.

3. International Emerging Standards: Summarizes pertinent information and studies from such groups as the International Atomic Energy Agency, the World Nuclear Association, etc. and provides recommendations based on this review that are relevant to the Board of Health's mission as described above, including modern best international practices and other emerging standards and technologies. Identify internationally accepted best practices that can be implemented to mitigate the risk of radioactive releases, discussing technologies available to reduce emissions and maintain a focus on pollution prevention and reduction, including strategies for emergency hazards enumerated in the Commonwealth of Virginia Emergency Operations Plan.

Center for Nuclear Waste Regulatory Analyses Experience

CNWRA routinely utilizes reports, especially summaries of reports, to provide recommendations for developing and revising regulatory frameworks. With regard to uranium milling, CNWRA has reviewed reports and developed recommendations for NRC to consider when developing regulatory guidance on conventional milling and *in-situ* recovery uranium milling. Projects CNWRA has completed include:

- Revision of standard review plan for *in-situ* leach uranium extraction license applications, NUREG–1569

- Development of standard review plan for conventional mill and heap leach facilities

In addition, CNWRA reviewed reports, including international standards, to recommend regulatory guidance for land disposal of liquid wastes at *in-situ* uranium recovery facilities. Examples are

- Evaluation of land application as an appropriate method for disposal of liquid wastes at uranium *in-situ* recovery facilities.

- Revision of statistical methods for evaluation of water quality in the standard review plan for *in-situ* recovery uranium extraction applications, NUREG–1569.

The following are some specific projects that CNWRA has completed that are particularly relevant to this Statement of Needs.

Technical and Regulatory Analysis To Support Development of a New U.S. Nuclear Regulatory Commission Regulation Governing Uranium Mining and Recovery

This project assisted NRC in establishing regulations specifically for application to all uranium recovery facilities. Existing NRC regulations at 10 CFR Part 40, “Domestic Licensing of Source Material,” apply broadly to all facilities receiving title to, receiving, possessing, using, transferring, or delivering source and byproduct materials. These regulations have been used for uranium recovery licensing but do not address *in-situ* leaching facilities, which comprise the majority of current uranium extraction operations in the United States. In addition, NRC wished to address use of uranium mill tailings impoundments as a potentially cost-effective location to dispose of materials from reclamation and cleanup of other fuel cycle facilities and to resolve inconsistencies, inadequacies, and operational problems identified during application of 10 CFR Part 40 and other NRC regulations to uranium mining and extraction facilities, resulting in a stand-alone regulation for these facilities.

CNWRA activities that were completed under the task included development of a report identifying issues to be addressed in 10 CFR Part 41 including (i) clarifications or improvements to existing regulatory requirements, (ii) inconsistencies or conflicts within or among existing regulations, (iii) operational problems identified during implementation of existing regulations, (iv) requirements necessary for regulating *in-situ* leaching facilities, (v) incorporation of NRC decisions and policies that have been effected since the completion of 10 CFR Part 40, and (vi) criteria for disposing of materials from reclamation and cleanup of other fuel cycle facilities. CNWRA also prepared the Regulatory Analysis, including the Small Business Regulatory Enforcement Fairness Act Analysis.

The final report from this project included text for a proposed new NRC regulation that included specific recommendations for acceptable contaminant concentrations and radioactivity levels.

Prepared a Baseline Risk-Informed, Performance-Based Approach For *In-Situ* Leach Uranium Extraction Licensees

This project drew upon extensive CNWRA involvement in regulation of *In-Situ* leach Uranium Recovery facilities and processes for the NRC. The report was published as an NRC NUREG series document and remains in wide use by NRC and Uranium Recovery licensees. The report included a description of *in-situ* leach facilities operations including plant operation; aquifer restoration; instrumentation; waste management; reclamation, decontamination, and decommissioning; management controls and operating procedures; radiation safety controls and monitoring; respiratory protection program; bioassay program; contamination control programs; groundwater and surface water monitoring programs; management audit and control program; and reporting requirements.

The report also included (i) an approach to risk assessment that addressed surface environment chemical hazards, surface environment radiological hazards, groundwater chemical and radiological contamination hazards and (ii) consequence analyses that included chemical hazard consequence analyses for a variety of relevant chemicals, radiological hazard consequence analyses for a variety of substances and operations, groundwater contamination hazard consequence analyses, pregnant lixiviant field spill hazard consequence analysis, transportation hazard risk analysis, tornado hazard and consequence analysis, seismic hazard and consequence analysis, and performance measures. The report concluded with risk insights and recommendations for each of the areas for which consequence analyses had been conducted.

Updated U.S. Nuclear Regulatory Commission Regulatory Guides

CNWRA has contributed to updates and revisions to NRC regulatory guides addressing the following topics:

- Radiological Effluent and Environmental Monitoring at Uranium Mills
- Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)
- Bioassay of Effluent Streams and the Environment at Uranium Mills
- Standard Format and Content of License Applications for Uranium Mills
- General Guidance for Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills
- Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities
- Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings

- Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations

- Onsite Meteorological Measurement Program for Uranium Recovery Facilities—Data Acquisition and Reporting

- Calculation of Radon Flux Attenuation by Earthen Uranium Mill Tailings Covers

- Standard Format and Content of Decommissioning Plans for Materials Licensees

Updates to and Revision of U.S. Nuclear Regulatory Commission Standard Review Plans for Uranium Recovery Facilities

This tasking included updates or revisions to NRC standard review plans for licensing actions under requirements of both Title I and Title II of the Uranium Mill Tailings Radiation Control Act.

Exponent Engineering and Scientific Consulting Experience

Exponent Engineering and Scientific Consulting is well prepared to conduct the literature review and analysis by its extensive experience researching, synthesizing, and summarizing chemical hazard and safety information, potential health and environmental exposures and risks of metals and other chemicals, emerging national and international regulatory guidance and standards, and technologies for pollution prevention and reductions, as illustrated in the following examples:

- Exponent toxicologists and environmental scientists contributed to the EPA Metals Framework Guidance and have published a summary of the application of this guidance to assessing the health and ecological risks of metals in the environment.[1]

- Exponent was commissioned by the Tennessee Valley Authority to write comprehensive white papers summarizing the state of the science regarding health and environmental effects of arsenic and of selenium, and the potential release of these substances from coal ash. These papers were made available to the general public at: http://www.tva.com/ kingston/exponent /index.htm.

- Exponent epidemiologists and toxicologists conducted and published a meta-analysis of low-level arsenic exposure and bladder cancer risk[2] as well as a meta-analysis of hair dyes and the risk of bladder cancer (findings published in Cancer Causes & Control).

III. B. Statement of Needs—Ongoing Technical Advice and Assistance to Commonwealth of Virginia Staff

1. Coordinate with VDH staff and be available to attend at least monthly progress meetings to develop analyses of the following items and to develop and provide a final report. The Contractor must be available to meet with VDH staff, either face-to-face or via conference calls, as needed to develop interim deliverables and the final report that:

[1]Menzie, C.A., L.M. Ziccardi, Y.W. Lowney, A. Fairbrother, S.S. Shock, J.S. Tsuji, D. Hamai, D. Proctor, E. Henry, S.H. Su, M.W., Kierski, M.E. McArdle, and L.J. Yost. "Importance of Considering the Framework Principles in Risk Assessment for Metals." *Environm Sci Techno.* Vol. 43, No. 22. pp. 8,479–8,482. 2009.
[2]Mink, P.J., D.D. Alexander, L.M. Barraj, M.A. Kelsh, and J.S. Tsuji. "Low-Level Arsenic Exposure in Drinking Water and Bladder Cancer: A Review and Meta-Analysis. *Regul Toxicol Pharmacol.* Vol. 52. pp. 299–310. 2008.

a) Compares the Commonwealth's existing statutes and regulations to recommendations in the initial report (referenced in Part I above);

b) Identifies areas where VDH's existing regulations might need to be modified or expanded to ensure protection of public health and the environment;

c) Recommends changes (including statutory changes) to meet these needs.

d) Evaluation must include a review of the following:

1) Waterworks Regulations (12VAC5-590 et seq.);

2) Disease Reporting and Control Regulations (12VAC5-90-90 et seq.) (requirements for reporting by healthcare providers and laboratories);

3) Private Well Regulations (12VAC5-630 et seq.) Develops conceptual framework and initial project costs to determine the impact on quantity and quality of water in private wells and springs and recommended procedures for replacing or remediating affected supplies. Framework should be capable of characterizing an inventory of impacted wells, springs, recreational waters and cisterns.

4) Facilitate the stakeholder process, including any potentially inspected regulated community (at least 5 statewide meetings with separate final report) to gauge concerns and identify possible solutions concerning regulation of public water supplies and private wells as to water quality and quantity.

5) Regulations concerning recreational use of waters (campgrounds, summer camps, etc.).

e) Determines and characterizes available data (including national and Virginia-specific data) on potential health outcomes related to exposures of concern. Determines if current reporting requirements and laboratory testing capability cover chemicals likely to be encountered in mining operations under consideration. Determines if current tobacco use surveillance is adequate for establishing baseline data for rates of lung cancer, silicosis, and radon-associated health problems using standard epidemiological analytic methods. Determines whether other available data is sufficient to establish baseline rates for conditions of concern (e.g., current silicosis reporting data) or if retrospective or other studies are indicated to determine baseline rates. Evaluate and propose changes to cancer, congenital malformation reporting if necessary.

f) Develop and test case report investigation worksheets and other documents for local Health Department and Central Office use in any necessary investigations for relevant health outcomes.

g) Determine locus of responsibility for the long-term monitoring of adverse health effects ensuring worker health and safety as well as additional recommended monitoring.

h) Monitoring work spaces, monitoring exposures for mine workers, tracking of worker cumulative exposures, adequacy of existing MSHA regulations and comparisons with international standards for radon and radon daughters.

i) Develops a recommended framework for environmental, human health and animal health monitoring so that data can be maintained in compatible systems for analyzing health effects, including long term monitoring.

j) Determines potential impacts (if any) on cisterns and onsite sewage systems.

CNWRA has assembled a team of scientists and engineers with expertise in the environmental issues and regulation of uranium mining and ore processing, and leading epidemiologists, toxicologists, environmental scientists, industrial hygienists, statisticians, and clinicians with expertise in conducting complex occupational and environmental health studies. Our team will assist the Virginia Department of Health with the development of surveillance and well-designed epidemiologic studies to evaluate short- and long-term health outcomes associated with mining operations as determined in our proposed literature review. Recommendations will be provided on scientifically rigorous studies that implement guidelines on accurately assessing exposures of concern and potential health endpoints as indicated by human and animal studies.
The following project summaries demonstrate the experience of the project team in performing work similar to that required by the above Statement of Needs.

Center for Nuclear Waste Regulatory Analyses Experience

CNWRA routinely coordinates with NRC in the development of new regulations and guidance related to the nuclear fuel cycle, and uranium processing and waste disposal. Commonly, coordination is conducted for financial and programmatic items as well as technical items. These meetings can consist of a diverse group of individuals with different viewpoints. CNWRA has experience working in small and large groups to achieve general and specific work objectives. Because NRC is a regulator and a principal client, CNWRA is very familiar with issues associated with statutory jurisdictions, developing regulations that are protective of public health and the environment, and revising regulations where necessary.
In addition, CNWRA has experience ensuring that uranium milling applicants meet regulations established by NRC and EPA. This experience has come from reviewing the new, renewal, and amendment uranium milling license applications for NRC listed below:

- Crow Butte Resources, Inc. license renewal application;
- Health physics review of Uranerz Energy Corporation license application for Nichols Ranch *in-situ* uranium recovery;
- Revision of standard review plan for *in-situ* leach uranium extraction license applications, NUREG–1569;
- Technical assistance for the development of supplemental environmental impact statement for the Dewey Burdock *In-Situ* Recovery Project;
- Development of standard review plan for conventional mill and heap leach facilities;
- Technical assistance for the development of a final supplemental environmental impact statement for the Nichols Ranch *In-Situ* Uranium Recovery Project; and
- Development of the technical basis for revision of Regulatory Guide 8.30, “Health Physics Surveys In Uranium Recovery Facilities.

CNWRA staff also participated with NRC in public meetings conducted with respect to development of 10 CFR Part 63 and the Yucca Mountain Review Plan.

Exponent Engineering and Scientific Consulting Experience

The work, as described in the RFP, will be conducted as a collaborative effort between Virginia Department of Health staff, the consulting scientists, and with significant input from stakeholders. Therefore, experience and aptitude for engaging stakeholders, working towards consensus in groups with diverging interests, and effectively facilitating stakeholder input under sometimes difficult circumstances will be critical for the success of the Uranium Study. Two strengths of Exponent scientists are the ability to (i) synthesize and communicate complex scientific and technical issues to non-scientists and lay audiences and (ii) facilitate and work collaboratively with diverse groups of stakeholders. Exponent scientists have participated in and chaired numerous scientific panels and regulatory advisory groups, presented complex technical issues to city, state, and federal legislators, and worked collaboratively with state health and environmental agencies to develop and improve water, sediment, and air quality guidelines. Exponent scientists are often engaged to assess critical issues of great public concern and have often presented their findings at public meetings and with concerned citizens. Exponent would bring this experience to the Uranium Study.

As an example, Exponent scientists designed and implemented a comprehensive stakeholder participation program as part of their involvement in an environmental investigation and risk assessment at a mine in northwest Alaska. Engaging a diverse group of stakeholders was critical to the project's success. The efforts included numerous public meetings of varying format, multi-day workshops, regular update and strategy meetings with state regulators, and development of a technical review workgroup.

Exponent conducted an arsenic biomonitoring and environmental exposure study of over 400 residents in a small community in New York State.[3] This effort involved several public meetings and extensive interaction with participants and the community. The purpose of the study was to address questions by the public and regulatory agencies regarding whether residents were being exposed to elevated arsenic levels in soil.

Exponent project staff, Drs. Michael Garry and Joyce Tsuji, provided health risk and toxicology support to Salt Lake City and its citizens in the aftermath of a petroleum company's pipeline rupture that spilled crude oil in Red Butte Creek and sickened a number of residents in the community.

Extensive work has been done at Exponent to quantify the association between occupational trichloroethylene (TCE) exposure and risk of liver cancer, non-Hodgkins lymphoma, multiple myeloma, and leukemia. Analyses conducted by Exponent staff in this area of research are the most comprehensive and current quantitative evaluations of TCE exposure and cancer risk in humans (findings have been published in top peer-reviewed scientific journals such as the *International Archives of Occupational* and *Environmental Health* and *Occupational Medicine*).

Exponent scientists drafted technical/scientific guidance for conducting hazard and risk assessment of alloys suitable for meeting emerging international regulatory systems [e.g., Globally Harmonized System of Classification and Labeling of Chemicals (GHS),

[3]Tsuji, J.S. M.D. Van Kerkhove, R.S. Kaetzel, C.G. Scrafford, P.J. Mink, L.M. Barraj, E.A. Crecelius, and M. Goodman. "Evaluation of Exposure to Arsenic in Residential Soil."" *Environ Health Perspect.* Vol. 113, No. 12. pp. 1,726–1,740. 2005

Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)] for chemical risk assessment and hazard classification protective of human health. The guidance specifically addressed methods for assessing hazards based on particular characteristics of the alloys, metal speciation, and protocols for bioaccessibility testing to predict bioavailability.

Exponent scientists participate on state, national and international expert panels [e.g., U.S. Environmental Protection Agency (EPA) Science Advisory Board, U.S. National Academy of Sciences, Institute of Medicine, National Institute of Environmental Health Sciences, World Health Organization, Health Canada, and United Kingdom Environment] and, therefore, bring cutting-edge knowledge of scientific advances and regulatory practices in the area of chemical exposure, hazard assessment, and risk reduction.

Please see Table 3-1 for an overview of several selected environmental and occupational epidemiologic studies conducted by Exponent. Projects that have involved public health risk communication activities are also included in Table 3-1.

Table 3-1. Select Environmental and Occupational Epidemiologic Studies Conducted By Exponent Engineering and Scientific Consulting

Project Title	Location	Contract Duration
Environmental Health Assessment Study Among Residents	Idaho	September 2011 to present
Community Health Study of Vinyl Chloride and Brain Cancer	Illinois	2010
Cancer Mortality and Oil Production in the Amazon Region of Ecuador	Ecuador	June 2006 to March 2007
Biomonitoring and Environmental Assessment of Community Arsenic Exposure	Middleport, New York	2003-2004
Cancer Mortality Study of Possible Residential Chromium Exposures	Willits, California	2002–2003
Assessment of Perchlorate Exposure and Newborn Thyroid Function	California	2002-2007
Review of Delaware Department of Public Health Report	Indian River Area and Delaware	Six weeks
Environmental Cause of Orofacial Cleft Defects	Harris County, Texas	Non-Funded Research Project
Investigation of Brain Tumors in Petroleum Research Workers	California	2002-2005
Assessment of TCE* Exposure and Health Effects in Aerospace Workers	Arizona	1996-1998
Occupational Health Study of Radio Frequency	Arizona, Illinois, and Florida	1996-2001
Weather Factors and Cardiovascular, Infectious Disease, and Asthma	California	2003-2004
Occupational EMF† Exposures and Cardiovascular Disease	United States	2004-2005
Radiation Treatment and Mesothelioma Incidence	United States	2006-2007
*TCE = trichloroethylene †EMF = electric magnetic fields		

Exponent has extensive experience in identifying the most pertinent data sources for characterizing multiple health outcomes associated with toxic exposures. In the recent

past, epidemiologists at Exponent have conducted retrospective cohort and ecologic studies of cancer incidence, as well as other chronic disease endpoints, using publically-available data sets.

Exponent physicians and epidemiologists have a significant amount of experience in developing and testing case report investigation documents for relevant health outcomes. For example, Dr. Mark Roberts spent 17 years in the Oklahoma State Department of Health, Epidemiology Section, and has extensive public health expertise involving infectious disease and environmental health issues. During his time at the State Department of Health, he directed investigations ranging from foodborne illness to disease clusters surrounding landfills, hazardous waste sites, and refineries. He developed intake forms for incoming calls to use as a reporting tool on all investigation activities. The investigations that were initiated by Dr. Roberts from these intake forms were varied and resulted in numerous epidemiologic studies. The majority of the study findings were published in the Oklahoma State Department of Health Disease Bulletin; however some results were published in the CDC's Morbidity and Mortality Weekly Report. Dr. Mark Roberts will serve in a senior advisory capacity on epidemiology and public health issues on this project.

Exponent's project team includes scientists with expertise in regulations for disease reporting and control, as well as team members with laboratory testing capabilities. As such, we will be able to determine if current reporting and laboratory methods cover chemicals likely to be present in uranium mining operations under consideration. Our team includes physicians (e.g. Mark Roberts, M.D., Ph.D) and former directors of laboratories (e.g. Gary Mosher, CIH) with years of experience in performing these analyses.

Several staff members at Exponent have expertise in working with a variety of surveillance systems. For example, we have designed and constructed workplace injury surveillance systems, analyzed trends in workplace injuries, and evaluated occupational injury, illness, and fatality data from multiple databases including that of OSHA. We have also analyzed data from numerous traffic safety surveillance databases (e.g. FARS, NASS GES, NASS CDS and state motor vehicle crash databases) to assess vehicle safety, effectiveness of daytime running light use, and other factors influencing automotive crash risks.

As noted above for arsenic, Exponent scientists have considerable experience in designing and conducting biomonitoring studies to evaluate populations potentially exposed to chemicals in the environment, including soil, water, and food-chain exposures for residential, recreational, and subsistence populations.[4,5,6] Exponent scientists have also designed and assessed community exposure prevention programs for metals in the environmental as a result of mining and smelting.

Exponent industrial hygienists have the depth and breadth of experience to design, execute, and/or make recommendations on long-term monitoring of adverse health effects ensuring

[4]Tsuji, J.S., M.D. Van Kerkhove, R.S. Kaetzel, C.G. Scrafford, P.J. Mink, L.M. Barraj, E.A. Crecelius, and M. Goodman. "Evaluation of Exposure to Arsenic in Residential Soil. *Environ Health Perspect.* Vol. 113, No. 12. pp. 1,736–1,740. 2005.

[5]Tsuji, J.S., P.R.D. Williams, M.R. Edwards, K.P. Allamneni, M.A. Kelsh, D.J. Paustenbach, and P.J. Sheehan. "Evaluation of Mercury in Urine As An Indicator of Exposure to Low-Levels of Mercury Vaor. *Environ Health Perspect.* Vol. 111, No. 4. pp. 623–630. 2003.

[6]Tsuji, J.S. and S. Robinson. "Separating Potential Source Exposure From Background Exposure in Subsistence Populations in Developing Countries." *Toxicology.* Vols. 181–182. pp. 467–470. 2002.

worker health and safety.[7,8,9] Members of our Center for Occupational and Environmental Health have served as corporate health and safety directors, occupational physicians, radiation safety officers and industrial hygienists. We have worked in mining environments, developed and implemented radiation health and safety plans, and monitored workplace environments to assess potential risks to human health. Exponent also has extensive experience with the technical matters and corporate issues involved with radioactive spills and decontamination of materials.

Recently, Exponent evaluated and commented on a new rule proposed by the Mine Safety and Health Administration (MSHA) regarding coal dust. Our industrial hygienists evaluated coal mining operations and tested a new dust sampling device in a laboratory setting. We also evaluated the unique sampling requirements proposed in this rule. In addition to the industrial hygiene issues, our epidemiologists evaluated long term health effects related to coal dust exposures, our risk assessors critiqued the health risk assessment conducted by MSHA and our economist evaluated the financial cost that would be imposed on mining companies if the rule were to be enacted. Comments were made at public meetings and our reports were formally submitted to MSHA.

Exponent industrial hygienists and health scientists have substantial experience gathering personal air samples, assisting agencies and companies in interpreting the results and implementing changes when necessary. These efforts have occurred under State and Federal environmental and/or occupational health guidelines, including the Occupational Safety and Health Administration (OSHA) and MSHA. Exponent staff have reviewed, made recommendations for improvement, and designed environmental and medical monitoring programs to assess occupational exposures. For example, at the Red Dog lead/zinc mine in Northwest Alaska, Exponent scientists conducted a review of the occupational health program and developed a comprehensive Risk Management Plan for protection of worker health from exposure to metals and dust. The plan included a review of the existing program, prioritization for implementation of improvement, and quantifiable milestones for monitoring effectiveness of the program.

III. B. 2. Statement of Needs—Water Quality Monitoring

a) Water Quality Monitoring plan for surface waters, including but not limited to:
1) Human health risks associated with chemical toxicity;
2) Human health risks associated with radiological toxicity; and,
3) Human health risks associated with consumption of affected animal and marine populations.

b) Water Quality Monitoring plan for groundwater, including but not limited to:
1) Human health risks associated with chemical toxicity;

2) Human health risks associated with radiological toxicity;

[7]Dahlstrom, D.L.and P. Jonmaire. "Occupation Health and Safety Programs for Hazardous Waste Workers." *Protecting Personnel at Hazardous Waste Sites.* Chapter 3, 2nd Edition. W.F. Martin, ed. Stoneham, Butterworth-Heinemann. 1999.
[8]Dahlstrom, D.L., S.J. Sherman, and P. Jonmaire. "Occupational Health and Safety Programs for Hazardous Waste Workers. *Protecting Personnel at Hazardous Waste Sites.* Chapter 3, 2nd Edition. S.P. Levine and W.F. Martin, eds. Stoneham, Butterworth-Heinemann. 1993.
[9]Dahlstrom, D.L. J. Melius, and R. Castello. "Medical Survelillance Programs. *Occupational Medicine.* Chapter 32, 2nd Edition. C. Zenz, ed. Chicago, Illinois: Yearbook Medical Publishers. 1986.

3) Human health risks associated with consumption of affected animal and marine populations; and,

4) The potential impact on groundwater quality and quantity as these affect public wells, private wells and springs.

c) Adequacy of Virginia's Water Quality Standards for groundwater and surface waters, and Virginia's Waterworks Regulations as they relate to human health outcomes:

1) To address water-soluble radionuclides or absorbed chemicals;

2) To address the potential for undiluted tailings liquids to exceed existing Safe Drinking Water Act standards for uranium; and,

3) To address the potential for revised Public Drinking Water System's monitoring schedules for radiological contaminants and other hazardous substances within potentially impacted areas.

d) Evaluate the existing standards for the safe disposal of mine waste as it pertains to human health.

e) Evaluate necessary components of full environmental impact analysis.

f) Methods for incorporating "As Low As Reasonably Achievable" (ALARA) standards into Commonwealth regulations, like those that exist for radiological protection.

g) Recommendations for compliance period financial assurance mechanisms providing for minimization of long-term impacts to water resources and necessary remediation.

h) Recommendations for environmental monitoring, including but not limited to:
1) Required components of an environmental monitoring plan;
2) Recommended goals to include in an environmental monitoring plan; and,
3) Recommended baseline and characterization data needed.

i) Evaluation of NRC regulations for milling and tailings management given state-specific climate (e.g., rainfall) and hydrologic considerations.

Center for Nuclear Waste Regulatory Analyses Experience

CNWRA has conducted multiple projects that involved the evaluation of uranium mining and processing impacts on surface water, and has conducted similar evaluations of potential impacts of other sites contaminated with radioactive materials. The following is a list of projects involving such evaluations:

- Umetco Gas Hills Mining Company Above Grade Tailings Impoundment Technical Evaluation Report
- Technical Evaluation Report for the Plateau Resources Limited Shootaring Canyon, UT Reclamation Plan
- Technical Evaluation Report for the Kennecott Uranium Co. Sweetwater Uranium Project Reclamation Plan
- Technical Evaluation Report for the Pathfinder Mines Shirley Basin Reclamation Plan

- Review of the White Mesa, Blanding, UT, Reclamation Plan
- Completion of the Crowe Butte Environmental Assessment and Technical Evaluation Report
- Preparation of the Safety Evaluation Reports for the Cogema Christensen and Irigaray *In-Situ* Leach Facilities

Exponent Engineering and Scientific Consulting Experience

Dr. Michael Garry, Exponent's Principal Investigator for this project, is an expert in food chain transport of metals and other chemicals and fish consumption issues, and has advised municipalities on these issues as they relate to water and sediment quality guidelines in Washington State. Exponent scientists have applied their extensive regulatory experience in the relevant technical issues to review, comment on, and develop state guidance related to water quality.

Exponent scientists are currently conducting a multi-pathway evaluation of human health and ecological risks at a former phosphorous refinery site in Montana at which metals and radionuclides are the primary chemicals of concern. The site is located in a mixed residential and industrial area with associated occupational and public health issues, including the potential for impacts to private drinking water wells and a major surface water body with multiple beneficial use designations. In addition to risks associated with exposure to metals (arsenic, lead, cadmium, antimony and others), both chemical and radiological hazards associated with uranium, radon, and other radionuclides are being evaluated. The investigation is addressing transport of chemicals to groundwater and surface water from fugitive dusts, stack emissions, infiltration from the tailings pond, and surface runoff. The study will evaluate if Federal and State water quality guidelines for both direct contact (e.g., drinking water, recreational uses) and indirect exposures (transport through the food chain) are being met. Upon completion of the study, Exponent will make recommendations for remedial actions and/or monitoring where current conditions fall short of regulatory standards.

Exponent conducted a multidisciplinary assessment of the effects of fugitive dust associated with a lead/zinc mine in northwestern Alaska. Detection of elevated metals concentrations in sensitive tundra habitats raised community concerns about risks from subsistence foods and adverse effects to the environment. Our environmental engineers and scientists evaluated transport and fate, and conducted human health and ecological risk assessments for lead, zinc, cadmium and other metals in the areas surrounding the mine, road, and port facilities. A critical feature to the success of this project is the extensive efforts to work cooperatively with, and elicit substantive input from, all stakeholders to identify and prioritize issues, review ongoing studies, and plan for future efforts. This included regular community meetings and workshops with multiple regulatory agencies, village residents, Exponent developed a risk management plan to minimize the potential for effects of dust on human health and the environment over the life of the mine and is currently developing specific implementation plans within that framework, including a Worker Dust Protection Plan, a Communication Plan, a Monitoring Plan, and an Uncertainty Reduction Plan (the latter plan identifies specific studies needed to address data gaps and/or information needs to ensure public health). Each of these plans was designed to meet all Federal and State regulations, as well as more stringent internal guidelines.

As described previously (under Section III.B.1), Exponent scientists have also worked with State regulatory agencies responsible for water quality standards for the protection of public health and the environment.

Clear Creek Associates Experience

Clear Creek Associates has extensive experience in the characterization and remediation of environmental impacts to surface water and groundwater. This experience is illustrated by the following projects.

Clear Creek provides environmental consulting services for investigation of a groundwater sulfate plume and remedial actions conducted pursuant to a Mitigation Order on Consent between the Arizona Department of Environmental Quality and Freeport-McMoRan Sierrita, Inc. The sulfate plume has migrated beneath the developed area of Green Valley and impacted drinking water supplies.

Clear Creek provides hydrogeologic and water management consulting services to support the remediation conducted by Miami at the Pinal Creek Water Quality Assurance Revolving Fund Site. Releases of contaminants and hazardous substances have occurred from the mining and processing facilities, including: process solution impoundments, tailings piles, leach dumps, waste rock piles, spills, and as storm water runoff. Erosion of waste piles, especially tailings piles, has also resulted in the release of contaminants to water courses. Particulate fallout of wind-blown tailings and from copper smelters in the area has also contributed to the spread of contamination.

Since 1999, Clear Creek has provided hydrogeological consulting services to support investigation of groundwater impacts at the Cyprus Tohono Corporation Mine Site, south of Casa Grande, Arizona. In 2009, Freeport McMoRan Corporation and Cyprus Tohono Corporation entered into a Settlement Agreement with the U.S. Environmental Protection Agency (EPA) to conduct a groundwater Remedial Investigation/Feasibility Study at the Site. A primary component of this characterization and remediation project involves an evaluation of the generation, fate, and transport of radionuclides, including uranium and its decay elements, in mine materials, soil, and groundwater. Clear Creek performed groundwater and contaminant transport modeling to simulate radionuclide transport at the site.

Additionally, Clear Creek has coordinated and overseen installation of over sixty new monitor wells to characterize groundwater conditions over a 30 square mile area. Clear Creek was responsible for preparing the overall Conceptual Site Model (CSM), which describes site hydrogeology, contaminant transport pathways, and the nature and extent of groundwater impacts at the site. One key component of the CSM involved investigating and characterizing transport pathways in the vicinity of a mill tailings impoundment and former evaporation ponds.

Clear Creek evaluated the seepage generated by tailing impoundments totaling about 1,300 acres immediately adjacent to the Gila River at the Hayden Smelter complex near Winkelman, Arizona. Using the HELP Model (1997, Environmental Laboratory USAE Waterways Experiment Station; Version 3.07), Clear Creek simulated the infiltration of natural precipitation through the tailings and into the underlying groundwater system. Several scenarios were developed including scenarios with and without a 4-foot thick layered low-permeability cap. Sieve analyses of the tailings collected by Asarco staff were used to characterize the soil properties of the tailings for input to the model.

Since completion of this project, Clear Creek has been retained to manage the development of Best Available Demonstrated Control Technologies (BADCT) for dozens of facilities at the Smelter Complex. This work is on-going.

Clear Creek completed an assessment of current and future pit dewatering activities at the Bagdad Mine, including a review of the effectiveness of in-pit drain-holes and pumping from adjacent dewatering wells. The study relied on a review of existing geologic and hydrologic data and included field tasks to address key data gaps.

Clear Creek evaluated future pit dewatering needs for the Dos Pobres Open Pit mine in Safford, Arizona. The Dos Pobres pit currently extends to a depth of about 900 feet which is at or below the regional water table. Further deepening of the pit will result in groundwater flow into the pit. The hydrogeology of the pit area is complex as it is affected by a major fault that crosses the pit. To assess future pit dewatering needs, Clear Creek developed a cost-effective spreadsheet evaluation of groundwater flow that can be modified by mine engineers as conditions and mine plans change over time.

3.b Key Staff Qualifications

CNWRA has assembled a highly experienced in-house team of subject matter experts and subcontractors to meet the needs of the Workgroup under the tight time constraints of this project. Tables 3-2, 3-3, and 3-4 show the proposed team organization and individual assignments based on the Statement of Needs. Resumes of key staff are provided in Section 3.c.

Table 3-2. Staff Assignments
III. A. Statement of Needs—Initial Literature Analysis and Recommendations

Statement of Need	CNWRA Staff	Exponent Staff
1. Virginia & Other Relevant Studies: Utilizing summary information prepared by the Uranium Working Group agencies from the existing Virginia uranium mining studies (that is, National Academy of Sciences/National Academies Press [NAS/NAP], Virginia Beach, Roanoke River Basin, Chmura, as well as other relevant studies), and make recommendations relevant to the Board of Health's mission to protect public health and the environment. The summary should include, but not be limited to: uranium milling and mining, public drinking water systems, private wells, cisterns, springs, and recreational water issues, human and animal health (including occupational and reproductive health; teratogenesis; mutagenesis; carcinogenesis; unintentional injury; chronic disease; and toxic exposures (both acute and chronic), silicosis, and other unusual occurrences of diseases of public health concern with special attention to vulnerable populations such as infants and children).	J. Durham R. Benke	M. Garry V. Perez A. Santamaria
a) Review available scientific literature on: 1) epidemiologic studies measuring long-term effects of exposures to radioactive materials and toxic substances as might be encountered in mining operations of the type proposed for Virginia; 2) limitations of available studies and recommendations of public health experts on design of relevant studies.		
b) Assist VDH with development of surveillance and epidemiologic studies to evaluate short and long term health effects associated with mining. Studies must include consideration of sources for accurate, valid baseline levels of materials of concern in the environment and in animals and humans.	J. Durham R. Benke	S. McCarthy G. Mosher
2. Existing Regulatory Programs	J. Durham A. Ghosh S. Hsiung R. Lenhard	
3. International Emerging Standards	S. Hsiung A. Ghosh	D. Hoel

Table 3-3. Staff Assignments
III. B. 1. Statement of Needs—Ongoing Technical Advice and Assistance to Commonwealth of Virginia Staff

Statement of Need	CNWRA Staff	Exponent Staff	Clear Creek Staff
a) Compares the Commonwealth's existing statutes and regulations to recommendations in the initial report	All As Needed	All As Needed	

Table 3-3. Staff Assignments
III. B. 1. Statement of Needs—Ongoing Technical Advice and Assistance to Commonwealth of Virginia Staff

Statement of Need	CNWRA Staff	Exponent Staff	Clear Creek Staff
b) Identifies areas where VDH's existing regulations might need to be modified or expanded to ensure protection of public health and the environment	All As Needed	All As Needed	
c) Recommends changes (including statutory changes) to meet these needs	All As Needed	All As Needed	
d) Evaluation must include a review of the following:			
1) Waterworks Regulations (12VAC5-590 et seq.)	G. Walter		M. Alter
2) Disease Reporting and Control Regulations (12VAC5-90-90 et seq.)		S. McCarthy G. Mosher M. Roberts	
3) Private Well Regulations (12VAC5-630 et seq.)	G. Walter		M. Alter
4) Facilitate the stakeholder process	Project Manager	Subject Matter Experts As Needed	Subject Matter Experts As Needed
5) Regulations concerning recreational use of waters		M. Garry A. Santamaria	
e) Determines and characterizes available data on potential health outcomes related to exposures of concern		M. Garry V. Perez J. Tsuji	
f) Develop and test case report investigation worksheets and other documents for local Health		G. Mosher M. Roberts E. Anderson	
g) Determine locus of responsibility for the long-term monitoring of adverse health effects		G. Mosher M. Roberts E. Anderson	
h) Monitoring work spaces, monitoring exposures for mine workers etc	J. Durham R. Benke	G. Mosher	
i) Develops a recommended framework for environmental, human health and animal health monitoring	R. Benke	M. Garry A. Santamaria M. Roberts	
j) Determines potential impacts (if any) on cisterns and onsite sewage systems	G. Walter		M. Alter

Table 3-4. Staff Assignments
III. B. 2. Statement of Needs—Water Quality Monitoring

Statement of Need	CNWRA Staff	Exponent Staff	Clear Creek Staff
a) Water Quality Monitoring plan for surface waters			
1) Human health risks associated with chemical toxicity		M. Garry J. Tsuji	
2) Human health risks associated with radiological toxicity	J. Durham R. Benke	M. Garry D. Hoel	

Table 3-4. Staff Assignments III. B. 2. Statement of Needs—Water Quality Monitoring			
Statement of Need	**CNWRA Staff**	**Exponent Staff**	**Clear Creek Staff**
3) Human health risks associated with consumption of affected animal and marine populations		M. Garry A. Santamaria J. Tsuji	
b) Water Quality Monitoring plan for groundwater, including but not limited to			
1) Human health risks associated with chemical toxicity		M. Garry J. Tsuji	
2) Human health risks associated with radiological toxicity	J. Durham R. Benke	M. Garry D. Hoel	
3) Human health risks associated with consumption of affected animal and marine populations		M. Garry A. Santamaria J. Tsuji	
4) The potential impact on groundwater quality and quantity as these affect public wells, private wells and springs	G. Walter H. Başağaoğlu		M. Alter
c) Adequacy of Virginia's Water Quality Standards for groundwater and surface waters, and Virginia's Waterworks Regulations as they relate to human health outcomes			
1) To address water-soluble radionuclides or absorbed chemicals	J. Durham R. Benke		
2) To address the potential for undiluted tailings liquids to exceed existing Safe Drinking Water Act standards for uranium	J. Durham R. Benke	M. Garry D. Hoel	M. Alter
3) To address the potential for revised Public Drinking Water System's monitoring schedules	J. Durham R. Benke	M. Garry D. Hoel	
d) Evaluate the existing standards for the safe disposal of mine waste as it pertains to human health	A. Ghosh S. Hsiung	M. Garry	
e) Evaluate necessary components of full environmental impact analysis.	R. Lenhard		
f) Methods for incorporating "As Low As Reasonably Achievable"	J. Durham		
g) Recommendations for compliance period financial assurance mechanisms	A. Ghosh S. Hsiung		
h) Recommendations for environmental monitoring			
1) Required components of an environmental monitoring plan	R. Lenhard H. Başağaoğlu	M. Garry	M. Alter
2) Recommended goals to include in an environmental monitoring plan	G. Walter	M. Garry	M. Alter
3) Recommended baseline and characterization data needed			

Table 3-4. Staff Assignments III. B. 2. Statement of Needs—Water Quality Monitoring			
Statement of Need	**CNWRA Staff**	**Exponent Staff**	**Clear Creek Staff**
i) Evaluation of NRC regulations for milling and tailings management given state-specific climate (e.g., rainfall) and hydrologic considerations	R. Lenhard A. Ghosh S. Hsiung		M. Alter

Dr. James Durham will act as Project Manager. Dr. Durham's contact information is:

Dr. James Durham
jsdurham@cnwra.swri.edu
210-522-6081

Dr. Durham is a Principal Engineer at CNWRA and has a Ph.D. in Nuclear Engineering from the University of Illinois-Urbana. He was a major contributor to two standard review plans for uranium recovery licensing reviews and he was the principal investigator for a project that collected air samples to evaluate the adequacy of the airborne effluent system at a licensee's facility. He developed Varskin 3, a skin dose calculation tool and the associated user's manual for the U.S. Nuclear Regulatory Commission (NRC). He was the principal investigator evaluating the effects of potential natural phenomena and aviation accidents at the proposed Pa'ina Hawaii, LLC, irradiator facility for the NRC. He was also a major contributor to the environmental review conducted as part of the Nuclear Fuel Services, Inc., license renewal. Before joining the Geosciences and Engineering Division, Dr. Durham was an assistant professor in the Department of Environmental and Radiological Health Sciences at Colorado State University. He taught lectures and laboratories in radiation physics, internal and external dosimetry instrumentation, and waste management. He served 5 years as chair of the Radiation Safety Committee and advised five Master of Science candidates. In addition to acting as Project Manager, he will be the Subject Matter Expert for topics in the Statement of Needs related to radiological health effects and safety.

Dr. Gary R. Walter will serve as Assistant Project Manager and a Subject Matter Expert on topics in the Statement of Needs related to surface water, groundwater, and water supply.

Dr. Walter is Manager of the Department of Earth, Material, and Planetary Sciences in the SwRI Geosciences and Engineering Division of which CNWRA is also a part. Dr. Walter has a Ph.D. in Hydrology from the University of Arizona and more than 30 years experience managing projects on soil and groundwater contamination including remediation of acid mine drainage and other impacts of mining operations such as seepage from tailings impoundments and evaporation ponds. Dr. Walter was a subject matter expert in the development of the Generic Environmental Impact Statement for *In-Situ* Leach Uranium Milling Facilities.[10] He has also conducted evaluations of the performance of uranium mill tailings impoundments for NRC and the performance of cover designs for defense radioactive waste isolation.

As Assistant Project Manager, Dr. Walter will work in close association with Dr. Durham to assure continuity of coordination with the Workgroup.

[10]NRC. NUREG–1910, "Generic Environment Impact Statement for *In-Situ* Leach Uranium Milling Facilities." Washington, DC: U.S. Nuclear Regulatory Commission. 2009.

Additional key staff and Subject Matter Experts include

- Dr. Roland Benke (CNWRA)
- Dr. Robert Lenhard (CNWRA)
- Dr. Hakan Başağaoğlu (CNWRA)
- Dr. Amit Ghosh (CNWRA)
- Dr. Sui-min “Simon” Hsiung (CNWRA)
- Dr. Michael Garry (Exponent)
- Dr. Vanessa Perez (Exponent)
- Ms. Sheila McCarthy (Exponent)
- Dr. Annette Santamaria (Exponent)
- Mr. Gary Mosher (Exponent)
- Mr. Michael Alter (Clear Creek)
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Also available to assist the project team will be the following advisors on toxicology and industrial hygiene:

- Dr. Joyce Tsuji (Exponent)
- Dr. Elizabeth Anderson (Exponent)
- Dr. David Hoel (Exponent)
- Dr. Mark Roberts (Exponent)

The specific roles and experience of these staff are described as follows.

Dr. Roland Benke will be a Subject Matter Expert on topics in the Statement of Needs related to radiation exposures and worker safety. Dr. Benke is a Principal Engineer with CNRWA and has a Ph.D. in Nuclear Engineering from the University of Michigan. Dr. Benke is a certified health physicist with 16 years experience in nuclear engineering, radiological health, and risk analysis. Dr. Benke is an associate editor of *Health Physics*, The Radiation Safety Journal. His background includes radiological dose assessment, radiation detection and measurement, environmental monitoring and characterization, and nondestructive evaluation. At CNWRA, Dr. Benke contributes to performance assessments for the geologic disposal of high-level nuclear waste and evaluation of risk insights. With lead responsibility in the areas of probabilistic risk assessment and consequence analysis, Dr. Benke is a member of the team developing computer software for safety assessment and evaluation of nuclear facility operations. He served as a lead technical reviewer in the safety evaluation of preclosure handling and aging operations at a potential geologic repository for high-level waste. Dr. Benke performs independent computational simulations for radiation shielding and contributes to the determination of leak path factors for airborne particulates. He has served as principal investigator for redistribution modeling of radionuclides in soil and led a field work campaign on airborne resuspension measurements. Dr. Benke also provides technical support to the U.S. Nuclear Regulatory Commission on updating regulatory guidance for health physics surveys and on licensing uranium recovery operations. He has supported facility decommissioning projects that evaluated the indoor resuspension factor for license termination and assessed the clearance of materials and equipment from nuclear facilities. Dr. Benke developed a hybrid computational model for transport of radioactive contaminants in fractured rock and has participated in computational research projects on rapid dose assessments for complex radiation source and receptor geometries, high-energy cosmic radiation shielding, and radon gas generation and emission from solid waste landfills.

Dr. Hakan Başağaoğlu will be a Subject Matter Expert on topics in the Statement of Needs related to potential impacts to groundwater and groundwater monitoring requirements. Dr. Başağaoğlu is a Principal Scientist with CNWRA and has more than 15 years' experience in flow and contaminant transport in subsurface fractured and porous domains at pore scale to field scale. He has been involved in (i) developing client-motivated numerical models and (ii) providing technical support for regulatory analysis and performance assessments of potential high-level waste disposal or uranium in-situ leaching sites. Dr. Başağaoğlu has a Ph.D. in Civil and Environmental Engineering from the University of California-Davis.

Dr. Robert Lenhard will be a Subject Matter Expert for Statement of Needs topics related to development of environmental assessments and NRC regulation of uranium milling and waste management. Dr. Lenhard is Program Manager for Environmental Protection and Waste Management for Non-High Level Waste at CNWRA. In this capacity he manages all of CNWRA's work related to uranium recovery and waste management. He is also responsible for scoping and managing CNWRA's environmental assessment projects under NEPA. Dr. Lenhard has a Ph.D. in Soil Physics from Oregon State University.

Dr. Amitava Ghosh will be a Subject Matter Expert for Statement of Needs topics related to uranium mining operations, best practices, and regulations. Dr. Ghosh is a Staff Engineer at CNWRA. He has a Ph.D. in Mining Engineering from the University of Arizona and more than 25 years of consulting and research experience in mining engineering and geological engineering with specialization in rock mechanics/rock engineering and performing reliability/risk assessments. He specializes in applications of numerical simulations, probabilistic methods and risk assessment methodologies, field and laboratory experiments, blasting, rock fracture mechanics, and fractal geometry. Dr. Ghosh developed the geotechnical portion of NRC's Standard Review Plan for reviewing the reclamation plans of uranium mill tailings sites under Title II of the Uranium Mill Tailings Radiation Control Act (NUREG–1620). He has also developed the geotechnical portion of a new standard review plan for conventional uranium mill and heap leach facilities. The review methods in the geotechnical section of this SRP include use of probabilistic methods to demonstrate safety of a uranium facility. Dr. Ghosh conducted independent confirmatory analyses and developed the safety evaluation report for several uranium mill tailings facilities. He also inspected a uranium reclamation facility, as a part of the Nuclear Regulatory Commission team, for activities associated with construction of mill tailings disposal cells.

Dr. Simon Hsiung is a Staff Engineer at CNWRA and will serve as a Subject Matter Expert for Statement of Needs topics related to uranium mining operations, best practices, and regulations. Dr. Hsiung is a mining engineer with a broad range of experience in geotechnical engineering and integrated safety analysis. He has more than 35 years of research and consulting experience in the disciplines of mining engineering and rock mechanics. Dr. Hsiung has conducted research and provided technical assistance in rock mechanics, geotechnical engineering, and natural phenomena and human-induced hazard assessment to NRC and other clients. He has developed technical evaluation reports for uranium tailings, reclamation plans for source material licenses in areas related to dynamic and static stability of slopes, potential liquefaction of foundation soils, settlement effects on radon barrier integrity, and integrated safety analyses for NRC-licensed nuclear fuel fabrication facilities. His recent experience includes (i) reviewing structural designs for mixed oxide and gas centrifuge facilities; (ii) developing safety evaluation reports for NRC on several license applications for mixed oxide, gas centrifuge, laser enrichment, and independent spent fuel storage installation facilities with focuses on tornado and high-wind evaluation; slope stability, liquefaction potential, aircraft crash, snow, and hurricane hazard characterization, tornado and human-made missile impact assessments, settlement and soil bearing capacity determination; (iii) performing final structural

design review (including foundation design and soil-structure interaction analysis) and construction inspections on gas centrifuge facilities; and (iv) reviewing the U.S. Department of Energy license application for a high-level nuclear waste geologic repository at Yucca Mountain, Nevada.

Dr. Michael Garry will be the Project Manager for Exponent and manage Exponent's assignments to the project. He will also serve as a Subject Matter Expert on Statement of Needs topics related to environmental toxicology and risk assessment. Dr. Garry has over 20 years of experience analyzing the biological effects of chemicals on humans and other organisms. He has extensive experience analyzing mechanisms of toxicity for both metals and organic chemicals, and has developed science-based toxicity criteria and guidelines and critically reviewed those developed by others. He has worked extensively on metals related issues both in the U.S. and internationally in Europe, Asia, and South America. Dr. Garry has conducted or participated in health risk assessments in support of environmental investigations and remediation at smelter and mining sites in Indonesia and throughout the western United States. As the lead toxicologist in a multidisciplinary study of fugitive dust impacts from an active lead/zinc mine in northwestern Alaska, Dr. Garry evaluated the potential for impacts to human health through multiple exposure pathways, including direct contact and through consumption of subsistence foods. As the project manager and lead toxicologist he is responsible for an ongoing multipathway human health and ecological risk assessment of a former elemental phosphorous facility focused on metals and radionuclides. Dr. Garry is also a nutritionist and has provided nutritional counseling for pregnant women and children both in the U.S. and Africa. In particular, he applies his unique background in both toxicology and nutrition to address subsistence, tribal, and recreational fish consumption issues in the Pacific Northwest. Dr. Garry is equally adept at the technical aspects of modeling biological exposure, and communicating risks and health issues to the public. He has worked extensively with stakeholder groups including tribal entities, municipalities, non-governmental organizations, academics, industry, and the general public. Dr. Garry has taught courses in environmental health, toxicology and risk assessment, engaged in community education and outreach, and led or participated in numerous workshops. He has also collaborated with the U.S. Environmental Protection Agency on several projects, including the compilation and review of fish and shellfish arsenic speciation and toxicity data.

Dr. Vanessa Perez will be the Subject Matter expert for Epidemiology and Biomonitoring. Dr. Perez is a Senior Scientist within Exponent's Center for Epidemiology & Computational Biology of Exponent's Health Sciences practice. She is an active member of the Society for Epidemiologic Research (SER) and of the International Society for Pharmacoepidemiology. Dr. Perez has worked on several different human health issues in the healthcare, biotech, and pharmaceutical industries. She has conducted state of the art scientific reviews aimed at assisting in future surveillance, clinical diagnosis, and treatment of disease. Her most recent work involved identifying the most susceptible populations for severe Respiratory Syncytial Virus (RSV) in order to determine who would benefit most from ongoing RSV infection research and therapeutic development. Dr. Perez has also developed study designs for several epidemiologic studies and has performed in-depth epidemiologic data analyses for various types of research including clinical trials and intervention studies. She currently is involved in conducting two cancer incidence studies, including a large-scale community study, to understand associations between target exposures of interest and cancer incidence and mortality. Dr. Perez has authored several peer-reviewed papers that have been published in top scientific journals and has presented her research findings at scientific conferences including SER and the International Congress of Infectious Diseases

Ms. Sheila A. McCarthy will be a Subject Matter Expert for Industrial Hygiene. Ms. McCarthy is a Certified Industrial Hygienist (CIH) and Managing Scientist in Exponent's Health Sciences Center Occupational and Environmental Medicine. Ms. McCarthy is experienced in the fields of industrial hygiene and risk assessment involving potential exposures to fibers, pesticides, metals, organic, and inorganic chemicals, as well as physical agents such as noise, heat, and sources of ionizing and non-ionizing radiation. Her experience includes performing industrial hygiene studies to evaluate OSHA compliance, illness clusters, and indoor air quality evaluations, and conducting historical and quantitative exposure assessment in support of site-specific risk assessments. As a CIH, Ms. McCarthy has conducted exposure assessments for both occupational and environmental settings. In these settings, she has developed and implemented sampling methodologies and evaluated a number of agents including fibers, metals, particulate matter, volatile organic compounds, bioareosols, mold, non-ionizing radiation, and noise. Examples of her work include a historical exposure assessment that required the evaluation of thousands of industrial hygiene sampling reports, for the purpose of developing a job exposure matrix that provided 8-hr time-weighted average exposures for various occupations involving asbestos-containing products. Her work has also included assessments of indoor air quality within concentrated animal feeding operations and measurements of emissions from these types of facilities. She conducted a study measuring the radio-frequency signals from an active network of automated meter reader systems in residential areas. Ms. McCarthy recently conducted a comprehensive analysis of exposure data related to metal fumes, including hexavalent chromium, from common welding activities in light of new OSHA regulations related to hexavalent chromium. Ms. McCarthy teaches at the University of California Extension Program at Davis. Her lectures focus on industrial hygiene and physical agents in the workplace (noise, radiation, heat/cold stress, and ergonomics).

Annette B. Santamaria will be a Subject Matter Expert for Toxicology. Dr. Santamaria is a board-certified toxicologist with over 20 years of multidisciplinary experience critically evaluating a broad range of toxicological, epidemiological, and clinical studies, conducting exposure and human health risk assessments, and communicating results to clients and governmental agencies. She has experience with assessing exposure to a variety chemicals, metals, nanomaterials, consumer products, (e.g., personal care products, cosmetics, paints, cleaning products, air fresheners), pharmaceuticals, and medical devices. She has provided technical support and assisted in the preparation of a variety of reports for regulatory compliance and/or litigation purposes. Dr. Santamaria has critically reviewed the toxicological and epidemiological literature to evaluate the association between exposure to manganese and neurotoxicity and has prepared comments on a variety of draft risk assessments that were conducted to develop guidance and regulatory levels for ambient manganese levels prepared by agencies in the U.S. and Canada.

Mr. Gary E. Mosher will assist Ms. McCarthy in matters related to Industrial Hygiene. Mr. Mosher is a certified industrial hygienist with extensive experience (30+ years) in health, safety, and environmental issues, primarily in the foundry and related industries. He is recognized as an expert on all aspects of silica within the domestic and international metalcasting industry and related supplier industries. Mr. Mosher's metalcasting industry experience spans a number of classic occupational health areas including heavy metals, thermal decomposition products, carbon monoxide, noise and NORM used in these facilities. His experience as a director of an accredited industrial hygiene laboratory adds an understanding of analysis and its limitations. This understanding, coupled with his years of gathering personal air samples, assisting companies in interpreting the results and implementing changes, provides a seasoned perspective on the use and application of exposure data. Mr. Mosher's experience include represented the foundry industry in all relevant environmental health and safety matters relating to silica before professional societies, state

and federal regulatory agencies and/or advisory committees, elected officials within state legislatures and members of U.S. Congress.

Mr. Michael Alter is a Principal Hydrogeologist based in the Leesburg, Virginia office of Clear Creek Associates. He will serve as a Subject Matter Expert for topics in the Statement of Needs related to local water supply impacts and regulations, and on best practices for mine water and waste management. Mr. Alter has worked on mine water management and hydrogeologic studies at various North American mining sites since 1995. His recent focus has been characterization and remediation of radionuclide contamination associated with legacy hard rock mining operations. Mr. Alter understands mine water management challenges associated with mining and mineral processing and has been responsible for preparing groundwater/aquifer protection permits and discharge permits for mines and mine facilities, including mill tailing impoundments, leach stockpiles, waste-rock stockpiles, and process water conveyances and collection impoundments. His related expertise includes geochemistry of mine materials and solutions, mine facility siting, chemistry of closed underground mines, *in-situ* leaching operations, mine pit hydrology and pit lake geochemistry, regulatory guidance for mining projects, permit acquisition, and mine contaminant transport in bedrock and basin-fill settings. Mr. Alter has a M.Sc. in Geology from Arizona State University and is a Professional/Registered Geologist in Virginia, Pennsylvania, and Arizona.

The following Exponent staff will be available as Project Advisors as needed to assist the Subject Matter Experts.

Joyce S. Tsuji, Ph.D., DABT, Fellow ATS—Toxicology and Risk Assessment—Dr. Tsuji is a Principal Scientist within the Center for Toxicology and Mechanistic Biology of Exponent's Health Sciences practice. She is a board-certified toxicologist and a Fellow of the Academy of Toxicological Sciences. Dr. Tsuji has extensive risk assessment experience with metals and other chemicals at mining and other sites in the United States, Canada, and internationally, including in Southeast Asia on projects for industry, trade associations, EPA and state agencies, the U.S. Department of Justice, the Australian EPA, municipalities, and private citizens. She has designed and directed dietary and environmental exposure studies and community programs involving health education and biomonitoring for populations potentially exposed to metals in the environment, including soil, water, and food-chain exposures. Dr. Tsuji directed a large biomonitoring and environmental exposure study of arsenic in soil for a community in New York State. She has conducted multiple risk assessments of various metals and other chemicals in soil, water, air, fish and other foods, consumer products, and medical devices. She has also assessed health risks of milling reagents and drilling muds. Sampling and evaluation has included uranium at some of the mining sites. Dr. Tsuji has served on expert panels on toxicology and health risks issues for the National Academy of Sciences/ National Research Council (including current service on the Board on Environmental Studies and Toxicology and the Committee on Toxicology), Institute of Medicine, and federal and state agencies. She also has years of experience working cooperatively with principal scientists at SWRI and Clear Creek Associates on mining sites.

Mark A. Roberts, M.D., Ph.D.—Occupational Medicine and Regulatory Epidemiology—Dr. Roberts is board certified by the American Board of Preventive Medicine in Occupational and Environmental Medicine. He is a Fellow of the American College of Occupational and Environmental Medicine and is a member of the College's Board of Directors. He has a wide range of experiences in clinical occupational and environmental medicine, as well as epidemiological studies of health complaints in communities and industrial settings. Dr. Roberts' professional training and experience covers a broad spectrum from public health to corporate medicine. His 17 years of experience in the Oklahoma State Department of Health

brings practical public health expertise involving infectious disease and environmental health issues. From 1990 to 1998, he was Assistant/Associate Professor at the Medical College of Wisconsin's Department of Preventive Medicine. He has also served on the Agency for Toxic Disease Registry (ATSDR) Board of Scientific Advisors. He has directed large-scale communication efforts relative to public health issues as well as worked with corporations to communicate health risks of products and manufacturing processes. Dr. Roberts has extensive experience in dealing with the public, both in public meeting forum as well as interviews with the media (radio, TV and newspapers).

Elizabeth L. Anderson, Ph.D., Fellow ATS—Regulatory Toxicology—Dr. Anderson has over 25 years of experience in working both within government institutions and for corporate entities. For the U.S. Environmental Protection Agency (EPA), she co-authored the first Federal policies to adopt risk assessment and risk management as the basis for setting health protective policies and guidelines for conducting carcinogen risk assessment. She founded and directed the Agency's Carcinogen Assessment Group and the central risk assessment programs for 10 years. Also, she has worked extensively on international risk assessment issues to address human health and ecological consequences of exposure to environmental toxicants, including for private companies, governments, the World Health Organization, and the Pan American Health Organization.

David G. Hoel, Ph.D.—Epidemiology and Radiation Risk Assessment—Dr. Hoel is a Principal Scientist in Exponent's Health Sciences Center for Epidemiology, Biostatistics, and Computational Biology. He has more than 40 years of experience in the fields of epidemiology, statistics, and risk analysis. He is internationally known for his work in risk assessment and has served on and also chaired numerous committees for the World Health Organization, the United Nations, the U.S. National Academy of Sciences, NIH, EPA and FDA. For over 20 years, Dr. Hoel was the Director of the Division of Risk Assessment at the National Institute of Environmental Health Sciences. This Division focused on the development of quantitative methods of estimating human health risks from environmental and occupational exposures. In addition to working with asbestos and chemicals, he is especially active in the area of radiation risk assessment. He also has been active in studies conducted by the National Research Council, including reports on beryllium, depleted uranium, radiation effects in space travel, and radiation dose reconstruction from atomic testing. Dr. Hoel is also a Distinguished University Professor at the Medical University of South Carolina.

3.c Resumes of Key Staff

JAMES S. DURHAM, Ph.D.

Current Position:

Principal Engineer
Center for Nuclear Waste Regulatory Analyses
Geosciences and Engineering Division
Southwest Research Institute®

Experience:

At CNWRA, Dr. Durham contributes to the performance assessments of the potential geologic repository for high-level nuclear waste at Yucca Mountain, Nevada, and to the evaluation of risk insights. He managed the Biosphere Characteristics Project, and led a project to write a user guide for the performance assessment code Total-system Performance Assessment (TPA) Version 6.1. He was a major contributor to two standard review plans for uranium recovery licensing reviews and he was the principal investigator for a project that collected air samples to evaluate the adequacy of the airborne effluent system at a licensee's facility. He developed VARSKIN 3, a skin dose calculation tool and the associated user's manual for NRC. He was the principal investigator evaluating the effects of potential natural phenomena and aviation accidents at the proposed Pa'ina Hawaii, LLC, irradiator facility for the NRC. He was also a major contributor to the environmental review conducted as part of the Nuclear Fuel Services, Inc., license renewal.

Before joining GED, Dr. Durham was an assistant professor in the Department of Environmental and Radiological Health Sciences at Colorado State University. He taught lectures and laboratories in radiation physics, internal and external dosimetry instrumentation, and waste management. He served 5 years as chair of the Radiation Safety Committee and advised five Master of Science candidates. His research involved design and development of an extremity dosimeter and an *in-situ*, long-term monitor for radioactive contamination based on optically stimulated luminescence readout of aluminum oxide.

From 1995 through 1998, Dr. Durham was the principal engineer for the Cesium Chloride Legacy Safety Program in the 324 Building, a Hazard Category 2 nonreactor nuclear facility located on the Hanford Site for Pacific Northwest National Laboratory and for B&W Hanford Company. While at PNNL from 1986 through 1995, he participated in radiation safety assessments at several Department of Energy sites, and he was the manager and principal investigator for a project to measure extremity doses received by Pantex employees during weapon disassembly operations. His research included several projects in the field of beta and skin dosimetry, including managing a project to study the biological effects of hot particles on pigskin for the Electric Power Research Institute.

Special Expertise:

Dr. Durham has special expertise as a health physicist with diverse experience in many areas of nuclear engineering and radiological health. His background includes radiation detection and measurement, skin dosimetry, education, and environmental monitoring.

Education:

1987 Ph.D., Nuclear Engineering, University of Illinois, Urbana-Champaign, Illinois
1984 M.S., Nuclear Engineering, University of Illinois, Urbana-Champaign, Illinois
1980 B.S., Nuclear Engineering, University of Illinois, Urbana-Champaign, Illinois

Previous Positions:

Senior Research Engineer, Center for Nuclear Waste Regulatory Analysis (CNWRA®), SwRI, San Antonio, Texas: 2005-2008.

Assistant Professor, Colorado State University, Department of Environmental and Radiological Health Sciences, Ft. Collins, Colorado; 1998-2005.

Project Engineer, B&W Hanford Company, Richland, Washington; 1996-1998.

Technical Group Manager, Battelle Pacific Northwest National Laboratory, Project Management and Engineering Technical Group, Richland, Washington; 1995-1996.

Senior Research Scientist, Battelle Pacific Northwest National Laboratory, Health Protection Department, Richland, Washington; 1986-1995

Professional Registrations and Affiliations:

Health Physics Society
American Nuclear Society
International Solid State Dosimetry Organizing Committee

Publications:

Akselrod, M.S., S.W.S. McKeever, M. Moscovitch, D. Emfietzoglou, J.S. Durham, and C.G. Soares. 1996. A Thin-Layer Al2O3:C Beta TL Detector. Radiation Protection Dosimetry. Vol. 66, Nos. 1–4. pp. 105–110.

Akselrod, M.S., A.L. Odegove, and J.S. Durham. 1994. Aluminum Oxide Exoelectron Dosimetry. Radiation Protection Dosimetry. Vol. 54, Nos. 1–3. pp. 353–356.

Benke, R.R., D.M. Hooper, J.S. Durham, D.R. Bannon, K.L. Compton, M. Necsoiu, and R.N. McGinnis, Jr. 2009. Measurement of Airborne Particle Concentrations Near the Sunset Crater Volcano, Arizona. Health Physics. Vol. 96, No. 2. pp. 97–117.

Blue, T.E., B.W. Wehring, S.J. Briggs, C.S. Wepprecht, J.S. Durham, and J.W. Blue. 1986. Dosimetry in Fast-Neutron Therapy by Automatic Readout of CR–39. Nuclear Instruments and Methods. Vol. B14. pp. 589–595.

Blue, T.E., J.W. Blue, J.S. Durham, D.B. Harris, A.S. Hnesh, and J.J. Ryes. 1983. D-He(3) Proton Yield as a Diagnostic for F-T and D(2)-Filled Inertial Confinement Fusion Experiments. Journal of Applied Physics. Vol. 54. pp. 615–620.

Blue, T.E., J.J. Reyes, J.S. Durham, B.W. Wehring, J.W. Blue, and W.K. Roberts. 1983. Dosimetry with CR–39 in TE Liquid for Clinical Neutron Beams. Transactions of the American Nuclear Society. Vol. 44. p. 484. (Nominated for Radiation Protection and Shielding Division "Best Paper" Award.)

Durham, J. 2009. Environmental Assessment for the Renewal of U.S. Nuclear Regulatory Commission License No. SNM–1097 for Global Nuclear Fuel—Americas, Wilmington Fuel Fabrication Facility. San Antonio, Texas: CNWRA.

Durham, J. 2008. Environmental Assessment for the Renewal of U.S. Nuclear Regulatory Commission License No. SNM–1227 for AREVA NP, Inc., Richland Fuel Fabrication Facility. San Antonio, Texas: CNWRA.

Durham, J., A. Ghosh, J. Stamatakos, K. Das, and C. Dinwiddie. 2007. Topical Report on the Effects of Potential Aviation Accidents and Natural Phenomena at the Proposed Pa'ina Hawaii, LLC. Irradiator Facility. San Antonio, Texas: CNWRA.

Durham, J.S. 2006. NUREG/CR–6918, VARSKIN 3: A Computer Code for Assessing Skin Dose from Skin Dose Contamination. Springfield, Virginia: The National Technical Information Service.

Durham, J.S. 2006. Concepts, Quantities, and Dose Limits in Radiation Protection Dosimetry. Radiation Measurements. Vol. 41, Supplement 1. pp. S28–S35.

Durham, J.S. 2004. Considerations for Applying VARSKIN MOD 2 to Skin Dose Calculations Averaged Over 10 cm2. Health Physics Supplement. Vol. 86. pp. S11–S14.

Durham, J.S., X. Zhang, F. Payne, and M.S. Akselrod. 2002. Design of a Finger Ring Extremity Dosimeter Based on OSL Readout of Aluminum Oxide. Radiation Protection Dosimetry. Vol. 101. pp. 65–68.

Durham, J.S. 1996. Chapter 15—Skin Dose Assessment. Applications of New Technology: External Dosimetry. J. Higginbotham, ed. Madison, Wisconsin: Medical Physics Publishing.

Durham, J.S. and D.L. Gardner. 1993. Methodology for Performing Measurements to Release Material From Radiological Control. PNL–8820. Richland, Washington: Battelle Pacific Northwest Labs.

Durham, J.S. 1991. Hot Particle Dose Calculations Using the Computer Code VARSKIN MOD2. Radiation Protection Dosimetry. Vol. 39, Nos. 1–3. pp. 79–84.

Durham, J.S. 1992. NUREG/CR–5873, VARSKIN MOD2 and SADDE MOD2: Computer Codes for Assessing Skin Dose From Skin Contamination. Washington, DC: U.S. Nuclear Regulatory Commission.

Durham, J.S. and M.W. Lantz. 1991. Determination of Gamma Absorbed Dose Rates and Charged Particle Equilibrium From Hot Particles. Radiation Protection Management. Vol. 8, No. 3. pp. 35–41. (Received Editor's Award for Excellence 1991.)

Durham, J.S., S.E. Merwin, and K.L. Swinth. 1991. Skin Dose Evaluations Using Exoelectron Dosemeters. Radiation Protection Dosimetry. Vol. 39. pp. 67–70.

Durham, J.S., W.D. Reece, and S.E. Merwin. 1991. Modeling Three-Dimensional Beta Sources for Skin Dose Calculations Using VARSKIN MOD2. Radiation Protection Dosimetry. Vol. 37, No. 2. pp. 89–94.

Durham, J.S., T.E. Blue, B.W. Wehring, M.H. Ragheb, and J.W. Blue. 1989. Microdosimetry in Fast-Neutron Therapy by Automatic Readout of CR–39 Solid State Nuclear Track Detectors. Nuclear Instruments and Methods in Physics Research. Vol. B36. pp. 319–331.

Durham, J.S., T.E. Blue, B.W. Wehring, M. Ragheb, and J.S. Blue. 1988. Microdosimetry in Neutron Therapy by Automatic Readout of CR–39 SSNTDs. Transactions of the American Nuclear Society. Vol. 56. pp 9–12.

Durham, J.S. 1987. The development of the solid state nuclear track detector CR–39 Plastic as a microdosimeter for high energy neutron beams. Ph.D. dissertation. University of Illinois. Urbana, Illinois.

Durham, J.S. 1984. Use of solid state nuclear track detectors as a diagnostic for a dense plasma focus." Master's thesis. University of Illinois. Urbana, Illinois.

Fisher, D.A., C.C. Badger, H. Breitz, J.F. Eary, J.S. Durham, T.E. Hui, R.L. Hill, and W.B. Nelp. 1991. Internal Radiation Dosimetry for Clinical Testing of Radiolabeled Monoclonal Antibodies. Antibody, Immunoconjugates, and Radiopharmaceuticals. Vol. 4, No. 4. pp. 655–664.

Gerdin, G., J.S. Durham, and R. Ilic. 1981. Solid State Nuclear Track Detectors and High Fluences of Light Ions. Nuclear Tracks. Vol. 5, No. 3. pp. 299–209.

Ilic, R., G. Gerdin, J.S. Durham, B. Wehring, W. Stygar, and T. Emoto. 1980. Dense Plasma Focus Studies With Solid State Nuclear Track Detectors (SSNTD). Bulletin of the American Physical Society. Vol. 25. p. 9.

James, A.C., J.K. Briant, J.S. Durham, and A. Birchall. 1994. Annexe H, Absorbed Fractions for Alpha, Beta, Positron, and Electron Emissions. Human Respiratory Tract Model for Radiological Protection, International Commission on Radiological Protection Report No. 66. Oxford, England: Pergamon Press.

James A.C., P. Gehr, R. Masse, R.G. Cuddihy, F.T. Cross, A. Birchall, J.S. Durham, and J.K. Briant. 1991. Dosimetry Model for Bronchial and Extrathoracic Tissues of the Respiratory Tract. Radiation Protection Dosimetry. Vol. 37, No. 4. pp. 221–230.

Kaurin, D.G.L., J.W. Baum, M.W. Charles, D.P.J. Darley, J.S. Durham, M.J. Scannel, and C.G. Soares. 1996. Hot Particle Intercomparison Dosimetry Measurements. Proceedings from the 9th International Congress of the International Radiation Protection Association, April 14–10, 1996. Vienna, Austria. Fontenay–aux–Roses, France: International Radiation Protection Association. pp. 3-20 to 3-28.

Klein, D.M., E.G. Yukihara, S.W.S. McKeever, J.S. Durham, M.S. Akselrod. 2006. *In-Situ,* Long-Term Monitoring System for Radioactive Contaminants. Radiation Protection Dosimetry. Vol. 119. pp. 421–424.

Klein, D.M., E.G. Yukihara, E. Bulur, J.S. Durham, M.S. Akselrod, and S.W.S. McKeever. 2005. An Optical Fiber Radiation Sensor for Remote Detection of Radiological Materials. IEEE Sensors Journal. Vol. 5, No. 4. pp. 581–588.

Reece, W.D., J.S. Durham, S.E. Merwin, and M.P. Moeller. 1993. Nonstochastic Skin Effects From Discrete Radioactive Particles Emitting High-Energy Spectra. EPRI TR–102658. Palo Alto, California: Electric Power Resource Institute.

Reece, W.D., J.S. Durham, S.E. Merwin, and M.P. Moeller. 1992. Threshold Levels for Nonstochastic Skin Effects From Low-Energy Discrete Radioactive Particles. EPRI TR–100048. Palo Alto, California: Electric Power Resource Institute.

Reece, W.D., S.D. Miller, and J.S. Durham. 1988. NUREG/CR–5276, SADDE (Scaled Absorbed Dose Distribution Evaluator) A Code to Generate Input for VARSKIN. PNL–6761. Washington, DC: U.S. Nuclear Regulatory Commission.

Stinchcomb, T.G., J.S. Durham, and D.R. Fisher. 1991. Obtaining S Values for Rectangular-Solid Tumors Inside Rectangular-Solid Host Organs. Medical Physics. Vol. 18, No. 3. pp. 555–558.

Vargo, G.J., E.E. Hickey, J.S. Durham, and S.F. Snyder. 1993. Analysis of Area Monitoring Options for Westinghouse Hanford Company. PNL–8934. Richland, Washington: Battelle Pacific Northwest Labs.

Presentations:

Durham, J. 2006. Skin Dosimetry and VARSKIN 3. Presentation at the 51st Health Physics Society Annual Meeting, June 25–29, 2006. Providence Rhode Island. McLean, Virginia: Health Physics Society.

Durham, J., K. Krobl, H. Karagiannis, and S. Sherbini. 2006. A Backscatter Correction Model for Three-Dimensional Beta Sources. Presentation at the 51st Health Physics Society Annual Meeting, June 25–29, 2006. Providence, Rhode Island. McLean, Virginia: Health Physics Society.

Durham J. 2005. Adding Radionuclides to the VARSKIN 3 Library Correctly. Presentation at the 50th Health Physics Society Annual Meeting, July 10–14, 2005. Spokane, Washington. McLean, Virginia: Health Physics Society.

GARY R. WALTER, Ph.D., P.G.

Current Position:

Manager
Technical Resources
Department of Earth, Material, and Planetary Sciences
Geosciences and Engineering Division
Southwest Research Institute®

Experience:

Dr. Walter has more than 30 years' experience in the fields of hydrogeology and environmental remediation. While at Southwest Research Institute, Dr. Walter has managed programs for the characterization of cementitious materials for use in radioactive waste disposal and been a consultant to NRC on projects related to the environmental impacts of *in-situ* uranium recovery and performance of engineered covers for uranium mill tailings. He has conducted independent research on the effect of gas generation on radon emissions from landfills receiving radium-bearing waste. He has also managed projects related to alternative transportation fuel production and environmental impacts under the Hydrogen Technology Information Service and is a key participant in the Institute's program on carbon capture, conversion, and sequestration. This work included participating in the development of a risk assessment technique for evaluating the impacts of permafrost thawing due to climate change.

He specializes in applying numerical models to environmental and water supply problems. Dr. Walter has developed and applied computer programs to simulate groundwater flow and transport of reactive chemical constituents, as well as vapor-phase transport and the analysis of complex well hydraulics problems. He has managed environmental and water resource investigations throughout the United States, and in the England, Venezuela, and Japan.

Special Expertise:

Dr. Walter is skilled in the use of numerical models for simulating groundwater flow and transport under saturated and unsaturated conditions. He has also managed investigation of the properties controlled low-strength materials for waste isolation applications.

Education:

Ph.D., Hydrology, University of Arizona, 1985
M.A., Geology, University of Missouri, Columbia, 1974
B.A., Chinese and Sociology, University of Kansas, 1969

Previous Positions:

President of Hydro Geo Chem, Inc. 1999 to 2002

Professional Registrations and Affiliations:

Registered Geologist in Wyoming, No. PG-2748

American Geophysical Union, National Ground Water Association, Society of Petroleum Engineers

Refereed Publications:

Walter, G.R., R. R. Benke, and D. A. Pickett. In Review. Effect of Biogas Generation on Radon Emissions from Landfills Receiving Radium-Bearing Waste from Shale Gas Development. Submitted to Journal of the Air & Waste Management Association.

Walter, G.R., M. Necsoiu, and R. McGinnis. 2012. Estimating Aquifer Channel Recharge Using Optical Data Interpretation. Ground Water, 50(1), 68–76.

Necsoiu, M., S. Leprince, D.M. Hooper, C.L. Dinwiddie, R.N. McGinnis, and G.R. Walter. 2009. Monitoring migration rates of an active subarctic dune field using optical imagery. Remote Sensing of Environments. 113, pp. 2,441–2,447.

Walter, G.R. 2003. Fatal flaws in measuring landfill gas generation rates by empirical well testing. Journal of the Air and Waste Management Association. Vol. 53, pp. 461–468.

Festger, A. and G.R. Walter. 2002. The capture efficiency map: the capture zone under time-varying flow. Ground Water. 40(6), pp. 619–628.

Philip, R.D. and G.R. Walter. 1992. Prediction of Flow and Hydraulic Head Fields for Vertical Circulation Wells. Ground Water. 30(5), pp. 765–773.

Neuman, S.P., G.R. Walter, H.W. Bentley, J.J. Ward, and D.D. Gonzalez. 1983. Determination of horizontal aquifer anisotropy with three wells. Ground Water, Vol. 22, pp. 66–72.

Publications and Presentations:

G.R. Walter, SPE, S.A. Stothoff, D.M. Necsoiu, and C.L. Dinwiddie. 2011. Integrated Methodology for Mapping and Monitoring Permafrost and Seasonally Frozen Ground. Arctic Technology Conference, February 7-9, Houston Texas. Society of Petroleum Engineers Paper OTC 22046.

G.R. Walter. 2009. Feasibility of Producing Alternative Liquid Transportation Fuels from Landfill Gas. Presentation to National Environmental Monitoring Conference. San Antonio, Texas.

G.R. Walter. 2009. Emerging Technologies for Alternative Transportation Fuels from Domestic Resources and Their Carbon Footprints. Presented to Society of American Military Engineers. San Antonio, Texas.

Pabalon, R., S. Painter, G. Walter and P. Bertetti. 2008. CO_2 Releases from Deep Storage Formations into Drinking Water Aquifers—Assessment of Potential Impacts on Drinking Water Quality. Poster, American Geophysical Union Fall Meeting. San Francisco, California.

Walter, G.R. 2008. Carbon Dioxide Sequestration in the United States: Technical Direction, Regulation and New Research. Invited presentation to Japanese National Institute for Advanced Industrial Science and Technology. Tsukuba, Japan.

Walter, G.R. 2007. Prospects for Generation of Hydrogen as an Automotive Fuel Using Nuclear Fission Reactors in the United States. Report to Hydrogen Information Technology Service Subscribers by Southwest Research Institute.

Walter, G.R. 2005. Screening Level Analysis of Radon Emissions Produced from Landfill Disposal of Water Treatment Residues Containing Radium. Poster. Presented at American Water Works Association Annual Conference and Exposition, June 11–14, 2005. San Francisco, California.

Walter, G.R., R.R. Benke and D.A. Pickett. 2005. Potential Radon Emissions Due to Biogas Generation at TENORM Land Disposal Sites . Proc. Society Petroleum Engineers. Exploration and Production Environmental Conference, March 7-9, 2005. Galveston, Texas.

Walter, G.R., R.R. Benke, and D.A. Pickett. 2004. Potential exposures to radionuclides originating from technologically enhanced naturally occurring radioactive materials emitted by landfill gas extraction and control systems. Presented at WASTECON2004, Solid Waste Association of North America, September 21–23, 2004. Phoenix, Arizona.

Walter, G.R., S.J. Smith, L. Major, and J. Tang. 2001. Evaluating landfill bioreactions using a numerical model. Proceedings from the 14th Annual Symposium Arizona Hydrological Society. Tucson, Arizona.

Gallier, T., G.R. Walter, and R. Strassburg. 2001. Protecting groundwater wells before contamination strikes: a proactive approach. Presented at the 2001 Annual Conference of the American Water Works Association. Washington, DC.

Festger, A.D. and G.R. Walter. 2000. Design of a Plume Containment System Under Time varying Flow and Pumping Considerations. Presented at the Arizona Hydrological Society Environmental Technologies for the 21st Century Symposium. Phoenix, Arizona.

Festger, A.D. and G.R. Walter. 1999. Performance of Plume Containment Systems Under Time-varying Flow and Pumping Considerations. National Ground Water Association 1999 Petroleum Hydrocarbons Conference. Houston, Texas.

Slater, J.C., G.R. Walter, J.R. Norris, M. Wood, and W.A. Fuller. 1999. Optimization of a Containment Wellfield Design. Presented at SME Annual Meeting. Denver, Colorado.

Tang, J., G.R. Walter, and M.W. Kuhn. 1999. Field Pilot Study of Trench Air Sparging for Remediation of Petroleum Hydrocarbons in Groundwater. Presented at *In-situ* and On-Site Bioremediations 5th International Symposium. San Diego, California.

Smith, S.J., J. Pepe, and G.R. Walter. 1995. The Effect of Variable Injection Rates on Air Sparging Patterns in Heterogeneous, Porous Media. Presented at Annual Symposium of Arizona Hydrological Society. Tucson, Arizona.

McCaulou, D.R., W.T. Weinig, and G.R. Walter. 1995. Evaluation of Vertical Circulation Wells for Enhanced Bioremediation. Proceedings from the 3rd International Symposium on *In-Situ* and On-Site Bioremediations. San Diego, California.

Walter, G.R., R.D. Philip, and S.J. Smith. 1993. Chicken/Egg Arguments in the Establishment of Soil Cleanup Standards. Presented at Hazmacon '93. San Jose, California.

Walter, G.R., and J.R. Norris. 1991. Hydrochemical zoning in the Pinal Creek alluvium. Presented at the U.S. Geological Survey Toxic Substances Hydrology Technical Meeting. Monterey, California.

Norris, J.R., G.R. Walter, and T.A. Conto. 1991. Controls on acid water migration through the Pinal Creek alluvial aquifer, Globe-Miami Mining District, Arizona. Proceedings from the Symposium on Environmental Management for the 1990's. Society of Mining, Metallurgy, and Exploration. Denver, Colorado.

Philip, R.D. and G.R. Walter. 1991. Simple techniques for evaluating the feasibility of soil vapor extraction. Presented at Environmental Technology Expo, April 8–12, 1991. Chicago, Illinois.

Walter, G.R., A. Yiannakakis, and M. Hauptmann. 1990. Gas in a Hat. Proceedings from the Superfund 90 Conference, Hazardous Materials Control Research Institute, November 26–28, 1990. Washington, DC.

Walter, G.R., H.W. Bentley, V.K. Gupta, and J. Carrera. 1987. Computer Assisted Site Investigation and Management: A Tool for Assessing and Managing Groundwater Contamination. Proceedings from the National Water Well Association Conference on Solving Ground Water Problems With Models. Denver, Colorado.

Walter, G.R. and H.W. Bentley. 1986. The value and pitfalls of numerical modeling applied to groundwater contamination investigations. Proceedings from the Symposium on Current Practices for Hazardous Waste Management in Arizona. Phoenix, Arizona.

Gupta, V.K. and G.R. Walter. 1985. Toward a general philosophy for the interpretation of aquifer tests. (Abs) EOS, 66(46), p. 890.

Kuhn, M.W., G.R. Walter, and V.K. Gupta. 1985. Automatic parameter estimation techniques applied to a multiwell aquifer test. (Abs) EOS 66(46), p. 890.

Walter, G.R. 1985. Nonadvective transport processes in rocks of very low permeability. Proceedings from the Symposium on Hydrogeology of Rocks of Low Permeability, International Association of Hydrogeologists, 17th International Congress.

Walter, G.R. 1985. The Effects of Molecular Diffusion on Groundwater Solute Transport Through Fractured Tuff. Ph.D. Dissertation, University of Arizona.

Kuhn, M.W., W.A. Stensrud, and G.R. Walter. 1985. Comparison of hydraulic properties of fractured dolomite determined by pressure pulse, slug/bailer, and pumping tests. Proceedings from the Symposium on Hydrogeology of Rocks of Low Permeability, International Association of Hydrogeologists, 17th International Congress.

Carrera, J., G.R. Walter, M.W. Kuhn, H.W. Bentley, and G. Swanick. 1984. Three-dimensional modeling of saline pond leakage calibrated by INVERT-3, a quasi-three-dimensional, transient, parameter-estimation program. Proceedings from the 1984 Conference on Practical Applications of Ground-Water Modeling, NWWA. Worthington, Ohio.

Walter, G.R., H.W. Bentley, J.J. Ward, and D.D. Gonzalez. 1983. Continuum and non-continuum aspects of groundwater movement at the Waste Isolation Pilot Plant, Southeastern New Mexico, EOS (abs), 64(45), p. 713.

Walter, G.R. 1983. A three-well technique for determining formation anisotropy at the Waste Isolation Pilot Plant (WIPP) Southeast New Mexico. Sandia Contractor Report, SAND83–7011, p. 12.

Walter, G.R. 1982. Theoretical and experimental determination of matrix diffusion and related solute transport properties of fractured tuffs from the Nevada Test Site. Los Alamos National Lab., LA–9471–MS, p. 132.

Walter, G.R. and G.M. Thompson. 1982. A repeated pulse technique of evaluating the hydraulic properties of tight formations, Ground Water, 20(2), pp. 186–193.

Walter, G.R. 1980. Hydrochemical and geologic database to support the KBS-II Plan. In Review of the KBS-II Plan for Handling and Final Storage of Unprocessed Spent Nuclear Fuel, Swedish Ministry of Industry, Os I:27, pp. 183–204.

Walter, G.R., R.E. Kidd, and G.M. Lamb. 1979. Management techniques for the control of salt-water encroachment in coastal aquifers. Published by the Alabama Geological Survey.

Walter, G.R. and R.E. Kidd. 1978. Changes in water chemistry near the fresh water-saltwater transition zone. (Abs.) EOS Trans., 59(12), p. 1,063.

Walter, G.R. 1977. Water Resources in Geologic and Hydrologic Environmental Atlas of Mobile and Baldwin Counties, Alabama. P. H. Moser and R. L. Chermock, eds. Alabama Geological Survey Open File Report, pp. 97–170.

Walter, G.R. 1974. The morphological and sedimentological development of a small artificial channel in the Missouri Ozarks. Masters Thesis, University of Missouri. Columbia, Missouri.

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Current Position:

Principal Engineer
Center for Nuclear Waste Regulatory Analyses
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Experience:

Dr. Benke is a certified health physicist with 16 years experience in nuclear engineering, radiological health, and risk analysis. Dr. Benke is an associate editor of *Health Physics*, The Radiation Safety Journal. His background includes radiological dose assessment, radiation detection and measurement, environmental monitoring and characterization, and nondestructive evaluation. At CNWRA, Dr. Benke contributes to performance assessments for the geologic disposal of high-level nuclear waste and evaluation of risk insights. With lead responsibility in the areas of probabilistic risk assessment and consequence analysis, Dr. Benke is a member of the team developing computer software for safety assessment and evaluation of nuclear facility operations. He served as a lead technical reviewer in the safety evaluation of preclosure handling and aging operations at a potential geologic repository for high-level waste. Dr. Benke performs independent computational simulations for radiation shielding and contributes to the determination of leak path factors for airborne particulates. He has served as principal investigator for redistribution modeling of radionuclides in soil and led a field work campaign on airborne resuspension measurements. Dr. Benke also provides technical support to the U.S. Nuclear Regulatory Commission on updating regulatory guidance for health physics surveys and on licensing uranium recovery operations. He has supported facility decommissioning projects that evaluated the indoor resuspension factor for license termination and assessed the clearance of materials and equipment from nuclear facilities.

Special Expertise:

Using existing radiation survey instrumentation, Dr. Benke's research has significantly advanced the technology to locate radiation sources and determine external dose with updated dosimetric models for radiological protection. Dr. Benke developed, demonstrated, and patented a novel method for determining radionuclide depth distributions using *in-situ* gamma-ray spectrometry. He has measured and modeled radon emanation from soil and conducted an experimental comparison of *in-situ* and laboratory gamma-ray spectroscopy of natural radionuclides in desert soil. Dr. Benke developed a hybrid computational model for transport of radioactive contaminants in fractured rock and has participated in computational research projects on rapid dose assessments for complex radiation source and receptor geometries, high-energy cosmic radiation shielding, and radon gas generation and emission from solid waste landfills.

Education:

2000 Ph.D., Nuclear Engineering, University of Michigan
1996 M. Eng., Radiological Health Engineering, University of Michigan
1994 B.S., Nuclear Engineering, University of Michigan

Previous Positions:

Los Alamos National Laboratory, Graduate research fellow, Summer 1996

Science Applications International Corporation, Graduate research fellow, Summer 1995

Kernforschungszentrum Jülich, Germany, Nuclear engineering international exchange intern, Summer 1994

Chrysler Corporation, Product quality engineering intern, Summer 1993

General Dynamics, Software development intern, Summer 1992

Professional Registrations and Affiliations:

Certified Health Physicist, American Board of Health Physics, since November 2003
American Academy of Health Physics
Health Physics Society
American Nuclear Society

Publications and Presentations:

"New SwRI technique gives handheld spectrometers imaging capability." *R&D Magazine*. http://www.rdmag.com/Application-Notes/2011/04/Test-Measurement-New-SwRI-technique-gives-handheld-spectrometers-imaging-capability/. April 1, 2011.

Benke, R.R., A.T. Gray, and P.A. LaPlante. "Simple Biosphere Model for Non-Site-Specific Performance Assessments." Paper 3518. Proceedings of the 13th International High-Level Radioactive Waste Management Conference, Albuquerque, New Mexico, April 10–14, 2011. LaGrange Park, Illinois: American Nuclear Society. pp. 658–662. 2011.

Benke, R., J. Jeong, G. Adams, R. Nes, H. Jung, and B. Dasgupta. "Probabilistic Radiological Consequence Module for Systematic Safety Analysis." Paper 3434. Proceedings of the 13th International High-Level Radioactive Waste Management Conference, Albuquerque, New Mexico, April 10–14, 2011. LaGrange Park, Illinois: American Nuclear Society. pp. 601–607. 2011.

Benke, R. "Recent Advancements in Radiation Survey Measurement, Source Imaging, Radiation Transport Computation, and Radiological Dose Estimation." Proceedings of 2009 ISRSM (International Symposium on Radiation Safety Management), "Radiation Safety Leading to Green Nuclear Energy." November 4–6, 2009. Daejeon, Republic of Korea. pp. 21–42. 2009.

Benke, R. "Advanced Radiation Method for Surveys (ARMS)." Internal Research and Development (IR&D) Poster. San Antonio, Texas: Southwest Research Institute. 2009.

Benke, R.R., D.M. Hooper, J.S. Durham, D.R. Bannon, K.L. Compton, M. Necsoiu , and R.N. McGinnis, Jr. "Measurement of Airborne Particle Concentrations Near the Sunset Crater Volcano, Arizona." Health Physics. Vol. 96, No. 2. pp. 97–117. 2009.

Benke, R. "Proprietary IR&D Focused Project: Radiological Survey Measurement Approaches for Direct Readout of Effective Dose Rate." San Antonio, Texas: Southwest Research Institute. 2008.

Benke, R.R. and G.R. Adams. "Potential Indoor Worker Exposure From Handling Area Leakage—Example Event Sequence Frequency Analysis." Presented at the American Nuclear Society Topical Meeting—Decommissioning, Decontamination, and Reutilization, Chattanooga, Tennessee, September 16–19, 2007. LaGrange Park, Illinois: American Nuclear Society. pp. 228–260. 2007.

Benke, R.R. "Analytical and Numerical Solutions of the Expected Number of Occurrences for Combinations of Event Sequences Due to Variability." Applied Mathematics and Computation. Vol. 190. pp. 1,824–1,838. 2007.

Benke, R.R., B.E. Hill, and D.M. Hooper. "Fluvial Redistribution of Contaminated Tephra: Description of an Abstracted Model." Presented at the 11th International High-Level Radioactive Waste Management Conference—Global Progress Toward Safe Disposal, Las Vegas, Nevada, April 30–May 4, 2006. LaGrange Park, Illinois: American Nuclear Society. pp. 958–962. 2006.

Benke, R.R. and M.D. Waters. "Consequence Sensitivity Analyses for a Risk-Informed Review of a Preclosure Safety Analysis." Presented at the 8th International Conference on Probabilistic Safety Assessment and Management, New Orleans, Louisiana, May 14–18, 2006. M.G. Stamatelatos and H.S. Blackman, eds. PSAM–0440. New York City, New York: ASME Press. 2006.

Benke, R. and B. Dasgupta. "Probabilistic Risk Analysis Methodology for Preclosure Operations at a Geologic Nuclear Waste Repository." Presented at the 7th International Conference on Probabilistic Safety Assessment and Management, Berlin, Germany, June 14–18, 2004. G. Spitzer, U. Schmocker, and V.M. Dang, eds. London, United Kingdom: Springer-Verlag. Vol. 6. pp. 3,130–3,135. 2004.

Benke, R.R. and S. Painter. "Modeling Conservative Tracer Transport in Fracture Networks With a Hybrid Approach Based on the Boltzmann Transport Equation." Water Resources Research. Vol. 39, No. 11. p. 1,324. 2003.

Benke, R.R. and K.J. Kearfott. "Demonstration of a Collimated In-Situ Method for Determining Depth Distributions Using Gamma-Ray Spectrometry." Nuclear Instruments and Methods in Physics Research, Section A. Vol. 482, No. 3. pp. 814–831. 2002.

Benke, R.R., B. Dasgupta, B. Sagar, and A. Chowdhury. "A Methodology for Preclosure Risk Assessment for a Geologic Nuclear Waste Repository." Presented at the 6th International Conference on Probabilistic Safety Assessment and Management, San Juan, Puerto Rico, June 23–28, 2002. Oxford, United Kingdom: Elsevier Science, Ltd. pp. 983–988. 2002.

Benke, R.R. and K.J. Kearfott. "An Improved In-Situ Method for Determining Depth Distributions of Gamma-Ray Emitting Radionuclides." Nuclear Instruments and Methods in Physics Research, Section A. Vol. 463, No. 3. pp. 939–412. 2001.

Benke, R.R., B. Dasgupta, D. Daruwalla, A.H. Chowdhury, and B. Jagannath. "Incorporation of the MELCOR Code Into the Preclosure Consequence Analyses for the Yucca Mountain Project." Presented at the 46th Annual Meeting of the Health Physics Society; American Radiation Safety Conference and Exposition, Cleveland, Ohio, June 10–14, 2001. Health Physics. Vol. 80, Supplement 6. p. S114. 2001.

Benke, R.R. Performance Assessment of a Nuclear Waste Repository at Yucca Mountain. Presented at Oregon State University, Corvallis, Oregon. 2000.

Benke, R.R. and K.J. Kearfott. "Accounting for 222Rn Loss During Oven Drying for the Immediate Laboratory Gamma-Ray Spectroscopy of Collected Soil Samples." Applied Radiation and Isotopes. Vol. 52, No. 2. pp. 271–287. 2000.

Benke, R.R. and K.J. Kearfott. "Simulations of an In-Situ Method for Measuring Radionuclide Depth Distributions." Presented at the 1999 Winter Meeting, Long Beach, California, November 14–18, 1999. American Nuclear Society Transactions. Vol. 81. pp. 237–238. 1999.

Benke, R.R. and K.J. Kearfott. "Suggested Sample-Processing Procedure for Immediate Gamma-Ray-Spectroscopy Determinations of 226Ra Activities in Soil Samples." Journal of Applied Radioactivity Measurements. Vol. 10, No. 4. pp. 34–41. 1999.

Benke, R.R. and K.J. Kearfott. "Soil Sample Moisture Content as a Function of Time During Oven Drying for Gamma-Ray Spectroscopic Measurements." Nuclear Instruments and Methods in Physics Research, Section A. Vol. 422. pp. 817–819. 1999.

Benke, R.R. and K.J. Kearfott. "Determining Radionuclide Depth Distributions in Large Area Sources Using In-Situ Gamma-Ray Spectrometry." Health Physics. Vol. 76, Supplemental 6. p. S26. 1998.

Benke, R.R. and K.J. Kearfott. "A Correction Accounting for 222Rn Loss in the Immediate Laboratory Gamma Spectroscopy of Collected Soil Samples." Health Physics. Vol. 74, Supplemental 6. p. S26. 1998.

Benke, R.R. and K.J. Kearfott. "Comparison of In-Situ and Laboratory Gamma Spectroscopy of Natural Radionuclides in Desert Soil." Health Physics. Vol. 73, No. 2. pp. 350–361. 1997.

Benke, R.R. and K.J. Kearfott. "Initial Determination of 222Rn Removal Constants for Exhalation in Undisturbed Desert Soil and Accelerated Loss During Soil Sample Drying." Health Physics. Vol. 72, Supplemental 6. p. S27. 1997.

Benke, R.R., K.J. Kearfott, D. Schoep, and C. Tung. "In-Situ Gamma spectroscopy for the Yucca Mountain Site Characterization Project." Health Physics. Vol. 70, Supplemental 6. p. S39. 1996.

Dasgupta, B., G. Adams, R. Benke, R.K. Johnson, and M. Waters. "Safety Assessment Tool Developed for Nuclear Fuel Handling Facilities." Presented at the 8th International Conference on Probabilistic Safety Assessment and Management, New Orleans, Louisiana, May 14–18, 2006. M.G. Stamatelatos and H.S. Blackman, eds. PSAM–0436. New York City, New York: ASME Press. 2006.

Dasgupta, B., A. Chowdhury, R. Benke, and B. Jagannath. "Review Methodology for Preclosure Safety Analysis of Proposed Geologic Repository." Presented at the 10th International High-Level Radioactive Waste Management Conference, Las Vegas, Nevada, March 30–April 12, 2003. LaGrange Park, Illinois: American Nuclear Society. 2003.

Dasgupta, B., R. Benke, T. Maxwell, and N. Eisenberg. "Preclosure Safety Analysis Tool Version 2.0 User Guide." San Antonio, Texas: CNWRA. 2003.

Dasgupta, B., R. Benke, B. Sagar, R. Janetzke, and A. Chowdhury. "Preclosure Safety Analysis Tool Development—Progress Report II." San Antonio, Texas: CNWRA. 2002.

Dasgupta, B., R. Benke, D. Daruwalla, A. Ghosh, R. Janetzke, and A. Chowdhury. "Preclosure Safety Analysis Tool Development—Progress Report." San Antonio, Texas: CNWRA. 2001.

Dasgupta, B., D. Daruwalla, R. Benke, A. Chowdhury, and B. Jagannath. "Methodology for Assessment of Preclosure Safety for Yucca Mountain Project." Presented at the 2001 9th International High-Level Radioactive Waste Management Conference, Las Vegas, Nevada, April 29–May 2, 2001.

Dasgupta, B., D. Daruwalla, R. Benke, and A.H. Chowdhury. "Development of a Tool and Review Methodology for Assessment of Preclosure Safety Analysis—Progress Report." San Antonio, Texas: CNWRA. 2000.

Hamby, D.M. and R.R. Benke. "Uncertainty of the 131I Ingestion Dose Conversion Factor." Radiation Protection Dosimetry." Vol. 82, No. 4. pp. 245–256. 1999.

Harvey, R.P., D.M. Hamby, and R.R. Benke. "Age-Specific Uncertainty of the 131I Ingestion Dose Conversion Factor." Health Physics. Vol. 84, No. 3. pp. 334–343. 2003.

Hooper, D.M. and R. Benke. "Fluvial Redistribution of Contaminated Tephra: Process-Level Modeling and Parameter Estimation." Presented at the 11th International High-Level Radioactive Waste Management Conference—Global Progress Toward Safe Disposal, Las Vegas, Nevada, April 30–May 4, 2006. LaGrange Park, Illinois: American Nuclear Society. pp. 963–966. 2006.

Hooper, D.M., M. Necsoiu, and R.R. Benke. "Final Status Report of Field Observations From Sunset Crater, Arizona." San Antonio, Texas: CNWRA. 2008.

Jantezke, R., R. Benke, and D. Hooper. "TEPHRA Version 1.0." Software Validation Test Plan and Report for the Volcanic Ash Dispersal and Deposition Code. San Antonio, Texas: CNWRA. 2008.

Maxwell, T., B. Dasgupta, G. Adams, R. Benke, and N. Eisenberg. "Preclosure Safety Analysis Tool User Guide, Version 3.0." San Antonio, Texas: CNWRA. 2005.

Mohanty, S., R. Benke, R. Codell, K. Compton, D. Esh, D. Gute, L. Howard, T. McCartin, O. Pensado, G. Adams, T. Ahn, P. Bertetti, L. Browning, G. Cragnolino, D. Dunn, R. Fedors, B. Hill, D. Hooper, P. LaPlante, B. Leslie, R. Nes, G. Ofoegbu, R. Pabalan, R. Rice, J. Rubenstone, J. Trapp, B. Winfrey, and L. Yang. "Risk Analysis for Risk Insights Progress Report." San Antonio, Texas: CNWRA. 2005.

Necsoiu, M., D. Hooper, and R. Benke. "Surface Lithology, Vegetation, and Tephra Characterization Using a Combined Analysis of Optical and Radar Imagery. Presented at the American Society for Photogrammetry and Remote Sensing Conference, Tampa, Florida, May 7–11, 2007.

Necsoiu, M., D. Hooper, and R. Benke. "Final: Summary of the Relationship Between Known Tephra Deposits, Tephra Isopachs, and Topography at Lathrop Wells Volcano, Nevada." San Antonio, Texas: CNWRA. 2008.

Nes, R. and R.R. Benke. "Potential Indoor Worker Exposure From Handling Area Leakage—Dose Calculation Methodology and Example Consequence Analysis. Presented at the American Nuclear Society Topical Meeting—Decommissioning, Decontamination, and Reutilization, Chattanooga, Tennessee, September 16–19, 2007. LaGrange Park, Illinois: American Nuclear Society. pp. 120–123. 2007.

Painter, S.L. and R. Benke. "Hybrid Models for Contaminant Transport in Fractured Rock (IR&D Final Report)." San Antonio, Texas: Southwest Research Institute. 2002.

Povetko, O., R. Benke, A. Kouznetsov, and V. Golikov. "Testing of a Hybrid Approach for Rapid Direct Radiation Gamma Dose Assessments for Complex Source/Receptor Geometries." Health Physics. Vol. 93, Supplement 1. p. S42. 2007.

Sagar, B., R. Benke, and S. Mohanty. "Use of Risk Information in Regulatory Review." Presented at the NEA/IGSC Workshop on Management of Uncertainty in Safety Cases—The Role of Risk, Stockholm, Sweden, February 2–4, 2004.

Turner, D., P. Mackin, R. Benke, C. Dinwiddie, M. Smith, J. Stamatakos, S. Atkinson, L. Canter, R. Fedors, and B. Strye. "Review of Mixed Oxide Fuel Fabrication Facility Draft Environmental Impact Statement." San Antonio, Texas: CNWRA. 2002.

Walter, G.R., R.R. Benke, and D.A. Pickett. "Implications of Landfill Gas Emissions for Disposal of Radon-Generating TENORM in Municipal Solid Waste Landfills (IR&D Poster)." San Antonio, Texas: Southwest Research Institute. 2006.

Walter, G.R., R.R. Benke, and D.A. Pickett. "Potential Radon Emissions Due to Biogas Generation at TENORM Land Disposal Sites." Presented at the 2005 Society of Petroleum Engineers Exploration and Production Environmental Conference, Galveston, Texas, March 7–9, 2005. Paper No. SPE 93934. San Antonio, Texas: CNWRA. 2005.

Walter, G.R., D.A. Pickett, and R.R. Benke. "Implications of Landfill Gas Emissions for Disposal of Radon-Generating TENORM in Municipal Solid Waste Landfills (IR&D Report)." San Antonio, Texas: Southwest Research Institute®. 2004.

Walter, G.R., R. Benke, and D. Pickett. "Potential Exposures to Radionuclides Originating From Technologically Enhanced Naturally Occurring Radioactive Materials Emitted by Landfill Gas Extraction and Control Systems." Presented at the 2004 Solid Waste Association of North America WASTECON, Phoenix, Arizona, September 21–22, 2004.

Weldy, J., R. Benke, R. Brient, R. Pabalan, and L. Yang. "NUREG–1640, Radiological Assessments for Clearance of Equipment and Materials From Nuclear Facilities." Washington, D.C.: NRC. 2001.

Wood, J.L., R.R. Benke, S.M. Rohrer, and K.J. Kearfott. "A Comparison of Minimum Detectable and Proposed Maximum Allowable Soil Concentration Cleanup Levels for Selected Radionuclides." Health Physics. Vol. 76, No. 4. pp. 413–417. 1999.

Awards, Honors, and Other:

Benke, R.R. Invited speaker at Saint Mary's Hall Issues Day, *"A Matter of National Security: Are domestic surveillance, full body scans, pat-downs, and behavior profiling a violation of the American citizen's civil rights?"* Presented "Full Body Scanners: Radiological Health Implications." Saint Mary's Hall, San Antonio, Texas. March 24, 2011.

Benke, R.R., K.J. Kearfott, and D.S. McGregor. "Method and System for Determining Depth Distribution of Radiation-Emitting Material Located in a Source Medium and Radiation Detector System for Use Therein." U.S. Patent Nos. 6,528,797 (March 4, 2003) and 6,727,505 (April 27, 2004).

HAKAN BAŞAĞAOĞLU, Ph.D.

Current Position:

Principal Scientist
Center for Nuclear Waste Regulatory Analyses
Geosciences and Engineering Division
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Experience:

Dr. Başağaoğlu has more than 15 years' experience in flow and contaminant transport in subsurface fractured and porous domains at pore scale to field scale. He has been involved in (i) developing client-motivated numerical models and (ii) providing technical support for regulatory analysis and performance assessments of potential high-level waste disposal or uranium in-situ leaching sites.

At the pore scale, Dr. Başağaoğlu developed numerical models, based on the lattice-Boltzmann method, to simulate the fate and transport of multiple inert and reactive colloidal particles and multiphase/multicomponent flows in geometrically complex fractured porous domains. He also developed radial diffusion models to simulate inactivation of particle-associated microorganisms in waste water disinfection using chlorine and ozone and determined rate parameters for methyl *tert*-butyl ether (MTBE) degradation in contaminated soil samples.

At the field scale, Dr. Başağaoğlu developed various numerical models or used existing models to determine optimal capacity expansion planning in multi-aquifer systems and optimal conjunctive operation of surface and subsurface water resources, predict optimal safe groundwater yield and landsubsidence, and locate potential waste disposal sites using geographic information systems.

Dr. Başağaoğlu also has experience in conducting field-scale pump-test analyses and interpreting and analyzing the results.

Special Expertise:

Dr. Başağaoğlu is an expert in pore-scale and continuum-scale flow and contaminant transport in subsurface environments in the context of model development and provides technical support for regulatory analyses of engineering structures. In particular, he is an expert in (i) continuum-scale flow and transport in unsaturated and saturated rocks with particular emphasis on fracture-matrix interactions and colloid-facilitated radionuclide transport, (ii) groundwater operation and remediation aspects of uranium in-situ leaching, and (iii) colloidal transport and its engineered deliveries in fractured and fractured porous domains in bioremedial and biomedical applications.

Education:

2000 Ph.D., Civil and Environmental Engineering, University of California, Davis
1993 M.Sc., Geological Engineering Middle East Technical University, Turkey
1991 B.S., Geological Engineering Middle East Technical University, Turkey

Previous Positions:

Research Associate, Department of Geosciences, Oregon State University, Corvallis, Oregon; 2005–2006.

Research Associate, Idaho National Laboratory, Idaho Falls, Idaho, and Washington State University, Pullman, Washington; 2003–2005.

Post-doctoral Associate, Department of Civil and Environmental Engineering, University of California, Davis, California; 2000–2003.

Water Resources Engineer, Department of Water Resources, Sacramento, California (permanent intermittent position); 1999–2000.

Research Assistant, Department of Civil and Environmental Engineering, University of California, Davis, California; 1996–2000.

Visiting Researcher, Department of Land, Air, Water Resources (Hydrologic Science) University of California, Davis, California; 1995–1996.

Research/Teaching Assistant, Department of Geological Engineering, Middle East Technical University, Ankara, Turkey; 1991–1995.

Professional Registrations and Affiliations:

American Geophysical Union.

Publications:

Başağaoğlu, H., S. Succi , C. Manepally, R. Fedors, and D. Wyrick. Sensitivity of the Active Fracture Model Parameter to Fracture Network Orientation and Injection Scenarios. *Hydrogeology Journal* (in press). 2009.

Loge, F.J., E. Lambertini, M.A. Borchardt, T.R. Ginn, and H. Başağaoğlu. Effects of Etiological Agent and Bather Shedding of Pathogens in Interpretation of Epidemiological Data Used to Establish Recreational Water Quality. Risk Analysis, 29(2): 257–266. 2009.

Painter, S., H. Başağaoğlu, and A. Liu. Robust Representation of Dry Cells in Single-Layer MODFLOW Models. Ground Water, 873–881. doi:10.1111/j.1745-6584.00483.x 2008.

Başağaoğlu, H., P. Meakin, S. Succi, G.R. Redden, and T.R. Ginn. Two-dimensional lattice-Bolztmann Simulation of Colloid Migration in Rough-Walled Narrow Flow Channels. Physical Review E, 77, 031405. 2008.

Dietrich, J.P., F.J. Loge, T.R. Ginn, and H. Başağaoğlu. Inactivation of Particle Associated Microorganisms in Waste Water Disinfection: Modeling of Ozone and Chlorine Reactive Diffusive Transport in Poydispersed Suspensions. Water Research, 41(10): 2189–2201. 2007.

H. Başağaoğlu, P. Meakin, S. Succi, and R. Rotondi. Density Fluctuations in lattice Boltzmann Simulations of Multiphase Fluids in a Closed System. Physica A-Statistical Mechanics and Its Applications, 374(2): 691–698. 2007.

Başağaoğlu, H., P. Meakin, S. Succi, and J. Welhan. Boundary Effects on the Onset of Nonlinear Flow in Porous Domains. Europhysics Letters, 73(6): 858–863. 2006.

Başağaoğlu, H., P. Meakin, C.T. Green, and M. Mathew. Multiphase Transport in Geometrically Simple Fracture Intersections. Physica A-Statistical Mechanics and Its Applications, 362(1): 17–22. 2006.

Başağaoğlu, H., P. Meakin, and S.Succi. Energy Dissipation Measures in Three-dimensional Porous Media, Physical Review E, 72, 046705. 2005.

Başağaoğlu H., C.T. Green, P. Meakin, and B.J. McCoy. lattice-Boltzmann Simulation of Coalescence-Driven Island Coarsening. Journal of Chemical Physics, 121(16): 7987–7995. 2004.

Başağaoğlu, H., T.R. Ginn, and B.J. McCoy. Radial Pore Diffusion Model with Nonuniform Intra-Particle Porosities. Journal of Environmental Engineering, ASCE, 130(10): 1170–1179. 2004.

Başağaoğlu, H., E.E. Chung, D. Gandhi, K.M. Scow, B.J. McCoy, and T.R. Ginn. Rate Parameters for MTBE Degradation Via a Radial Diffusion Model. Journal of Environmental Engineering, ASCE, 129(6): 565–570. 2003.

Dietrich, J.P., H. Başağaoğlu, T.R. Ginn, and F.J. Loge. Preliminary Assessment of Transport Processes Influencing the Penetration of Chlorine into Wastewater Particles and Subsequent Inactivation of Particle-associated Organisms. Water Research, 37(1): 139–149. 2003.

Başağaoğlu H., B.J. McCoy, T.R. Ginn, F.J. Loge, and J.P. Dietrich. A Diffusion Limited Sorption Kinetics Model with Polydispersed Particles of Distinct Sizes and Shapes. Advances in Water Resources, 25(7): 755–772. 2002.

Başağaoğlu, H., T.R. Ginn, and B.J. McCoy. Comment on Model Coupling Intra-Particle Diffusion/Sorption, Nonlinear Sorption and Biodegradation Process by H.K. Karapanagioti, C.M. Gossard, K.A. Strevett, R.C. Kolar, and D.A. Sabatini. Journal of Contaminant Hydrology, 57(3–4): 303–310. 2002.

Başağaoğlu, H., T.R. Ginn, C.T. Green, and B.J. McCoy. Modeling Transport in Heterogeneous Media: Tracer Dynamics in Complex Flow Networks. American Institute of Chemical Engineers Journal (AIChE J), 48(5): 1122–1132. 2002.

Başağaoğlu, H., T.R. Ginn, and B.J. McCoy. Formulation of a Soil-Pesticide Model Based on a Compartmental Approach. Journal of Contaminant Hydrology, 56(1–2): 1–24. 2002.

Başağaoğlu, H. and B.J. McCoy. A Linear Driving Force Model for Diffusion and Reaction with Interphase Partitioning. American Institute of Chemical Engineers Journal (AIChE J), 47(3): 754–757. 2001.

Larson, K.J., H. Başağaoğlu, and M.A. Marino. Prediction of Optimal Safe Groundwater Yield and Land Subsidence in the Los Banos-Kettleman City Area, California, Using a Calibrated Numerical Model. Journal of Hydrology, 242, 79–102. 2001.

Başağaoğlu, H. T.R. Ginn, B.J. McCoy, and M.A. Marino. A Linear Driving Force Approximation to a Radial Diffusive Model. American Institute of Chemical Engineers Journal (AIChE J), 46(10): 2097–2105. 2000.

Chu, X., H. Başağaoğlu, M.A. Marino, and R.E. Volker. Aldicarb Transport in the Subsurface Environment: Comparison of Models. Journal of Environmental Engineering, ASCE, 126(2): 121–129. 2000.

Başağaoğlu, H., M.A. Marino, and R.H. Shumway. δ-Form Approximating Problem for a Conjunctive Water Resource Management Model. Advances in Water Resources, 23(1): 69–81. 1999.

Botzan, M.T., A.I. Necula, M.A. Marino, and H. Başağaoğlu. Benefit-cost Model for an Artificial Recharge Scenario in the San Joaquin Valley, California. Water Resources Management, 13, 189–203. 1999.

Botzan, M.T., M.A. Marino, and H. Başağaoğlu. Drought-Subsidence Prediction Model for the Western San Joaquin Valley, California. Water International, 24(3): 221–228. 1999.

Başağaoğlu, H. and M.A. Marino. Joint Management of Surface and Ground Water Supplies. Ground Water, 37(2): 214–222. 1999.

Başağaoğlu, H., M.A. Marino, and M.T. Botzan. Land Subsidence in the Los Banos-Kettleman City Area, California: Past and Future Occurrence. Physical Geography, 20(1): 67–82. 1999.

Başağaoğlu, H., C. Erturk, M.A. Marino, and N. Usul. Selection of Waste Disposal Sites Using GIS. Journal of the American Water Resources Association, 33(2): 455–464. 1997.

Başağaoğlu, H. and H. Yazicigil. Optimal Capacity Expansion Planning in Multi-Aquifer Systems. Journal of Water Resources Planning and Management, ASCE, 120(6): 836–856. 1994.

Presentations (Talks and Poster Presentations at National and International Conferences):

Başağaoğlu, H., S. Succi, S.Melchionna, S. Allwein, and H. Dixon. Numerical and Experimental Pore-Scale Analyses of Inert and Reactive Multiple Colloidal Particles in Complex Flow Domains. American Geophysical Union (AGU) Meeting, San Francisco, California, December 2008 (poster presentation).

Başağaoğlu, H., P. Meakin, S. Succi, and D. Wildenschild. Multiphase Flow in Micro-Fracture Junctions. American Geophysical Union (AGU) Meeting, San Francisco, California, December 2005.

Başağaoğlu, H., P. Meakin, S.Succi and J.Welhan. The Onset of Nonlinear Flow in Three-Dimensional Heterogeneous Flow Domains Based on Energy Dissipation Measures. American Geophysical Union (AGU) Meeting, San Francisco, California, December 2005 (poster presentation).

Başağaoğlu, H. and P. Meakin. Application of lattice Boltzmann Model to Two-Phase Flow in Granular Media, Flow in Fracture Intersections, and Thin-film Coarsening. The 13th International Conference on the Discrete Simulation of Fluid Dynamics (DSDD-04), Boston, Massachusetts. 2004.

Başağaoğlu, H, and P. Meakin. Simulation of Colloidal Transport Via the lattice Boltzmann Method. INRA (Inland Northwest Research Alliance) Symposium, Salt Lake City, Utah. 2003.

Başağaoğlu, H., T.R. Ginn, B.J. McCoy. Diffusion Limited Reactive Radial Diffusion Model with Multiple Non-Identical Porous Soil Particles. Fall Meeting of AGU, San Francisco, California (poster presentation). 2001.

Ginn, T.R., H. Başağaoğlu, B.J. McCoy, and K.M. Scow. A Diffusion Limited Reactive Radial Diffusion for the Aging/sequestration Process. Fall Meeting of AGU, San Francisco, California (Poster Presentation). 2001.

Başağaoğlu, H. and B.J. McCoy. A Linear Driving Force Model for Diffusion and Reaction with Interphase Partitioning. Fall Meeting of American Institute of Chemical Engineers (AICHE), Los Angeles, California. 2000.

Başağaoğlu, H., T.R. Ginn, and B.J. McCoy. A Soil-Pesticide Transport Model Via a Compartmental Approach. Fall Meeting of AGU, San Francisco, California (poster presentation). 2000.

Başağaoğlu,H., T.R.Ginn, and M.A. Marino. The Linear Driving Force Model Approach for a Radial Diffusive Model. Fall Meeting of AGU, San Francisco, California. 1999.

Başağaoğlu,H. and M.A. Marino. Conjunctive Management Model for Yolo Basin, California. Water Resources and Urban Environment, 25th Annual Conference on Water Resources Planning and Management by the American Society of Civil and Environmental Engineering, Chicago, Illinois. 1998.

Başağaoğlu,H., A.J.Gusman, and M.A.Marino. Comparison of Selected Analytical and Numerical Pesticide Transport Models. Proceedings of AWRA/UCOWR Symposium: Water Resources Education, Training, and Practice (Edited by J.J. Warwick), pp.133–142, Keystone, Colorado. 1997.

Başağaoğlu, H., and M.A. Marino. Optimal Operating Policies for the Joint Use of Surface and Ground Water Resources. 5th Scientific Assembly of the International Association of Hydrological Science, IAHS'97, Rabat, Morocco. 1997.

Başağaoğlu,H, and M.A. Marino. Joint Management of Surface and Ground Water Supplies, American Water Resources Association (AWRA)'s Annual Conference and Symposium on Conjunctive Use of Water Resources: Aquifer Storage and Recovery, Long Beach, California. 1997.

Başağaoğlu,H. and M.A. Marino. A Chance Constraint Model for Joint Management of Stream-Aquifer System. Integrated Management of Surface and Ground Water, UCOWR'96 Proceedings, pp. 136–146. San Antonio, Texas. 1996.

Başağaoğlu,H. and M.A. Marino. Conjunctive Management of Surface and Ground Water Resources. Fall Meeting of AGU, San Francisco, California. 1995.

Misirli F, H. Başağaoğlu, and H. Yazicigil. A Comparison of Two Ground Water Management Models for Optimal Waste Containment. Assessing and Managing Health Risk from Drinking Water Contamination: Approaches and Applications, IAHS, Publication No. 233, pp.277–285, Rome, Italy. 1995.

Başağaoğlu, H. and H. Yazicigil. Removal of Non-Linearity in the Objective Function of Capacity Expansion Models for Groundwater Development. Advances in Civil Engineering, First Technical Congress, Vol. II, pp. 830–839. Gazi Magosa, North Cyprus. 1994.

Awards and Honors:

Best Paper Award ("Drought Subsidence Prediction Model for the Western San Joaquin Valley, California" with T. Botzan and Miguel A. Marino), International Water Resources Association, Carbondale, Illinois, 2001.

University of California Toxic Substances Research and Training Program Traineeship (1999–2000)

Jastro-Shields Graduate Research Scholarship (1997 and 1997–98)

Graduate Student Travel Award (1997)

Tuition waiver fellowship from the Department of Civil & Environmental Engineering, University of California, Davis (1996–97)

Placed first in graduation class (1991)

ROBERT J. LENHARD, Ph.D.

Current Position:

Program Manager
Environmental Protection and Waste Management for Non-High-Level Radioactive Waste
Center for Nuclear Waste Regulatory Analyses
Geosciences and Engineering Division
Southwest Research Institute®

Experience:

Dr. Lenhard has more than 20 years experience. His work has been initiating, managing, and conducting projects that investigate fluid behavior in the subsurface, particularly in the vadose zone. The projects were designed to explore and elucidate the fundamental mechanisms that govern multiphase flow and chemical transport in soils and aquifers. He applies his knowledge to better predict and measure the subsurface behavior of fluids for practical and theoretical applications.

As a technical leader, he has published several seminal papers addressing innovative modeling and measurement of fluid flow behavior in three-phase air-oil-water systems. Work included developing theoretical models of multiphase fluid flow and contaminant transport; designing contaminant mobility experiments; and measuring integrated effects of physical, chemical, and biological interactions of multiphase fluid systems in porous media. His efforts have been applied to the remediation of contaminated soils and aquifers as well as to reservoir engineering associated with the petroleum industry. Dr. Lenhard has published more than 40 peer-reviewed papers in leading scientific journals. He has also given numerous invited presentations nationally and internationally and serves as an associate editor for two scientific journals: *Vadose Zone Journal* and *Journal of Contaminant Hydrology*.

As a manager, Dr. Lenhard oversees quality successful projects within costs. He currently manages projects on vadose zone fluid dynamics, solute transport in variably saturated porous and fractured media, regional-scale groundwater flow in arid to semi-arid environments, and *in-situ* uranium recovery from subsurface strata. He also develops strategic and tactical plans for developing programs in fluid flow and transport phenomena, builds and fosters interdisciplinary and multi-institutional teams, and develops and maintains strong working relationships with clients.

Special Expertise:

Dr. Lenhard is a world leader in constitutive theory that is needed for predicting the flow of multiple fluid phases in porous media. He has developed computer algorithms for predicting relationships among fluid relative permeabilities, saturations, and pressures. His models, or variations thereof, are commonly used in computer codes predicting the flow of gas, oil (nonaqueous phase liquids), and water in the subsurface. He has also extended his models to account for hysteresis in relative permeability-saturation-pressure relations. Dr. Lenhard is a porous media physicist, who can apply his expertise to various practical and theoretical problems.

Education:

1984 Ph.D., Soil Physics, Oregon State University, Corvallis, Oregon
1978 M.S., Forest Soils, University of Idaho, Moscow, Idaho
1976 B.S., Forest Science, Humboldt State University, Arcata, California

Previous Positions:

Geoscience Discipline Leader, Subsurface Science Initiative, Idaho National Engineering & Environmental Laboratory, Idaho Falls, Idaho; 1/2001-5/2006.

Staff Scientist, Hydrology, Pacific Northwest National Laboratory, Richland, Washington; 9/1999-1/2001.

Head, Department of Soil & Water Sciences, Sultan Qaboos University, Muscat, Oman; 8/1995-8/1999.

Senior Research Scientist, Hydrology, Battelle Pacific Northwest Laboratories, Richland, Washington; 10/1989-7/1995.

Research Scientist, Virginia Polytechnic Institute & State University (Virginia Tech), Blacksburg, Virginia; 5/1985-10/1989.

Professional Registrations and Affiliations:

Member of the American Geophysical Union
Member of the Soil Science Society of America

Publications and Presentations:

Refereed Publications

Lenhard, R.J. and G.L. Bloomsburg. 1979. Capillary Pressure-Saturation Relationships for a Forest Soil. Am. Soc. Agric. Engr. Trans., Vol. 22:357–360.

Lenhard, R.J. and R.H. Brooks. 1985. Comparison of Liquid Retention Curves with Polar and Non-Polar Liquids. Soil Sci. Soc. Am. J., Vol. 49:816–821.

Lenhard, R.J. and R.H. Brooks. 1986. Effects of Clay-Solution Interactions on Water Retention. Am. Soc. Civil Engr., J. Irrig. Drain. Engr., Vol. 112:28–38.

Lenhard, R.J. 1986. Changes in Void Distribution and Volume During Compaction of a Forest Soil. Soil Sci. Soc. Am. J., Vol. 50:462–464.

Parker, J.C., R.J. Lenhard, and T. Kuppusamy. 1987. A Parametric Model for Constitutive Properties Governing Multiphase Fluid Conduction in Porous Media. Water Resour. Res., Vol. 23:618–624.

Kuppusamy, T., J. Sheng, J.C. Parker, and R.J. Lenhard. 1987. Finite Element Analysis of Multiphase Immiscible Flow Through Soils. Water Resour. Res., Vol. 23:625–632.

Lenhard, R.J. and J.C. Parker. 1987. Measurement and Prediction of Saturation-Pressure Relationships in Three Phase-Porous Media Systems. J. Contam. Hydrol., Vol. 1:407–424

Parker, J.C. and R.J. Lenhard. 1987. A Model for Hysteretic Constitutive Relations Governing Multiphase Flow, 1. Saturation-Pressure Relations. Water Resour. Res., Vol. 23:2,187–2,196.

Lenhard, R.J. and J.C. Parker. 1987. A Model for Hysteretic Constitutive Relations Governing Multiphase Flow, 2. Permeability-Saturation Relations. Water Resour. Res., Vol. 23:2,197–2,206.

Lenhard, R.J. and J.C. Parker. 1988. Experimental Validation of the Theory for Extending Two Phase Saturation-Pressure Relations to Three Fluid Phase Systems for Monotonic Drainage Paths. Water Resour. Res., Vol. 24:373–380.

Lenhard, R.J. and R.H. Cuenca. 1977. A Simple Method of Obtaining Su-Brooks Retention Parameters. J. Irrig. & Drain. Engr., ASCE, Vol. 114:363–367.

Lenhard, R.J., J.H. Dane, J.C. Parker, and J.J. Kaluarachchi. 1988. Measurement and Simulation of One-Dimensional Transient Three-Phase Flow for Monotonic Liquid Drainage. Water Resour. Res., Vol. 24:853–863

Lenhard, R.J., J.C. Parker, and S. Mishra. 1989. On the Correspondence Between Brooks-Corey and van Genuchten Models. J. Irrig. & Drain. Engr., ASCE, Vol. 115:744–751.

Lenhard, R.J., J.C. Parker, and J.J. Kaluarachchi. 1989. A Model for Hysteretic Constitutive Relations Governing Multiphase Flow, 3. Refinements and Numerical Simulations. Water Resour. Res., Vol. 25:1,727–1,736.

Parker, J.C. and R.J. Lenhard. 1989. Vertical Integration of Three Phase Flow Equations for Analysis of Light Hydrocarbon Plume Movement. Transport in Porous Media, Vol. 5:187–206.

Lenhard, R.J. and J.C. Parker. 1990. Estimation of Free Hydrocarbon Volume from Fluid Levels in Monitoring Wells. Ground Water, Vol. 28:57–67.

Lenhard, R.J. and J.C. Parker. 1990. Discussion of Estimation of Free Hydrocarbon Volume from Fluid Levels in Monitoring Wells by R.J. Lenhard and J.C. Parker and Volume Estimation of Light Nonaqueous Phase Liquids in Porous Media by Farr, et al. Ground Water, Vol. 28:800–801.

Parker, J.C. and R.J. Lenhard. 1990. Determining Three Phase Permeability-Saturation-Pressure Relations from Two Phase System Measurements. J. Petroleum Sci. Engr., Vol. 4:57–65.

Kaluarachchi, J.J., J.C. Parker, and R.J. Lenhard. 1990. A Numerical Model for Areal Migration of Water and Light Hydrocarbon in Unconfined Aquifers. Adv. Water Resour., Vol. 13:29–40.

Gee, G.W., C.T. Kincaid, R.J. Lenhard, and C.S. Simmons. 1991. Recent Studies of Flow and Transport in the Vadose Zone. U.S. National Report to International Union of Geodesy and Geophysics 1987-1990. Reviews of Geophysics, Supplement, Vol. 29:227–239.

Lenhard, R.J., J.C. Parker, and J.J. Kaluarachchi. 1991. Comparing Simulated and Experimental Hysteretic Two-Phase Transient Fluid Flow Phenomena. Water Resour. Res., Vol. 27:2,113–2,124.

Lenhard, R.J. 1992. Measurement and Modeling of Three-Phase Saturation-Pressure Hysteresis. J. Contaminant Hydrology, Vol. 9:243–269.

Lenhard, R.J., T.G. Johnson, and J.C. Parker. 1993. Experimental Observations of Nonaqueous-Phase Liquid Subsurface Movement. J. Contaminant Hydrology, Vol. 12:79–101.

Busby, R.D., R.J. Lenhard, and D.E. Rolston. 1995. An Investigation of Saturation-Capillary Pressure Relations in Two- and Three-Fluid Systems for Several NAPLs in Different Porous Media. Ground Water, Vol. 33:570–578.

Lenhard, R.J., M. Oostrom, C.S. Simmons, and M.D. White. 1995. Investigation of Density-Dependent Gas Advection of Trichloroethylene: Experiment and a Model Validation Exercise. J. Contaminant Hydrology, Vol. 19:47–67.

Oostrom, M., J.H. Dane, B.C. Missildine, and R.J. Lenhard. 1995. Error Analysis of Dual-Energy Gamma Radiation Measurements. Soil Science, Vol. 160:1–15.

White, M.D., M. Oostrom, and R.J. Lenhard. 1995. Modeling Fluid Flow and Transport in Variably Saturated Porous Media with the STOMP Simulator 1. Nonvolatile Three-Phase Model Description. Adv. Water Resour., Vol. 18:353–364.

Lenhard, R.J., M. Oostrom, and M.D. White. 1995. Modeling Fluid Flow and Transport in Variably Saturated Porous Media with the STOMP Simulator 2. Verification and Validation Exercises. Adv. Water Resour., Vol. 18:365–373.

Morel-Seytoux, H.J., P.D. Meyer, M. Nachabe, J. Touma, M.T. van Genuchten, and R.J. Lenhard. 1996. Parameter Equivalence for the Brooks-Corey and van Genuchten Soil Characteristics: Preserving the Effective Capillary Drive. Water Resources Res., Vol. 32(5):1,251-1,258.

Oostrom, M. and R.J. Lenhard. 1996. Radon Transport into Dwellings: Considering Groundwater as a Potential Source. Geophysical Research Letters, Vol. 23(13):1,577–1,580.

Herman, D.C., R.J. Lenhard, and R.M. Miller. 1997. Formation and Removal of Hydrocarbon Residual in Porous Media: Effects of Attached Bacteria and Biosurfactants. Environ. Sci. Technol., Vol. 31(5):1,290–1,294.

Oostrom, M. and R.J. Lenhard. 1998. Comparison of Relative Permeability-Saturation-Pressure Parametric Models for Infiltration and Redistribution of a Light Nonaqueous-Phase Liquid in Sandy Porous Media. Adv. Water Resour., Vol. 21:145–157.

Lenhard, R.J. and M. Oostrom. 1998. A Parametric Model for Predicting Relative Permeability-Saturation-Capillary Pressure Relationships of Oil-Water Systems in Porous Media with Mixed Wetability. Transport in Porous Media, Vol. 31:109–131.

Oostrom, M., J.H. Dane, C. Hofstee, and R.J. Lenhard. 1998. On the Use of Single-Source Gamma Radiation for Improved Calibration and Measurements in Porous Media Systems. Soil Science, Vol. 163:646–656.

Lenhard, R.J., A.R. Kacimov, A.M. Tartakovsky, and H. AbdelRahman. 2002. Modeling Residual NAPL in Water-Wet Porous Media. J. Sci. Res.: Agricultural Sciences, Sultan Qaboos Univ., Oman, Vol. 7:1–7.

Oostrom, M., C. Hofstee, R.J. Lenhard, and T.W. Wietsma. 2003. Flow Behavior and Residual Saturation Formation of Liquid Carbon Tetrachloride in Unsaturated Heterogeneous Porous Media. J. Contaminant Hydrol., Vol. 64:93–112.

Oostrom, M. and R.J. Lenhard. 2003. Carbon Tetrachloride Flow Behavior in Unsaturated Hanford Caliche Material: An Investigation of Residual NAPL. Vadose Zone J., Vol. 2:25–33.

Delshad, M., R.J. Lenhard, M. Oostrom, G.A. Pope, and S. Yang. 2003. A Mixed-Wet Hysteretic Relative Permeability and Capillary Pressure Model for Reservoir Simulations. SPE Reservoir Evaluation & Engineering, Vol. 6(5):328–334.

Tartakovsky, A.M., S.P. Neuman, and R.J. Lenhard. 2003. Immiscible Front Evolution in Randomly Heterogeneous Porous Media. Physics of Fluids, Vol. 15(11):3,331–3,341.

Lenhard, R.J., M. Oostrom, and J.H. Dane. 2004. A Constitutive Model for Air-NAPL-Water Flow in the Vadose Zone Accounting for Immobile, Non-Occluded (Residual) NAPL in Strongly Water-Wet Porous Media. J. Contaminant Hydrol., Vol. 73:283–304.

White, M.D., M. Oostrom, and R.J. Lenhard. 2004. A Practical Model for Mobile, Residual, and Entrapped NAPL in Porous Media. Ground Water, Vol. 42(5):734–746.

Lenhard, R.J., A.K. Yonk, P.M. Wright, and J.D. Herzog. 2004. The Idaho National Engineering and Environmental Laboratory (INEEL) Site: An Overview of Site History and Soil and Groundwater Contamination Issues. Vadose Zone J., Vol. 3:1–5.

Oostrom, M., M.D. White, R.J. Lenhard, and P.J. Van Geel. 2005. A Comparison of Models Describing Residual NAPL Formation in the Vadose Zone." Vadose Zone J., Vol. 4(1):163–174.

Lenhard, R.J. and P. Meakin. 2007. Water Behavior in Layered Porous Media with Discrete Flow Channels: Results of a Large-Scale Experiment. Vadose Zone J., Vol. 6(3):458–470.

Proceedings and Reports

Parker, J.C., R.J. Lenhard, and T. Kuppusamy. 1986. Modeling Multiphase Contaminant Transport in Groundwater and Vadose Zones. Proc. from the Conf. on Petroleum, Hydrocarbons and Organic Chemicals in Groundwater, November 1986. Houston, Texas.

Lenhard, R.J. and J.C. Parker. 1986. Measurement of Pressure-Saturation Relations and Saturated Permeabilities of Water and Trichloroethylene in Quincy Soil. Prepared for Battelle, Pacific Northwest Laboratories, Richland, Washington. (Subcontract B–N3935–A–E).

Parker, J.C., R.J. Lenhard, and T. Kuppusamy. 1987. Measurement and Estimation of Permeability-Saturation-Pressure Relations in Three Phase Porous Media Systems. Proceedings from the International Conf. on Impact of Physico-Chemistry on the Study, Design and Optimization of Processes in Natural Porous Media, June 1987. Nancy, France.

Parker, J.C., J.J. Kaluarachchi, and R.J. Lenhard. 1988. Experimental and Numerical Investigations of Constitutive Relations Governing Multiphase Flow. Proceedings from the Conf. on Validation of Flow and Transport Models for the Unsaturated Zone, May 1988. Ruidoso, New Mexico.

Parker, J.C., R.J. Lenhard, and T. Kuppusamy. 1988. Physics of Immiscible Flow in Porous Media. EPA 600/S2–87/101, Washington, DC: U.S. Environmental Protection Agency.

Simmons, C.S., J.F. McBride, J.W. Cary, and R.J. Lenhard. 1990. Subsurface Flow Physics of Immiscible Organic Liquids. Pacific Northwest Laboratory Annual Report for 1989 to the DOE Office of Energy Research: Part 2 Environmental Sciences, pp. 48–55, PNL–7200 Part 2. Richland Washington: Pacific Northwest Laboratory.

Simmons, C.S., J.W. Cary, R.J. Lenhard, and J.F. McBride. 1991. Subsurface Organic Fluid Flow Research. Pacific Northwest Laboratory Annual Report for 1990 to the DOE Office of Energy Research: Part 2 Environmental Sciences, pp. 37–50, PNL–7600 Part 2. Richland Washington: Pacific Northwest Laboratory.

Last, G.V., R.J. Lenhard, B.N. Bjornstad, J.C. Evans, K.R. Roberson, F.A. Spane, J.E. Amonette, and M.L. Rockhold. 1991. Characteristics of the Volatile Organic Compounds-Arid Integrated Demonstration Site. PNL-7866, p. 90. Richland Washington: Pacific Northwest Laboratory

Lenhard, R.J. and J.C. Parker. 1992. Modeling Multiphase Fluid Hysteresis and Comparing Results to Laboratory Investigations. Proceedings from the Workshop on Indirect Methods for Estimating the Hydraulic Properties of Unsaturated Soils, M.Th. van Genuchten, F.J. Leij, and L.J. Lund (eds.). Riverside, California: University of California. pp. 233–248.

Lenhard, R.J., M.A. Gerber, and J.E. Amonette. 1992. Preliminary Evaluation of Selected In Situ Remediation Technologies for Volatile Organic Compound Contamination at Arid Sties. PNL-8333, p. 63. Richland, Washington: Pacific Northwest Laboratory.

Kaluarachchi, J.J., J.C. Parker, and R.J. Lenhard. 1992. Modeling Flow in Three Fluid Phase Porous Media with Nonwetting Fluid Entrapment. Subsurface Contamination by Immiscible Fluids, K.U. Weyer (ed.). Rotterdam, Netherlands: A.A. Balkema Publishers. pp. 141–147.

Simmons, C.S., J.F. McBride, R.J. Lenhard, and J.W. Cary. 1992. Organic Liquid Infiltration into Unsaturated Porous Media. Subsurface Contamination by Immiscible Fluids, K.U. Weyer (ed.). Rotterdam, Netherlands: A.A. Balkema Publishers, Rotterdam, Netherlands. pp. 213–219.

White, M.D., R.J. Lenhard, W.A. Perkins, and K.R. Roberson. 1992. Arid-ID Engineering Simulator Design Document. PNL–8445. Richland Washington: Pacific Northwest Laboratory. p. 116.

White, M.D. and R.J. Lenhard. Numerical 1993. Analysis of a Three-Phase System with a Fluctuating Water Table. Proceedings from the 13th Annual American Geophysical Union Hydrology Days. Fort Collins, Colorado: Hydrology Days Publications, Colorado State University. pp. 219–236.

Lenhard, R.J. 1994. Scaling Fluid Content-Pressure Relations of Different Fluid Systems in Porous Media. Proceedings from the 14th Annual American Geophysical Union Hydrology Days. Fort Collins, Colorado: Hydrology Days Publications, Colorado State University. pp. 223–235.

Lenhard, R.J., R.S. Skeen, and T.M. Brouns. 1995. Contaminants at DOE Sites and Their Susceptibility to Bioremediation. Bioremediation: Science and Applications, Soil Science Society of America, H.D. Skipper and R.F. Turo (eds.), Chapter 10, pp. 157–172.

Oostrom, M., R.J. Lenhard, and M.D. White. 1995. Infiltration and Redistribution of Dense and Light Nonaqueous Phase Liquids in Partly Saturated Sand Columns. Proceedings from the 15th Annual American Geophysical Union Hydrology Days. Fort Collins, Colorado: Hydrology Days Publications, Colorado State University. pp. 215–226.

Oostrom, M., R.J. Lenhard, and M.D. White. 1996. Numerical Evaluation of Groundwater as a Supply for Radon in Dwellings. Proceedings from the XI International Conference on Computational Methods in Water Resources. A.A. Aldema et al. (eds.). London, United Kingdom: Kluwer Academic. pp. 193–200.

Oostrom, M., C. Hofstee, R.J. Lenhard, R.C. Walker, J.H. Dane, and M.D. White. 1997. Physical Modeling of Multifluid Behavior in Porous Media. Proceedings from the 17th Annual American Geophysical Union Hydrology Days. Fort Collins, Colorado: Hydrology Days Publications, Colorado State University. pp. 241–254.

Lenhard, R.J., and M. Oostrom. 1999. Modeling Relations Among Relative Permeabilities, Fluid Saturations, and Capillary Pressures in Mixed-Wet Porous Media: Theory. Proceedings from the Characterization and Measurement of the Hydraulic Properties of Unsaturated Porous Media. Riverside California: U.S. Salinity Laboratory. pp. 179–187.

Oostrom, M., R.J. Lenhard, M. Delshad, and S.D. Robertson. 1999. Modeling Relations Among Relative Permeabilities, Fluid Saturations, and Capillary Pressures in Mixed-Wet Porous Media: Model Testing and Application to Oil-Water Systems. Proceedings from the Characterization and Measurement of the Hydraulic Properties of Unsaturated Porous Media. Riverside, California: U.S. Salinity Laboratory. pp. 189–198.

Delshad, M., R.J. Lenhard, M. Oostrom, G.A. Pope, and S. Yang. 1999. A Mixed-Wet Hysteretic Relative Permeability and Capillary Pressure Model in a Chemical Compositional Reservoir Simulator. Proceedings from the 1999 SPE Reservoir Simulation Symposium, February 14–17, 1999. SPE paper 51891. Houston, Texas.

Lenhard, R.J. 2001. Nonaqueous-Phase Fluid Behavior in the Vadose Zone: Model Development and Testing. Laboratory-Directed Research and Development: Annual Report for FY-2001, INEEL/EXT–03–00421, Idaho Falls, Idaho: Idaho National Engineering & Environmental Laboratory. pp. 346–348.

Lenhard, R.J. 2002. Nonaqueous-Phase Fluid Behavior in the Vadose Zone: Model Development and Testing. Laboratory-Directed Research and Development: Annual Report for FY-2002, INEEL/EXT–03–00390. Idaho Falls, Idaho: Idaho National Engineering & Environmental Laboratory. pp. 331–332.

Lenhard, R.J. 2002. Investigation of the Movement and Fate of Chlorinated Hydrocarbons. Laboratory-Directed Research and Development: Annual Report for FY-2002, INEEL/EXT–03–00390. Idaho Falls, Idaho: Idaho National Engineering & Environmental Laboratory. pp. 333–334.

Lenhard, R.J. 2003. Investigation of the Movement and Fate of Chlorinated Hydrocarbons. Laboratory-Directed Research and Development: Annual Report for FY-2003, INEEL/EXT–04–01772. Idaho Falls, Idaho: Idaho National Engineering & Environmental Laboratory. pp. 282–283.

Lee, B.D., R.J. Lenhard, and A.R. Miller. 2005. Mesoscale Tank Experiments for Investigating Carbon Tetrachloride Biodegradation. *In-Situ* and On-Site Bioremediation. Paper M–57. B.C. Alleman and M.E. Kelly (eds.) Columbus, Ohio: Battelle Press, Columbus, Ohio.

Book Contributions

Lenhard, R.J., M. Oostrom, and J.H. Dane. 2002. Multi-Fluid Flow: Introduction. Methods of Soil Analysis. Part 1: Physical Methods. J.H. Dane and G.C. Topp (eds.). Madison, Wisconsin: Soil Science of America. (peer reviewed)

Oostrom, M., J.H. Dane, and R.J. Lenhard. 2002. Multi-Fluid Flow: Fluid Contents. Methods of Soil Analysis. Part 4: Physical Methods. J.H. Dane and G.C. Topp (eds.). Madison, Wisconsin: Soil Science of America. (peer reviewed)

Lenhard, R.J., J.H. Dane, and M. Oostrom. 2002. Multi-Fluid Flow: Saturation-Pressure Relationships. Methods of Soil Analysis. Part 1: Physical Methods. J.H. Dane and G.C. Topp (eds.). Madison, Wisconsin: Soil Science of America. (peer reviewed)

Dane, J.H., R.J. Lenhard, and M. Oostrom. 2002. Multi-Fluid Flow: Relative Permeability Measurements. In: Methods of Soil Analysis. Part 1: Physical Methods. J.H. Dane and G.C. Topp (eds.). Madison, Wisconsin: Soil Science of America. (peer reviewed)

Lenhard, R.J., M. Oostrom, and J.H. Dane. 2002. Multi-Fluid Flow: Prediction of Capillary Pressure-Relative Permeability Relations. In: Methods of Soil Analysis. Part 1: Physical Methods. J.H. Dane and G.C. Topp (eds.). Madison, Wisconsin: Soil Science of America, Madison, Wisconsin. (peer reviewed)

Dane, J.H., and R.J. Lenhard. 2005.0 Hysteresis. Encyclopedia of Soils in the Environment, Vol. 2. D. Hillel (ed.). Oxford, United Kingdom: Elsevier Ltd. (peer reviewed)

Lenhard, R.J., J.H. Dane, and M. Oostrom. 2005. Immiscible Fluids. Encyclopedia of Soils in the Environment, Vol. 2. D. Hillel (ed.). Oxford, United Kingdom: Elsevier Ltd. (peer reviewed)

Invited Presentations

June 1988. Seminar at Battelle Pacific Northwest Laboratories, Richland, Washington. Modeling Hysteresis in Air-Oil-Water Fluid Systems.

May 1989. Seminar at Battelle Pacific Northwest Laboratories, Richland, Washington. Modeling Multiphase Flow and Saturation-Pressure Distributions in Soils and Aquifers.

June 1989. Seminar at R.S. Kerr Environmental Research Laboratory, Oklahoma City, Oklahoma. Modeling Multiphase Organic Chemical Transport in Soil and Groundwater.

September 1989. Seminar at Soil and Crop Sciences Department, Texas A&M University, College Station, Texas. Modeling Hysteretic Multiphase Permeability-Saturation-Pressure Relations in Porous Media.

September 1989. Seminar at Geosciences Department, New Mexico Institute of Mining and Technology, Socorro, New Mexico. Modeling Multiphase Hysteretic Constitutive Relations.

April 1990. Presentation at the DOE/OHER Subsurface Science Program workshop on Intermediate-Scale Experimentation to Investigate Microbiological, Chemical, and Hydrologic Processes Affecting Subsurface Reactive Contaminant Migration, April 24–26, 1990. Lewes, Delaware.

December 1990. Seminar at Agricultural Engineering Department, University of Idaho, Moscow, Idaho. Estimation of Subsurface Petroleum Liquid Volumes from Monitoring Well Data.

February 1991. Seminar at Environmental Sciences Department, Washington State University, Tri-Cities, Washington. Modeling of Multiphase Fluid Flow.

October 1991. Seminar at Geosciences Department, New Mexico Institute of Mining and Technology, Socorro, New Mexico. Nonunique Saturation-Pressure Relations in Two- and Three-Phase Fluid Systems: Measurement and Modeling.

October 1991. Seminar at Sandia National Laboratory, Albuquerque, New Mexico. Measurement and Modeling of Multiphase Hysteresis.

October 1991. Seminar at Agricultural & Chemical Engineering Department, Colorado State University, Fort Collins, Colorado. Two- and Three-Phase Saturation-Pressure Relations: Measurement and Modeling of Hysteresis.

February 1992. Seminar at the Department of Hydrology and Water Resources, University of Arizona, Tucson, Arizona. Measurement and Modeling of Three-Phase Saturation-Pressure Relations.

October 1992. Seminar at the Department of Geological Engineering, Geology, and Geophysics, Michigan Institute of Technology, Houghton, Michigan. Modeling Nonaqueous Phase Liquid Subsurface Movement.

November 1992. Seminar at the Department of Soil and Water Sciences, University of Arizona, Tucson, Arizona. Modeling Nonaqueous Phase Subsurface Movement.

April 1992. Presentation at the 13th Annual American Geophysical Union Hydrology Days, April 1, 1993. Fort Collins, Colorado. Modeling Subsurface Flow of Air-Oil-Water Systems.

April 1993. Seminar at the Oil and Gas Research Institute/Russian Academy of Sciences, Moscow, Russia. Two- and Three-Phase Saturation-Pressure Relations: Measurement and Modeling of Hysteresis.

November 1993. Presentation at the Bioremediation: Science, Applications, Regulations, & Education Symposium, November 6–7, 1993. Cincinnati, Ohio. Contaminant Mixtures at DOE Sites and Their Relevance to Bioremediation.

April 1993. Presentation at the 14th Annual American Geophysical Union Hydrology Days, April 1, 1993. Fort Collins, Colorado. Modeling Subsurface Flow of Air-Oil-Water Systems.

February 1994. Seminar at the Geology Department, Washington State University, Pullman, Washington. Measurement and Modeling of Multiphase Flow in Porous Geologic Material.

May 1994. Seminar at the Civil Engineering Department, University of Waterloo, Waterloo, Ontario, Canada. Integrated Multiphase Modeling Activities at Pacific Northwest Laboratory for the U.S. Department of Energy.

September 1994. Seminar at the Soil and Water Department, University of Arizona, Tucson, Arizona. Integrated Multiphase Modeling Activities at Pacific Northwest Laboratories for the U.S. Department of Energy—Density-Driven Vapor Flow of NAPLs.

May 1995. Seminar for the Soil Science Department, Oregon State University, Corvallis, Oregon. Experimental and Modeling Investigations of Organic Liquid Movement in the Subsurface.

October 1997. Presentation at an International Workshop on Characterization and Measurement of the Hydraulic Properties of Unsaturated Porous Media, October 22–24, 1997. Riverside, California. Modeling Relations Among Relative Permeabilities, Fluid Saturations, and Capillary Pressures in Mixed-Wet Porous Media: Theory.

August 1998. Seminar at the Institute of Terrestrial Ecology of Swiss Federal Institute of Technology, Zurich, Switzerland. Results of Two Studies Involving the Movement of Organic Contaminants in the Subsurface.

September 1998. Seminar at the Ministry of Water Resources of the Sultanate of Oman, Muscat, Oman. Using Predictive Tools to Model the Movement of Organic Contaminants in the Subsurface.

July 1999. Seminar at the Swiss Federal Institute of Technology, Zurich, Switzerland. Modeling Relations Among Relative Permeabilities, Saturations, and Pressures in Mixed-Wet Porous Media.

May 2002. Seminar at the University of Stuttgart, Stuttgart, Germany. Scaling Capillary Pressure-Saturation Relations in Water- and Mixed-Wet Porous Media.

January 2003. Keynote presentation at the International Conference on Soil & Groundwater Contamination & Cleanup in Arid Countries at Sultan Qaboos University, Muscat, Oman.

October 2003. Seminar at Utah State University, Logan, Utah. INEEL's Subsurface Science Initiative: Current and Future Activities.

November 2004. Seminar at Lawrence Berkeley National Laboratory for the Earth Sciences Division, Berkeley, California. Mesoscale Experiments: An Approach for Testing Models Describing Fluid Flow Through Fractured Porous Media.

August 2005. Seminar at the University of Edinburgh, Edinburgh, Scotland. Advances in Modeling Multiphase Fluid Flow.

September 2005. Seminar at Heriot-Watt University, Edinburgh, Scotland. Modeling Irreducible Oil in Three-Phase Water-Wet Porous Media.

Awards and Honors:

Received numerous distinguished service awards from Idaho National Laboratory and Pacific Northwest Laboratory for superior performance and team building from 1992-2004.

Professional and Scientific Committees and Activities:

- Serves on the Editorial Board (associate editor) of the *Journal of Contaminant Hydrology*, 1996-present
- Serves on the Editorial Board (associate editor) of the Vadose Zone Journal, 2002-present
- Served as Guest Editor of a Special Issue on INEEL Subsurface Science Research for the journal, Vadose Zone Journal, 2003-2004
- Served as a section editor of the Sultan Qaboos University Journal for Scientific Research: Agricultural Sciences, 1997-1999
- Served as Guest Editor of a Special Issue on Multiphase Flow for the journal, Advances in Water Resources, 1998
- Served as chairperson of the Unsaturated Zone Committee for the American Geophysical Union, 1994-1996
- Serves on the Unsaturated Zone Committee of the American Geophysical Union, 1991-present

- Chaired a special meeting on Description and Measurement of Constitutive Relations Governing Fluid Flow in Variably Saturated Media, Geologic Society of America, October 1994

- Chaired a special meeting on Multiphase Flow and Transport in Porous Media, American Geophysical Union, May 1993

- Chaired a special meeting on Multiphase Flow and Chemical Transport, Soil Science Society of America, November 1992

- Served on a technical/scientific steering committee for the VOC Arid-Site Integrated Demonstration for the U.S. Department of Energy, 1991-1995

- Co-chaired a special meeting on Recent Advances in Constitutive Relationships for Multiphase Flow in Porous Media at a Gordon Research Conference on Modeling of Flow in Permeable Media, August 1996

- Served as a contributor for the DOE Complex-Wide Vadose Zone Science and Technology Roadmap, 2000-2001

- Served on the scientific committee for an International Conference on Soil and Groundwater Contamination in Arid Countries, 2002-2003

AMITAVA "AMIT" GHOSH, Ph. D.

Current Position:

Staff Engineer
Engineering and Material Sciences
Center for Nuclear Waste Regulatory Analyses
Geosciences and Engineering Division
Southwest Research Institute®

Experience:

Dr. Ghosh has more than 25 years of consulting and research experience in mining engineering/geological engineering with specialization in rock mechanics/rock engineering and performing reliability/risk assessments. He specializes in applications of numerical simulations, probabilistic methods and risk assessment methodologies, field and laboratory experiments, blasting, rock fracture mechanics, fractal geometry, and artificial intelligence. Dr. Ghosh developed the geotechnical portion of the Standard Review Plan (SRP) for reviewing the reclamation plans of uranium mill tailings sites under Title II of the Uranium Mill Tailings Radiation Control Act (NUREG–1620). He has also developed the geotechnical portion of a new SRP on conventional uranium mill and heap leach facilities, which will be going for public comments. The review methods in the geotechnical section of this SRP also include use of probabilistic methods to demonstrate safety of a uranium facility. Dr. Ghosh conducted independent confirmatory analyses and developed the safety evaluation report for several uranium mill tailings facilities. He also inspected a uranium reclamation facility, as a part of the Nuclear Regulatory Commission team, for activities associated with construction of mill tailings disposal cells.

Dr. Ghosh played a vital role in preparing and conducting critical review to support NRC in developing regulatory positions for construction and operation of a geologic repository for nuclear waste at Yucca Mountain, several spent nuclear fuel storage installations, and irradiator facility in addition to several reclamation plans for uranium mill tailings facilities. Dr. Ghosh reviewed and, in some cases independently verified, potential hazards and their characterization in terms of their severity on repository facilities and operations. Handling of spent nuclear fuel canisters and waste packages were assessed using the Integrated Safety Assessment methodologies. He lead several investigations including estimation of ground response, assessment of the probability of failure of a slope as a function of consequence-tolerance level specified by the owner, soil-slope failure under static and seismic loads, and effects of repeated seismic events on stability of an underground excavation. He developed a report for the Korea Atomic Energy Research Institute on the effects of concrete degradation on long-term (more than 120 years) storage of spent nuclear fuel in dry storage. As the Principal Investigator for licensing proceedings of the Private Fuel Storage Facility, Dr. Ghosh reviewed and independently assessed the hazards to the storage casks and the facility from different external and internal hazards.

Dr. Ghosh has applied the probabilistic safety assessment methods to assess the design and performance of several nuclear-related facilities against different types of hazards including potential hazards at the underground facilities of the proposed repository at Yucca Mountain. He has extensive numerical modeling experience of complex rock engineering areas using both continuum (finite element, boundary element) and discontinuum (distinct element, particle-based) methods with special emphasis on use of probabilistic methodologies to account for the data and model uncertainties. He has applied his modeling skills to assess performance

of underground and surface mines, tunnels, rock and soil slopes, and earthen dams under both static and dynamic loading conditions.

Special Expertise:

Dr. Ghosh has special expertise in modeling and application of risk/reliability assessment; assessments of natural, human-induced, and operational hazards using risk-informed performance-based regulations; rock blasting; and stability of rock excavations. He has developed a methodology combining traditional rock engineering computational methods with risk assessment methodologies to estimate the probability of unacceptable performance of a design in terms of the level of consequences acceptable to the project or operation.

Education:

Ph.D. Mining Engineering, University of Arizona, Tucson, Arizona, U.S.A. (Dissertation: *Fractal and Numerical Models of Explosive Rock Fragmentatio*n)

M.S. Mining Engineering, University of Arizona, Tucson, Arizona, U.S.A. (Thesis: *A New Analytical Predictor of Ground Vibrations Induced by Blasting)*

B.Tech. (Honors) Mining Engineering, Indian Institute of Technology, Kharagpur, West Bengal, India.

Previous Positions:

Principal Engineer. Center for Nuclear Waste Regulatory Analyses. Southwest Research Institute. San Antonio, Texas, U.S.A.: 1999–2004.

Senior Research Engineer. Center for Nuclear Waste Regulatory Analyses. Southwest Research Institute. San Antonio, Texas, U.S.A.: 1994–1999.

Research Engineer. Center for Nuclear Waste Regulatory Analyses. Southwest Research Institute. San Antonio, Texas, U.S.A.: 1992–1994.

Post Doctoral Research Fellow. University of Nevada Reno, Reno, Nevada. U.S.A.: October 1990 to July 1992.

Teaching Associate. University of Arizona, Tucson, Arizona, U.S.A.: 1984 to September 1990.

Research Assistant. of Arizona, Tucson, Arizona, U.S.A.: 1984 to 1982.

Consultant. Hargis+ Associates, Inc., Phoenix, Arizona, U.S.A.: Summer 1988.

Research and Technical Service Engineer. IDL Chemicals Limited. Hyderabad, India. 1978-1981.

Professional Registrations and Affiliations:

- Member, Society of Mining, Metallurgy, and Exploration, Inc. of AIME
- Member, International Association for Mathematical Geology

- Member, American Rock Mechanics Association
- Associate Member, American Society of Civil Engineers
- Member, American Geophysical Union
- Session Chairman and Session Developer: 35th, 38th, and 42nd U.S. Symposiums on Rock Mechanics
- Paper Reviewer: 35th, 38th, and 42nd U.S. Symposiums on Rock Mechanics; First North American Rock Mechanics Conference; Society of Mining, Metallurgy, and Exploration, Inc.; Geotechnical and Geological Engineering; Engineering Geology; and Mathematical Geology

Awards and Honors:

- Winner of Rocha Medal 1992 of the International Society for Rock Mechanics in a worldwide competition for outstanding Ph.D. thesis in Rock Mechanics and Rock Engineering.
- Graduate Division Winner of 1989 SME Outstanding Student Paper Contest.
- Sulzer Memorial Scholarship at the Department of Mining and Geological Engineering, University of Arizona.
- Chandrakala Medal by the Mining, Metallurgical and Geological Institute of India and Institute Silver Medal at the Indian Institute of Technology (first position in the Mining Engineering batch of 1978).
- National Scholarship for academic excellence in High School.

Publications:

Technical Papers

Enright, M.P. and A. Ghosh. 2009. Reliability of a Rock Slope Against Plane Sliding Failure. Proceedings of the 10th International Conference on Structural Safety and Reliability (ICOSSAR), September 2009. Osaka, Japan.

Ghosh, A., F. Ferrante, and M. Enright. 2009. Reliability of a Rock Slope against Plane Sliding Failure. Proceedings from the International Conference on Rock Joints and Jointed Rock Masses 2009, January 2009. Tucson, Arizona.

Ghosh, A. and F. Ferrante. 2008. Reliability Estimation of Rock Slopes. ARMA 08-251. Proceedings from the 42nd U.S. Rock Mechanics Symposium and 2nd U.S./Canada Rock Mechanics Symposium. San Francisco, California.

Hsiung, S.M. and A. Ghosh. 2006. Seismic Response of Underground Excavations in Jointed Rock Mass. Proceedings from the 41st U.S. Symposium on Rock Mechanics. Golden, Colorado.

Mohanty, S., A. Ghosh, and G. Adams. 2006. Heat Transfer by Natural Convection Through Rubble Generated by Drift Degradation. Proceedings from the International High-Level Radioactive Waste Management Conference. Las Vegas, Nevada.

Ghosh, A. and B. Sagar. 2002. Assessment of Aircraft Crash Frequency During Take off and Landing at an Airport. PSAM6. Proceedings from the Probabilistic Safety Assessment and Management. Puerto Rico.

Ghosh, A. and B. Sagar. 2001. Preliminary Aircraft Crash Hazard Assessment at Proposed Yucca Mountain Repository. Proceedings from the International High-Level Radioactive Waste Management Conference.

Ghosh, A. and S.M. Hsiung. 2000. Acoustic Emission as an Indicator of Macrofailure of Rock. Proceedings from the 4th North American Rock Mechanics Symposium. Seattle, Washington.

Hsiung, S.M., A. Ghosh, J. Lankford, and A.H. Chowdhury. 2000. Fractal Pattern Characterization of Acoustic Emission for Continuous Damage Assessment of Reinforced Concrete Structure. Proceedings from the Symposium on Condition Monitoring of Materials and Structures, American Society of Civil Engineers. p. 2-20.

Ghosh. A. 1999. A FORTRAN Program for Estimating Weibull Distribution Parameters. Computers & Geosciences. Vol. 25, pp. 729–738.

Justus, P., J. Stamatakos, J. Firth, S.M. Hsiung, and A-b.K. Ibrahim. 1999. Incorporation of Tectonic Processes and Probabilistic Risk Assessments of the Proposed High-Level Radioactive Waste Repository at Yucca Mountain, Nevada: Nuclear Regulatory Commission Staff Approach. Transactions of the AGU, EOS, Spring Meeting Supplement, Vol. 15, p. S–1.

Fuerstenau, M.C., G. Chi, R.C. Bradt, and A. Ghosh. 1997. Increased Ore Grindability and Plant Through-put with Controlled Blasting. Mining Engineering, Vol. 48, No. 12.

Chi, G., M.C. Fuerstenau, R.C. Bradt, and A. Ghosh. 1996. Improved Comminution Efficiency Through Controlled Blasting During Mining. International Journal of Mineral Processing. Vol. 47.

Ghosh, A., S.M. Hsiung, and A.H. Chowdhury. 1995. Natural Rock Joint Profile Characterization Using Self-Affine Fractal Approach. Proceedings from the 35th U.S. Symposium on Rock Mechanics. Lake Tahoe, Nevada.

Ghosh, A., K. Fuenkajorn, and J.J.K. Daemen. 1995. Tensile Strength of Welded Apache Leap Tuff: Investigation of Scale Effects. Proceedings from the 35th U.S. Symposium on Rock Mechanics. Lake Tahoe, Nevada.

Ghosh, A. and J.J.K. Daemen. 1995. Rock Fragmentation in Bench Blasting–A Numerical Study. Proceedings from the 35th U.S. Symposium on Rock Mechanics, Lake Tahoe, Nevada.

Hsiung, S.M., A. Ghosh, and A.H. Chowdhury. 1995. Laboratory Investigation of Rock Joint Dynamic Behavior. Proceedings from the 2nd International Conference on Mechanics of Jointed and Fragmented Rock. Vienna.

Ghosh, A., S.M. Hsiung, A. Chowdhury, and J. Philip. 1995. Seismic Engineering Issues for a Proposed HLW Repository at Yucca Mountain. FOCUS'95. Proceedings from the American Nuclear Society Topical Meeting on Methods of Seismic Hazards Evaluation. Las Vegas, Nevada.

Ghosh, A. and S.M. Hsiung. 1995. On Characterization of Self-Affine Fractal Profiles. Proceedings from the 10th ASCE Engineering Mechanics Conference. University of Colorado at Boulder.

Hsiung, S.M., A. Ghosh, and A.H. Chowdhury. 1994. An Investigation of Rock Joint Models on Prediction of Joint Behavior Under Pseudostatic Cyclic Shear Loads. Proceedings from the 1st North American Rock Mechanics Symposium. University of Texas at Austin.

Ghosh, A. and J.J.K. Daemen. 1993. Fractal Characteristics of Rock Discontinuities. Engineering Geology, Vol. 34.

Hsiung, S.M., A. Ghosh, M.P. Ahola, and A.H. Chowdhury. 1993. Assessment of Conventional Methodologies for Joint Roughness Coefficient Determination. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, Vol. 30, No. 7.

Li, H., Y. Han, R.C. Bradt, and A. Ghosh. 1993. The Frictional Component of the Indentation Size Effect in Low Load Microhardness Testing. Journal of Materials Research. Vol. 8, No. 5.

Hsiung, S.M., A. Ghosh, M.P. Ahola, and A.H. Chowdhury. 1993. Assessment of Conventional Methodologies for Joint Roughness Coefficient Determination. Proceedings from the 34th U.S. Symposium on Rock Mechanics, University of Wisconsin. Madison, Wisconsin.

Ghosh, A. and J.J.K. Daemen. 1991. Validation of Exponential Decay Blast Vibration Predictor with Case Studies. Proceedings from the Annual Meeting of SME. Denver, Colorado.

Ghosh, A., J.J.K. Daemen and D. van Zyl. 1990. Fractal-Based Approach to Determine the Effect of Discontinuities on Blast Fragmentation. Proceedings from the 31st U.S. Symposium on Rock Mechanics. Colorado.

Kulatilake, P.H.S.W. and A. Ghosh. 1988. An Investigation into Accuracy of Spatial Variation Estimation Using Static Cone Penetrometer Data. Proceedings from the 1st International Symposium on Penetration Testing. Orlando, Florida.

Ghosh, A. and J.J.K. Daemen. 1987. An Expert System Approach to Geomechanics Design Problems. Proceedings from the 3rd International Conference on Innovative Mining Systems. University of Missouri at Rolla.

Ghosh, A., J.J.K. Daemen and S. Harpalani. 1987. Expert System for Coal Mine Roof Bolt Design. Proceedings from the 28th U.S. Symposium on Rock Mechanics. University of Arizona.

Ghosh, A. and P.H.S.W. Kulatilake. 1987. A FORTRAN Program for Generation of Multivariate Normally Distributed Random Variables. Computers & Geosciences. Vol. 13, No. 3.

Ghosh, A., R.C. Barkley and J.J.K. Daemen. 1986. Simulated Predictor of Ground Vibration Induced by Blasting. Proceedings from the 27th U.S. Symposium on Rock Mechanics. University of Alabama.

Ghosh, A. and J.J.K. Daemen. 1986. Best Source Modeling of Blast Vibration: Cube-Root Scaling, Square-Root Scaling or Site-Specific Scaling. Proceedings from the International Symposium on Environmental Geotechnology. Lehigh University.

Rasoul, E.A. and A. Ghosh. 1985. Design of Surface Mine Blasts. Arizona Conference of AIME.

Kulatilake, P.H.S.W., R.E. Finley, and A. Ghosh. 1985. Effect of Variability of Joint Orientation and Strength on Factor of Safety of Wedge Stability. Proceedings from International Symposium on Rock Joint. Bjorkliden, Lapland, Sweden.

Ghosh, A. and J.J.K. Daemen. 1985. Statistics–A Key to Better Blast Vibration Predictions. Proceedings from the 26th U.S. Symposium on Rock Mechanics. South Dakota School of Mines & Technology.

Ghosh, A. and J.J.K. Daemen. 1983. A Simple New Blast Vibration Predictor (Based on Wave Propagation Laws). Proceedings from the 24th U.S. Rock Mechanics Symposium. Texas A&M University.

Ghosh, A. 1981. Ground Vibration and Airblast from Blasting–How to Minimize Them. Proceedings from the Drilling and Blasting Symposium. University of Jodhpur, India.

Ghosh, A. 1981. Ground Vibration and Airblast from Blasting–Their Generation, Propagation and Effects on Structures. Third Advanced Rock Blasting Course. IDL Chemicals Ltd. India.

Technical Reports

Ghosh, A. and S. Hsiung. 2011. Effects of Tilted and Faulted Strata on Seismic Ground Motion. CNWRA Report to NRC.

Ghosh, A. and S. Hsiung. 2011. Tornado and Tornado-Generated Missile Hazards Assessment for Hexcel Plant at Decatur, Alabama. Report to Hexcel Corporation.

Ghosh, A., H. Jung, T. Mintz, D. Basu, and T. Wilt. 2011. Initial Long-Term Integrity Assessment of Spent Fuel Dry Storage—Final Report. Report to Korea Atomic Energy Research Institute. Daejeon, Korea.

Ghosh, A., J. Durham, and J. Stamatakos. 2010. Supplement to the final environmental assessment related to the proposed Pa'ina Hawaii, LLC underwater irradiator in Honolulu, Hawaii. CNWRA Report to NRC.

Ghosh, A. and M.P. Enright. 2010. Development of an Efficient Probabilistic Approach for Risk Assessment of Geotechnical Applications. Final Report for Focused Internal Research and Development Project 20.R9726 to Advisory Committee on Research, Southwest Research Institute, San Antonio, Texas.

Ghosh, A., H. Jung, T. Mintz, D. Basu, and T. Wilt. 2010. Long-Term Integrity Assessment of Dry Storage Of Spent Nuclear Fuel—Progress Report. Report to Korea Atomic Energy Research Institute. Daejeon, Korea.

Pabalan, R., C. Freitas, P. Shukla, and A. Ghosh. 2009. Assessment of Lead and Copper Azide Explosive Hazard Potential. CNWRA Report to Abbott Laboratories.

Hsiung, S.M., A. Ghosh, and A.H. Chowdhury. 2007. Site Response and Soil-Structure Interaction Analyses—A Progress Report. CNWRA Report to NRC.

Durham, J., A. Ghosh, J. Stamatakos, and K. Das. 2007. Final Topical Report on the Effects of Potential Natural Phenomena and Aviation Accidents at the Proposed Pa'ina Hawaii, LLC, Irradiator Facility. CNWRA Report to NRC.

Cox, P.A., J. Mathis, T. Wilt, A. Chowdhury, and A. Ghosh. 2006. Assessment of Structural Robustness Against Aircraft Impact at the Potential Repository at Yucca Mountain—Progress Report II. CNWRA Report to NRC.

Dannemann, K., S. Chocron, A. Ghosh, A. Minachi, and J. Walker. 2005. Characterization of Porous Rock at High Strain Rates. Final Report to SwRI Advisory Committee on Research.

Cox, P.A., J. Mathis, and A. Ghosh. 2005. Assessment of Structural Robustness Against Aircraft Impact at the Potential Repository at Yucca Mountain—Progress Report. CNWRA Report to NRC.

Campe, K. and A. Ghosh. 2005. NRC Staff Evaluation of Aircraft Impact Speeds and Angles Used by Applicant Private Fuel Storage, LLC (PFS) to Represent F-16 Crashes for Skull Valley Type Events. NRC staff position before the Atomic Safety and Licensing Board in connection with the State of Utah's Contention in the licensing proceedings of Private Fuel Storage Facility. Washington DC.

Manepally, C., R. Chen, K. Chiang, A. Chowdhury, B. Dasgupta, C. Dinwiddie, A. Garabedian, A. Ghosh, S. Green, D. Gute, L. Howard, S. Hsiung, L. Ibarra, P. Mackin, G. Ofoegbu, Y. Pan, D. Pomerening, J. Stamatakos, and D. Thorne. 2005. Humboldt Bay Independent Spent Fuel Storage Installation Safety Evaluation Report—Final Letter Report. CNWRA Report to NRC.

Hsiung, S., R. Chen, A. Chowdhury, P. Cox, B. Dasgupta,, D. Dunn, A. Garabedian, A. Ghosh, R. Green, D. Gute, B. Hill, M. Lesher, P. Mackin, C. Manepally, D. Pomerening, O. Povetko, M. Smith, J. Stamatakos, F. Thomassy. 2004. Idaho Spent Fuel Facility Safety Evaluation Report. CNWRA Report to NRC.

Ghosh, A., S.M. Hsiung, and D. Gute. 2003. Assessment of Appropriateness of Level of Design Details for Heating, Ventilation, and Air-conditioning System for Dry Transfer Facility 1 of the Proposed Repository at Yucca Mountain. CNWRA Report to NRC.

Stamatakos, J., A. Chowdhury, B. Dasgupta, D. Dunn, A. Ghosh, D. Gute, B. Hill, S. Hsiung, P. Mackin, C. Manepally, G. Ofoegbu, D. Pomerening, O. Povetko, R. Sewell, M. Smith. 2003. Diablo Canyon Independent Spent Fuel Storage Installation Safety Evaluation Report. CNWRA Report to NRC.

Stamatakos, J., D.A. Ferrill, D.J. Waiting, A.P. Morris, D.W. Sims, and A. Ghosh. 2003. Evaluation of Faulting as it Relates to Postclosure Performance of the Proposed High-Level Waste Repository at Yucca Mountain, Nevada. CNWRA Report to NRC.

Ghosh, A. 2003. Evaluation of Military Ordnance Impacts at the Proposed Private Fuel Storage Site in Skull Valley, Utah. CNWRA Report to NRC.

Ghosh, A. 2003. Evaluation of Impact Velocity and Impact Angle for F-16 Crashes at the Proposed PFS Site. CNWRA Report to NRC.

Ghosh, A. 2003. Probability of Munitions Impacts and Aircraft Crashes at a Proposed Private Fuel Storage Facility for Spent Nuclear Fuel in Utah. CNWRA Report to NRC.

M. Lescher, A. Ghosh, and B. Dasgupta. 2003. Assessment of the Subsurface Transporter System for the Proposed Repository at Yucca Mountain. CNWRA Report to NRC.

Ghosh, A. 2003. Assessment of Jettisoned Ordnance Impact Effects for the Private Fuel Storage Facility. CNWRA Report to NRC.

Ghosh, A. 2003. Probability Assessment of the Aircraft Crash Impact Hazard for the Private Fuel Storage Facility Based on Engineering Evaluations of Storage Cask and Canister Transfer Building Structural Integrity. CNWRA Report to NRC.

Ghosh, A. 2003. NRC Review of DOE Documents Pertaining to Key Technical Issue Agreement PRE 03.01. U.S. Nuclear Regulatory Commission to U.S. Department of Energy, Yucca Mountain Project.

Gute, G.D., G. Ofoegbu, F. Thomassy, S.M. Hsiung, G. Adams, A. Ghosh, B. Dasgupta, A. Chowdhury, and S. Mohanty. 2003. MECHFAIL: A Total-System Performance Assessment Code Module for Evaluation Engineered Barrier Performance Under Mechanical Loading Conditions. CNWRA 2003-06. CNWRA Report to NRC.

Stamatakos, J.A., D. A. Ferrill, D. J. Waiting, A. P. Morris, D. W. Sims, and A. Ghosh. 2003. Evaluation of Faulting as it Relates to Postclosure Performance of the Proposed High-level Waste Repository at Yucca Mountain, Nevada. CNWRA Report to NRC.

Ghosh, A. 2003. Extreme Wind/Tornado/Tornado Missile Hazard Analysis. CNWRA Report to NRC.

Dasgupta, B., A. Ghosh, A. H. Chowdhury, B. E. Hill, J. Stamatakos, and M. Lescher. Hazard 2002. Identification for the Geologic Repository Operations Area: A Progress Report. CNWRA Report to NRC.

Ghosh, A. 2001. Final Standard Review Plan for the Review of a Reclamation Plan for Mill Tailings Sites Under Title II of the Uranium Mill Tailings Radiation Control Act. CNWRA Report to NRC.

Gute, G.D., A. Ghosh, S.-M. Hsiung, A. H. Chowdhury. 2001. Assessment of Mechanical Response of Drip Shields under Repository Environment-Progress Report 2. CNWRA Report to NRC.

Ghosh, A. 2001. Accidents at Nearby Sites–Aircraft Crash Hazards; Accidents at Nearby Sites–Cruise Missile Testing at the UTTR. CNWRA Report to NRC.

Dasgupta, B., R. Benke, D. Daruwalla, A. Ghosh, R. Janetzke, and A. Chowdhury. 2001. PCSA Tool Development Progress Report. CNWRA Report to NRC.

Ghosh, A., D. Brogan, and D. J. Pomerening. 2001. Development of a Hazard Identification Database for Nearby Military and Industrial Facilities of the Proposed Repository at Yucca Mountain–Preliminary Report. CNWRA Report to NRC.

Ghosh, A., D. J. Pomerening, J. R. Weldy, G. D. Gute, C. S. Brossia, A. H. Chowdhury, and P. C. Mackin. 2000. Assessment Report of Topical Safety Analysis Report for the Centralized Interim Storage Facility. CNWRA Report to NRC.

Gute, G.D., D. J. Pomerening, B. Dasgupta, and A. Ghosh. 2000. Summary of Review of Topical Report on HI-STAR 100 and HI-STROM 100 System Deployment at High ZPA ISFSI Sites. (Holtec Report No: HI-982004). CNWRA Report to NRC.

McKague, H.L., C.B. Conner, A. Ghosh, P.L. La Femina, R.H. Martin, and W.C. Patrick. 2000. Final Report on Investigation of Geological and Rock Mechanical Characteristics of the Bracken Bat Cave, Comal County, Texas. CNWRA Report to Bat Conservation International. Austin, Texas.

Ghosh, A., G.I. Ofoegbu, R. Chen, D.J. Pomerening, J.A. Stamatakos, A.H. Chowdhury, J. Weldy, and M.W. McCann, Jr. 2000. Safety Evaluation Report of the Site-Related Aspects of the Private Fuel Storage Facility Independent Spent Fuel Storage Installation. CNWRA Report to NRC.

Gute, G.D., A. Ghosh, S.M. Hsiung, and A.H. Chowdhury. 2000. Assessment of Mechanical Response of Drip Shields under Repository Environment-Progress Report. CNWRA Report to NRC.

Ahola, M.P., S.M. Hsiung, and A. Ghosh. 1999. Rock Mass Behavior in the Transitional Zone Between Strong and Weak Rock Conditions. CNWRA Report to NRC.

Ghosh, A., D.J. Pomerening, and A.H. Chowdhury. 1999. Compatibility of Hi-storm 100 and Transtor™ Cask Systems with Private Fuel Storage Facility Site Characteristics and Design. CNWRA Report to NRC.

Hsiung, S.M., A. Ghosh, and J. Lankford. 1999. Prediction of Occurrence and Location of Rockburst in Highly Stressed Deep Underground Mines. Project No. 20-9974. Final Report to SwRI Advisory Committee on Research.

Ghosh, A. 1998. A Review of the Reclamation Plan for the Shirley Basin Mine Site, Shirley Basin, Wyoming, for Source Material License SUA–442. CNWRA Report to NRC.

Ghosh, A. 1998. Surety Update for Material License SUA–648, License Condition Above-grade Tailings Impoundment No. 54, for the Umetco Minerals Corporation, Gas Hills Site. CNWRA Report to NRC.

Ghosh, A., J. Stamatokos, S.M. Hsiung, R. Chen, A.H. Chowdhury, and H.L. McKague. 1998. Key Technical Issue Sensitivity Analysis With SEISMO and FAULTO Modules Within The TPA (Version 3.1.1) Code. CNWRA Report to NRC.

Ghosh, A., G. Stirewalt, and K. Poor. 1997. Faulting Code: Fault Displacement Consequence Module, Version 1.0 Model Description and User Guide. CNWRA Report to NRC.

Ghosh, A., S.M. Hsiung and A. H. Chowdhury. Seismic Response of Rock Joints and Jointed Rock Mass. NUREG/CR–6388 and CNWRA 95-013. Washington, DC: U.S. Nuclear Regulatory Commission.

Ghosh, A., S.M. Hsiung and A. H. Chowdhury. 1995. Progress Toward a Fractal Representation of Rock Joint Roughness. CNWRA 95-004. CNWRA Report to NRC.

Ghosh, A., S.M. Hsiung, D. J. Fox, A.H. Chowdhury, and D.D. Kana. 1995. Rock Joint Model Development for Cyclic Loads. CNWRA 95-022. CNWRA Report to NRC.

Hsiung, S.M., M.P. Ahola, A.H. Chowdhury, and A. Ghosh. 1994. Laboratory Characterization of Rock Joints. NUREG/CR–6178 and CNWRA 93-013. Washington, DC: U.S. Nuclear Regulatory Commission.

Ghosh, A., G. I. Ofoegbu, M. P. Ahola, S. M. Hsiung, and A. H. Chowdhury. 1995. Evaluation of ABAQUS as a Compliance Determination Computer Code. CNWRA 95-016. CNWRA Report to NRC.

Ghosh, A., S.M. Hsiung, A.H. Chowdhury, and M.P. Ahola. 1994. Evaluation of Rock Joint Models and Computer Code UDEC Against Experimental Results. NUREG/CR–6216 and CNWRA 93-024. Washington, DC: U.S. Nuclear Regulatory Commission.

Ghosh, A., S.M. Hsiung, G.I. Ofoegbu, and A.H. Chowdhury. 1994. Evaluation of Computer Codes for Compliance Determination Phase II. CNWRA 94-001. CNWRA Report to NRC.

Ghosh, A., S.M. Hsiung, M.P. Ahola, and A.H. Chowdhury. 1993. Evaluation of Coupled Computer Codes for Compliance Determination. CNWRA 93-005. CNWRA Report to NRC.

Hsiung, S.M., A.H. Chowdhury, W. Blake, M.P. Ahola, and A. Ghosh. 1992. Field Site Investigation: Effect of Mine Seismicity on a Jointed Rock Mass. CNWRA 92-012. CNWRA Report to NRC.

Ghosh, A. and J.J.K. Daemen. 1983. A New Analytical Predictor of Ground Vibrations Induced by Blasting. Volume IV of `Ground and Air Vibrations Caused by Surface Blasting,' Report to United States Bureau of Mines, Bureau of Mines open file report No. OFR 105(4) p. 84.

Ghosh, A. and J.J.K. Daemen. 1983. Ground and Air Vibrations Caused by Surface Blasting– Executive Summary, Volume I Report to the United States Bureau of Mines, Bureau of Mines open file report no. OFR 105(1) p. 84.

Presentations

Ghosh, A., F. Ferrante, and M. Enright. 2009. Reliability of a Rock Slope against Plane Sliding Failure. Presented at the International Conference on Rock Joints and Jointed Rock Masses 2009, January 2009. Tucson, Arizona.

Ghosh, A. and F. Ferrante. 2008. Reliability Estimation of Rock Slopes. ARMA 08-251. Presented at the 42nd U.S. Rock Mechanics Symposium and the 2nd U.S./Canada Rock Mechanics Symposium. San Francisco, California.

Hsiung, S.M. and A. Ghosh. 2006. Seismic Response of Underground Excavations in Jointed Rock Mass. Presented at the 41st U.S. Symposium on Rock Mechanics. Golden, Colorado.

Ghosh, A. and B. Sagar. 2002. Assessment of Aircraft Crash Frequency During Take Off and Landing at an Airport. PSAM6. Presented at the Probabilistic Safety Assessment and Management. Puerto Rico.

Ghosh, A. and B. Sagar. 2001. Preliminary Aircraft Crash Hazard Assessment at Proposed Yucca Mountain Repository. Presented at the International High-Level Radioactive Waste Management Conference.

Ghosh, A., S.M. Hsiung, and A.H. Chowdhury. 1995. Natural Rock Joint Profile Characterization Using Self-Affine Fractal Approach. Presented at the 35th U.S. Symposium on Rock Mechanics. Lake Tahoe, Nevada.

Ghosh, A., K. Fuenkajorn, and J.J.K. Daemen. 1995. Tensile Strength of Welded Apache Leap Tuff: Investigation of Scale Effects. Presented at the 35th U.S. Symposium on Rock Mechanics. Lake Tahoe, Nevada.

Ghosh, A. and J.J.K. Daemen. 1995. Rock Fragmentation in Bench Blasting–A Numerical Study. Presented at the 35th U.S. Symposium on Rock Mechanics. Lake Tahoe, Nevada.

Ghosh, A. 1995. Seismic Engineering Issues for a Proposed HLW Repository at Yucca Mountain. FOCUS'95. Presented at the American Nuclear Society Topical Meeting on Methods of Seismic Hazards Evaluation. Las Vegas, Nevada.

Ghosh, A. and S.M. Hsiung. 1995. On Characterization of Self-Affine Fractal Profiles. Presented at the 10th ASCE Engineering Mechanics Conference. University of Colorado at Boulder.

Hsiung, S.M., A. Ghosh, M.P. Ahola, and A.H. Chowdhury. 1993. Assessment of Conventional Methodologies for Joint Roughness Coefficient Determination. Presented at the 34th U.S. Symposium on Rock Mechanics, University of Wisconsin. Madison, Wisconsin.

Ghosh, A. and J.J.K. Daemen. 1987. An Expert System Approach to Geomechanics Design Problems. Presented at the 3rd International Conference on Innovative Mining Systems. University of Missouri at Rolla.

Ghosh, A., J.J.K. Daemen and S. Harpalani. 1987. Expert System for Coal Mine Roof Bolt Design. Presented at the 28th U.S. Symposium on Rock Mechanics. University of Arizona

Ghosh, A. and J.J.K. Daemen. 1986. Best Source Modeling of Blast Vibration: Cube-Root Scaling, Square-Root Scaling or Site-Specific Scaling. Presented at the International Symposium on Environmental Geotechnology. Lehigh University.

Ghosh, A. and J.J.K. Daemen. 1985. Statistics–A Key to Better Blast Vibration Predictions. Presented at the 26th U.S. Symposium on Rock Mechanics. South Dakota School of Mines & Technology.

Ghosh, A. and J.J.K. Daemen. 1983. A Simple New Blast Vibration Predictor (Based on Wave Propagation Laws). Presented at the 24th U.S. Rock Mechanics Symposium. Texas A&M University.

Faculty in University Courses and Workshops:

- Taught three courses in Mining Engineering curriculum at the University of Arizona: Introduction to Mining Engineering, Underground and Surface Mining Methods, and Unit Operations.

- Substitute instructor for Rock Excavation and Advanced Geomechanics courses.

- Supervised class projects on application of numerical methods for excavation design.

- Ground Vibration and Airblast from Blasting–Their Generation, Propagation and Effects on Structures. Third Advanced Rock Blasting Course. IDL Chemicals Ltd. India. 1981.

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Experience:

Dr. Hsiung is a mining engineer with a broad range of experience in geotechnical engineering and integrated safety analysis. He has more than 35 years of research and consulting experience in the disciplines of mining engineering and rock mechanics. He has authored over 130 technical papers and reports. For the last 30 years, Dr. Hsiung has conducted research and provided technical assistance in rock mechanics, geotechnical engineering, and natural phenomena and human-induced hazard assessment to NRC and other clients.

Dr. Hsiung worked on numerous research and consulting projects included solving practical ground control problems, designing longwall chain and yield pillars, evaluating room-and-pillar and multiple seam mining practices, investigating interactions of hydraulic power supports with rock strata of underground coal mines, and monitoring to support abandoned mine subsidence abatement. He also was responsible for a number of field investigations of entry roof deformation, roof strata movement at the longwall face, pillar stability, effectiveness of roof supports and hydraulic power supports, and surface subsidence induced by longwall mining.

At GED of SwRI, Dr. Hsiung provides technical support on performance and design review of a potential high-level waste geologic repository. He lead an effort of conducting soil-structure interaction analyses of a hypothetical waste handling facility to investigate the effects of characteristics of seismic ground accelerations, soil spatial variations, and soil geotechnical properties on structural seismic responses. In conducting the soil-structure interaction analyses, he also assessed the effects of key modeling parameters on analysis results. Dr. Hsiung has significantly contributed to (i) the design of a direct shear apparatus for dynamic experiments on large specimens, (ii) development of a rock joint constitutive model to better describe the dynamic joint behavior observed from laboratory experiments, (iii) field instrumentation and investigation of the effects of mining-induced seismicity on excavation response and local hydrology, and (iv) a small-scale (similitude) rock mass model experiment under scaled earthquake loads. He was a lead investigator in thermal-mechanical-hydrologic modeling of the U.S. Department of Energy (DOE) Drift Scale Heater Test under the international cooperative program DECOVALEX, developed an analytic relationship to assess effects of joint deformation on joint hydraulic conductivity, and developed a methodology to predict rockbursts in deep underground mines. Dr. Hsiung has developed technical evaluation reports for uranium tailings, reclamation plans for source material licenses in areas related to dynamic and static stability of slopes, potential liquefaction of foundation soils, settlement effects on radon barrier integrity, and integrated safety analyses for NRC-licensed nuclear fuel fabrication facilities. Dr. Hsiung also provided technical support to NRC on prelicensing activities relevant to high-level nuclear waste disposal, including review of DOE repository design and performance and conduct of independent site-response and soil-structure interaction analyses. His recent experience includes (i) reviewing structural designs for mixed oxide and gas centrifuge facilities; (ii) developing safety evaluation reports for NRC on several license applications for mixed oxide, gas centrifuge, laser enrichment, and independent spent fuel

storage installation facilities with focuses on tornado and high-wind evaluation; slope stability, liquefaction potential, aircraft crash, snow, and hurricane hazard characterizations; tornado and human-made missile impact assessments; settlement and soil bearing capacity determinations; (iii) performing final structural design review (including foundation design and soil-structure interaction analyses) and construction inspections on gas centrifuge facilities, and (iv) reviewing the DOE license application for high-level nuclear waste geologic disposal.

Special Expertise:

Geomechanical modeling, slope stability analyses, and site response analyses using the following computer codes:

- Universal Distinct Element Code (UDEC)
- Fast Lagrangian Analysis of Continua (FLAC)
- SASSI 2000—A System for Analysis of Soil-Structure Interaction
- Discontinuous Deformation Analysis (DDA)
- MSC Nastran
- ProShake
- EZ-FIRSK

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1984 Ph.D., Mining Engineering, West Virginia University
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Research Engineer, CNWRA, San Antonio, Texas; 1988–1990.

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Publications:

Hsiung, S.M. and A. Chowdhury. 2011. Seismic Effects on Soil-Structure Interactions. San Antonio, Texas: CNWRA.

Mohanty, S. and S.M. Hsiung. 2011. An Experimental Investigation of Single Fracture Flow Behavior Under Normal and Shear Loads. San Antonio, Texas: CNWRA.

Ghosh, A. and S.M. Hsiung. 2011. Effects of Tilted and Faulted Strata on Seismic Ground Motion. San Antonio, Texas: CNWRA.

Hsiung, S.M., J. Stamatakos, and A. Chowdhury. 2011. Review of Seismic, Tornado, and High-Wind Hazards and Structural Design Assessments of International Isotopes Fluorine Products, Inc. Fluorine Extraction Process & Depleted Uranium De-conversion Plant, Lea County, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M., J. Stamatakos, A. Chowdhury, and M. Roberts. 2010. Review of Seismic, Tornado, and High-Wind Hazards and Structural Design Assessments of General Electric-Hitachi Global Laser Enrichment Commercial Facility, Wilmington, North Carolina. San Antonio, Texas: CNWRA.

Hsiung, S.M., J. Stamatakos, and A. Chowdhury. 2009. Review of Seismic, Tornado, and High-Wind Hazards and Structural Design Assessments of AREVA Enrichment Services LLC Eagle Rock Enrichment Facility, Bonneville County, Idaho. San Antonio, Texas: CNWRA.

Hsiung, S.M., 2009. Review of Change Requests in the Applicability of Items Relied on for Safety for the Cylinder Receipt And Dispatch Building (CRDB) and the Bunkered Structure inside the CRDB for Natural Phenomena Events for the Louisiana Energy Services National Enrichment Facility. San Antonio, Texas: CNWRA.

Hsiung, S.M., A.H. Chowdhury, B. Dasgupta, PA Cox, and J. Stamatakos. 2008. Review of Seismic, Tornado and High-Wind Hazards and Structural Design Criteria for Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina. San Antonio, Texas: CNWRA.

Hsiung, S.M., T. Wilt, and A.H. Chowdhury. 2008. In-Office Review at Cherry Hill, New Jersey Design of the Cascade Halls 1 and 2 Module of the National Enrichment Facility Louisiana Energy Services, Eunice, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A.H. Chowdhury, 2008. Review Plan for Structural Final Design Verification of the Louisiana Energy Services National Enrichment Facility, LEA County, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh, and A.H. Chowdhury, 2007. Site Response and Soil-Structure Interaction Analyses—A Progress Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., A.H. Chowdhury, and B. Dasgupta. 2007. In-Office Review Civil Structural Design of the Mixed Oxide (MOX) Fuel Fabrication Building Shaw AREVA MOX Services Office, Aiken, South Carolina. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A.H. Chowdhury, 2006. Review of the Natural Phenomena and Structures–Related Issues for the AREVA NP Richland Facility Integrated Safety Analysis Summary. San Antonio, Texas: CNWRA.

Hsiung, S.M. 2006. Review of the Natural Phenomena-Related Issues for the Global Nuclear Fuel—Americas Balance of Plant Integrated Safety Analysis Summary. San Antonio, Texas: CNWRA.

Hsiung, S.M. 2006. Westinghouse Electric Company ISA Summary Technical Evaluation Report on Natural Phenomena. San Antonio, Texas: CNWRA.

Ofoegbu, G.I., R. Fedors, C. Grossman, S. Hsiung, L. Ibarra, C. Manepally, J. Myers, M. Nataraja, O. Pensado, K. Smart, and D. Wyrick D. 2006. Summary of Current Understanding of Drift Degradation and its Effect on Performance at a Potential Yucca Mountain Repository. CNWRA 2006-02. San Antonio, Texas: CNWRA.

Hsiung, S.M., S. Gonzalez, and A.H. Chowdhury, 2006. Site Response and Soil-Structure Interaction Analyses—A Progress Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., S. Gonzalez, and A.H. Chowdhury, 2006. Review of Seismic, Tornado, and High-Wind Hazards for and Structural Design of American Centrifuge Plant in Piketon, Ohio. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A. Ghosh. 2006. Seismic Responses of Underground Excavations in Jointed Rock Mass." Proceedings from Golden Rocks 2006, the 41st U.S. Symposium on Rock Mechanics (USRMS): 50 Years of Rock Mechanics–Landmarks and Future Challenges, June 17–21, 2006. Golden, Colorado.

Hsiung, S.M. 2006. Some Advancements to Discontinuous Deformation Analysis (DDA). The 7th World Congress on Computational Mechanics. July 16–22, 2006. Los Angles, California.

Hsiung, S.M., S. Gonzalez, K. Smart, and A.H. Chowdhury. 2005. Soil-Structural Interaction: Progress Report—Site Response Analyses. San Antonio, Texas: CNWRA.

Hsiung, S.M., A.H. Chowdhury, and M.S. Nataraja. 2005. Numerical Simulation of Thermal-Hydrological and Thermal-Mechanical Processes Observed at the Drift-Scale Heater Test at Yucca Mountain, Nevada. International of Rock Mechanics and Mining Sciences, Vol. 42. pp. 652–666.

Hsiung, S.M., G. Adams, A. Garabedian, and D. Thorne. 2005. Technical Evaluation of the Integrated Safety Analysis Summaries for the Westinghouse Uranyl Nitrate Bulk storage and Wastewater Treatment systems. San Antonio, Texas: CNWRA.

Manepally, C., R. Chen, K. Chiang, A.H. Chowdhury, B. Dasgupta, C. Dinwiddie, A. Garabedian, A. Ghosh, S. Green, D. Gute, L. Howard, S.M. Hsiung, L. Ibarra, P. Mackin, G. Ofoegbu, Y. Pan, D. Pomerening, J. Stamatakos, and D. Thorne. 2005. Humboldt Bay Independent Spent Fuel Storage Installation Safety Evaluation Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., S. Gonzalez, J. Stamatakos, and A.H. Chowdhury. 2004. Review of Seismic, Tornado, and High-wind Hazards and Structural Design Assessments of Louisiana Energy Services National Enrichment Facility, Lee County, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M., S. Gonzalez and A. Chowdhury. 2004. Review of Seismic, Tornado, and High-Wind Hazards and Structural Design Assessments of Louisiana Energy Services National Enrichment Facility, Lea County, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M., G. Adams, and L. Howard. 2004. Recommendations for Improving the Review Process of Fuel Cycle Facilities Integrated Safety Analysis. San Antonio, Texas: CNWRA.

Hsiung, S.M., et al. 2004. Idaho Spent Fuel Facility Safety Evaluation Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., S. Gonzalez and A. Chowdhury. 2004. Final Review Plan for Seismic, Tornado, and High-wind Hazards and Structural Design Assessments of Louisiana Energy Services National Enrichment Facility, Lee County, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M., G. Adams, A. Garabedia, and O. Povetko. Technical Evaluation of the Integrated Safety Analysis Summary for the Global Nuclear Fuel Dry Conversion and Hydrofluoric Acid Recovery Facilities. San Antonio, Texas: CNWRA.

Hsiung, S.M., G. Ofoegbu, D. Dunn, and D. Gute. 2004. Integrated Issue Resolution Status Report, Section 4.1.7—Design of Structures, Systems, and Components Important to Safety and Safety Controls, Rev. 2. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh, and D. Gute. 2004. Assessment of Appropriateness of Level of Details For Heating, Ventilation, and Air-Conditioning (HVAC) System for Dry Transfer Facility 1 of the Proposed Repository at Yucca Mountain. San Antonio, Texas: CNWRA.

Hsiung, S.M., J. Stamatakos and A.H. Chowdhury. 2003. Review of Seismic, Tornado, And High-wind Hazards For And Structural Design of American Centrifuge Lead Cascade Facility, Piketon, Ohio. San Antonio, Texas: CNWRA.

Hsiung, S.M., A.H. Chowdhury, and M.S. Nataraja. 2003. Thermal-Mechanical Modeling of a Large-Scale heater Test. GeoProc 2003. International Conference on Coupled T-H-M-C Processes in Geosystems: Fundamentals, Modeling, Experiments & Applications. pp. 153–160. Royal Institute of Technology, October 13–15, 2003. Stockholm, Sweden.

Hsiung, S.M., O. Povetko, and A. Chowdhury. 2003. Technical Evaluation of the Review Process for Fuel Cycle Facility Integrated Safety Analyses. San Antonio, Texas: CNWRA.

Stamatakos, J., and S.M. Hsiung. 2003. Diablo Canyon ISFSI Safety Evaluation Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., J. Stamatakos and A. Chowdhury. 2003. Review Plan for Seismic, Tornado, and High-Wind Hazards and Structural Design Assessments of American Centrifuge Lead Cascade Facility, Piketon, Ohio. San Antonio, Texas: CNWRA.

Gute, D., G. Ofoegbu, S.M. Hsiung, A. Ghosh, and B. Dasgupta. 2003. Mechfail: A Total-System Performance Assessment Code Module for Evaluating Engineered Barrier Performance Under Mechanical Loading Conditions. CNWRA 2003-06. San Antonio, Texas: CNWRA.

Yang, L., O. Povetko, and S.M. Hsiung. 2003. Characteristics of fuels to be Stored at the Proposed Idaho Spent Facility Final Report. San Antonio, Texas: CNWRA.

Hsiung, S.M. 2003. Yucca Mountain Review Plan, Section 2.1—Repository Safety Before Permanent Closure. Rev. 2. Final Report. NUREG–1804. Washington, DC: U.S. Nuclear Regulatory Commission.

Hsiung, S.M. and A.H. Chowdhury. 2003. Final Report for DECOVALEX III Task 2C: Thermal-Mechanical Modeling of the Drift-Scale Heater Test at Yucca Mountain. San Antonio, Texas: CNWRA.

Stamatakos, J., S.M. Hsiung, R. Chen, and A. Chowdhury. 2002. Review of Seismic and Geotechnical Hazards Assessments for Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A.H. Chowdhury. 2002. Review of Tornado/High Wind Hazard Assessment of Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A.H. Chowdhury. 2002. Review of Structural Design Criteria for Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina. San Antonio, Texas: CNWRA.

J. Parra, P. Xu, and S.M. Hsiung. 2002. Seismic Waves in Layered Viscoelastic Formation With Tilted, Multiple Fractures Sets. San Antonio, Texas: SwRI.

Hsiung, S.M., G. Ofoegbu, D. Gute, and D. Dunn. 2002. Issue Resolution Status Report—Chapter 2.1.7, Design of Structures, Systems, and Components Important to Safety. NUREG–1762. Washington, DC: U.S. Nuclear Regulatory Commission.

Hsiung, S.M. and G.H. Shi. 2001. Simulation of Earthquake on Underground Excavations Using Discontinuous Deformation Analysis (DDA). The 38th U.S. Rock Mechanics Symposium, July 7–10, 2001. Washington, DC.

Hsiung, S.M. 2001. Discontinuous Deformation Analysis (DDA) with nth Order Polynomial Displacement Functions. The 38th U.S. Rock Mechanics Symposium, July 7–10, 2001. Washington, DC.

Hsiung, S.M. and A.H. Chowdhury. 2001. DECOVALEX III Task 2C: Thermal-mechanical Modeling of The Drift-scale Heater Test at Yucca Mountain—Progress Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., R. Chen, G. Ofoegbu, D. Dunn, and D. Gute. 2001. Integrated Issue Resolution Status Report, Section 4.1.7—Design of Structures, Systems, and Components Important to Safety and Safety Controls. Rev. 1. San Antonio, Texas: CNWRA.

Gute, D., A. Ghosh, S.M. Hsiung, and A. Chowdhury. 2001. Assessment of Mechanical Response of Drip Shields Under Repository Environment—Progress Report 2. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A.H. Chowdhury. 2001. Review Plan for Tornado/High Wind Hazard Assessment of Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A.H. Chowdhury. 2001. Review Plan for Structural Design Criteria of Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina. San Antonio, Texas: CNWRA.

Stamatakos, J, S.M. Hsiung, A. Chowdhury, M. Miklas, R. Green, and C. Connor. 2001. Review and Evaluation of Site Characteristics of Naval Reactors Spent Fuel ISFSI Site at INEEL. CNWRA 2001-001, Rev. 1. San Antonio, Texas: CNWRA.

Ferrill, D., W. Dunne, S.M. Hsiung, and A. Morris. 2001. Review of Analysis Model Report (AMR) of Fracture Geometry Analysis for the Stratigraphic Units of the Repository Host Horizon. San Antonio, Texas: CNWRA.

David R. Turner, D.R., B. Russell, S.M. Hsiung, P.C. Mackin. 2001. Input to Commission Paper on Site Recommendation Review—Letter Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., J. Stamatakos, S. Mohanty, and A. Ibrahim. 2001 NRC Sensitivity and Uncertainty Analyses for a Proposed HLW Repository at Yucca Mountain, Nevada, Using TPA 3.1—Conceptual Model and Data, Section 3.4 Seismo Module Description. NUREG–1668, Vol. 1. Washington, DC: U.S. Nuclear Regulatory Commission.

Stamatakos, J., S.M. Hsiung, and A.H. Chowdhury. 2001. Final Review Plan for Seismic and Geotechnical Hazard Assessment of Mixed Oxide Fuel Fabrication Facility, Savannah River Site, South Carolina. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh, A.H. Chowdhury, and J. Lankford. 2000. Acoustic emission technique for damage assessment of reinforced concrete structures. Fourteenth Engineering Mechanics Conference (EM2000) of the American Society of Civil Engineers.

Hsiung, S.M., A. Ghosh, J. Lankford, and A.H. Chowdhury. 2000. Fractal Pattern Characterization of Acoustic Emissions for Continuous Damage Assessment of Reinforced Concrete Structures. Condition Monitoring of Materials and Structures. F. Ansari, ed. pp. 2–20.

Hsiung, S.M. and S. Mohanty. 2000. An Abstracted Model for Assessing the Effect of Seismically Induced Rockfall on the Waste package Performance for High-Level Radioactive Waste Disposal. Proceedings from the International Conference on Probabilistic Safety Assessment and Management, November 27–December 1, 2000.

Stamatakos, J.A., P.S. Justus, A. Ghosh, S. Hsiung, M. Miklas, R. Chen, and A-b.K. Ibrahim. 2000. Evaluation of radiological risk from seismotectonic processes at the candidate high-level repository at Yucca Mountain, Nevada, USA. IGC Brazil.

Ghosh, A. and S.M. Hsiung. 2000. Acoustic emission as an indicator of macrofailure of rock. The 4th North American Rock Mechanics Symposium, July 31–August 2, 2000. Seattle, Washington.

Chen, R., G.I. Ofoegbu, and S.M. Hsiung. 2000. Modeling drift stability in fractured rock mass at Yucca Mountain, Nevada—Discontinuum approach. The 4th North American Rock Mechanics Symposium, July 31–August 2, 2000. Seattle, Washington.

Hsiung, S.M., G. Shi, and A.H. Chowdhury. 2000. Assessment of Seismically Induced Rockfall in the Emplacement Drifts of the Proposed Repository at Yucca Mountain—Progress Report. San Antonio, Texas: CNWRA.

Gute, D., A. Ghosh, S.M. Hsiung, and A.H. Chowdhury. 2000. Assessment of Mechanical Response of Drip Shields Under Repository Environment—Progress Report. San Antonio, Texas: CNWRA.

Mohanty, S. and S.M. Hsiung. 2000. Total-System Performance Assessment (TPA) Version 4.0 Code—Module Description and User's Guide—Predecisional. San Antonio, Texas: CNWRA.

Chen, R., G. Ofoegbu, and S.M. Hsiung. 2000. Issue Resolution Report, Key Technical Issue: Repository Design and Thermal-Mechanical Effects—Letter Report. Rev. 3. San Antonio, Texas: CNWRA.

Gute, D., T. Krauthammer, S.M. Hsiung, and A.H. Chowdhury. 1999. Assessment of Mechanical Response of Waste Packages Under Repository Environment—Progress Report. San Antonio, Texas: CNWRA.

Chen, R., G.I. Ofoegbu, and S.M. Hsiung. 1999. Analysis of Drift Instability and Rockfall Due to Earthquake Ground Motion at Yucca Mountain, Nevada." Proceedings from the 37th U.S. Rock Mechanics Symposium, June 6–9, 1999. Vail, Colorado.

Hsiung, S.M., D. Fox, and A.H. Chowdhury. 1999. Effects of Repetitive Seismic Loads on Underground Excavations in Jointed Rock Mass. The 7th International Conference on Radioactive Waste Management and Environmental Remediation, September 24–30, 1999. Nagoya, Japan.

Ahola, M.P., S.M. Hsiung, and A. Ghosh. 1999. Rock-Mass Behavior in the Transitional Zone Between Strong and Weak Rock Conditions. San Antonio, Texas: CNWRA.

Hsiung, S.M., Chen, R., and G. Ofoegbu. 1999. Issue Resolution Report, Key Technical Issue: Repository Design and Thermal-Mechanical Effects—Letter Report. Rev. 2. San Antonio, Texas: CNWRA.

Hsiung, S.M. and A. Ghosh. 1999. Prediction of Occurrence and Location of Rockbursts in Highly-Stressed Deep Underground mines—Final Report. San Antonio, Texas: SwRI.

Mohanty, S. and S.M. Hsiung. 1999. Total-System Performance Assessment (TPA) Version 3.2 Code—Module Description and User's Guide—Predecisional. San Antonio, Texas: CNWRA.

Hsiung, S.M. and G. Ofoegbu. 1998. Issue Resolution Report, Key Technical Issue: Repository Design and Thermal-Mechanical Effects—Letter Report. Rev. 1. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1998. Draft Technical Evaluation Report for the Decommissioning and Reclamation Plan for the Shootaring Canyon Uranium Processing Facility for Source Material License SUA–1371. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1998. Technical Evaluation Report of the Slope Stability Evaluation for the Lucky Mc Uranium Mill Site Gas Hills, Wyoming, Tailings Reclamation Plan for Source Material License SUA–672. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh, J. Stamatakos, and R. Chen. 1998. Key Technical Issue Sensitivity Analysis with SEISMO and FAULTO Modules within the TPA (Version 3.1.1) Code. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1998. Technical Evaluation of Slope Design of the Tailings Retention Embankment at the Rio Algom Corporation Lisbon Mill Site, Utah. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1998. Technical Evaluation Report on Lucky Mc Mine Tailings Reclamation Plan, Material License SUA–672. San Antonio, Texas: CNWRA.

D. Fox, D., D. Kana, and S.M. Hsiung. 1998. Influence of Interface Roughness on Dynamic Shear Behavior in Jointed Rock. International Journal of Rock Mechanics and Mining Science. Vol. 35, No. 7. pp. 923–940.

Chen, R., S.M. Hsiung, and A. Chowdhury. 1998. Thermal-mechanical stability of emplacement drifts for a proposed nuclear waste repository at Yucca Mountain. Proceedings from the 4th International Symposium on Environmental Geotechnology and Global Sustainable Development. Boston, Massachusetts.

Mackin, P. and S.M. Hsiung. 1998. Development of an NRC Review Plan for UMTRCA Title II Site That Supports Requirements for Long-Term Care and Custody. Proceedings from the U.S. Department of Energy Long-Term Stewardship Workshop, June 2–3, 1998. Grand Junction, Colorado.

Hsiung, S.M. 1997. Experimental Study on Dynamic Behavior of Rock Joints." Coupled Thermo-Hydro-Mechanical Processes of Fractured Media, Mathematical and Experimental Studies. O. Stephansson, L. Jing, and C.F. Tsang eds.

Hsiung, S.M. 1997. Technical Evaluation of Slope Design for the Tailings Retention System at the Quivira Mining Company Ambrosia lake Site, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Technical Evaluation of Slope Design for the Tailings Retention Embankment at the United Nuclear Corporation Church Rock Mill Site, Gallup, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Acceptance Review of Plateau Resource Limited Decommissioning and Reclamation Plan for Shootaring Canyon Uranium Mill Facility. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Technical evaluation of Slope Design of the Tailings Retention System at the Home Stake Uranium Mill Site, Grants, New Mexico. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Technical Evaluation of Slope Design of the Tailings Retention Embankment at the Bear Creek Uranium Company Tailings Disposal Facility, Converse County, Wyoming. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Issue Resolution Report, Key Technical Issue: Repository Design and Thermal-Mechanical Effects—Letter Report. Rev. 0. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Detailed Technical Review of Decommissioning and Reclamation Plan for the Pathfinder Mines Corporation Shirley Basin Uranium Mill Site, Material License SUA–442. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Acceptance Review of the Decommissioning and Reclamation Plan for the Plateau Resource Limited Shootaring Canyon Uranium Processing Facility, Material License SUA–1371. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Inspection Report on Geotechnical Aspects of Reclamation Construction Activities at the American Nuclear Uranium Mill Facility, Gas Hills, Wyoming. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Inspection Report on Geotechnical Aspects of Reclamation Construction Activities at the Gas Hills Uranium Mill Facility of Umetco, Gas Hills, Wyoming. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Inspection report on the Exxon's Tailings Disposal Facility. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Inspection report for the Bear Creek Uranium Project. San Antonio, Texas: CNWRA.

Hsiung, S.M. 1997. Detailed Technical Review on Slope Stability Reclaimed Tailings Embankments 1, 2, and 2A Lucky Mc Mine Reclamation Project, Das Hills, Wyoming. San Antonio, Texas: CNWRA.

Kana, D., D. Fox, S.M. Hsiung, and A. Chowdhury. 1997. An Experimental Scale-Model Study of Seismic Response of an Underground Opening in Jointed Rock Mass. NUREG/CR–6404. Washington, DC: U.S. Nuclear Regulatory Commission.

Ahola, M.P., S.M. Hsiung, and D. Kana. 1996. Chapter 18—Experimental Study on Dynamic Behavior of Rock Joint. DECOVALEX—Mathematical and Experimental Studies of Coupled Thermo-Hydro-Mechanical Processes in Fractured Media. Elsevier Science Publishing, Inc.

Ghosh, A., S.M. Hsiung, and A. Chowdhury. 1996. Seismic Response of Rock Joints and Jointed Rock Mass. NUREG/CR–6388. Washington, DC: U.S. Nuclear Regulatory Commission.

Hsiung, S.M., R. Chen, A. Chowdhury, and A. Ghosh. 1996. NRC High-Level Radioactive Waste Program Annual Progress Report: Fiscal Year 1996—Chapter 7, Repository Design and Thermal-Mechanical Effects. NUREG/CR–6513, No. 1, CNWRA 96–OIA. Washington, DC: U.S. Nuclear Regulatory Commission.

Fox, D., D. Kana, and S.M. Hsiung. 1996. Characterization of Interface Roughness and Its Influence on Shear Behavior in Jointed Rock Dynamics. San Antonio, Texas: SwRI.

D. Kana, D. Fox, and S.M. Hsiung. 1996. Interlock/Friction Model for Dynamic Shear Response in Natural Jointed Rock. International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts. Vol. 33, No. 4. pp. 371–386.

Ghosh, A., S.M. Hsiung, and A. Chowdhury. 1996. Seismic Response of Rock Joints and Jointed Rock Mass. NUREG/CR–6178. CNWRA 95-013. Washington, DC: U.S. Nuclear Regulatory Commission.

Ghosh, A., S.M. Hsiung, D. Fox, A. Chowdhury, and D. Kana. 1995. Rock Joint Model Development for Cyclic Loads. CNWRA 95-022. San Antonio, Texas: CNWRA.

Ahola, M.P., R. Hofmann, S.M. Hsiung, and R. Manteufel. 1995. Numerical Study of Seismic Motion Effects on Drift Stability. Proceedings from the FOCUS 95 Methods of Seismic Hazards Evaluation, September 1995. Las Vegas, Nevada.

D. Kana, S.M. Hsiung, and A. Chowdhury. 1995. A Scale Model Study of Seismic Response of an Underground Opening in Jointed Rock. Proceedings from the 35th U.S. Symposium on Rock Mechanics, June 1995. Reno, Nevada. pp. 503–509.

Hsiung, S.M., A. Ghosh, and A. Chowdhury. 1995. On Natural Rock Joint Profile Characterization Using Self Affine Fractal Approach. Rock Mechanics, Daemen & Schultz eds. Balkema, Rotterdam. pp. 681–687.

Ghosh, A. and S.M. Hsiung. 1995. On Characterization of Self-Affine Fractal Profiles. Proceedings from the 10th Engineering Mechanics Conference, American Society of Civil Engineers, May 1995. Boulder, Colorado. pp. 179–182.

Hsiung, S.M., A. Ghosh, A. Chowdhury, and M. Ahola. 1995. Laboratory Investigation of Rock Joint Dynamic Behavior. Proceedings from the 2nd International Conference on Mechanics of Jointed and Faulted Rock, April 1995. Vienna, Austria.

Ofoegbu, G., A. Ghosh, M. Ahola, S.M. Hsiung, and A. Chowdhury. 1995. Evaluation of ABAQUS as a Compliance Determination Computer Code. CNWRA 95-016. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh, G. Stirewalt, B. Henderson, C. Fenrich, and R. Chen. 1995. Development of Rock Mechanics Properties Database—Progress Report. San Antonio, Texas: CNWRA.

Hsiung, S.M., M. Ahola, D. Kana, and S. Mohanty. 1995. Rock Mechanics, NRC High-Level Radioactive Waste Research at CNWRA July-December 1994. CNWRA 94–02S. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh and A. Chowdhury. 1995. Progress Toward a Fractal Representation of Rock Joint Roughness. CNWRA 95-004. San Antonio, Texas: CNWRA.

Hsiung, S.M., R. Hofmann, and R. Manteufel. 1995. Iterative Performance Assessment Phase 3: Status of Activities. CNWRA 95-007. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh and A. Chowdhury. 1994. An Investigation of Rock Joint Models on Prediction of Joint Behavior under Pseudostatic Cyclic Shear Loads." Proceedings 1st North American Rock Mechanics Symposium, June 1994. Austin, Texas.

M.P. Ahola, A. Chowdhury, S.M. Hsiung, and J. Philip. 1994. Comparison of Coupled Thermal-Mechanical-Hydrological Analyses of a Fractured Rock Mass. Proceedings from the 5th International Conference on High-Level Radioactive Waste Management, May 1994. Vol. (4), pp. 2,492–2,499, Las Vegas, Nevada.

Hsiung, S.M., A.H. Chowdhury, and D.D. Kana. 1994. Effects of repetitive seismic events on underground excavations. Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment, September 1994. Rockville, Maryland

Ofoegbu, G.I., S.M. Hsiung, A.H. Chowdhury, and J. Philip. 1994. Special considerations in repository siting: Potential for seismic pumping. Workshop on Rock Mechanics Issues in Repository Design and Performance Assessment, September 1994. Rockville, Maryland.

Mohanty, S., A.H. Chowdhury, S.M. Hsiung, and M.P. Ahola. 1994. Single Fracture Flow Behavior of Apache Leap Tuff Under Normal and Shear Load. CNWRA 94-024. San Antonio, Texas: CNWRA.

Hsiung, S.M., M.P. Ahola and S. Mohanty. 1994. Rock Mechanics, NRC High-Level Radioactive Waste Research at CNWRA, January-June 1994. CNWRA 94-01S. San Antonio, Texas: CNWRA.

Ahola, M.P., G. Ofoegbu, A.H. Chowdhury, and S.M. Hsiung. 1994. Thermo-Hydro-Mechanical Coupled Modeling: Big-Ben Experiment, TC3 DECOVALEX-PHASE III. CNWRA 94-021. San Antonio, Texas: CNWRA.

Hsiung, S.M., A. Ghosh, A.H. Chowdhury, and M.P. Ahola. 1994. NUREG/CR–6216, Evaluation of Rock Joint Models and Computer Code UDEC Against Experimental Results. Washington, DC: U.S. Nuclear Regulatory Commission.

Ofoegbu, G., S.M. Hsiung, A.H. Chowdhury, and J. Philip. 1994. NUREG/CR–6283, Field Site Investigation: Effect of Mine Seismicity on Groundwater Hydrology. Washington, DC: U.S. Nuclear Regulatory Commission.

Kana, D., D. Fox, and S.M. Hsiung. 1994. Effect of High-Order Physical Phenomena on Interface Constitutive Properties in Jointed-Rock Dynamics. Final Report. San Antonio, Texas: CNWRA

Hsiung, S.M., D. Kana, A. Ghosh, M. Ahola, A.H. Chowdhury. NUREG/CR–6178, Laboratory Characterization of Rock Joints. Washington, DC: U.S. Nuclear Regulatory Commission.

Ghosh, A., S.M. Hsiung, G. Ofoegbu, and A.H. Chowdhury. 1994. Evaluation of Coupled Computer Codes for Compliance Determination—Phase II. CNWRA 94-001. San Antonio, Texas: CNWRA.

Ghosh, A., S.M. Hsiung, G. Ofoegbu, and A.H. Chowdhury. 1993. Evaluation of Coupled Computer Codes for Compliance Determination. CNWRA 93-005. San Antonio, Texas: CNWRA.

Ahola, M.P., L. Lorig, A.H. Chowdhury, and S.M. Hsiung. 1993. Thermo-Hydro-Mechanical Coupled Modeling: Near Field Repository model, BMT3, DECOVALEX—Phase II. CNWRA 93-002. San Antonio, Texas: CNWRA.

Hsiung, S.M., W. Blake, A.H. Chowdhury, and J. Philip. Field Investigation of Mining-Induced Seismicity on Local Geohydrology. Proceedings from the 4th High-Level Radioactive Waste Management Conference, April 1993. Las Vegas, Nevada. pp. 913–920.

Hsiung, S.M., A. Ghosh, M.P. Ahola, and A.H. Chowdhury. 1993. Assessment of Conventional Methodologies for Joint Roughness Coefficient Determination. International Journal of Rock Mechanics and Mining Sciences and Geomechanics Abstracts. Vol. 30, No.7. pp. 825–830.

Hsiung, S.M., M.P. Ahola, A. Ghosh, and A.H. Chowdhury. 1993. NRC High-Level Radioactive Waste Research at CNWRA, July—December 1993—Chapter 4 Seismic Rock Mechanics. CNWRA 93–01S. San Antonio, Texas: CNWRA.

Hsiung, S.M., M.P. Ahola, A. Ghosh, and A.H. Chowdhury. 1993. NRC High-Level Radioactive Waste Research at CNWRA, January 1 Through June 30, 1993—Chapter 4 Seismic Rock Mechanics. CNWRA 93–01S. San Antonio, Texas: CNWRA.

Ahola, M.P., L.J. Lorig, A.H. Chowdhury, and S.M. Hsiung. 1992. DECOVALEX Phase I modeling studies: Coupled stress-flow model, TC1. 1st DECOVALEX Workshop, May 1992. Stockholm, Sweden.

Ahola, M.P., L.J. Lorig, A.H. Chowdhury, and S.M. Hsiung. 1992. DECOVALEX Phase I modeling studies: Multiple fracture model, BMT2. 1st DECOVALEX Workshop, May 1992. Stockholm, Sweden.

Hsiung, S.M., W. Blake, A.H. Chowdhury, and T.J. Williams. 1992. Effects of seismic events on a deep underground mine. Proceedings from the Induced Seismicity Workshop at the 33rd U.S. Symposium on Rock Mechanics, June 1992. Santa Fe, New Mexico.

Hsiung, S.M., A.H. Chowdhury, and J. Philip. 1992. Seismic field studies at Lucky Friday Mine, Mullan, Idaho. Nuclear Waste Technical Review Board's Panel on Structural Geology and Geoengineering, January 1992. Irvine, California.

Hsiung, S.M., A.H. Chowdhury, and M.P. Ahola. 1992. Options for Dynamic Analyses of Underground Facilities. ASCE Symposium on Dynamic Analysis and Design Considerations for High-Level Nuclear Waste Repositories. August 19–20, 1992.

Hsiung, S.M., W. Blake, A. Chowdhury, and T. Williams. 1992. Effects of Mining-Induced Seismic Events on a Deep Underground Mine. Pure and Applied Geophysics. Vol. 139, No. 3-4.

Hsiung, S.M., A.H. Chowdhury and M.P. Ahola. 1992. NUREG/CR–5817, NRC High-Level Radioactive Waste Research at CNWRA, January-June 1992—Chapter 4 Seismic Rock Mechanics. CNWRA 92–01S. Vol. 3, No. 1. Washington, DC: U.S. Nuclear Regulatory Commission.

Hsiung, S.M., A.H. Chowdhury, W. Blake, M.P. Ahola, and A. Ghosh. 1992. Field Site Investigation: Effect of Mine Seismicity on a Jointed Rock Mass. CNWRA 92-012. San Antonio, Texas: CNWRA.

Hsiung, S.M., M.P. Ahola, and A.H. Chowdhury. 1992. NRC High-Level Radioactive Waste Research at CNWRA, July 1 Through December 31, 1992—Chapter 4 Seismic Rock Mechanics. CNWRA 92–02S. San Antonio, Texas: CNWRA.

Hageman, J., S.M. Hsiung, et al. 1992. NUREG/CR–5804, Repository Operational Criteria Analysis. Washington, DC: U.S. Nuclear Regulatory Commission.

Ahola, M.P., L. Lorig, A.H. Chowdhury, and S.M. Hsiung. 1992. Thermo-Hydro-Mechanical Coupled Modeling: DECOVALEX - Phase I. CNWRA 92-006. San Antonio, Texas: CNWRA.

Ahola, M.P., L. Lorig, A.H. Chowdhury, and S.M. Hsiung. 1992. Thermo-Hydro-Mechanical Coupled Modeling: Multiple Fracture Model, BMT2 and Coupled Stress-Flow Model, TC1, DECOVALEX Phase 1. CNWRA 92-005. San Antonio, Texas: CNWRA.

Ahola, M.P., S.M. Hsiung, A.H. Chowdhury, D.D. Kana, and R. Hart. 1991. Experimental Determination of Properties of Natural Rock Joints in a Welded Tuff. 1991 ASME Applied Mechanics and Biomechanics Summer Conference, June 16–19, 1991. Columbus, Ohio.

Hsiung, S.M., D.D. Kana, A.H. Chowdhury, B.H.G. Brady, and J. Philip. 1991. Experimental Techniques for Dynamic Shear Testing of Natural Rock Joints. Proceedings from the 7th International Congress on Rock Mechanics, September 1991. Aachen, Germany.

Hsiung, S.M., S.D. McKinnon, A.H. Chowdhury, B.W. Vanzant, and J. Philip. 1991. Field Investigations for Seismic Effects on Mechanical and Geohydrologic Response of Underground Structures in Jointed Rocks. Proceedings from the 2nd Annual International Conference on High-Level Radioactive Waste Management, April–May 1991. Las Vegas, Nevada.

Hsiung, S.M. and A.H. Chowdhury. 1991. NUREG/CR–5817, NRC High-Level Radioactive Waste Research at CNWRA, Calendar Year 1991—Chapter 4 Seismic Rock Mechanics. CNWRA 91–01A. Vol. 2. Washington, DC: U.S. Nuclear Regulatory Commission.

Hsiung, S.M. 1990. Insufficient Consideration of Scale Effect in Rock Strength. Proceedings from the International Workshop on Scale Effects in Site Characterization, June 1990. Colorado School of Mines, Golden, Colorado.

Brady, B.H.G., S.M. Hsiung, A.H. Chowdhury, and J. Philip. 1990. Verification Studies on the UDEC Computational Model of Jointed Rock. International Conference on Mechanics of Jointed and Faulted Rock, April 1990. Vienna, Austria.

Hsiung, S.M. and A.H. Chowdhury. 1990. NUREG/CR–5817, Report on Research Activities for the Calendar Year 1990—Chapter 4 Seismic Rock Mechanics. CNWRA 90–01A. Washington, DC: U.S. Nuclear Regulatory Commission.

Brandshaug, T., B. Dasgupta, B.H.G. Brady, S.M. Hsiung, and A. Chowdhury. 1990. Qualification Studies on the Finite Element Code HONDO II Against Some Benchmark Analytical Problems. CNWRA 90-006. San Antonio, Texas: CNWRA.

Kana, D., D. Scheidt, B. Brady, A. Chowdhury, S.M. Hsiung, and B. Vanzant. 1990. Development of a Rock Joint Dynamic Shear Test Apparatus. CNWRA 90-005. San Antonio, Texas: CNWRA.

Brady, B.H.G., S.M. Hsiung, A.H. Chowdhury. 1990. Qualification Studies on the Distinct Element Code UDEC Against Some Benchmark Analytical Problems. CNWRA 90-004. San Antonio, Texas: CNWRA.

Ziaie, F., S.M. Hsiung, and S. Peng. 1989. Experimental Study of Line Electrode Method to Detect Underground Cavities. Proceedings from the 30th U.S. Symposium on Rock Mechanics, June 1989. University of West Virginia, Morgantown, West Virginia. pp. 369–376.

Hsiung, S.M., P. Tsang, and S. Peng. 1989. Yield Pillar Application under Strong Roof and Strong Floor Condition—A Case Study. Proceedings from the 30th U.S. Symposium on Rock Mechanics, June 1989. University of West Virginia, Morgantown, West Virginia. pp. 411–418.

Hsiung, S.M., S. Peng, and P. Lin. 1988. Subsidence Over Abandoned Mine Land and Its Causes—A Case Study. Proceedings from the ASCE Spring Convention, May 1988. Nashville, Tennessee.

Hsiung, S.M., S. Peng, and J. Jiang. 1988. Parameters Affecting the Shield Support Efficiency Under Weak Roof Conditions in Longwall Mining." Proceedings from the 21st Symposium Century Higher Production Coal Mining System—Their Implications, April 1988. Australia.

Hsiung, S.M., S. Peng, and P. Lin. 1988. Structures and Ground Damages Over Abandoned Mined Land. Proceedings from the 1988 Mine Drainage and Reclamation Conference, April 1988. Pittsburgh, Pennsylvania.

Hsiung, S.M., S. Peng and J. Jiang. 1988. Evaluation of Shield Support Performance by Numerical Methods. Mining Science and Technology. Vol. 7, No. 1. pp. 19–30.

Hsiung, S.M. and S. Peng. 1988. Development of Guidelines for Stabilizing and Monitoring the Effectiveness of Abating Subsidence-Prone Area. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1987. Guidelines for Subsidence Abatement Over Abandoned Mined Land. Second Annual Report to U.S. Office of Surface Mining. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M., P. Lin, and S. Peng. 1987. Investigation of the Causes of Surface Subsidence Over Abandoned Mined Land. Proceedings from the 1987 National Abandoned Mined Land Conference, October 1987. Little Rock, Arkansas.

Hsiung, S.M. and S. Peng. 1987. Method of Determining the Rational Load Capacity of Shield Supports at Longwall Faces. The Mining Engineer. Vol. 147, No. 313.

Hsiung, S.M., T. Jones, and R. Begley. 1987. The Use of Finite Element Models to Evaluate Potential Ground Control Problems in Multiple Seam Coal Mining. Proceedings from the Association of Engineering Geologist 30th Annual Meeting, October 1987. Atlanta, Georgia.

Hsiung, S.M. and S. Peng. 1987. In-Mine Assessment of Feasibility of Yield Pillar in Retreating Longwall Mining at Harries No. 1 and Lightfoot No. 2 Mines. Progress Report to the Peabody Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M., S. Peng and J. Jiang. 1987. Determination of the Rational Support Capacity by In-Mine Monitoring in North Branch Mine, Bayard, WV. Report to the North Branch Mine. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M., S. Peng and J. Jiang. 1987. Determination of the Rational Support Capacity by In-Mine Monitoring in Dobbin Mine, Bayard, WV. Report to the Dobbin Mine. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1987. An Evaluation of Longwall Shield Support Capacity for Golden Eagle Mine. Report to the Wyoming Fuel Company. Morgantown, West Virginia: West Virginia University.

Jones, T., R. Begley, and S.M. Hsiung, 1987. Geotechnical Evaluation of the Potential Implication of Mining the Alma Coal Lying Below the Partially Mined-Out Cedar Grove Coal. Report to the Hampton Operations, Westmoreland Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1987. Design Guidelines for Multiple Seam Mining. Coal Mining. Part 1, September 1987. pp. 42–46.

Hsiung, S.M. and S. Peng. 1987. Design Guidelines for Multiple Seam Mining. Coal Mining. Part 2, October 1987, pp. 48–50.

Lin, P., S.M. Hsiung, and S. Peng. 1987. Causes to the Subsidence Over Abandoned Mine Land—A Case Study. Proceedings from the 6th International Conference on Ground Control in Mining, June 1987. West Virginia University, Morgantown, West Virginia.

Hsiung, S.M. and S. Peng. 1987. Control of Floor Heave with Proper Mine Design—3 Case Studies. Mining Science and Technology. Vol. 4. pp. 257–272.

Su, W., S.M. Hsiung. and S. Peng. 1986. Interactive Effects on Multiple Seam Mining. Proceeding from the Symposium on Engineering Health and Safety in Coal Mining, SME. pp. 31–44.

Hsiung, S.M. and S. Peng. 1986. An Improved Longwall Mining Technique—Task 3: Longwall Mining Design. Final Report to the Energy Research Center, State of West Virginia. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1986. Guidelines for Subsidence Abatement Over Abandoned Mined Land. First Annual Report to the U.S. Office of Surface Mining. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M., W. Su, and S. Peng. 1986. Optimum Mining Plan for Multiple Seam Mining. Final Report to the Energy Research Center, State of West Virginia. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1986. Rock Property Determination for Lightfoot No. 1, Lightfoot No. 2, Harris No. 1, and Harris No. 2 Mines. Report to the Peabody Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1986. Evaluation of Floor Heave Problems in Harris No. 1 Mine. Report submitted to the Peabody Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1986. Evaluation of Five Options of Longwall Chain Pillar Layouts in Buchanan No. 1 Mine Using Finite Element Analysis. Report to the Consolidated Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1986. Feasibility Study of Pillaring at the 5 Rt. Section of No. 15–A Mine. Report to the No. 15-A Mine. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1985. Excessive Floor Heave due to the Interaction Effect of Undermining in Harris No. 2 Mine Using Finite Element Analysis. Report to the Peabody Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1985. An Investigation into the First Caving Weighting Failure and Its Effect on the 1st Rt. Longwall Panel, Lightfoot No. 2 Mine. Report to the Peabody Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1985. Ground Control Problems and Potential Remedial Measures at Bethenergy Mine No. 81. Report to the Bethenergy Coal Company. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1985. First caving and Its Effect—A Case Study. Proceedings from the 4th Conference on Ground Control in Mining, July 1985. West Virginia University. pp. 83–93.

Hsiung, S.M., W. Su and S. Peng. 1985. Ground Control Problems and Possible Remedial Measures at a Underground Coal Mine. Preprint No. 85-136, SME-AIME Annual Meeting, February 1985. New York City, New York.

Hsiung, S.M. and S. Peng. 1985. Chain Pillar Design for U.S. Longwall Panel." Mining Science and Technology. Vol. 2, No. 4, pp. 279–305.

Hsiung, S.M. and S. Peng. 1984. "Optimum Mining Plan for Multiple Seam Mining. Proceeding from the 25th U.S. Symposium on Rock Mechanics, June 1984. pp. 591–602.

Hsiung, S.M. and S. Peng. 1984. Development of Roof Control Criteria for Underground Longwall Mining. Final Report to the U.S. Office of Surface Mining. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1983. In-Mine Assessment of Pillar Stress and Entry Load in Main and Tail Entries in Retreating Longwall Mining at Quarto No. 4 Mine. Progress Report to the U.S. Bureau of Mines. Morgantown, West Virginia: West Virginia University.

Hsiung, S.M. and S. Peng. 1982. Development of Roof Control Criteria for Longwall Mining—Parametric Modeling I. Proceeding from the Symposium on Strata Mechanics, University of Newcastle, April 1982. Upon Tyne, United Kingdom. pp. 51–58.

Hsiung, S.M. and T. Shih. 1979. Creep Study on Shin Pin Creek Sandstone. Mining and Metallurgy.

Hsiung, S.M. and T. Shih. 1979. Creep Study on Sandstone and Limestone in Northern Taiwan—Annual Report. Tainan, Taiwan: National Cheng Kung University.

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Michael R. Garry, Ph.D.
Managing Toxicologist

Professional Profile

Dr. Garry has more than 20 years of experience analyzing the biological effects of chemicals on humans and other organisms. He has extensive experience analyzing mechanisms of toxicity for both metals and organic chemicals, and has developed science-based toxicity criteria and guidelines and critically reviewed those developed by others. In the field of regulatory toxicology, Dr. Garry has designed and overseen laboratory-testing programs aimed at understanding the mechanisms of toxicity and developing safe exposure levels for industrial chemicals. Dr. Garry has conducted safety evaluations for a variety of medical devices and consumer products. As an environmental toxicologist, he specializes in applying risk-based methods to the design, implementation, and analysis of environmental and remedial investigations. Dr. Garry has worked extensively on projects involving petroleum, pulp and paper, and mining sites developing and applying scientifically-based methods to assess ecological and human exposure and toxicity. These projects have been located in the U.S., Asia, South America, and Africa. He has also collaborated with U.S. EPA Region 10 on several projects, including the development of streamlined, risk-based screening software for indirect exposure to incinerator emissions, and compilation of seafood arsenic speciation and toxicity data.

Dr. Garry has conducted molecular and biochemical research at the Fred Hutchinson Cancer Research Center and at the University of Washington. He has used this knowledge and experience to evaluate function and replacement of genetically engineered cells, cell derivatives, and cell products. He is able to translate advances in basic science and technology into the practice of risk assessment and risk communication. Dr. Garry's experience in public health practice includes community education and outreach, program planning and administration, in-class teaching, and clinical counseling. He has assisted in the development, implementation, and management of a national health system with the Ministry of Health in Cameroon, West Africa. Dr. Garry has a doctoral degree in toxicology from the University of Washington, where his research focused on the cellular and molecular mechanisms of metal-induced reproductive, developmental, and inhalation toxicity.

Academic Credentials and Professional Honors

Ph.D., Toxicology, Department of Environmental and Occupational Health Sciences, University of Washington, 2006
M.S., Nutritional Biochemistry, University of Washington, 1989
B.S., Zoology, University of California at Davis, 1985

Environmental Pathology and Toxicology Traineeship, National Institute of Environmental Health Sciences, University of Washington, 1999–2003; Society of Toxicology, Outstanding Presentation Award, Risk Assessment Specialty Section, 2001 Annual Meeting; Student

Advisory Committee to Society of Toxicology National Council, 1999–2001; Hazardous Waste Operations and Emergency Response 40-hour training program; OSHA 8-hour Refresher Courses for Health and Safety

Peer Reviewer

- *Risk Analysis*
- *Human and Ecological Risk Assessment*

Languages

French

Publications

Tsuji JS, Garry MR. Advances in toxicity testing herald improvements and challenges for risk assessment. Risk Anal 2009; 29(4):490–491.

Garry MR, Kavanagh TJ, Faustman EM, Sidhu JS, Liao R, Ware C, Vliet PA, Deeb SS. Sensitivity of mouse lung fibroblasts heterozygous for GPx4 to oxidative stress. Free Rad Biol Med 2008; 44(6):1075–1087.

Petito Boyce C, Garry MR. Developing risk-based target concentrations for carcinogenic polycyclic aromatic hydrocarbon compounds assuming human consumption of aquatic biota. J Toxicol Environ Health, Part B 2003; 6:497–520.

Yost LJ, Shock S, Garry M, Garson YN, Sugino AK, Shields WJ. Health risk evaluation of PCBs from joint compound measured on surfaces and in air. Organohal Comp 2003; 63:413–416.

Petito Boyce C, Garry MR. Review of information resources supporting human exposure assessment models. Hum Ecol Risk Assess 2002; 8(6):1445–1487.

Chew CM, Lorenzana RM, Garry MR. U.S. EPA Region 10 screening model for indirect exposure to air emissions: Risk-based air concentrations. In: Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment, Sixth Volume. ASTM STP 1317. Dwyer FJ, Doane TR, Hinman ML (eds), American Society for Testing and Materials, 1997.

National Health Care Reorganization Task Force. Methodologie pour la mise au point de grilles de supervision des centres de sante. Ministry of Health, Republic of Cameroon, 1992.

Presentations and Published Abstracts

Garry MR. Communicating science to the public. Oral presentation at Society of Toxicology's 51st Annual Meeting, San Francisco, CA, 2012.

Garry MR, Saba T, Mohsen F, Hilbert B. Health assessment of methanol used in hydraulic fracturing fluids. Poster presented at Society of Toxicology's 51st Annual Meeting, San Francisco, CA, 2012.

Kimmel CA, Garry MR, DeSesso JM. Relationship between bent long bones, bent scapulae and wavy ribs: Malformations or variations? Birth Defects Res (Part A) 2011; 91:357.

Garry MR. Getting from biomonitoring to risk for perfluoroalkyl acids (PFAAs): critical data gaps for understanding the meaning of the measures. Oral presentation at the 2nd World Congress on Risk, Society for Risk Analysis, Guadalajara, Mexico, 2010.

Garry MR, Shock SS. Assessment of metals concentrations monitored in caribou collected near a mining transport road in northwest Alaska. Poster presented at the Society of Toxicology's 49th Annual Meeting, Salt Lake City, UT, 2010.

Garry MR, Deeb SS, Kavanagh TJ, Yu X, Vredevoogd MA, Kim E, Faustman EM. Differential modulation of stress signaling pathways by cadmium in cultured mouse lung fibroblasts heterozygous for GPx4. Poster presented at the Society of Toxicology's 46th Annual Meeting, Charlotte, NC, 2007.

Garry MR, Shock SS, Yost LJ, Kulas J, Shields WJ. Human health risk assessment of metals exposure through subsistence foods consumption and subsistence harvest activities near a mining transport road in northwest Alaska. Poster presented at the Society of Toxicology's 45th Annual Meeting, San Diego, CA, 2006.

Shock SS, Lowney YW, Peterson LD, Bessinger BA, Garry MR. Assessment of solubility and bioaccessibility of barite in mine-impacted soils. Poster presented at the Society of Toxicology's 45th Annual Meeting, San Diego, CA, 2006.

Garry MR, Shock SS, Yost LJ, Kulas J, Shields WJ. Assessment of metals concentrations in salmonberries and sourdock collected near a mining transport road in northwest Alaska. Poster presented at the Society of Toxicology's 44th Annual Meeting, New Orleans, LA, 2005.

Garry MR, Shock SS, Yost LJ, Kulas J, Shields WJ. Assessment of metals exposure associated with subsistence use of caribou collected near a mining transport road in northwest Alaska. Poster presented at the Society of Toxicology's 43rd Annual Meeting, Baltimore, MD, 2004.

Garry MR, Sidhu JS, Kavanagh TJ, Faustman EM. Differential modulation of stress and ubiquitination signaling pathways by cadmium, H_2O_2, and serum withdrawal in cultured mouse fibroblasts. Abstract 311. Oral presentation at the Society of Toxicology's 44th Annual Meeting, Salt Lake City, UT, 2003.

Yost LJ, Shock S, Garry M, Garson YN, Sugino AK. Health risk evaluation of PCBs measured in wipe samples from joint compound. Poster presented at the Society of Toxicology's 44th Annual Meeting, Salt Lake City, UT, 2003.

Garry MR. 2003. Red Dog mine DMTS risk assessment workplan. Oral presentation at the Alaska Forum for the Environment, Anchorage, AK, February 2003.

Garry MR, Kavanagh TJ, and Faustman EM, Sidhu JS, Deeb SS. Differential susceptibility to oxidative stress in mouse lung fibroblasts heterozygous for *GPx4*. Poster presented at the 9th Annual Meeting of The Society for Free Radical Biology and Medicine, San Antonio, TX, 2002.

Garry MR, Tsuji JS. Evaluating lead exposure at mining sites with heterogeneous soil types and lead bioavailability. Poster presented at the Society of Toxicology's 42nd Annual Meeting, Nashville, TN. Toxicologist 2002; 66(1-S), 500.

Yost LJ, Schoof RA, Garry MR. Estimation of dietary intake of inorganic arsenic in children. Fifth International Arsenic Meeting, Society of Environmental Geochemistry and Health, San Diego, CA, 2002.

Garry MR, Lowney YW, Tsuji JS. A critical analysis of assumptions used when evaluating intake of metals from homegrown vegetables. Poster presented at the Society of Toxicology's 41st Annual Meeting, San Francisco, CA. Toxicologist 2001; 60(1), Abstract 2007.

Tsuji JS, Garry MR. Metals exposure from homegrown produce at mining and smelting sites. Poster presented at the Society of Toxicology's 41st Annual Meeting, San Francisco, CA. The Toxicologist 2001; 60(1), Abstract 95.

Petito Boyce C, Garry MR. Development of carcinogenic PAH trigger levels for human consumption of aquatic biota based on modifications to the default bioconcentration factor and the use of toxicity equivalency factors. Presented at the Society for Risk Analysis annual meeting, December 4, 2000.

Garry MR, Kavanagh TJ, Faustman EM. Phosphatidylcholine hydroperoxide decreases mitochondrial membrane potential and oxidizes cardiolipin. Poster presented at the Society of Toxicology's 40th Annual Meeting, Philadelphia, PA. Toxicol Sci 2000; 54(1), Abstract 767:163.

Garry MR, Vredevoogd M, Faustman EM. Gene expression as a potential biomarker of inorganic mercury exposure in terrestrial ecosystem. Poster presented at the Society of Toxicology's 39th Annual Meeting, New Orleans, LA, 1999.

Garry MR, Kirchner SC, Schroeder JL, Faustman EM. Amplification and detection of RNA from mature human sperm. Poster presented at Pacific Northwest Association of Toxicology, Regional Chapter of the Society of Toxicology, 1997.

Prior Experience

Research Associate, University of Washington, 1998–2003
Toxicologist, Foster Wheeler Environmental Corporation, 1995–1999
Research Scientist, Fred Hutchinson Cancer Research Center, 1992–1995

Public Health Care Coordinator, Ministry of Health, Republic of Cameroon, 1989–1992
Program Coordinator, Women, Infants, and Children Program (WIC), U.S. Department of Agriculture, 1988–1989

Project Experience

Metals and Mining
Providing review and technical advising for a lead smelting facility in Peru undergoing environmental protection upgrades. Serving as project manager and providing technical expertise on toxicology, exposure, and risk assessment. Project involves complex air modeling and direct and indirect exposures to metals, particulates, and sulfur dioxide.

Serving as project manager and human health risk assessment and toxicology lead for a former elemental phosphorous refinery in Montana. Conducting a multi-pathway human health and ecological risk assessment focusing on chemical and radiological exposures. Chemicals of potential concern include elemental phosphorous, metals, uranium, radon and other radionuclides.

Designed a multi-pathway human health and ecological at a former lead smelter in East Helena, Montana. Served as project manager and human health toxicology and risk assessment leader. The assessment addressed onsite risks from current and future exposures to lead, arsenic, cadmium and other metals.

Conducted an assessment of potential health and environmental impacts of chromium in steel slag recycled as construction fill and railroad or road ballast. The assessment addressed concerns by the New York State Department of Environmental Conservation regarding unrestricted use of the material because of its chromium content. The evaluation considered typical uses of the steel slag and its specific characteristics, such as chromium content, physical and chemical characteristics, and leaching properties.

Served as human health technical lead on multi-discipline team evaluating the effects of lead shot and bullets used in upland game hunting on human health and wildlife. Project focused on a review of the state of knowledge, critical data gaps, and recommendations for future research. The team produced a technical white paper presenting the results of the review.

Directed a site characterization and risk assessment work plan at the former Old Dominion mining and smelter site in Arizona. Provided overall direction of the sampling and analysis design and oversight of development of the sampling and analysis plan. Metals of potential concern include arsenic, beryllium, cadmium, copper, chromium, lead, manganese, and zinc. The risk assessment will evaluate residential, occupational, and recreational exposure scenarios.

Provide toxicology and risk assessment consultation and review for a former smelter site in Arizona. Provide technical review of a probabilistic assessment evaluating exposure and risks from arsenic in soil at residential and industrial properties in a community in Arizona that received historical flooding from a tailings impoundment. Provided arsenic toxicology expertise and scientific input on distributions for exposure and arsenic bioavailability.

Provided toxicology, risk assessment, and risk communication expertise for an active zinc mine in northern Alaska. Detection of elevated metals in sensitive tundra habitats raised community concerns about risks from subsistence foods and adverse effects to the environment. The metals evaluated at the site included arsenic, antimony, barium, cadmium, chromium, lead, mercury, thallium, and zinc. Analyzed risks from potential exposure to metals in subsistence foods and the environment and conducted community meetings in native villages to discuss the analyses and results. Provided community relations support during interactions with village residents, Alaskan native corporations, and non-governmental organizations. The nature of the local village residents' reliance on subsistence hunting and harvesting in the area of the mine, road, and port made the project highly sensitive, resulting in significant media and public exposure.

Conducted and managed human health risk assessment in historical copper mining area in Arizona. Evaluation focused on direct exposure to metals in floodplain soils and stream sediments, and considered residential, occupational, and recreational exposure scenarios. Provide ongoing toxicology and risk communication expertise.

Conducted human health risk assessments for multiple sites in a former mining area in Utah under a voluntary engineering evaluation/cost analysis agreement with EPA. Unique aspects of these assessments included the focus on adult exposures under intermittent recreational use, or short-term occupational use scenarios. The primary site metals of concern are lead and arsenic in soils, and cadmium and zinc in water. The sites are being converted to recreational uses (e.g., mountain biking, hiking, and skiing).

Conducted a human health risk assessment for tailings and naturally mineralized soil at a former mill site in New Mexico as part of a voluntary removal action. The primary site constituents were manganese and zinc in groundwater, and lead, manganese, and arsenic in soil. Lead in soil was evaluated using EPA's adult and child lead models with site-specific assumptions where justified. Detailed site geochemistry studies and simulated gastrointestinal leaching tests indicated very low bioavailability of lead in soil.

As a part of an inter-disciplinary, international team, evaluated the health impacts of tailings discharged into a river system from a copper mine in Southeast Asia. This risk assessment entailed designing dietary, human exposure, and biomarker surveys. The survey collected information from 10 villages on dietary intake of crops grown in tailings, and fish or other animals that are exposed to metals in tailings. The exposure survey documented activities of the various populations and cultural groups that might affect the amount of exposure to tailings. Blood, urine, and hair were also collected from survey participants to assess exposure to various metals in tailings, including arsenic, cadmium, chromium, lead, and zinc. Analyzed potential correlations between biomarker and exposure data. Developed toxicity criteria for novel organic chemicals used in the milling process.

Conducted a human health risk assessment for a metals-affected floodplain for an industrial client in the Midwestern United States. The primary site metal of concern was lead. Technical issues addressed included delineating potentially exposed populations, identifying appropriate data and additional data requirements, and assessing bioavailability.

Provided technical analysis on issues related to residential arsenic and lead exposure in communities near one active smelter and two previously existing smelters. Reviewed and provided detailed comments and recommendations on ATSDR's Public Health Assessment and EPA's Baseline Human Health Risk Assessment. Specific issues addressed include the site approach for assessing intake of homegrown vegetables, health effects from environmental exposure to arsenic in the U.S., and the literature regarding low-dose effects of arsenic.

Provided toxicology and risk assessment support to a mining client evaluating risks from exposure to arsenic in a recreational area of a mining-related NPL site in Montana. Reviewed and commented on an EPA-led human health risk assessment of recreational exposures to arsenic in soil.

Provided toxicological analysis and expertise in a case involving alleged health effects from consumption of an herbal tea purchased from a San Francisco herbalist. Analyzed the potential for the plaintiff's symptoms to be caused or exacerbated by exposure to metals from the herbs or brewing equipment, exposure to a plant toxin (i.e., podophylotoxin), and pre-existing health conditions. The case was subsequently settled.

Wrote a manuscript evaluating the potential for lead to cause endocrine disruption. Critically evaluated the epidemiological and experimental data regarding lead and potential endocrine-related effects. Limited evidence suggests that lead may affect male reproduction, but at exposure levels far above those that cause neurological effects in children, which is considered the critical effect for the purposes of risk assessment and regulatory policy.

Participated on a team conducting a health risk assessment of tetraethyl lead in sediments at a loading facility. Evaluated the current literature on organic lead toxicity and developed an alternative toxicity criterion to EPA's reference dose using available human occupational biomonitoring data.

Wrote a chapter on state and federal mercury regulations as they apply to petroleum refineries, for a monograph on mercury toxicity and treatability in petroleum-industry effluents.

Developed an alternative lead cleanup level for a Florida industrial site using recent scientific literature to support changes to the default values for critical parameters in EPA's adult lead model for predicting blood lead levels. The modifications supported a lead soil cleanup level as high as 2,600 ppm, compared to a level of 888 ppm calculated in a previous study using only EPA default values.

Wrote sections of a White Paper pertaining to potential exposure to elemental mercury from various sources, including mercury-containing paint and dental amalgams. Identified appropriate biomarker measures for elemental mercury, arsenic, and lead, and characterized reference levels and levels of concern. Reviewed and modified an ATSDR Fact Sheet on elemental mercury exposure. Modifications included clarification of possible toxic effects under low-exposure conditions, and development of a section on reducing mercury exposure to the general population, and in particular to residents of houses that may be built over mercury-contaminated soil.

Solvents

Conducted a toxicological and epidemiological literature review to assess chemical toxicity and provide perspective on the potential for occupational exposure to chloroform, carbon tetrachloride, and 1,1,1-trichloroethane to result in development of cancer, with an emphasis on esophageal cancer. The findings were documented in a state-of-the-science report, and resulted in the plaintiffs agreeing to dismiss their complaint.

Provided technical support for a manufacturing facility that detected tetrachloroethylene and trichloroethylene in the well supplying water to a large work force. Provided review and analysis of key toxicological and epidemiological issues regarding trichloroethylene to the client. Identified critical issues in EPA's Trichloroethylene Health Risk Assessment and discussed those issues in a public forum that included leading regulators and scientists in the field.

Provided toxicological expertise in a case involving residential exposure to trichloroethylene and tetrachloroethylene in groundwater. Evaluated the potential for health effects of the two compounds at specific exposure levels relative to requested medical screening exams.

Petroleum Sites

Conducted a health assessment of methanol used in hydraulic fracturing ("fracking") fluids. The evaluation focused on potential exposure to groundwater impacted by methanol-containing fracking fluids, and incidental ingestion of river and stream waters that received treated flowback.

Provided toxicological expertise on dispersants and petroleum chemicals related to the Deepwater Horizon release in the Gulf of Mexico, including both technical analysis and interpretation for non-scientists. Provided input on proposed medical monitoring programs.

In support of a research grant evaluating PAH bioavailability, drafted a White Paper on the regulatory toxicology of Polycyclic Aromatic Hydrocarbons (PAHs), focusing on current regulatory approach to health assessment of PAHs, proposed modifications to the regulatory approach, and the implications of those modifications to environmental assessment of PAHs. Provided expertise on absorption, distribution, metabolism, and excretion of PAHs.

Member of team that provided toxicology and health risk support to a city following an oil spill in a river from a pipeline leak. Assessed air exposures to those living along the river from volatile emissions. Provided recommendations on air sampling.

Conducted a probabilistic analysis to quantitatively evaluate the range of the potential contribution of facility emissions to ambient air concentrations of selected chemicals from an oil refinery in the Middle East. The study characterized variability and uncertainty in predicted facility-related air concentrations.

Wrote a technical paper evaluating carcinogenic PAH bioaccumulation in aquatic species. The evaluation focused on modifications to the water-to-tissue bioconcentration factor used in

calculating PAH trigger levels for human consumption of fish and crustaceans. Recommendations included incorporating factors to account for dissolved organic carbon content in the water column and differential distribution of PAHs in the edible and inedible portions of fish. Manuscript published in a peer-reviewed journal.

Conducted human health and ecological screening-level risk assessment to address marine sediments in the vicinity of an oil company's petroleum storage facility in Washington State. Assessment included sediment and shellfish ingestion pathways and addressed bioassay and specific chemical data. Chemicals of potential concern included metals, SVOCs, petroleum hydrocarbons, and PCBs.

Conducted a data-gap analysis and recommended a sampling plan to be included in a remedial investigation at the property of a former tanker terminal in New York. Performed a human health and ecological risk assessment. Chemicals of concern for the risk assessment included PAHs, chlorobenzene, ethyl ether, lead, asbestos, and PCBs. Ecological receptors were both aquatic and terrestrial, and included muskrats, bald eagles, gulls, herons, crab, and sturgeon.

Developed toxicity reference values (TRVs) for the effects of petroleum hydrocarbons on terrestrial mammals and birds for the Washington State Department of Ecology as part of the Duwamish brownfields program. Methods included mathematical modeling of petroleum constituent toxicity data and resulted in separate TRVs for aliphatic and aromatic constituents.

Conducted human health and ecological risk assessments on multiple petroleum release sites at U.S. Navy bases in Washington State. Applied MTCA interim policy for evaluation of risk from petroleum releases, and the Narcosis model to predict petroleum uptake and toxicity in aquatic receptors. Modeled risk from shellfish ingestion to a subsistence fishing population, used Monte Carlo probabilistic analyses, and conducted temporal and spatial contaminant trend analyses. Chemicals of potential concern included BTEX, PAHs, and petroleum hydrocarbons.

Developed a work plan for a risk-based screening-level assessment for a service station in Alaska undergoing renovation to include a restaurant. Evaluated potential ecological and human health risks associated with exposure to petroleum hydrocarbons and other organic compounds through groundwater ingestion, soil ingestion, and vapor inhalation. Chemicals of potential concern included BTEX, petroleum hydrocarbons, and ethylene glycol.

Project manager for ASTM-sanctioned training of state regulators and consultants in risk-based corrective action (RBCA). Provided input to planning of RBCA policy and marketing strategy, and provided technical and editorial support for ASTM-sanctioned training of regulators in multiple states on RBCA at petroleum release sites.

Performed a risk-based screening-level assessment for a former service station in Alaska that was subsequently occupied by a commercial restaurant. Evaluated the potential human health risks associated with exposure to petroleum hydrocarbons through groundwater ingestion, soil ingestion, and vapor inhalation. Modeled groundwater benzene and toluene transport to assess potential offsite risks.

Assisted in developing a guidance document to aid in the application of RBCA legislation at petroleum release sites for the Michigan Department of Natural Resources.

Dioxins, PCBs, and Pesticides

Conducted a toxicological and epidemiological literature review to assess chemical toxicity and provide perspective on the potential for residual levels of agricultural fumigants (ethylene dibromide, dichlorobromopropane, chlorinated propenes and propanes) in groundwater to cause various alleged health effects (miscarriage, birth defects, cancers, asthma, attention deficit hyperactivity disorder, lupus) in a community in Hawaii. Co-author of a state-of-the-science report documenting relationship between the chemicals and health effects of interest.

Provided risk assessment and toxicology support in a comprehensive human health risk assessment evaluating potential worker exposure to PCBs discovered in concrete joint compound in a flightline area for commercial aircraft in Washington. Evaluated risk assessment approach for novel exposure pathways, including contact with surfaces as measured by wipe samples. Researched current regulatory guidance within EPA for non-liquid PCBs and evaluated applicable assessments conducted nationwide. Site characterization suggested limited migration potential for PCBs from joint compound. The risk assessment results supported phased removal of PCB-containing material that was both health-protective and practical.

Provided toxicological expertise in a human health risk assessment to evaluate potential effects of mercury and PCBs in sediments in an urban lake in New York State. Analyzed and reported on the potential toxicity from methyl mercury and PCBs to humans from fish consumption. Highlighted the uncertainties in EPA's approach to risk assessment of methylmercury and PCBs and reported on alternative methods for analyzing their toxicity.

Conducted an analysis of the contribution of effluent from the Tosco refinery in Richmond, California, to the total maximum daily load of dioxins into the San Francisco Bay. Specific issues addressed included total mass loading estimates to the Bay from all sources and contributions from the Tosco refinery, dioxins fingerprinting patterns in the Tosco effluent and Bay waters, and the appropriate use of background comparisons. Based on these analyses, demonstrated that contributions to dioxin loads in effluent from the Tosco oil refinery were minimal. Summarized findings in a technical memorandum submitted to the San Francisco Bay Regional Water Quality Control Board.

Conducted a terrestrial ecological risk assessment as part of a supplemental field study at the U.S. Army Rocky Mountain Arsenal in Colorado. Developed and applied mathematical models to predict chemical bioaccumulation in the food chain. Chemicals of concern included aldrin, dieldrin, endrin, DDT, DDE, and chlordanes. Ecological receptors included bald eagles, kestrels, owls, prairie dogs, deer mice, rabbits, and starlings.

Pulp and Paper

Provided toxicology, risk assessment, and site characterization expertise for the City of Port Angeles, Washington, for review of the remedial investigation (RI) and interim actions conducted at the Rayonier Mill Site. The RI process was conducted as part of a collaborative

effort between Rayonier, Washington State Department of Ecology (WDOE), and the Lower Elwha Klallam Tribe, to establish the nature and extent of potential impacts from the historical acid sulfite pulp and paper mill. Reviewed site characterization, remedial action, and remedial investigation data and reports. Provided detailed technical evaluation and critique. Summarized findings in comments submitted to WDOE. Provided specific expertise on subsistence fish consumption, design and implementation of food consumption surveys, and interpretation of fish consumption data for regulatory decision-making.

Managed and conducted an epidemiological analysis of age-adjusted disease-specific mortality rates in a community near a pulp and paper mill in Washington State. Results indicated that elevated crude mortality rates noted in Washington State Department of Health Vital Statistics tables were largely due to population age distributions in the community relative to statewide age distributions.

Provided toxicological and risk assessment analysis on odor and health issues for a pulp mill in Camas, Washington, that had a release of hydrogen sulfide and mercaptans that reached a school. The strong odors at the school resulted in children feeling acutely ill, with some being sent to the local hospital. Evaluated the epidemiological and experimental literature on these compounds, particularly with regard to chronic, low-dose exposure, long-term effects, and sensitive subpopulations. Provided input on the nature of the risk and latest scientific information for state and local health agencies to promote better risk communication.

Provided toxicological and risk assessment expertise on a project team assessing ecological and human health risks associated with terrestrial and marine impacts at a non-operational pulp mill in Sitka, Alaska. Task leader for developing toxicity reference values of terrestrial receptors. Evaluated benthic succession and recovery following organic enrichment from wood waste and pulp effluent. Assessment addressed soils, sediments, groundwater, and marine waters. Target aquatic receptors included crabs, flatfish, mussels, and benthic invertebrates. Bioaccumulation and impacts on higher-trophic-level species were addressed through modeling. Chemicals of concern included pesticides, dioxins, metals, PAHs, petroleum hydrocarbons, and PCBs.

Multipathway and Multichemical Analysis

Provided technical expertise in the development of a framework to assess arsenic and chromium exposure and toxicity to children from chromated copper arsenic (CCA)-treated wood. Evaluated the potential exposures to arsenic by children playing on play structures and decks made of CCA-treated wood. Developed approaches for evaluating this novel exposure scenario, and wrote a White Paper regarding issues for risk assessment, which was provided to the U.S. EPA for consideration in developing their assessment for these exposures. Researched and developed a White Paper evaluating occupational exposure to CCA in wood products. The project involved analysis of the available scientific data and identification of critical uncertainties for exposure parameters that would benefit most from additional research. Results of the analyses were presented to ATSDR, EPA, and the Consumer Product Safety Commission.

Provided technical expertise, analysis, development, and review for Demographics and Databases project funded by the Human Health Exposure Assessment (HHEA) Technical Implementation Panel (TIP) of the American Chemistry Council (ACC). Led task to identify,

research, document, and characterize databases providing distributions of demographic, consumer product use, and residential building characteristics that are necessary in modeling exposure to chemicals in consumer products. Summarized the results in a report to ACC and a manuscript published in a peer-reviewed journal.

Developed simplified screening model for assessing human health risk from indirect exposure to incinerator emissions for EPA Region 10. Reviewed environmental risk assessments from incinerator sites. Reviewed proposed EPA indirect exposure guidelines and provided comments. Evaluated lead and PCB chemical fate data. Evaluated available seafood arsenic speciation data and potential health risk, and reported findings and recommendations.

Conducted a human health risk assessment as part of a comprehensive sediment investigation at two shipyards in San Diego Bay. The assessment focused on consumption of fish and shellfish from the site. Potential chemicals of concern at the site included chromium, mercury, copper, lead, PCBs, PAHs, and tributyltin. The evaluation considered both recreational and subsistence consumption patterns. The initial screening used an *in situ* bioassay to measure metals uptake into mussel tissue, followed by screening with human health–based tissue criteria. The second tier of the assessment incorporated both deterministic and probabilistic risk assessment to evaluate potential exposure to metals in native fish and shellfish from the site.

Developed an interim groundwater maximum allowable concentration for formaldehyde based on groundwater ingestion for a paper company in North Carolina. Evaluated potential risks to humans associated with exposure via this pathway.

Conducted a streamlined risk evaluation addressing groundwater impacts and designed to aid in deciding whether to conduct a removal action at a naval submarine base in Washington State. Assessed human exposure to groundwater used as drinking water and for irrigation. Chemicals of concern included benzene, toluene, ethylbenzene, naphthalene, vinyl chloride, 1,1-dichloroethane, 1,2-dichloroethane, carbon tetrachloride, 1,2-trichloroethane, and 1,1,2,2-tetrachloroethane.

Regulatory Toxicology

Conducted an integrated developmental and reproductive toxicology and endocrine modulation assessment of a crop protection compound in the context of proposed revisions to the European Commission Directive 91/414/EEC. The analysis specifically evaluated how proposed new "cut-off" criteria would affect the compound's future authorization for use in the European Union.

Conducted data review, analysis, and summary for evaluation of functional equivalence of Other Scientifically Relevant Information (OSRI) to EPA's Tier 1 screening battery for evaluating the potential for estrogen, androgen or thyroid effects. Provided review and verification accuracy, consistency and interpretation of the data relied on and cited in EPA's response.

Developed technical/scientific guidance for conducting hazard and risk assessment of alloys suitable for meeting emerging international regulatory systems (e.g., GHS, REACH) for chemical risk assessment and classification schemes that are protective of human health. The

guidance included: 1) grouping of alloys based on their particular characteristics of relevance for exposure and health risk; 2) read-across for relating similar metal forms, as appropriate based on the scientific evidence, and 3) protocols for bioavailability and bioaccessibility testing.

Conducted a technical review of Arizona's proposed soil remediation levels (SRLs) and provided comments to the Arizona Department of Environmental Quality. Chemical-specific comments that resulted in modification of the proposed standards addressed the SRLs for barium, beryllium, chromium, iron, manganese, and vanadium. Additional comments addressed issues affecting all SRLs, including soil ingestion rates, and the target risk level assumed for exposure to carcinogenic chemicals.

Directed toxicological investigations on a confidential industrial chemical with the aim of deriving the necessary data to develop a scientifically valid occupational exposure limit. Reviewed existing occupational exposure-limit documentation for the compound. Evaluated available toxicological and chemical research on the compound of interest and related compounds. Developed a detailed research plan designed to address data gaps and uncertainties in the existing toxicological database and provide the requisite data to develop a health-protective occupational exposure limit. Evaluated proposals submitted by contract research laboratories (CRLs) and, based on a specific, defined process, selected a CRL to conduct the laboratory research. Conducted Phase 1 of the research program involving genetic toxicology testing.

Conducted a technical review of Arizona's proposed Surface Water Quality Standards (SWQS) and provided comments to the Arizona Department of Environmental Quality. Chemical-specific comments addressed the fish-tissue criteria for cadmium and the drinking-water standard for barium. Additional comments addressed assumptions regarding exposure through full and partial body contact with water, and the method by which relative source contribution of a chemical from the water body is calculated.

Research Experience

- Graduate Research Associate: Genetic susceptibility to oxidative injury induced by chemical exposure, NIEHS, 1998–2003
- Research Scientist: Dietary modification of lipid biochemistry and risk factors for cancer, NIH, 1992–1995
- Graduate Research Associate: Fish oils and modification of risk factors for cardiovascular disease, NIH, 1987–1989

Research Awards

- National Institute of Environmental Health Sciences, University of Washington, Environmental Pathology and Toxicology Training Grant, 1999–2003
- National Institute of Environmental Health Sciences, Center for Ecogenetics, University of Washington, Small Project Grant, 2001

Professional Affiliations

- Society of Toxicology
- Society for Free Radical Biology and Medicine
- Northwest Society of Environmental Toxicology and Chemistry

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Vanessa Perez, Ph.D.
Senior Scientist

Professional Profile

Dr. Vanessa Perez is a Senior Scientist in Exponent's Health Sciences Center for Epidemiology, Biostatistics, and Computational Biology. Dr. Perez has worked with clients on several different human health issues in healthcare, biotech, pharmaceuticals, and law. She conducts state of the art scientific reviews aimed at assisting in future surveillance, clinical diagnosis, and treatment of disease; assists clients in developing study designs and performing in-depth epidemiologic data analyses for various types of research including clinical trials and intervention studies; project manages and provides epidemiologic support in the area of medical device products and health outcomes; and has been involved in conducting large-scale community studies to understand associations between target exposures and various health endpoints including respiratory disease outcomes.

Prior to joining Exponent in 2010, Dr. Perez graduated with her Ph.D. in epidemiology from the University of Michigan. Her research focused on understanding the relationship between psychological stress and influenza as well as studying the influence of illness behavior on possible transmission of infection within the community setting. In both her training and time at Exponent, Dr. Perez has authored peer-reviewed papers that have been published in top scientific journals and has presented her research findings at scientific conferences including the Society for Epidemiologic Research and the International Congress of Infectious Diseases.

Academic Credentials and Professional Honors

Ph.D., Epidemiological Science, University of Michigan, Ann Arbor, 2010
M.S., Biostatistics, University of Michigan, Ann Arbor, 2007
B.S., Applied Mathematics, University of California, Los Angeles, 2005

Rackham Merit Fellowship, University of Michigan, 2009–2010; National Institutes of Health Training Grant, Center for Research on Ethnicity, Culture, and Health, University of Michigan, 2007–2009; Rackham Merit Fellowship, University of Michigan, 2005–2006

Languages

Spanish

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Peer-Reviewed Publications

Aiello AE, Perez V, Coulborn RM, Davis BM, Uddin M, Monto AS. Facemasks, hand hygiene, and influenza among young adults: A randomized intervention trial. PLoS One 2012; 7(1):e29744. Epub 2012 Jan 25.

Holscher HD, Czerkies LA, Cekola P, Litov R, Benbow M, Santema S, Alexander DD, Perez V, Sun S, Saavedra JM, Tappenden KA. Bifidobacterium lactis Bb12 enhances intestinal antibody response in formula-fed infants: A randomized, double-blind, controlled trial. Journal of Parenteral and Enteral Nutrition Jan 2012; 36(1 Suppl):106S–17S.

Perez V, Uddin M, Galea S, Monto AS, Aiello AE. Stress, adherence to preventive measures for reducing influenza transmission, and influenza-like illness. Journal of Epidemiology and Community Health. Prepublished January 10, 2011 DOI:10.1136/jech.2010.117002.

Aiello AE, Murray G, Perez V, Davis B, Coulborn RM, Uddin M, Waterman S, Shay D, Monto AS. Mask use and seasonal influenza-like illness among young adults: A randomized intervention trial. Journal of Infectious Disease Feb 15 2010; 201(4):491–498.

Aiello AE, Coulborn RM, Perez V, Larson EL. Effect of hand hygiene on infectious disease risk in the community setting: A meta-analysis. American Journal of Public Health 2008; 98:1372–1381.

Diaz-Perez S, Ferguson D, Wang C, Csankovszki G, Wang C, Tsai SC, Dutta D, Perez V, Kim S, Eller CD, Salstrom J, Ouyang Y, Teitell MA, Kaltenboeck B, Chess A, Huang S, Marahrens Y. A deletion at the mouse Xist gene exposes trans-effects that alter the heterochromatim of the inactive X chromosome and the replication time and DNA stability of both X chromosomes. Genetics 2006; 174(3):1115–1133.

Diaz-Perez S, Ouyang Y, Perez V, Cisneros R, Regelson M, Marahrens Y. The element(s) at the nontranscribed Xist locus of the active X chromosome controls chromosomal replication timing in the mouse. Genetics 2005; 171:663–672.

Kabanov AV, Komarov VM, Perez V. Mechanism of accumulation in large electric dipole moment of the DNA molecule. Biofizika 2005; 50:434–451.

Abstracts and Presentations

Perez V, Alexander DD, Cushing CA, Weed DL. Processed meat consumption and stomach cancer: A meta-analysis of prospective epidemiologic studies. Poster presentation, 3rd North American Congress of Epidemiology, Montreal, QC, June 21–24, 2011.

Perez V, Galea S, Kalbfleisch J, Monto AS, Aiello AE. Effect of influenza-like illness symptoms on hand hygiene and other health habits among US university students. Poster presentation, 14th International Conference on Infectious Disease, Miami, FL, March 9–12, 2010.

Perez V, Aiello AE. The efficacy of influenza vaccine on cardiovascular events in adults: A meta-analysis and evaluation of the literature. Poster presented at the 42nd Annual Society for Epidemiologic Research (SER) Meeting, Anaheim, CA, June 23–26, 2009.

Lu YC, Galea S, Perez V, Liu G, Coulborn RM, Uddin M, Monto AS, Aiello AE. Social support, fear, and willingness to comply with non-pharmaceutical interventions against pandemic influenza among US university students. Talk presented at the World Federation of Public Health Associations 12th World Congress on Public Health, Istanbul, Turkey, April 27–May 1, 2009.

Perez V, Uddin M, Galea S, Monto AS, Aiello AE. Psychosocial effects of influenza in the university setting. Poster presented at the Annual Biomedical Conference for Minority Students, Orlando, FL, November 5–8, 2008.

Perez V, Monto AS, Aiello AE. Effect of stress on intervention compliance and influenza-like illness rates. Poster presented at the 41st Annual SER Meeting, Chicago, IL, June 24–27, 2008.

Perez V, Monto AS, Murray GF, Coulborn RM, Aiello AE. Fear, stress, and reported pandemic influenza response among university students in the US. Poster presented at the 13th International Conference on Infectious Disease, at the Kuala Lumpur Convention Center, Kuala Lumpur, Malaysia, June 19–22, 2008.

Professional Affiliations

- Society for Epidemiologic Research (member)
- International Society for Pharmacoepidemiology (member)

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Sheila A. McCarthy, CIH
Managing Scientist

Professional Profile

Ms. Sheila McCarthy is a Certified Industrial Hygienist and Managing Scientist in Exponent's Health Sciences Center Occupational and Environmental Medicine. Ms. McCarthy is experienced in the fields of industrial hygiene and risk assessment involving potential exposures to fibers, pesticides, metals, organic, and inorganic chemicals, as well as physical agents such as noise, heat, and sources of ionizing and non-ionizing radiation. Her experience includes performing industrial hygiene studies to evaluate OSHA compliance, illness clusters, and indoor air quality evaluations, and conducting historical and quantitative exposure assessment in support of site-specific risk assessments.

As a CIH, Ms. McCarthy has conducted exposure assessments for both occupational and environmental settings. In these settings, she has developed and implemented sampling methodologies and evaluated a number of agents including fibers, metals, particulate matter, volatile organic compounds, bioaerosols, mold, non-ionizing radiation, and noise. Examples of her work include a historical exposure assessment that required the evaluation of thousands of industrial hygiene sampling reports, for the purpose of developing a job exposure matrix (JEM) that provided 8-hr time-weighted average (TWA) exposures for various occupations involving asbestos-containing products. Her work has also included assessments of indoor air quality within concentrated animal feeding operations (CAFOs) and measurements of emissions from these types of facilities. She conducted a study measuring the radio-frequency (RF) signals from an active network of automated meter reader systems in residential areas. Ms. McCarthy recently conducted a comprehensive analysis of exposure data related to metal fumes, including hexavalent chromium, from common welding activities in light of new OSHA regulations related to hexavalent chromium.

Ms. McCarthy teaches at the University of California Extension Program at Davis. Her lectures focus on industrial hygiene and physical agents in the workplace (noise, radiation, heat/cold stress, and ergonomics).

Prior to her work in public health, Ms. McCarthy has over 10 years experience in the engineering and computer science fields.

Academic Credentials and Professional Honors

M.H.S., Johns Hopkins Bloomberg School of Public Health, 2004
B.E.E., The Catholic University of America, 1991

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Publications and Presentations

Hicks JB, McCarthy SA, Mezei G, Sayes CM. PM1 particles at coal- and gas-fired power plant work areas. Annals of Occupational Hygiene 2012; 56:182–193.

McCarthy SA, Hicks JB. Reaction to California's heat illness and prevention regulation. American Industrial Hygiene Annual Conference (AIHce), May 26, 2010.

Hicks J, McCarthy SA. Hexavalent chromium air sampling data from welding and steel cutting. Electric Power Research Institute, Report no. 1016821, October 2009.

McCarthy SA, Suen M, Rey P, Hicks JB. Fungal concentrations during typical household activities. American Industrial Hygiene Annual Conference (AIHce), June 2, 2009.

Hicks J. Program on technology innovation: Nanoparticles at coal and gas fired power plants. Electric Power Research Institute (EPRI), Report No. 1016820, December 2008.

Rule AM, Chapin AR, McCarthy SA, Gibson KE, Schwab KJ, Buckley TJ. Assessment of an aerosol treatment to improve air quality in a swine Concentrated Animal Feeding Operation (CAFO). Environmental Science and Technology 2005; 39(24):9649–9655.

Centeno JA, Kolker A, Gibb HJ, McCarthy SA. Potential health risks from long-term mercury exposure, a medical geology opportunity. 9th International Symposium on Metal Ions in Biology and Medicine, Lisboa, Portugal, May 21–24, 2006.

Chapin AR, McCarthy SA, Rule AM, Gibson KE, Buckley TJ, Schwab KJ. Antibiotic-resistant bacteria in air and water associated with chicken and hog facilities. 104th General Meeting of the American Society for Microbiology, New Orleans, LA, May 23–27, 2004.

Prior Experience

Project Manager, Sciences International Inc., 2006
Senior Associate, Sciences International Inc., 2004–2006
Research Coordinator, Johns Hopkins Bloomberg School of Public Health, March–August 2002; January–April 2004
Intern, General Electric, Aircraft Engine Division, 2003
Instructor, K Computing, 1999–2001
System Support Engineer, Silicon Graphics Inc. (SGI), 1997–1999
System Administrator, HT Medical, 1995–1997
Electronics Engineer, Naval Surface Warfare Center, Department of Defense, U.S. Navy, 1991–1995

Professional Affiliations

- American Industrial Hygiene Association, 2004–present
- Local chapters for the AIHA
  - Northern California Section of the American Industrial Hygiene Association, 2009–present, Treasurer 2010 - present
  - Potomac Section of the American Industrial Hygiene Association, 2004–2007
  - Chesapeake Section of the American Industrial Hygiene Association, 2002–2004
- Society of Risk Analysis, 2006–present
- Deputy Managing Editor, *Risk Analysis: An International Journal*, 2007–2008

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Annette B. Santamaria, Ph.D., M.P.H., DABT
Managing Scientist

Professional Profile

Dr. Annette Santamaria is a Managing Scientist in Exponent's Health Sciences Center for Toxicology and Mechanistic Biology. Dr. Santamaria is a board-certified toxicologist with 20 years of multidisciplinary experience critically evaluating a broad range of toxicological, epidemiological, and clinical studies, conducting exposure and human health risk assessments, and communicating results to clients and governmental agencies. She has experience with assessing exposure to a variety chemicals, nanomaterials, consumer products, (e.g., personal care products, cosmetics, paints, cleaning products, air fresheners), pharmaceuticals, and medical devices, and is certified in FDA's regulations through the Regulatory Affairs Professional Society. She has provided technical support and assisted in the preparation of a variety of reports for regulatory compliance and/or litigation purposes. Dr. Santamaria has provided consulting support in several toxic tort cases involving exposure to a variety of chemicals or pharmaceuticals and has critically evaluated available literature on the risks associated with occupational exposures. She has also prepared many exposure assessments for consumer products to ensure compliance with California's Proposition 65 regulations.

Prior to joining Exponent, Dr. Santamaria provided toxicological and epidemiological consulting at ENVIRON Corporation. Her doctoral training was in molecular toxicology in which she studied the pharmacological mechanism of a treatment for psoriasis called PUVA, and her public health training focused on health policy and epidemiology. She has published in several peer-reviewed journals and has presented seminars on a variety of topics.

Academic Credentials and Honors

Ph.D., Toxicology, University of Texas School of Public Health, 2001
M.P.H., Johns Hopkins School of Hygiene and Public Health, 1990
B.S., Biology, High Point University, 1983

Licenses and Certifications

Diplomate, American Board of Toxicology, 1996
SCUBA certification, PADI, 1983

02/12

Publications

Santamaria AB, Sulsky SI. Risk assessment of an essential element: Manganese. Journal of Toxicology and Environmental Health Part A 2010; 73(2):128–155.

Santamaria AB. Manganese exposure, essentiality, and toxicity. Indian Journal of Medical Research 2008; 128(4):484–500.

Santamaria AB, Cushing C, Antonini JM, Finley BL, Mowat FS. State-of-the-science review: Does manganese exposure during welding pose a neurological risk? Journal of Toxicology and Environmental Health, Part B: Critical Reviews 2007; 10(6):417–465.

Antonini JM, Santamaria AB, Jenkins NT, Albini E, Lucchini R. Fate of manganese associated with the inhalation of welding fumes: Potential neurological effects. Neurotoxicology 2006; 27(3):304–310.

Tsuji JS, Maynard AD, Howard PC, James JT, Lam CW, Warheit DB, Santamaria AB. Research strategies for safety evaluation of nanomaterials, Part IV: Risk assessment of nanoparticles. Toxicological Sciences 2006; 89(1):42–50.

Finley BL, Santamaria AB. Current evidence and research needs regarding the risk of manganese-induced neurological effects in welders. Neurotoxicology 2005 Mar; 26(2): 285–289.

Haws L, Harris M, Su S, Birnbaum L, DeVito M, Farland W, Walker N, Connor K, Santamaria A, Finley B. Development of a refined database of relative potency estimates to facilitate better characterization of variability and uncertainty in the current mammalian TEFs for PCDDs, PDCFs, and dioxin-like PCBs. Organohalogen Compounds 2004; 66:3426–3432.

Haws L, Harris M, Su S, Walker N, Birnbaum L, DeVito M, Farland W, Connor K, Santamaria A, Finley B. A preliminary approach to characterizing variability and uncertainty in the mammalian PCDD/F and PCB TEFs. Organohalogen Compounds 2004; 66:3439–3445.

Melnikova VO, Santamaria AB, Bolshakov SV, Ananthaswamy HN. Mutant p53 is constitutively phosphorylated at serine 15 in UV-induced mouse skin tumors: involvement of ERK1/2 MAP kinase. Oncogene 2003; 22:5958–5966.

Fisher JB, Santamaria AB. Dissolved organic constituents in coal-associated waters and implications for human and ecosystem health. Proceedings, 9th Annual International Petroleum Environmental Conference, Albuquerque, NM, October 22–25, 2002.

Santamaria AB, Davis DW, Nghiem DX, Ullrich SE, McConkey DJ, Kapoor M, Lozano G, Ananthaswamy HN. p53 and Fas Ligand are required for psoralen and UVA-induced apoptosis in mouse epidermal cells. Cell Death and Differentiation 2002; 9(5):549–560.

Prochaska HJ, Santamaria AB, Talalay P. Rapid detection of inducers of enzymes that protect against carcinogens. Proceedings, National Academy of Sciences 1992; 89(5): 2394–2398.

Wilcock KE, Santamaria AB, Frankos VH, Fisher HW, Laden F, Platz EA, Jackson BA. Perspectives on adverse reaction rates associated with the use of high osmolar ionic and low osmolar nonionic contrast media. Journal of the American College of Toxicology 1990; 9:563–607.

Prochaska H, Santamaria AB. Direct measurement of NAD(P)H:quinone reductase from cells cultured in microtiter wells: A screening assay for anticarcinogenic enzyme inducers. Analytical Biochemistry 1988; 169:328–336.

DeLong M, Santamaria AB, Talalay P. Role of cytochrome P1-450 in the induction of NAD(P)H:quinone reductase in a murine hepatoma cell line and its mutants. Carcinogenesis 1987; 8:1549–1553.

DeLong M, Dolan P, Santamaria AB. Beuding E. 1,2-Dithiol-3-thione analogs: Effects on NAD(P)H:quinone reductase and glutathione levels in murine hepatoma cells. Carcinogenesis 1986; 7:977–980.

Book Chapters

Santamaria AB. Historical Overview of Nanotechnology and Nanotoxicology. In: Methods in Molecular Biology: Nanotoxicity. Reineke J (ed), Humana Press, Springer Publishing Group, in press.

Santamaria AB, Sayes CM. Toxicological studies with nanoscale materials. In: Nanotechnology Environmental Health and Safety. Hull M, Bowman D (eds), Elsevier, 2010.

Santamaria AB, Ferriby L, Harris M, Paustenbach D. Use of biomarkers in risk assessment. In: Toxicologic Biomarkers. DeCaprio A (ed), Oxford, UK: Taylor and Francis, 2006.

Presentations and Abstracts

Gentry R, Santamaria A, Sulsky S, Shipp A, Van Landingham C, Fuller W, Fast K, Taylor M, Roper J. Comparative exposure assessment: use of PBPK modeling for the essential element manganese. The Toxicologist 2012 Mar; p.11.

Kaden DA, Santamaria AB, Harris A, Imse J, Travers M, Schoof R. Exposure and toxicity of chemicals resulting from natural gas extractions and hydraulic fracturing. The Toxicologist 2012, Mar: p 455.

Santamaria AB, Kaden D. Dose-response at very low exposures: biological rhymes and reasons. Presented at the Medichem Annual Meeting, Heidelberg, Germany, 2011.

Santamaria AB. Nanomaterials in consumer products: Do they pose a hazard? Presented at the International Conference of the Environmental Implications and Applications of Nanotechnology, University of Massachusetts, Amherst, June 2009.

Santamaria AB. The safety of nanomaterials in personal care products. Presented at the "Supply Side EAST" Conference, Secaucus, NJ, April 2009.

Santamaria AB, Mundt DJ. Overview of the health and safety issues regarding nanomaterials. Webinar presented to the Sidley and Austin law firm, April 2009.

Praolini F, Guilem M, Mundt D, Mundt K, Santamaria AB. Preparing for the future: Proposal for an International Nanomaterial Exposure Registry (INER). Presented at the NANOSAFE annual meeting, "International conference on Safe Production and use of Nanomaterials" in Grenoble, France, 2008.

Santamaria AB. Evaluating the safety of nanomaterials used in the forestry industry. Presented at the Technical Association of the Pulp and Paper Industry (TAPPI) meeting, "International Conference on Nanotechnology for the Forest Products Industry," St. Louis, MO, November 2008.

Santamaria AB. Nutritional and toxicological aspects of manganese intake. Presented at the Workshop on Health Risk Assessment of Essential Metals, University of Ottawa, Canada, May 2008.

Santamaria AB. Nanotechnology and food packaging. Presented at the Intertech PIRA meeting Global Legislation for Food Contact Packaging, Alexandria, VA, April 2008.

Santamaria AB. Manganese in the environment and workplace. Presented at the Department of Defense18th Annual Cleaner, Sustainable Industrial Materials & Processes Workshop, Coronado, CA, March 2008.

Santamaria AB. Consumer and occupational exposure to nanomaterials. Continuing Education course presented at the Society of Toxicology Annual Meeting, Seattle, WA, March 2008.

Santamaria AB. What modifications may be needed when conducting risk assessments for nanomaterials? Presented at the Society for the Advancement of Material and Process Engineers Annual Meeting, Baltimore, MD, June 2007.

Santamaria AB. What's nano about nanotoxicology? Web-based seminar presented on behalf of the Cosmetic, Toiletry, and Fragrance Association for their members, May 2007.

Santamaria AB. Safety of nanoscale ingredients in personal care products. Presented at the Intertech Pira meeting, Regulations for Nanotechnology in Consumer Products, Washington, DC, February 2007.

Santamaria AB. Nanotechnology: A risky future? Presented at the Harris Martin Meeting, Cutting Edge Toxic Torts, Scottsdale, AZ, December 2006.

DeMott RP, Williams HI, Santamaria AB. Population pollution: Establishing a framework for characterizing surface water risks from pharmaceuticals and population-derived constituents. Presented at the Society for Risk Analysis Annual Meeting, Baltimore, MD, December 2006.

Daugherty D, Mundt KA, Mundt DJ, Santamaria AB, Adams R. Guarding the promise: Managing the environmental and occupational health uncertainties of nanotechnology today. Presented at the 3rd International Congress of Nanotechnology in San Francisco, CA, November 2006.

Santamaria AB. Safety of nanoscale materials in personal care products. Presented at the FDA public meeting on Nanotechnology on behalf of the Cosmetic, Toiletry, and Fragrance Association, Washington DC, October 2006.

Santamaria AB. Is It Safe? How toxic are nanomaterials? Seminar presented at the NanoTX Meeting, Dallas, TX, September 2006.

Santamaria AB. Issues regarding toxicology and workplace safety of nanomaterials. Seminar presented at the Magnolia Hotel, Houston, TX, September 2006.

Santamaria AB, Mundt K. Occupational epidemiology and risk assessment: A seminar on science and occupational health decision making. Course taught in Frankfurt, Germany, on March 6–9, 2006.

Santamaria AB, Mundt DJ, Mundt K. Risk assessment of nanoparticles: Issues and datagaps. Presented at the American College of Toxicology Annual Meeting, Williamsburg, VA, November 2005.

Santamaria AB. Welder studies—What have they told us? Presented at the Health Effects of Welding Conference, National Institute for Occupational Safety and Health and West Virginia University, Morgantown, WV, July 2005.

Santamaria AB. Speaker and co-chairperson of the symposium entitled "Emerging Issues in Risk Assessment and Risk Perception of Nanomaterials," 44th Annual Meeting of the Society of Toxicology Annual Meeting, New Orleans, LA, March 2005.

Santamaria AB, Rachman NJ. Risk assessment and safety evaluations of nanomaterials in consumer products. The Toxicologist 2005 Mar; 84(S-1):653.

Cushing CA, Santamaria AB. Promises and pitfalls of biomonitoring data. Presented at the Society for Risk Analysis, Orlando, FL, December 2004.

Santamaria AB. Manganese neurotoxicity and welding. Presented to the American Conference Institute, New Orleans, LA, November 2004.

Santamaria AB. Manganese neurotoxicity and welding. Presented to the American Occupational and Environmental Health Physicians, San Antonio, TX, November 2004.

Santamaria AB, Li A, Mowat F, Cushing C, Finley B. Potential neurological effects of manganese exposure during welding: a state-of-the-science review. The Toxicologist 78(S-1):394. Presented at the 43rd Annual Meeting of the Society of Toxicology, Baltimore, MD, March 2004.

Santamaria AB, Fisher JB. Dissolved organic constituents in coal-associated waters and implications for human and ecosystem health. The Toxicologist 72(S-1):396. Presented at the 42nd Annual Meeting of the Society of Toxicology, Salt Lake City, UT, March 2003.

Davis DW, Santamaria AB, Lawler J, Ananthaswamy H, McConkey DJ. Coordinate regulation of bleomycin-induced apoptosis by p53 target genes in the murine lung. The Toxicologist 72(S-1):66. Presented at the 42nd Annual Meeting of the Society of Toxicology, Salt Lake City, UT, March 2003.

Santamaria AB, Haussmann G. Using technical experts effectively in litigation. Seminar presented to Shook, Hardy, & Bacon Law Firm in Houston, TX, September 2002.

Santamaria AB. The toxicologist as an expert witness. Seminar presented at the University of Texas Graduate School of Biomedical Sciences, Houston, TX, 2001.

Santamaria AB, Davis DW, Nghiem DX, McConkey DJ, Ullrich SE, Ananthaswamy HN. Role of p53 in the Induction of apoptosis by psoralen and ultraviolet-A radiation (PUVA). The Toxicologist 60(1):80. Presented at the 40th Annual Meeting of the Society of Toxicology, San Francisco, CA, March 2001.

Santamaria AB, Davis DW, McConkey DJ, and Ananthaswamy HN. Induction of apoptosis in mouse epidermal cells by psoralen and ultraviolet-A radiation (PUVA). Abstract presented at the 13th International Congress on Photobiology, San Francisco, CA, March 2000.

Santamaria AB, Kapoor M, Lozano G, Ananthaswamy HN. Post-translational modification of p53 following treatment with psoralen and UV-A radiation (PUVA). Toxicological Sciences 54(1):359. Presented at the 39th Annual Meeting of the Society of Toxicology, Philadelphia, PA, March 2000.

Santamaria AB, Davis DW, McConkey DJ, Ananthaswamy HN. Induction of apotosis in mouse epidermal cells by psoralen and UV-A radiation: Involvement of p53 and p21waf1/cip1. Poster presented at the Annual Meeting of the American College of Toxicology, McLean, VA, March 1999.

Santamaria AB, Ananthaswamy HN. Mechanistic studies of PUVA-induced apoptosis. Toxicological Sciences 48(1):157. Presented at the 38th Annual Meeting of the Society of Toxicology, New Orleans, LA, March 1999.

Santamaria AB. Risk assessment as a tool in litigation: A discussion of the uses and the limitations. Platform presentation at the Annual Meeting of the Gulf Coast Chapter of the Society of Toxicology, Austin, TX, November 1996.

Santamaria AB, Plunkett LM. Multiple chemical sensitivity: A discussion of the issues. Seminar presented to Vinson and Elkins law firm in Houston, TX, September 1995.

Rudenko L, Santamaria AB, Starr TB. Recommendations for increasing the relevance of rodent bioassays results to human cancer risk assessment. Poster presented at the Annual Meeting of the Society for Risk Analysis, Waikiki, HI, December 1995.

Santamaria AB. Chemical risk assessment. Seminar presented at the annual fall meeting of the Association of Official Analytical Chemists (AOAC) in College Park, Maryland, October 1994.

Santamaria AB. The potential impact of medical monitoring on cancer mortality. Poster presented at the Fourth Annual Meeting of the International Society for Environmental Epidemiology and the International Society for Exposure Analysis, in Cuernavaca, Mexico, August 1992.

Workshops and Committees

Proposed and developed a new Specialty Section called "Nanotoxicology" to the Society of Toxicology and was the President during 2008-2010 and Past-President during 2010–2011.

Invited participant in a NSF-sponsored workshop in Melbourne, Australia entitled, "Sustainable Nanomanufacturing" in February, 2008.

Invited participant in a roundtable, "What are the critical data gaps in risk assessment of nanomaterials and how can nanotoxicology studies be designed to fill these gaps?" First International Conference on Nanotoxicology: Biomedical Aspects in Miami, FL, January, 2006.

Invited participant of a workshop called, "Developmental Approaches for Evaluation of Toxicological Interactions of Nanoscale Materials" held by the University of Florida, November, 2004.

Prior Experience

- Senior Managing Scientist, ENVIRON International Corporation, 2005–2012
- Managing Scientist, Exponent, 2002–2005
- Toxicologist, Scientific Evidence, 2001–2002
- Doctoral student in Toxicology, University of Texas School of Public Health, MD Anderson Cancer Center, 1995–2001
- Senior Associate, ENVIRON International Corporation, 1990–1997,
- Senior Research Technician, Department of Pharmacology, Johns Hopkins University School of Medicine, 1984–1990

Project Experience

Consumer Products

Reviewed the toxicology and epidemiology literature to evaluate the potential for adverse health effects resulting from the use of nanomaterials in a variety of consumer products. Also reviewed current or proposed occupational and environmental regulations in the US and Europe regarding nanomaterials.

Reviewed *in vitro* and *in vivo* studies conducted to evaluate the potential for dermal penetration of nanoparticles. Evaluated the weight-of-the-evidence for dermal penetration of nanoparticles resulting from the use of cosmetics and sunscreens.

Prepared a draft guidance document entitled, "Recommended Approaches for Industry on the Safety Evaluation of Nanoscale Ingredients in Personal Care Products" that was submitted to The US Food and Drug Administration by the Personal Care Products Council.

Prepared Proposition 65 exposure assessments for a variety of consumer and professional use products for large consumer products manufacturers. This required an understanding of the use of the product and realistic exposure modeling to provide a conservative assessment of exposure.

Assisted in the derivation of No Significant Risk Levels (NSRLs) for chemicals used in consumer products when this information was not available on the Proposition 65 list.

Pharmaceutical/Medical Devices

Reviewed and evaluated Investigational New Drug Applications (INDs), New Drug Applications (NDAs), post-marketing studies, and FDA Advisory Committee Meeting documents for a variety of pharmaceuticals, including antibiotics, chemotherapeutic agents, contrast media, and drugs used to treat diabetes in the context of litigation or regulatory support.

Prepared safety assessments of the ingredients of several over-the-counter dermal and oral products developed for infant use.

Managed a large pharmaceutical case involving a patent dispute regarding a chiral antibiotic and prior art issues. Reviewed and analyzed the preclinical, pharmacokinetic, and the post-marketing studies for the drug. Assembled a large database of references and assisted in the preparation of a response to a Motion to Amend and an expert report.

Evaluated the safety of specific excipients used in pharmaceuticals and over-the-counter products.

Evaluated the causal association of an amino acid called L-tryptophan (LT) and the Eosinophilia Myalgia Syndrome (EMS) in the context of litigation. LT had been available as a nutritional supplement until it was removed from the market. Reviewed and critically analyzed all available case reports, epidemiological studies, and clinical studies on EMS, the toxicological and *in vitro* studies on LT, and documents on the manufacturing process of LT. Conducted extensive reviews of plaintiff and expert depositions and assisted in the selection of research proposals for studying the relationship between LT and EMS. Provided the client with monthly update reports summarizing new literature.

Prepared a supplemental new drug application (sNDA) for the use of a chemotherapeutic agent called bleomycin to treat patients with pleural effusion. This involved reviewing and critically evaluating all the available studies on bleomycin, including in vitro data, toxicological studies, case reports, and clinical studies. The sNDA was submitted to and approved by the Food and Drug Administration.

Reviewed the toxicological, clinical, and epidemiological literature to determine whether there was an association between breast implants and autoimmune diseases for several litigation cases. In addition, reviewed literature on infections resulting from implants and on the ability to perform radiographic examinations of women with breast implants.

Prepared a document evaluating the potential relationship between testicular atrophy and testicular tumors resulting from an antibiotic proposed for use in livestock. This document was prepared as part of a new animal drug application that was submitted to the Center for Veterinary Medicine at the FDA.

Foods

Prepared safety assessments for a variety of chemical or naturally occurring substances in foods and food additives to determine if the residual or intended additive levels posed any health risks.

Prepared generally recognized as safe (GRAS) self-affirmation documents and direct and indirect food additive petitions for a variety of substances to be used in foods or food packaging. Reviewed and summarized chemical, toxicological, and clinical data and/or studies and prepared dossiers and organized expert panels for GRAS notification submissions to FDA.

Prepared a risk assessment of the use of iodine in eggs. Organized a panel meeting of experts to evaluate the risk assessment and prepared a food additive petition for submission to the FDA.

Prepared a risk assessment for chloroform residues in chicken resulting from the use of a chlorine-containing decontamination water bath. The residual levels were determined not to pose a health hazard.

Environmental Exposure

Reviewed the toxicological and human literature to evaluate the association between exposure to manganese and neurotoxicity. Prepared comments on a variety of draft risk assessments that were developed by regulatory agencies in the U.S. and Canada to develop guidance and regulatory levels for ambient manganese levels. Presented an overview of the toxicology of manganese and environmental and occupational exposure issues in several seminars.

For TSCA compliance audits, reviewed several toxicological studies to determine if they needed to be submitted to EPA under TSCA 8e.

Evaluated *in vitro* and *in vivo* studies that were conducted with dioxins, furans and dioxin-like PCBs to establish relative potency estimates (REPs) and characterize the variability and uncertainty in the mammalian WHO toxicity equivalency factors (TEFs).

In the context of litigation, reviewed the available toxicological and human studies on "toxic mold" (*Stachybotrys chartarum*) to determine whether there is a causal association between mold exposure and a variety health complaints for several cases.

Reviewed case-specific documents, including environmental investigations, medical records, health surveys, depositions, and answers to interrogatories regarding alleged health effects resulting from exposure to mold at a high school.

Prepared a variety of timelines on the health effects, environmental occurrence, and regulatory history of benzene, PAHs, coal tar, chromium, and lead.

Participated in a variety of toxic tort cases involving environmental exposure to various chemicals (e.g., solvents, hydrocarbons, metals, asbestos). Included the review of toxicological, epidemiological, and occupational studies, depositions, expert reports, and exposure data, and identifying alternative causes for a variety of claimed health effects.

Occupational Exposure

Reviewed the toxicological and human literature to evaluate whether there is an association between the exposure to manganese during welding and neurotoxicity.

Evaluated mechanism and latency issues regarding exposure to benzene and hematopoietic diseases.

Reviewed the toxicological and human literature to evaluate the association between exposure to diacetyl and respiratory health conditions.

Reviewed the literature on the mechanisms of carcinogenicity to evaluate the current state of knowledge regarding the existence of thresholds for carcinogens, in particular, asbestos.

Reviewed occupational and epidemiological studies on asbestos to evaluate whether there are sufficient data to correlate tissue burden levels with exposure levels.

Managed a litigation support project that involved the review of extensive documentation on plaintiffs, expert witnesses, and industrial hygiene data from six tire-manufacturing plants. Critically evaluated available epidemiological studies on tire workers and toxicological studies on the chemicals used in the manufacturing of tires. The litigation focused on exposure to asbestos, carbon black, and talc.

Reviewed the scientific literature available on several man-made mineral fibers to select a safe non-asbestiform alternate material for use in automobile brakes.

Prepared a report on the potential for toxicity resulting from the use of carbon disulfide in viscose rayon industry. Reviewed and critically evaluated several occupational and toxicological studies on carbon disulfide and the risk of ocular diseases.

Reviewed industrial hygiene reports, medical records, depositions and other documents for a case involving alleged health effects resulting from the "sick building syndrome" in individuals working in a courthouse in Chicago. The case involved several plaintiffs claiming multiple chemical sensitivity and other health problems.

Professional Affiliations

- Society of Toxicology
- Regulatory Affairs Professional Society
- Delta Omega, National Public Health Honor Society

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Gary E. Mosher, CIH
Senior Managing Scientist

Professional Profile

Mr. Gary Mosher is a Senior Managing Scientist in Exponent's Health Sciences Center for Occupational and Environmental Health. Mr. Mosher is a certified industrial hygienist with extensive experience (30+ years) in health, safety, and environmental issues, primarily in the foundry and related industries. He is recognized as an expert on all aspects of silica within the domestic and international metalcasting industry and related supplier industries. He provides litigation support as either an expert consultant or witness in toxic tort–product liability lawsuits involving silica.

Mr. Mosher's metalcasting industry experience spans a number of classic occupational health areas including heavy metals, thermal decomposition products, carbon monoxide, and noise. His experience as a director of an accredited industrial hygiene laboratory adds an understanding of analysis and its limitations. This understanding, coupled with his years of gathering personal air samples, provides a seasoned perspective on the use and application of exposure data.

Mr. Mosher's work developing emission factors for foundry process were adapted into state air toxics regulations in the mid 1990's. These factors also were incorporated into pollution codes in other parts of the world such as Australia and Italy. Later work earned Mr. Mosher a best paper awards from the American Foundry Society 2004 and 2007.

Mr. Mosher's experience include represented the foundry industry in all relevant environmental health and safety matters relating to silica before professional societies, state and federal regulatory agencies and/or advisory committees, elected officials within state legislatures and members of U.S. Congress. These activities culminated in him being presented with the 2005 AFS Environmental, Health and Safety Service Award. This annual award is presented to individuals who have greatly contributed to improving environmental, health and safety within the metal casting industry.

Academic Credentials and Professional Honors

M.S., Industrial Health, University of Michigan, Ann Arbor, 1975
B.S., Environmental Science Engineering, University of Michigan, Ann Arbor, 1974

Licenses and Certifications

Diplomate, American Board of Industrial Hygiene, #1592

02/11

Peer Reviewed Publications/ Research

Crandell GR, Schifo JF, Mosher G. CERP organic HAP emission measurements for iron foundry and their use in development of an AFS HAP guidance document. Paper Transactions of the American Foundry Society 2006; 114:819–835.

Schifo J, Radia J, Crandell G, Mosher G. Iron foundry hazardous air pollutants: What we know and what we don't. Paper Transactions of the American Foundry Society 2003; 111:1173–1190.

Mosher GE. Nickel and chromium exposures in foundries melting/pouring alloys containing low or trace levels of nickel or chrome. Transactions of the American Foundrymen's Society 1980; 88:515–518.

Huelsen WB, Mosher GE, Carter GL. An examination of the potential free silica formation during the grinding of gray iron. Transactions of the American Foundrymen's Society 1979; 87:707–712.

Publications

Mosher GE. Prepare your foundry for OSHA's Silicosis Inspection Program. Modern Casting 1996 Aug; 86(8):44.

Mosher GE. Calculating emission factors for pouring, cooling and shake-out. Modern Casting 1994 Oct; 84(10):28–31.

Mosher GE. Environmental: What's hot and what's not (environmental and occupational safety regulations covering foundries). Modern Casting 1992 Feb; 82(2):32–33.

Kornegay B, Lanham G, Mosher GE. Clean Air Act needs planning, concerted action. Modern Casting 1991 Jul; 81(7):43–45.

Mosher GE. Environmental: What's hot and what's not. Modern Casting 1991 Feb; 81(2):32.

Mosher GE. EPA Publishes new land ban regulations. Modern Casting 1990 Jan; 80(1):40–41.

Mosher GE. OSHA classifies castings as hazardous materials. Modern Casting 1985 Sept; 75(9):42.

Siebel MK, Mosher GE. Detecting and controlling vibration white finger. Modern Casting 1984 Aug; 74(8)34–36.

Kanicki DP, Mosher GE. Living up to OSHA's standards. Modern Casting 1980 Sept; 70(9):44–48.

Papers/Proceedings

Mosher GE. Nationwide foundry waste survey results. Proceedings, American Foundrymen's Society 4th Annual Environmental Affairs Conference–Strategic Planning: Environmental Affairs, pp. 312–313, Milwaukee WI, August 28, 1991.

Mosher GE. Strategic planning—Toxics reporting. Proceedings, American Foundrymen's Society 4th Annual Environmental Affairs Conference–Strategic Planning: Environmental Affairs, pp. 196–209, Milwaukee WI, August 27, 1991.

Mosher GE. Industrial hygiene in the pattern shop. Pattern and Corebox Technology Proceedings of AFS/CMI Conference, (Supplementary Paper) Rosemont, IL, October 12, 1982.

Presentations

Mosher G. Medical surveillance for silica. Webinar, American Foundry Society, November 12, 2009.

Mosher G. Medical surveillance for silica. American Foundry Society 21st Annual Environmental Health & Safety Conference, Indianapolis, IN, August 17, 2009.

Mosher G. OSHA's National Emphasis Program (NEP)–Silica" American Foundry Society 20th Annual Environmental Health & Safety Conference, St. Louis, MO, August 26, 2008.

Mosher G. Hot topics in the EH&S arena – Update: Status on MACT standards. American Foundry Society 109th Casting Congress, St Louis, MO, April 18, 2005.

Mosher G. How MACT will make things better for employee exposures. OSHA Course No. 3210 – Applied Foundry Principles, Cleveland, OH, March 31, 2005.

Mosher G. Iron & Steel Foundry MACT update. Cast Metals Institute Class–Cupola Melting for Engineers, Itasca, IL, March 29, 2005.

Mosher G. Update on foundry MACTs – Past, present & future. American Foundry Society Mo-Kan Chapter, Kansas City, MO, March 17, 2005.

Mosher G. Silica – The issue that just won't go away. Indiana Safety and Health Conference, Indianapolis, IN, May 25, 2004.

Mosher G. Silica – The issue that just won't go away. Foundry Association of Michigan Environmental Issues Meeting, Lansing, MI, April 19, 2004.

Mosher G, Maresca C, Downey S. Silica proposed rules. Panel Presentation, American Foundry Society Metal Casting Industry Government Affairs Conference, Washington, DC, March 22, 2004.

Keramida V, Casper J, Mosher G. Featured Session–OSHA Standards Update–Silica control and its huge impact on manufacturing. 13th Annual Business and Industry Environmental Health & Safety Symposium, Cincinnati, OH, March 18, 2004.

Mosher G. Iron and Steel Foundry MACT: Update. American Foundry Society Wisconsin Regional Conference, Milwaukee, WI, February 12, 2004.

Mosher G. EPA-MACT & OSHA–Silica: Are they piling it on? Casting Industry Suppliers Association Annual Meeting, Rosemont, IL, November 20, 2003.

Mosher G. Where do things stand with the Iron and Steel Foundry MACT. American Foundry Society 15th Annual Environmental Health & Safety Conference, Indianapolis, IN, August 18, 2003.

Mosher G. Iron and Steel MACT update. American Foundry Society 107th Casting Congress, Milwaukee, WI, April 27, 2003.

Mosher G. EPA's Push to Implement the New 'Maximum Achievable Control Technology' (MACT) Standards. American Foundry Society Toledo Chapter Meeting, Bowling Green, OH, January 8, 2003.

Mosher G. Regulatory and legal update and applicability of EPA air toxic standards affecting foundries. American Foundrymen's Society Mo-Kan Chapter, Kansas City, MO, September 19, 2002.

Mosher G. The AFS Chapter and national issues interaction for the good of our industry. American Foundry Society Chapter Officers Conference, American Foundry Society Headquarters, Des Plaines, IL, August 2002.

Mosher G. MACT update. American Foundry Society 106th Casting Congress, Kansas City, MO, May 4, 2002.

Mosher G. What to expect from the final iron and steel MACT standards. American Foundry Society 13th Environmental, Health and Safety Conference, Indianapolis, IN, August 20, 2001.

Mosher G. The AFS Chapter and national issues interaction for the good of our industry. American Foundry Society Chapter Officers Conference, American Foundry Society Headquarters, Des Plaines, IL, August 2001.

Mosher G. Environmental/legislative update. Casting Industry Suppliers Association Spring Conference, Naples, FL, April 9, 2001.

Mosher G. Iron and steel MACT update. American Foundry Society Metal Casting Industry Government Affairs Conference, Washington DC, April 2, 2001.

Mosher G. Environmental update: EPA – Iron and steel foundry MACT; Aluminum foundry & diecasting MACT; OSHA–Silica. American Foundry Society New England Chapter, Auburn, MA, February 13, 2001.

Mosher G. Overview of current environmental, health and safety issues facing the industry. Casting Industry Suppliers Association, Rosemont, IL, November 16, 2000.

Mosher G. Silica: OSHA's latest attack on silica users. American Foundry Society 12th International Environmental Health & Safety Conference, Lake Buena Vista, FL, October 9, 2000.

Mosher G. Government Affairs Liaison and the AFS Chapter. American Foundry Society Chapter Officers Conference, Des Plaines, IL, September 7, 2000.

Mosher G. Update on iron and steel MACT. American Foundry Society Metal Casting Industry Government Affairs Conference, Washington, DC, May 7, 2000.

Mosher G. OSHA & respirable silica: New standard on the horizon? American Foundry Society 104th Casting Congress, Pittsburgh, PA, April 8, 2000.

Mosher G. Environmental update: EPA – Iron and steel foundry MACT/aluminum foundry & diecasting MACT/OSHA–Silica. American Foundry Society, Michiana Chapter, Plymouth, IN, April 3, 2000.

Mosher G. Environmental update – Continuing the partnership. Casting Industry Suppliers Association, San Diego, CA, March 28, 2000.

Mosher G. Environmental issues facing foundries. American Foundry Society Northwest Pennsylvania Chapter, Erie, PA, March 21, 2000.

Mosher G. Environmental Issues Facing Foundries. American Foundry Society Pittsburgh Chapter, Monroeville, PA, March 20, 2000.

Mosher G. Environmental Update: EPA – Iron and steel foundry MACT/Aluminum foundry & diecasting MACT/OSHA–Silica. Conestoga Foundrymen's Association, Lancaster, PA, February 16, 2000.

Mosher G. The OSHA Silica Permissible Exposure Limit (P.E.L.) issue. American Foundry Society Wisconsin Regional Conference, Milwaukee, WI, February 10, 2000.

Mosher G. Current EH&S issues. Casting Industry Suppliers Association, Rosemont, IL, November 12, 1999.

Mosher G. Silica–OSHA's target for a new standard. American Foundrymen's Society 11th Annual Environmental Health and Safety Conference, Lake Buena Vista, FL, October 4, 1999.

Mosher G. How EH&s issues are driving a closer relationship between foundries and suppliers. Casting Industry Suppliers Association, Naples, FL, April 9, 1999.

Mosher G. The effect on foundries of OSHA lowering the silica PEL. Ohio Safety Council Congress, Cleveland, OH, March 31, 1999.

Mosher G. Panel Presentation: Foundry Environmental Projects. American Foundrymen's Society Casting Congress, St. Louis, MO, March 14, 1999.

Mosher G. Panel Presentation: Update on MACT Standards for Iron and Steel Foundries. American Foundrymen's Society 10th Annual Environmental Health and Safety Conference, Indianapolis, IN, August 18, 1998.

Mosher G. Silica – New regulations on the horizon and what AFS is doing about it. California Cast Metals Association Annual Meeting, Sacramento, CA, May 15, 1998.

Mosher G. Update on EPA and OSHA regulatory activities and initiatives affecting foundries. Central New York Chapter of American Foundrymen's Society, Syracuse, NY, February 12, 1998.

Mosher G. Preparing for a SEP inspection. Chicago Local Section of the American Industrial Hygiene Association Symposium on Silicosis The Preventable Disease, Des Plaines, IL, October 10, 1997.

Mosher G. Update EPA and OSHA regulatory activities and initiatives affecting foundries. American Foundrymen's Society Timberline Chapter, Littleton, CO, January 15, 1997.

Mosher G. Time to try something new. Foundry Compliance Assistance Workshop, Louisiana Department of Environmental Quality, Baton Rouge, LA, June 27, 1996.

Mosher G. Update on OSHA's Special Emphasis Programs–Silica and EPA activities regarding solid waste. American Foundrymen's Society Chicago Chapter Management Night, Rosemont, IL, February 20, 1996.

Mosher G. Development of foundry MACT standards by EPA. American Coal and Chemical Institute, Boca Raton, FL, January 1996.

Hundreds of additional presentation covering a wide range of environmental health and safety issues and topics.

International Presentations

Mosher G. Reuse of foundry waste in USA – Advancing beneficial re-use in the United States. International Conference, Foundry Waste Possibilities of the Future, San Sebastian, Spain, November 13, 2001.

Mosher G. Silica. CIATF International Conference on Environmental Protection, Leipzig, Germany, May 25, 2000.

Mosher G. Trends in upcoming environmental legislation and compliance which will impact the foundry industry. 23rd Canadian Foundrymen's Conference, Hamilton, Ontario, Canada, September 22, 1995.

Mosher G. Control of foundry air lead: Update. 98th American Foundrymen's Society Casting Congress and Cast Expo, Hamilton, Ontario, Canada, May 2, 1994.

Mosher G. Coping with regulations on waste disposal in the melt department. 98th American Foundrymen's Society Casting Congress and CastExpo, Hamilton, Ontario, Canada, May 1, 1994.

Mosher G. Review of regulations: Noise and dust – USA. Electric Furnace Conference, Toronto, Ontario, Canada, November 14, 1991.

Mosher G. Effects of environmental issues on the future of North American foundry operations. American Foundrymen's Society Canadian Regional Conference, Hamilton, Ontario, Canada, October 10, 1991.

Mosher G. Making castings in a fish bowl. 21st Canadian Foundrymen's Conference, Hamilton, Ontario, Canada, October 20, 1989.

Prior Experience

President, Mosher Environmental & Occupational Health Consulting, 2006–2010
Vice-President Environmental Health & Safety, American Foundry Society, 1975–2005
Advancing responsibilities culminating in VP EH&S in 1996

Peer Reviewer

- Reviewer, Recommendations for Control of Occupational Safety and Health Hazards. . . Foundries, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio, , DHHS (NIOSH) No. 85-116, September 1985

- Reviewer, Occupational Health Hazard Control Technology for the Foundry Industry–Instructors Guide, U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio, January 1981

Advisory Appointments

- American Chemistry Council's Silica Panel/Silica Coalition 1989–2005
- American Foundry Society Aluminum MACT Task Force 1999–2003
- American Foundrymen's Society Air Quality Committee 1986–present
- American Foundrymen's Society MACT Task Force 1993–2005
- American Foundrymen's Society Occupational Health & Safety Committee 1975–present
- American Foundrymen's Society EPA Sand Task Group 1995–1996
- American Foundrymen's Society Segmental Vibration Task Force 1981–1985
- American Foundrymen's Society Silica Alliance 2000–2004
- American Foundrymen's Society Solid Waste and Wastewater Committee 1986–present
- American Industrial Hygiene Association Engineering Committee 1978–1984
- American Industrial Hygiene Association Engineering Committee, Chair 1981–1982
- American Industrial Hygiene Law Committee 1980
- American Society for Testing and Materials Committee E34 on Occupational Health & Safety, T.G. 16 Silica 1979–1982
- ASTM International Committee E34 on Occupational Health & Safety 1978–present
- ASTM International Committee E34.16 on Silica 1996–1998
- Casting Emissions Reduction Program (CERP) Steering Committee 1994–2005
- Environmental Technology and Advisory Committee, Pittsburg State University, School of Technology and Applied Sciences 1994–1995
- Comite International des Associations Techniques de Foundries (CIATF) Commission 4, Environmental Protection 1986–2005
- Foundry Industry Task Force on Silica 1998–2000
- Foundry Industry Recycling Starts Today (FIRST) Steering Committee 1998–2000
- Foundry Nickel Committee 1978–1981
- OSHA's Silica, Crystalline Safety and Health Topics Page 2007–present
- OSHA's Lead Safety and Health Topics Page, Editorial Board 2007–present
- Recyclers of Copper Alloy Products (RECAP) 1990–1992

Professional Affiliations

- Air and Waste Management Association
- American Association for the Advancement of Science
- American Chemical Society
- American Foundry Society
- American Industrial Hygiene Association
- ASTM International

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Joyce S. Tsuji, Ph.D., DABT, Fellow ATS
Principal

Professional Profile

Dr. Joyce Tsuji is a Principal Scientist within the Center for Toxicology and Mechanistic Biology of Exponent's Health Sciences practice. She is a board-certified toxicologist and a Fellow of the Academy of Toxicological Sciences. Dr. Tsuji specializes in assessing exposure and risks associated with chemicals, and in communication of scientific issues. She has worked on projects in the United States and internationally for industry, trade associations, U.S. EPA and state agencies, the U.S. Department of Justice, the Australian EPA, municipalities, and private citizens.

Dr. Tsuji's experience includes human health and environmental toxicology related to a wide variety of chemicals in the environment, consumer products, and medical devices. She has designed and directed dietary and environmental exposure studies and community programs involving health education and biomonitoring for populations potentially exposed to chemicals in the environment, including soil, water, and food-chain exposures. She has also assessed exposure and health risks associated with chemical exposures from air, foods, medical devices, and a variety of consumer products (e.g., cleaners, air fresheners, cosmetics, paints and coatings, carpets, glues, wood preservatives, building materials, and children's toys and play equipment), including those containing nanotechnology or nanomaterials. Dr. Tsuji has served on expert panels on toxicology and health risks issues for the National Academy of Sciences/National Research Council (including their Board on Environmental Studies and Toxicology), Institute of Medicine, and federal and state agencies.

Academic Credentials and Professional Honors

Ph.D., Environmental Physiology, Department of Zoology, University of Washington, 1986 (National Science Foundation (NSF) Fellowship; NSF Dissertation Improvement Grant)
B.S., Biological Sciences, Stanford University, 1980 (Honors and Distinction; Phi Beta Kappa; Fox Fund Award for the Outstanding Stanford Graduate in Biological Sciences)
Other coursework: Aquatic Toxicology, Hatfield Marine Sciences Center, Oregon; Mid-America Toxicology Course, Kansas; Tropical Ecology, Organization for Tropical Studies, Costa Rica

Licenses and Certifications

Fellow of the Academy of Toxicological Sciences, 2007
Diplomate of the American Board of Toxicology, 1992 (re-certified to 2012; requirements for re-certification through 2017 have been met)

Publications

Menzie CA, Ziccardi LM, Lowney YW, Fairbrother A, Shock SS, Tsuji JS, Hamai D, Proctor D, Henry E, Su SH, Kierski MW, McArdle ME, Yost LJ. Importance of considering the framework principles in risk assessment for metals. Environ Sci Technol 2009; 43(22):8478–8482.

Tsuji JS, Garry MR. Advances in toxicity testing herald improvements and challenges for risk assessment. Risk Anal 2009; 29(4):490–491.

Mink PJ, Alexander DD, Barraj LM, Kelsh MA, Tsuji JS. Low-level arsenic exposure in drinking water and bladder cancer: A review and meta-analysis. Regul Toxicol Pharmacol 2008; 52:299–310.

Tsuji JS, Yost LJ, Barraj LM, Scrafford CG, Mink PJ. Use of background inorganic arsenic exposures to provide perspective on risk assessment results. Regul Toxicol Pharmacol 2007; 48:59–68. [One of Elsevier's Top 10 cited articles on Scopus™ 2007–2008].

Barraj LM, Tsuji JS, Scrafford CG. The SHEDS-Wood Model: Incorporation of observational data to estimate exposure to arsenic for children playing on CCA-treated wood structures. Environ Health Perspect 2007; 115(5):781–786.

Barraj LM, Tsuji JS. Letter to the editor. Risk Anal 2007; 27(1):1–3.

Tsuji JS, Maynard AD, Howard PC, James JT, Lam C-W, Warheit DB, Santamaria AB. Research strategies for safety evaluation of nanomaterials. Part IV: Risk assessment of nanoparticles. Toxicol Sci 2006; 89(1):42–50.

Tsuji JS, Van Kerkhove MD, Kaetzel RS, Scrafford CG, Mink PJ, Barraj LM, Crecelius EA, Goodman M. Evaluation of exposure to arsenic in residential soil. Environ Health Perspect 2005; 113(12):1736–1740.

Tsuji JS, Benson R, Schoof RA, Hook GC. Response to additional support for derivation of an acute/subchronic reference level for arsenic. Regul Toxicol Pharmacol 2004; 40:372.

Tsuji JS, Benson R, Schoof RA, Hook GC. Health effect levels for risk assessment of childhood exposure to arsenic. Regul Toxicol Pharmacol 2004; 39:99–110.

Schoof RA, Tsuji JS, Benson R, Hook GC. Response to Byrd et al. (2004) comment on health effect levels for risk assessment of childhood exposure to arsenic. Regul Toxicol Pharmacol 2004; 40:374–375.

Yost LJ, Tao S-H, Egan SK, Barraj LM, Smith KM, Tsuji JS, Lowney YW, Schoof RA, Rachman NJ. Estimation of dietary intake of inorganic arsenic in U.S. children. Hum Ecol Risk Assess 2004; 10:473–483.

Massot M, Huey RB, Tsuji J, van Berkum FH. Genetic, prenatal, and post natal correlates of dispersal in hatchling fence lizards. Behav Ecol 2003; 14:650–655.

Tsuji JS, Williams PRD, Edwards MR, Allamneni KP, Kelsh MA, Paustenbach DJ, Sheehan PJ. Evaluation of mercury in urine as an indicator of exposure to low levels of mercury vapor. Environ Health Perspect 2003; 111(4):623–630.

Tsuji JS, Robinson S. Separating potential source exposure from background exposure in subsistence populations in developing countries. Toxicology 2002; 181–182:467–470.

Tsuji JS, Serl KM. Current uses of the EPA lead model to assess health risk and action levels for soil. Environ Geochem Health 1996; 18(1):25–33.

Kalvig BA, Maggio-Price L, Tsuji JS, Giddens WE. Salmonellosis in laboratory-housed iguanid lizards (*Sceloporus* spp). J Wildl Dis 1991; 27(4):551–556.

Tsuji JS, Huey RB, van Berkum FH, Garland Jr. T, Shaw RG. Locomotor performance of hatchling fence lizards (*Sceloporus occidentalis*): Quantitative genetics and morphological correlates. Evolut Ecol 1989; 3:240–252.

van Berkum FH, Huey RB, Tsuji JS, Garland Jr. T. Repeatability of individual differences in locomotor performance and body size during early ontogeny of the lizard *Sceloporus occidentalis* (Baird & Girard). Funct Ecol 1989; 3:97–105.

Tsuji JS. Seasonal profiles of standard metabolic rate of lizards (*Sceloporus occidentalis*) in relation to latitude. Physiol Zool 1988; 61:230–240.

Tsuji JS. Thermal acclimation of metabolism in *Sceloporus* lizards from different latitudes. Physiol Zool 1988; 61:241–253.

van Berkum FH, Tsuji JS. Interfamilial differences in sprint speeds of hatchling *Sceloporus occidentalis* (Reptilia: Iguanidae). J Zool London 1987; 212:511–519.

Tsuji JS, Kingsolver JG, Watt WB. The in-flight thermal physiological ecology of a butterfly (*Colias*). Oecologia 1986; 69:161–170.

Stevenson RD, Peterson CR, Tsuji JS. The thermal dependence of locomotion, tongue flicking, digestion and oxygen consumption in the wandering garter snake. Physiol Zool 1985; 58:46–57.

Tracy CR, van Berkum FH, Tsuji JS, Stevenson RD, Nelson J, Barnes B, Huey RB. Errors resulting from linear approximations of heat balance equations in biophysical ecology. J Thermal Biol 1984; 9:261–264.

Feder ME, Gibbs AG, Griffith GA, Tsuji JS. Thermal acclimation in salamanders: Fact or artifact? J Thermal Biol 1984; 9:255–260.

Book Chapters

Institute of Medicine. 2011. Breast cancer and the environment: A life course approach. National Academy Press. Co-authored parts of the report with other committee members.

Tsuji JS, Mowat FS, Donthu S, Reitman M. Application of toxicology studies in assessing the health risks of nanomaterials in consumer products. pp. 543–580. In: Nantoxicity: From In Vitro and In Vivo Models to Health Risks. S.C. Sahu and D.A. Casciano (eds), John Wiley & Sons, Chichester, West Sussex, UK, 2009.

Published Abstracts of Presentations

Tsuji JS, Mowat FS. Health risks of carbon nanotubes: What can we learn from mineral fibers or ultrafine particulates? Toxicologist 2007; 96(1):7.

Mowat FS, Tsuji JS. Assessment of health risks of carbon nanotubes: Where do we go from here? Toxicologist 2007; 96(1):8.

Tsuji JS, Mowat FS, Kaetzel RS. Approaches for risk assessment and risk management of nanomaterials: "Inert" metal oxides. Toxicologist 2006; 90(1), Abstract 2201.

Mink PJ, Alexander DD, Barraj LM, Kelsh MA, Tsuji JS. Meta-analysis of low level arsenic exposure and bladder cancer: Implications for risk assessment in the United States. Toxicologist 2006; 90(1), Abstract 2184.

Yost LJ, Tsuji JS, Scrafford CG. Implications of changes in the arsenic cancer slope factor for risk communication. Toxicologist 2006; 90(1), Abstract 2180.

Tsuji JS. Emerging issues in risk assessment and risk perception of nanomaterials. Toxicologist 2005; 78(1-S) Abstract 648.

Tsuji JS, Kerkhove MD, Scrafford CS, Kaetzel RS. Biomonitoring of a community for soil arsenic exposure. Toxicologist 2005; 78(1-S), Abstract 693.

Tsuji JS, Williams PR, Edwards MR, Avadhanam KP, Paustenbach DJ. Is mercury in urine indicative of exposure to low levels of mercury vapor? Toxicol Sci 2002; 66(1-S), Abstract 979.

Garry MR, Tsuji JS. Evaluating lead exposure at mining sites with heterogeneous soil types and lead bioavailability. Toxicol Sci 2002; 66(1-S), Abstract 500.

Tsuji JS, Garry MR. Metals exposure from homegrown produce at mining and smelting sites. Toxicol Sci 2001; 60(1–S): Abstract 95.

Garry MR, Lowney YW, Tsuji JS. A critical analysis of assumptions used when evaluating intake of metals from homegrown vegetables. Toxicol Sci 2001; 60(1–5): Abstract 2077.

Goodman M, Tsuji JS. Is sulfate in drinking water a hazard for infants? Toxicol Sci 2000; 54(1-S), Abstract 1174:250.

Schoof RA, Tsuji JS. The role of outdoor dust in exposures to chemicals in soil: Case studies for arsenic. Toxicol Sci 2000; 54(1-S), Abstract 1168:249.

Tsuji JS, Schoof RA, Hook GC. Subchronic health effect levels for childhood exposure to arsenic. Toxicol Sci 2000; 54(1-S), Abstract 346:73.

Tsuji JS, Serl KM. Multipathway exposure and risks to mercury in soil. Toxicol Sci 1998; 42(1-S), Abstract 1139:231.

Tsuji JS, Serl K, Fricke JR. Predicted versus observed blood lead levels for a smelter site. Fund Appl Toxicol 1997; 36(1):Part 2, Abstract 1706:336.

Recent Presentations

Tsuji JS, Bogen K. Human biokinetic model of nickel release from medical devices. Poster Presentation, 50th Annual Meeting of the Society of Toxicology, Washington, D.C., March 6–10, 2011.

Tsuji JS, Li AA. Mechanism-based evaluation of xenobiotic toxicity: Translation of National Academy of Sciences recommendations to practice. 8th International Conference on Early Toxicity Screening: Mechanism-based Evaluation of Adverse Drug Effects: Early Elimination of NCE [new chemical entity] with Hepatotoxicity and Idiosyncratic Toxicity: Scientific Concepts, Challenges and Promising Approaches, Seattle, WA, June 17–18, 2010.

Tsuji JS. Invited panel participant. Product safety: How companies can minimize their risk of product liability litigation. Nanotech 2010 Conference sponsored by the Nano Science and Technology Institute, Anaheim, CA, June 21–24, 2010.

Tsuji JS, Hentz K, Rosenbloom, S. Health risk of internal nickel exposure from medical devices. Poster presentation. Annual Meeting of the Society of Toxicology, Salt Lake City, UT, March 7–11, 2010.

Tsuji JS. Health risks of nanotechnology in consumer products. Invited speaker. Environmental Health and Safety: Policy, Regulation, and Product Safety. Nanotech 2009 Conference sponsored by the Nano Science and Technology Institute, Houston, TX, May 3–7, 2009.

Tsuji JS, Mowat FS. Application of toxicity studies for risk assessment in the real world. Presentation within workshop on Agglomeration Versus Dispersion: How Nanoparticle Behavior Affects Exposure and Toxicity *In Vitro*, *In Vivo*, and in the Real World. Workshop organizer and chairperson. Annual Meeting of the Society of Toxicology. Baltimore, MD, March 15–19, 2009.

Tsuji JS. Environmental health: Nanomaterials: nifty or naughty? Invited panel participant. Society for Environmental Journalists. Stanford University, Stanford, CA, September 7, 2007.

Tsuji JS. Background arsenic exposure from diet and water provide perspective for assessing arsenic exposure from other sources. Invited speaker for session on Risk Characterization and Risk Assessment. Conference on Urban Environmental Contamination and Health Under the Microscope: The Aftermath of Hurricane Katrina. The Society for Environmental Geochemistry and Health, New Orleans, LA, July 22–25, 2007.

Tsuji JS. From slippery slope factor to drinking water standard: How risk assessment affects the arsenic MCL. Invited speaker for session on Natural Poisons and Unnatural Products. American Water Works Association Annual Conference, Toronto, Ontario, June 27, 2007.

Tsuji JS, Mowat FS. Exposure and toxicology of nanomaterials. Invited speaker for Nano Safety and Health Forum. Society for the Advancement of Materials and Process Engineering (SAMPE) Conference, Baltimore, MD, June 6, 2007.

Tsuji JS, Mowat FS. Health risks of carbon nanotubes: What can we learn from mineral fibers or ultrafine particulates? Workshop organizer and chairperson. Annual Meeting of the Society of Toxicology. Charlotte, NC, March 25–29, 2007.

Tsuji J, Mowat F. Assessment of products containing nanomaterials. Symposium entitled, "Regulating nanotechnology: Developing stakeholder consensus for future rulemaking by EPA, FDA and OSHA." Division of Chemistry and the Law of the 232nd American Chemical Society National Meeting. San Francisco, CA, September 10–14, 2006.

Tsuji JS, Mowat FS. Risk assessment of nanoscale metal particles. Invited presentation at the Environmental Protection Agency (EPA) Region 5 Nanotechnology for Site Remediation Workshop. Chicago, IL, September 6–7, 2006.

Mowat FS, Tsuji J. Nanotechnology and the water market: Applications and health effects. Abstract 747. Presented at 9th Annual NSTI Nanotechnology Conference and Trade Show. Boston, MA, May 7–11, 2006.

Tsuji JS, Mowat FS. Potential benefits and hazards of nanotechnology in water. Session on Natural Poisons and Unnatural Products. American Water Works Association Annual Conference. San Francisco, CA, 2005.

Tsuji JS. Emerging issues in risk assessment and risk perception of nanomaterials. Symposium organizer and chairperson at the Society of Toxicology annual meeting, New Orleans, LA, 2005.

Tsuji JS. Assessing children's exposure to arsenic treated wood. Society of Toxicology continuing education course on Fundamentals of Risk Assessment and Applications of Recent Methods to Difficult Problems, Salt Lake City, UT, 2003.

Tsuji JS. Childhood lead exposure pathways and risk factors for lead exposure at U.S. mining and smelting sites. Plenary speaker for Local Solutions Smart Future Conference and Celebration, Working and Living with Lead, Port Pirie, South Australia, 2003.

Tsuji JS, Yost L, Barraj L. Background inorganic arsenic exposures in children. Session on CCA Treated Wood—Regulations, Science, and Risk Assessment. The Annual International Conference on Soils Sediments and Water, University of Massachusetts, Amherst, MA, October 22, 2003.

Tsuji JS, Williams P. Use of biomonitoring versus risk assessment methods for evaluating human exposures. Platform presentation at the Society of Risk Analysis Annual Meeting, New Orleans, LA, 2002.

Tsuji JS, Benson R, Schoof RA, Hook GC. Childhood Health Effect Levels for Arsenic. Poster presentation at the 5th International Conference on Arsenic Exposure and Health Effects, San Diego, CA, 2002.

Tsuji JS, Robinson S. Separating potential source exposure from background exposure in subsistence populations in developing countries. Invited symposium presentation at the 9th International Congress of Toxicology Conference, Brisbane, Australia, 2001.

Tsuji JS, Schoof RA, Robinson S, Seidel P. Dietary arsenic in subsistence populations from Indonesia. Invited presentation at the 4th International Conference on Arsenic Exposure and Health Effects, San Diego, CA, 2000.

Tsuji JS. Chairman and introductory speaker for a session on community health monitoring and education programs. National Environmental Policy Institute Conference on Lead in Soil and Blood Lead of Children, 1998.

Science Advisory Boards/Panels

National Research Council, Board on Environmental Studies and Toxicology (2010–2013).

National Research Council Standing Committee on the Use of Emerging Science in Environmental Health Decisions, sponsored by the National Institute of Environmental Health Sciences (2011-2012).

Institute of Medicine of the National Academies, Committee on Breast Cancer and the Environment: The Scientific Evidence, Research Methodology, and Future Directions, sponsored by Susan G. Komen for the Cure (2010–2011).

Peer reviewer of the National Research Council report, Eighteenth Interim Report of the Committee on Acute Exposure Guideline Levels (2010).

National Research Council Standing Committee on Toxicology (2008–2011).

National Research Council Standing Committee on Risk Analysis Issues and Reviews, sponsored by EPA (2007–2010). Served on the organizing committee and/or as a panel member for workshops on various toxicological and risk assessment issues, including effects of receptor-mediated events on dose-response assessment, relevance of mouse liver tumors, exposure measurement error in epidemiological studies, interpretation of bioassay and human biomonitoring data for thyroid active chemicals, and exposure science in the 21st century. Chaired the organizing committee and moderated two workshops for EPA.

- Quantitative Approaches to Characterizing Uncertainty in Human Cancer Risk Assessment Based on Bioassay Results, June 2007.
- Characterizing the Potential Human Toxicity from Low Doses of Pharmaceuticals in Drinking Water: Are New Risk Assessment Methods or Approaches Required? December 2008.

National Research Council Ad hoc organizing committee member and panel participant in EPA's symposium, Toxicity Pathway-Based Risk Assessment: Preparing for Paradigm Change, May 11–13, 2009, Washington, DC.

Independent expert review panel for the Flin Flon, Manitoba, and Creighton, Saskatchewan Human Health Risk Assessment. Coordinated by Toxicology Excellence for Risk Assessment (2009).

National Research Council Subcommittee on Emergency and Continuous Exposure Guidance Levels for Selected Submarine Contaminants (development of health-protective short-term and long-term airborne levels for acetaldehyde, hydrogen chloride, hydrogen fluoride, hydrogen sulfide, and propylene glycol dinitrate). Wrote chapter on acetaldehyde for published report (2008–2009).

Independent expert review panel for the Sudbury Soils Study Ecological Risk Assessment. Sudbury Mining District, Ontario. Coordinated by Toxicology Excellence for Risk Assessment (2007).

National Research Council subcommittee commissioned by NASA to review and comment on Spacecraft Water and Air Exposure Guidelines for various organic and inorganic chemicals in spacecraft and space stations. Assisted the NASA contractor in modeling increases in blood lead levels due to bone loss in space (2001–2008).

Peer review of two National Institute for Occupational Safety and Health (NIOSH) research protocols designed to gather data for evaluating inhalation risks posed by nanoparticles and nanotubes. Coordinated by Toxicology Excellence for Risk Assessment (2007).

Independent expert review panel for the Sudbury Soils Study Human Health Risk Assessment. Sudbury Mining District, Ontario. Coordinated by Toxicology Excellence for Risk Assessment (2006).

National Research Council Subcommittee on Emergency and Continuous Exposure Guidance Levels for Selected Submarine Contaminants (development of health-protective short-term and long-term airborne levels for acrolein, carbon dioxide, carbon monoxide, formaldehyde, hydrazine, methanol, monoethanolamine, nitric oxide, nitrogen dioxide, oxygen, ammonia, benzene, 2,6-di-tert-butyl-4-nitrophenol, Freon 12, Freon 114, hydrogen, 2190 oil mist, ozone, toluene, xylene). Wrote chapters on formaldehyde and Freon 12 for published reports (2003–2007).

Peer reviewer of the National Research Council subcommittee report that commented on the U.S. EPA Risk Assessment of the Coeur d' Alene Basin (2005).

State of Washington scientific panel to evaluate protective measures and remedies for area-wide soil contamination of arsenic and lead in the state resulting from past pesticide use, mining and smelting, and other sources. This panel was advisory to the state task force convened to reach practical and protective solutions for widespread areas of the state that exceed state standards for lead and arsenic in soil (2002).

National Research Council subcommittee to evaluate the health protectiveness of the Navy's proposed submarine escape action levels for carbon monoxide, hydrogen chloride, hydrogen cyanide, nitrogen dioxide, sulfur dioxide, hydrogen sulfide, chlorine, and ammonia. Toxic levels of these gases may be expected from fires associated with a disabled submarine. Wrote chapter on hydrogen sulfide for the published report (2001).

Expert review panel commissioned by the U.S. Army to review a risk assessment of closure of the Jefferson Proving Grounds in Indiana and reuse as a wildlife refuge. Metals and radionuclides were a primary concern (2001).

National Academy of Sciences subcommittee to evaluate the EPA drinking water level for copper. Coauthored the report *Copper in Drinking Water*, published by the National Research Council (1999–2000).

National Academy of Sciences peer reviewer of the National Research Council's drinking water document for arsenic (1998).

Washington State Department of Ecology technical committee on the human health-based surface water quality criteria for arsenic. The purpose of the committee was to determine whether new data existed of sufficient quantity and quality to merit changing the state human health-based surface water criteria for arsenic (1997–1998).

External expert panel to assess the relative importance of environmentally related human health problems in the State of Washington. This work was a part of EPA's Pilot Comparative Risk Project, Region 10 (1997).

Prior Experience

Regional Manager of Risk Assessment Practice, Foster Wheeler Environmental, 1998
Senior Toxicologist; Director of Risk Assessment and Toxicology, Kleinfelder, Inc., 1992–1997
Senior Scientist, Environmental Toxicology International, Inc., Program Director, 1987–1992
Post-doctorate research on quantitative genetics; teaching faculty for courses on human physiology and vertebrate natural history, University of Washington, 1986–1987

Selected Project Experience

Product Safety

Conducted state-of-the-science reviews of potential exposure and health effects related to nanometal oxides, carbon nanotubes and nanofibers, and other nanomaterials proposed for use in several products with widespread consumer uses. Evaluated exposure and health effects literature related to worker or consumer exposure and potential environmental effects. Directed a team of material scientists and toxicologists to assess the potential for exposure and health risks to nanoparticles from these products during manufacture and consumer use.

Evaluated potential applications of nanotechnology and the available knowledge on health risks for home care and cleaning products.

Directed a literature review and assessment of studies of potential exposure and health effects associated with nanometal pigments used in sunscreen formulations. Provided senior review of a survey of toxicology studies on nanoscale silver and silver in general with relevance for use in personal care products.

Evaluated potential safety concerns of a sanitizing device on a water dispenser. The assessment included evaluation of the sanitizing agent as well as potential reaction byproducts depending on whether the water source was untreated water or treated (chlorinated or ozonated) water.

Provided toxicology and health risk support for assessment of chemical leaching results for various plumbing fixture parts.

Assessed exposure and health risks of leaching of metals (e.g., chromium, cobalt, iron, neodymium, nickel, and tungsten) from alloys used in various implanted medical devices. Projects involved potential device failures as well as assessments in support of FDA submissions for device approvals. Types of devices included metal on metal hip replacements, structural and cardiovascular devices, electronic components, surgical instruments, and radiation shielding devices.

Directed the development and application of a biokinetic model for internal nickel release to evaluate the representativeness of *in vitro* leaching tests based on clinical data on serum nickel levels. Used the model to assess health risks of several devices based on *in vitro* leaching data and clinical reports.

Served as senior reviewer for health evaluation of silver release from medical devices involving silver coatings and for the design of an animal study of an indwelling catheter.

Conducted an evaluation of potential health risks for organic chemicals identified from leaching and volatilization tests of a device and control unit intended to be implanted for nerve stimulation. Commented on the implications of the test results for the intended application. Provided perspective on potential exposures and toxicity given the intended use and other known and approved exposures to these chemicals.

Served as the senior toxicologist for several projects involving metals (e.g., lead, cadmium), phthalates, or other organic chemicals in toys or consumer products, including interpretation of the results of sampling and chemical analysis for potential exposure and health risks. Assisted a toy manufacturer with assessment of potential chemicals in their products that might be associated with reported dermatitis in children.

Investigated levels of brominated flame retardants and other chemicals in fabric used in children's products that might potentially be associated with reported skin reactions. Evaluated health risks of formaldehyde, 1,4-dioxane, parabens, and other chemicals reported in children's bath products and other personal care products.

Assessed levels of formaldehyde in bedding products including the effects of laundering and different drying methods. Evaluated the results for consumer exposure and health risk and compliance with current international regulatory guidance levels.

Evaluated the toxicology of cleaning and sanitizing agents for a Fortune 500 consumer product company negotiating backflow device requirements with health authorities. Communicated the nature of the toxicity of the ingredients and compared exposure during a backflow event with other dietary or cosmetic exposures to these chemicals.

Researched the toxicology of the more than 22 ingredients in carpet glue for a glue manufacturer who was sued along with the carpet manufacturer, carpet installers, and landlord of a retail space in which tenants claimed multiple chemical sensitivity and other long-term health effects from short-term exposure to a newly installed carpet.

Directed an assessment of exposure and health risks for chemicals associated with fragrances used in various consumer products. Evaluated the potential for certain compounds to react with ozone and assessed the toxicity of the reaction by-products. Compiled comprehensive literature summaries and identified data gaps and areas for additional research and investigation.

Provided senior direction for development of a framework to assess arsenic and chromium exposure and toxicity to children from chromated copper arsenic (CCA)-treated wood used for play equipment and residential decks. This project involved analysis of the available scientific data and identification of critical uncertainties for exposure parameters that would benefit most from additional research. Presented the analysis to the Agency for Toxic Substances and Disease Registry and EPA. Commented on EPA's deterministic risk assessment of CCA-treated wood and on the agency's probabilistic exposure model for assessing exposures to wood

treatment chemicals. Testified at EPA's FIFRA Science Advisory Panel meetings and before the Consumer Product Safety Commission regarding background exposures to inorganic arsenic via diet and water in comparison to CCA exposures.

Metals

Worked with a team of epidemiologists on a meta-analysis of low levels arsenic exposures and cancer. Eight studies of arsenic exposures and bladder cancer met these criteria (e.g., low level exposure, case-control or cohort study design, nutritionally sufficient populations). The results of the meta-analysis were submitted to the EPA Science Advisory Board (SAB) reviewing the cancer slope factor for arsenic and were published. Also provided technical comments to the SAB regarding arsenic toxicology and nutrition, perspective on background exposure via diet and water, and information from health studies from a number of smelting sites.

As a part of an inter-disciplinary, international team, evaluated the health effects of metals and other constituents in tailings discharged into a river system from a copper mine in Southeast Asia. Served as the senior toxicologist for the human health risk assessment. This risk assessment entailed designing a dietary, human exposure, and biomarker survey of subsistence populations in the area and overseeing the implementation of the survey at the site. The survey information was used in both screening-level and detailed probabilistic assessments of risks to these populations. Trained local scientists in how to conduct risk assessments and presented preliminary results to a government scientific review panel.

Analyzed news reports of health effects on dock workers from exposure to an arsenical wood-treating solution that leaked from shipping containers at an African port. Separated symptoms associated with arsenic poisoning from those possibly due to hemorrhagic fevers or other local health problems.

Served as the senior toxicologist for a probabilistic risk assessment of arsenic in soil in a community in Arizona that received historical flooding from a tailings impoundment. Provided arsenic toxicology expertise and scientific input on distributions of values for arsenic bioavailability and other inputs to the Monte Carlo risk assessment.

Participated in an EPA working group involving the Agency for Toxic Substances and Disease Registry, state and local health agencies, interested parties, and concerned residents of a Superfund and Environmental Justice site in Denver with elevated levels of arsenic and lead over a large residential area. A primary source of the elevated arsenic levels was found to be historic use of an herbicide for lawns. Attended monthly meetings over a 2.5-year period and provided comments on data collection, bioavailability of metals, biomonitoring, risk assessment, and the toxicology of arsenic and lead. Participated in focused technical meetings on the short-term toxicology of arsenic in children and pica soil ingestion by children.

Served as senior toxicologist on a case involving lead-containing brass in water meter parts for a water department of a large municipality in California. The water department was seeking cost recovery from a supplier that provided water meters and valves containing more lead than specified in the order. The water department also had concerns for public exposures. Our work

involved evaluation of the leach test information and conducting various exposure simulations of the potential effect on blood lead levels of children.

Directed human health and ecological efforts to evaluate risks before and after reclamation of an abandoned mine site in a wildlife refuge in Northern California. These assessments were performed for the State Department of Fish and Wildlife. Features of the site included an acidic pit lake, tailings and waste rock piles, and mine drainage and mineralization of groundwater and a nearby creek.

Appointed as an expert for a U.S. district court on health risks related to lead, arsenic, and other inorganic and organic chemicals for an 11-mile^2 area of the city of Dallas, Texas. The study area included a former secondary lead smelter, several battery and metals reclamation facilities, numerous other industries, a large public housing project, single and multi-family private residents, and schools.

Conducted risk assessments and health risk reviews and worked with federal and state regulators to evaluate various health issues in areas near a large open pit copper mine and smelter in Utah. The areas included residential and recreational area soils affected by past air emissions or by deposition of metals in tailings during flooding from a stream channel. Evaluated the results of an environmental exposure and biomonitoring program for lead and arsenic in children for use in assessing health risks and cleanup levels. Also assessed drinking water exposure to sulfate and other inorganic constituents in groundwater. Provided a scientific review of the toxicity of sulfate to humans that U.S. EPA Region 8 relied on to set a site-specific action level for sulfate in groundwater used for drinking water.

Directed the human health and ecological risk assessments for tailings and naturally mineralized soil at a former mill site in New Mexico. The primary site constituents were manganese and zinc in groundwater and lead, manganese, and arsenic in soil. Lead in soil was evaluated using EPA's adult and child lead models with site-specific assumptions when justified. Detailed site geochemistry studies and simulated gastrointestinal leaching tests indicated very low bioavailability of lead in soil. This work was conducted as a part of a voluntary removal action.

Evaluated claims by a couple in New Mexico that past weekend exposures to elevated levels of metals and fluoride in their drinking water put them at risk of future disease.

Retained as an expert in two separate legal suits at a mining site in Washington. One suit involved releases of acrylamide in drilling muds to groundwater; the other, cyanide and metals concentrations in surface water and groundwater near the gold mine. Assessed the potential health risks of chemical concentrations to populations in the vicinity. Testified before a jury in the latter case.

Provided toxicology and exposure assessment support for a litigation case involving a competitive shooter who alleged that his health effects and elevated blood lead level were caused by the conditions of an indoor firing range. Assessed lead data from range samples and designed an exposure study at an outdoor range to distinguish lead exposure from the shooting equipment and style of firing versus ventilation conditions of the range. Also evaluated whether

the alleged health effects were related to the chelation therapy and whether this treatment was applied appropriately.

Retained by a county in Oregon to direct a risk assessment of elemental mercury and cinnabar ore in soil at the site of a former small-scale refining operation. The RI/FS was conducted under the state voluntary cleanup program and involved close coordination with state toxicologists. The risk assessment evaluated direct exposures to soil as well as mercury vapor emissions and potential effects on groundwater and migration to nearby rivers.

Conducted risk assessments for a former copper smelter in Tacoma, Washington. Risks were assessed for arsenic and lead in soil and slag in nearby residential areas and for more than eight metals, PAHs, PCBs, and aniline compounds in soil, slag, demolition debris, groundwater, and surface water on the smelter site. Risks of the site to aquatic life and fishermen were also considered. Participated in discussions of health issues with EPA; in risk communication at public meetings and with citizen groups; and in a technical work group with EPA, the state, NOAA, and other trustees to design and implement toxicity testing and assessment of sediment impacts.

Directed a risk assessment of metal concentrations under baseline and post-mine-development conditions as a part of the permitting process for a gold mine in Montana. Because the mine site is located near the confluence of two rivers, fish consumption was a major pathway of exposure in addition to potential effects on groundwater. Assisted in risk communication.

Directed health risk assessments of lead smelter sites in Montana, Utah, and Washington. Reviewed and commented on the health risks of smelter sites in Kansas City, Idaho, Illinois, and Texas. Chemicals of concern included lead, arsenic, and cadmium. Evaluated blood lead and urinary arsenic concentrations of residents and environmental sampling data. Assessed impacts from air, water, soil, and dust using EPA's integrated exposure/uptake biokinetic (IEUBK) lead model for the Montana site.

Conducted a health risk assessment of a lead smelter site on the Missouri River in Omaha, Nebraska, that was proposed for brownfield redevelopment as a park. Assessed health risks during demolition and construction as well as afterwards to visitors and maintenance workers of the park. Also considered the potential impacts resulting from flooding of the site. Discussed health risk issues with the state regulators, and participated in public meetings. This work facilitated the cleanup and redevelopment of the site by addressing health risk concerns.

Served as project manager under a contract with EPA for conducting a risk assessment of a reservoir in Montana filled with sediments from upstream mining and smelting activities. The site covers hundreds of acres involving potential impacts to aquatic life, wetlands, bird life, and local drinking water wells. The risk assessment involved coordination among various agencies (EPA, the State of Montana, the U.S. Fish and Wildlife Service, the Montana State Department of Fish and Game), the public, and the principal responsible party.

Calculated health-based soil remediation goals in support of risk-based closure and commercial redevelopment of a zinc plant site in Oklahoma. Lead, arsenic, and cadmium in soil and smelter debris used as fill material were the primary health concerns.

Provided technical review and comments on an engineering evaluation/cost assessment for a zinc plant site in southern Illinois. Evaluated site-specific uses of EPA's IEUBK lead model for estimating lead risk for residential soil with isolated areas of lead-containing smelter debris for both sites. Also calculated lead risks to workers using an adult lead model.

At another zinc plant site in Oklahoma, directed screening-level assessments of exposure and risk and made recommendations for communicating the necessity of closing private wells because of potential risks associated with cadmium in groundwater.

Conducted focused health evaluations for zinc plants in Texas and Tasmania. Presented findings for the Texas site to the regulators and in a brief televised news interview.

Assessed the toxicity of mine tailings to cattle and food chain transfer of metals in tailings to humans consuming beef or beef liver. This study was a part of a successful project in Arizona to use cattle to revegetate and stabilize mine tailings slopes.

Reviewed the scoring of arsenic by the Canadian Government's Substance Selection Committee, which implemented the Ontario Ministry of the Environment Scoring System for Assessing Environmental Contaminants. Provided technical comments on the environmental fate and persistence, aquatic toxicity, and carcinogenicity of different forms of arsenic. Reviewed a draft Environment Canada report on the long-range transport of metals in the environment with specific focus on the sources and migration of mercury.

Provided health risk and toxicology expertise for an active cadmium refinery in Denver, Colorado. Reviewed risk assessments, evaluated air emissions, interpreted health data of residents, discussed technical issues with the state agencies, and communicated risk to the public. This site required environmental cleanup for cadmium, lead, and arsenic.

As an expert for the Environmental Protection Authority of Victoria, conducted a focused risk assessment of lead in soil from a past battery recycling plant in Melbourne, Australia. Residential development had already commenced at the site without prior remediation. This assessment was instrumental in justifying that health protective actions were necessary.

Provided comments on EPA's assessment of health risks and potential cleanup levels associated with arsenic and other metals in soil from a mining site near Salmon, Idaho. The site is in a remote area, contains an inn and primitive campgrounds, and is located near two creeks. Stream-side tailings deposited downstream of the site were also a concern. Site-specific issues included the bioavailability of the ore and the amount of exposure associated with recreational or livestock use of the area. Worked with EPA scientists in developing risk assessment assumptions.

Reviewed the NPL ranking of a mine waste site in Idaho that received one of the highest scores. Comments primarily focused on the lack of consideration of the bioavailability of arsenic and lead in the mine waste. Provided senior toxicology input to the assessment of both human health and ecological impacts, wetland areas, and a nearby river. Worked on behalf of the responsible parties to help ensure that up-to-date scientific methods and site-specific assumptions were considered. Provided oversight on bioavailability and geochemical studies of the soils and waste rock.

Retained as the senior toxicologist for a risk evaluation of mine tailings in Coeur d'Alene River and Lake in Idaho. Provided technical input and risk communication regarding the likelihood of adverse effects associated with exposure to metals in surface water, fish, and beach sediments resulting from tailings releases from upstream mining. Communicated the findings of the risk evaluation at a press conference. Later retained as an expert on human health issues in the natural resource damage suit. Evaluated the available data relating various sources of environmental lead in the Coeur d'Alene basin to blood lead levels of children.

Served as a senior advisor for human health investigations of environmental and dietary exposures associated with a zinc mine, haul road, and concentrate loading facility in northern Alaska. Native American concerns included deposition or uptake of metals into berries, caribou muscle and organs, and fish. Reviewed data collection work plans and risk evaluations of environmental data.

Assessed the bioavailability and adverse health effects of arsenic-containing ore and mercury contamination of an old gold mining site in Alaska that was turned into a children's playground. Negotiated a site-specific approach for setting cleanup levels with the Alaska Department of Environmental Conservation. This study developed a cleanup level for arsenic based on a health risk assessment that incorporated the low bioavailability of the ore form of arsenic.

Provided senior direction and review of an evaluation of thallium levels in cement kiln dust and exposures to workers at a cement plant in Florida. Recommendations were made for reducing thallium levels to protect the health of workers.

Assessed exposure to lead and arsenic in soil from historic sandblasting and repainting of water tanks in residential neighborhoods in Seattle, Washington.

Medical/Biological Monitoring

Designed and directed an arsenic exposure investigation and biomonitoring study of more than 400 residents living near a pesticide manufacturing plant. The study included a detailed census of the community, public communications, administration of a survey of individual characteristics affecting exposure, and collection and reporting of biological samples (urine and toenails) and environmental samples (house dust, soil, vegetables) for arsenic analysis. The data collected were used in a cross-sectional statistical evaluation of soil arsenic exposure in the community.

Evaluated potential for health effects and provided technical consulting pro bono to a homeowner who drank well water with elevated arsenic levels, including review of well water data, medical records and biomonitoring results.

Served as the senior toxicologist of a team that designed and conducted an environmental and dietary exposure study to assess potential metals exposure of highland, lowland, and estuarine populations living along a river that carried tailings from a mine and mill in Southeast Asia. This study also included biomonitoring of inorganic substances in blood, urine, and hair to correlate with other measures of exposure.

Developed work plans for community protection measure programs to address residual risks to lead and arsenic in residential soil at a former smelting area in Utah and for several communities in the tri-state mining district in Oklahoma. The programs involved health education, blood lead and urinary arsenic monitoring, health intervention, and environmental abatement, if warranted. These programs were developed cooperatively with federal, state, and local health agencies. Worked with EPA and state and local health departments in interpreting blood lead and environmental lead data for risk management decisions at the Leadville, Colorado, mining and smelting site.

Served as a toxicology expert in legal cases involving children in Oklahoma. The families alleged that their children's prior blood lead levels resulted from wind-blown dust from mine waste piles and had caused behavioral and academic problems in school. Evaluated sources of exposure for each child and the potential effects associated with their blood lead levels.

For two residential areas in the Midwest involving releases of elemental mercury from gas meter regulators in homes, provided information on the toxicity of elemental mercury, biomonitoring of individuals for exposure, and background sources of elemental mercury. Provided risk communication and technical support in developing strategy for working with EPA Region 5 on what levels might constitute a concern in homes. Conducted a pooled analysis of studies examining the relationship between mercury levels in air and in urine. Based on this analysis, recommended limits to the usefulness of biomonitoring for mercury vapor.

Directed an evaluation of beryllium exposure in workers manufacturing aluminum alloy products. Reviewed air and wipe sample data and provided a review of the available scientific and medical information regarding the likelihood of disease and strengths and limitations of medical monitoring tests.

Retained as an expert on the toxicology and health risk of metals associated with contamination of private wells by acid mine drainage in Arizona. Served as the senior lead of the human health risk assessment team and worked with county and state health officials to assess and communicate to residents the potential health effects indicated by well water sampling results. Manganese was the primary chemical of concern. As a part of a settlement for a class action lawsuit, proposed an approach to exposure screening and medical monitoring and worked with plaintiffs' expert from a local university to develop a medical monitoring program for residents.

Provided testimony in a class action lawsuit in Washington State regarding the alleged need for medical monitoring for all residents in the vicinity of a smelter living on soil with arsenic and lead levels above background levels. Key issues included the lack of sensitivity of tests at these low exposure levels and the low risk of adverse effects.

Risk Communication

Evaluated residual lead levels in dust and cleanup efforts for a former printing facility building in Colorado that was converted for use as a charter school. Explained lead exposure and health issues at two town hall meetings for parents, teachers, and students.

Provided toxicological expertise and risk communication for a school district dealing with the issue of lead in drinking water of schools. Assessed the sampling data, recommended further testing and controls, and discussed the nature of the risks and solutions with school officials. Contributed to press releases and communication to parents.

Met with a daycare owner and concerned parents in a residential area near a former smelter to discuss their potential health concerns associated with soil sampling results for arsenic and lead on the property.

Selected as an external expert to engage in a brainstorming session to assess the relative importance of environmentally related human health problems in the State of Washington. This work was a part of EPA's Pilot Comparative Risk Project, Region 10, 1997.

Participated in public meetings and news conferences as a health risk expert. Explained health issues to concerned parents at a daycare facility near a Superfund site. Evaluated and communicated potential health risks of a nearby hazardous waste site cleanup to the cast and crew of a television studio in California.

Air Toxics (see also Volatile Organic Compounds and Petroleum)

Evaluated health-based levels for short-term and long-term exposures to numerous inorganic and organic chemicals in air while serving on several expert committees for the National Research Council/National Academy of Sciences.

Conducted a state-of-the-science review of the toxicological basis for short-term and long-term air quality criteria for methylene chloride. Evaluate air guidelines developed by agencies in the United States, Canada, Europe, Israel and by the World Health Organization. This project was followed by a review of the scientific basis supporting short-term and long-term exposure limits for airborne levels of 12 other chemicals.

Retained as the senior toxicologist on odor and health issues for a pulp mill in Camas, Washington, that had a release of hydrogen sulfide and mercaptans that reached a school. The strong odors at the school resulted in children feeling acutely ill with some being sent to the local hospital. Discussed the nature of the risk and latest scientific information with state and local health agencies to promote better risk communication and attended a public meeting.

Provided senior review of a health evaluation of workers exposed to hydrogen sulfide, mercaptans, and other sulfur compounds in air at a geothermal energy plant. Issues of concern also included potential toxic interactions among these compounds.

As an expert for a city, evaluated the potential health effects of odorous chemicals (primarily hydrogen sulfide and mercaptans) associated with emissions from a wastewater treatment plant. A critical issue was the distinction of odor levels that are a public nuisance, possibly resulting in subjective effects in some individuals, but that do not cause clinically defined adverse health effects.

Retained by the U.S. Department of Justice as a toxicology expert to help assess cases involving enforcement actions by EPA for two sites with potential public exposures: one with chromium in groundwater, the other with accidental releases of hydrogen sulfide from a plant into a community. Testified on findings at an administrative hearing for the hydrogen sulfide case.

Evaluated the inhalation toxicology and health risks of criteria pollutants, metals, and silica for an application submitted to the Texas Air Board for permitting of modernized equipment at a copper smelter. The permit was approved.

Directed multipathway risk assessments of hazardous and municipal waste incinerators. Researched the health effects of incineration ash. Incineration sites included New Jersey, Kentucky, some midwestern states, and Seattle, Washington. Chemicals of primary concern for potential risks were metals, dioxins, and furans.

Served as senior reviewer of risk assessments and scientific reviews of the health risks associated with cement kilns burning hazardous waste. Participated in an investigation of occupational exposures and health and safety issues for cement kiln dust.

Assessed the nature of health risks associated with chemicals emitted by semiconductor industries (projects for four different companies) in Arizona. Chemicals emitted by operations were primarily acute toxicants, such as acids or bases and some solvents, rather than chemicals with potential long-term cumulative effects. Communicated risks to regulators and concerned citizens at a public hearing and assisted in preparing a corporate environmental report and other information for the public. The projects involved emissions from proposed facilities that were subsequently permitted; from operating facilities; and from a circuit-board manufacturing plant that had a fire.

Served as a toxicology and risk assessment expert in commenting on proposed hazardous air pollutant (HAP) rules for non-federal HAPs in the State of Arizona. Participated in a series of public hearings and communicated the latest scientific information to the Arizona Association of Industries (AAI), public interest groups, and the Arizona Department of Environmental Quality (ADEQ). Commended by ADEQ, AAI, and public representatives for scientific contributions to the process and facilitation of consensus.

Subsequently, commented on the revised HAPs program proposed by the State of Arizona. In addition to comments on the overall process, specific comments were submitted on the health-based methodology and use of the toxicological literature in developing short-term and long-term air criteria for individual chemicals.

Served as the senior toxicologist as a part of a team of industrial hygiene and air quality specialists investigating possible causes and remedies for various health complaints suffered by staff working in the neonatal intensive care unit of a hospital in Nevada. Possible causes investigated included re-entrainment of boiler exhaust, other problems with the ventilation system, or indoor sources of chemicals.

Selected by a major cancer research facility and the local fire department to help settle a dispute regarding the acute inhalation toxicity of formalin and its classification according to the Uniform Fire Code. Strict interpretation would have required the facility to shut down because only a small amount of formalin would have been allowed per building. Provided the scientific interpretation on the toxicity of formalin versus formaldehyde that resolved the conflicting conclusions provided by experts for each of the parties, thereby allowing the facility to operate and the fire department to be confident that health would be protected in the event of a fire.

For a major health care organization, conducted an independent review of a risk assessment of benzene in air at a daycare facility located on petroleum-contaminated soil.

On behalf of the surviving family, provided a summary of opinion as a toxicology expert in a case involving the death of a refrigerator repairman by carbon dioxide poisoning from dry ice used in a broken freezer. The key issues considered were the physiological and toxicological effects of elevated carbon dioxide levels and whether the repairman would have been able to rescue himself from the situation.

Pesticides and Herbicides

Conducted detailed toxicology evaluations of ethylene dibromide, dibromochloropropane, 1,3-dichloropropene, 1,2-dichloropropane, 1,2,3-trichloropropane, and epichlorohydrin for cases involving alleged exposures to fumigants from drift off of fields and from groundwater contamination. Specifically evaluated the scientific evidence related to whether exposure to these chemicals would cause the alleged health effects.

Evaluated health risks associated with residential exposure to pesticides and herbicide releases as a result of a fire at a nearby grain silo and a warehouse in Oregon containing more than 100 agricultural chemicals. Emergency response action levels were developed to guide remediation of residential soil contaminated by surface runoff of water used in fighting the fire.

Retained specifically to resolve risk assessment and cleanup levels issues with the state regulatory agency for persistent pesticides and herbicides in soil at an agricultural chemical site in Oregon.

Provided senior oversight on an evaluation of health and environmental effects of pesticides and herbicides used by Northwest utilities on vegetation and on utility poles.

In support of a settlement for a major retailer, evaluated the toxicity of their waste stream (mostly cardboard, although damaged packages of pesticides, herbicides, or fertilizers were also alleged to have been contributed) relative to other wastes that were historically sent to a landfill in Washington that had accepted municipal, medical, and hazardous waste.

Conducted a risk assessment of residual levels of chlorinated organic pesticides in "clean" fill used for remediating a residential area in California. Evaluated direct exposure via ingestion of soil and indirect exposure from eating home vegetable gardens.

Supervised expert toxicology work regarding a potential poisoning caused by an organophosphate pesticide and the use of pesticides on school buses and likely effects on children.

Volatile Organic Compounds (see also Air Toxics)

Served as an expert witness for a case involving a perchloroethylene (PCE) plume in groundwater attributed to a former laundry and dry cleaning facility in Wyoming. Testified in court regarding the toxicology of PCE, health risks (via drinking water and volatilization in indoor air) to residents living over the plume, and effects on aquatic biota as a result of groundwater reaching a river. The court's decision regarding the lack of an imminent and substantial endangerment reflected this testimony.

Directed and peer-reviewed assessments of health and environmental impacts of chemicals in groundwater as a part of landfill closures and corrective actions at multiple landfill sites in California, Montana, Washington, and Arizona. The evaluations included potential effects on drinking water wells and irrigation water, soil vapor exposure, and migration of volatile organic chemicals (e.g., trichloroethylene (TCE), PCE, vinyl chloride, chloroform) in groundwater to surface water bodies with exposure to aquatic organisms and fishermen. Detailed analysis of the human toxicology of these chemicals was also conducted to assess the limitations of the regulatory criteria, which are largely based on animal data.

Assessed sources and likely exposures to TCE and its breakdown products, 1,2-dichloroethene and vinyl chloride, in groundwater, soil gas, and indoor air samples at an industrial plant and for nearby residential properties in western Washington. Soil gas and air samples also included other volatile chemicals. Conducted a screening of health risks for the site and provided comments on a health consultation by the state department of health.

Retained as a toxicology expert by a county in Arizona for pending litigation concerning a landfill. The landfill had received multiple waste streams over time, including both hazardous, municipal, and construction debris. Evaluated the site environmental data and exposures at nearby retail stores, a restaurant, and motel that had elevated levels of volatile organic compounds in their well water.

Evaluated concentrations of volatile organic chemicals in air within a commercial building in southern California to assess whether volatile chemicals in groundwater were migrating into the building at concentrations of health concern for workers. Exposures were found to be less than California worker health criteria.

Evaluated the potential health risks of groundwater containing volatile organic chemicals in support of a legal settlement for a property owner adjacent to a major Superfund site in Washington.

Provided senior review for a facility in which workers received historical exposure to TCE in drinking water. This project included an evaluation of the scientific literature and current debates on the health risks of TCE and other volatile chlorinated compounds.

Worked with a team of epidemiology and toxicology experts to provide written comments on EPA's risk assessment of TCE.

Developed risk-based cleanup levels for acetone, methyl ethyl ketone, methylene chloride, and toluene in soil at an industrial facility in North Carolina. Modeled exposure by soil ingestion, dermal contact, and inhalation of volatile emissions.

PCBs

Assessed the adverse effects of PCBs and priority pollutants in uplands soils and river sediments on the environment (including aquatic organisms and associated terrestrial wildlife) and on public health at a former utility substation on the Willamette River in Oregon that was to be redeveloped into a museum. Designed a tissue residue study of local fish and used the results to derive more realistic bioaccumulation rates for PCBs in sediment. Presented the risk assessment to the Oregon Department of Environmental Quality (ODEQ). The cleanup based on this risk assessment was approved by ODEQ.

Assessed possible changes in cleanup levels for PCBs in sediments of an urban waterway in Commencement Bay, Washington. Evaluated the recent toxicological literature, sediment concentrations, fish consumption rate studies, and changes in regulatory guidance.

Provided senior review for a remedial investigation and ecological and health risk assessment of marine sediments in an urban harbor in southern California. Project efforts included sampling of sediment chemistry and biota, as well as implementation of aquatic and sediment bioassays. The primary chemicals of concern were PAHs from petroleum solvents, metals, PCBs, and persistent pesticides.

Assessed the relative hazards posed by PCBs compared with those posed by PAHs at a coal gasification and metal recycling NPL site in Washington. The study supported a *de minimis* settlement by the utility companies that had contributed transformers with residual PCB oil.

Dioxins/Furans, Pentachlorophenol

For a public housing authority, evaluated the potential for exposures to dioxin and furan compounds detected in soil of an apartment complex that was built on a site with past industrial uses. Assessed patterns of exposure over the site, subpopulations with highest potential for exposure, and the feasibility and limitations of biomonitoring for dioxins and furans.

On behalf of a city in Washington State, commented on the proposed changes in the state cleanup level regulations for dioxins and furans in soil. Provided scientific input on the toxicological basis of such criteria. Also on behalf of the city, provided comments on a remedial investigation report of a local pulp mill site with dioxins and furans in soil.

Investigated potential exposures and health risks of dioxins and furans emitted by a cement plant in Arizona. Supervised modeling and risk communication efforts.

Provided risk assessment input for a remedial investigation of a pole yard and wood products facility in Montana. Helped design sampling to collect the necessary data for a risk assessment and provided technical input on the need for interim remedial actions. The primary concern regarded pentachlorophenol and dioxins/furans released to soil and groundwater from former dip tanks for wood treatment. Groundwater releases threatened a sole-source aquifer. Reviewed and commented on the state's risk assessment work plan and risk assessment drafts. Addressed issues of particular concern to the community such as the toxicity of dioxins/furans.

Conducted a RCRA evaluation of human health and ecological risks for a wood-treating facility bordering wetlands, a wildlife refuge, and a major tributary of the Columbia River. Primary issues of concern were transport of copper, chromium, arsenic, pentachlorophenol, and PAHs to the wetlands via contaminated groundwater. Soil sampling revealed these chemicals as well as petroleum hydrocarbons and dioxins. The potential toxicity of sediment samples was also assessed.

Served as a toxicologist for EPA in evaluating effects to human health and aquatic organisms resulting from organic chemicals (pentachlorophenol, creosote, PAHs) and metals (copper, chromium, arsenic) in soil, groundwater, marine sediments, and surface water from a Pacific Northwest wood-treating facility. Dioxins and furans were also elevated in soil as a result of a retort fire.

Retained as an expert witness in support of litigation regarding the potential health effects and cleanup levels at an industrial site in northern California involving various activities, including lumber storage, wood treatment, wood products manufacturing, and railroad engine construction. Testified at two court hearings.

Provided senior oversight for risk assessment and risk communication about dioxins and PCBs in onsite and offsite residential soil at a pulp mill in Washington State.

Petroleum Sites

Provided toxicology and health risk support to a city following an oil spill in a river from a pipeline leak. Provided recommendations on air sampling, assessed air exposures to those living along the river from volatile emissions, met with concerned citizens regarding health effects and potential concerns, and participated in focus group meetings with citizens and state and local health agencies.

Directed a health risk assessment of a fuel additive in sediments at an overseas offshore loading facility. The assessment evaluated the current literature on chemical toxicity and included design of site-specific data collection and analysis to quantify exposure. Assessed health risks via fish ingestion probabilistically using Monte Carlo techniques. Developed a survey of local practices related to fishing and designed experiments to quantify cooking loss of the additive. Educated scientific experts of the foreign court on health risk assessment and presented the risk assessment findings.

Conducted an evaluation of health and environmental effects at the site of a former Pacific Northwest boat repair and cannery site that was to be redeveloped into a resort. Issues of primary concern included petroleum hydrocarbons in soil and the aquatic toxicity of tributyltin in marine sediments and in groundwater that discharges to the surface water in the harbor. Evaluated the toxicity of tributyltin in sediments specifically to mussels and oysters. PAHs and lead were also elevated in subsurface soils and in groundwater. Potential human exposures included those of children playing on the beach and people eating seafood collected at the site.

Retained as a toxicology expert for property owners and tenants potentially affected by a groundwater plume of heating oil from a utility site in Spokane, Washington. Provided technical comments on site investigation plans and a risk assessment and assisted the citizens in understanding the health risks and state RI/FS process.

Reviewed and directed multiple risk assessments of petroleum hydrocarbons in soil and groundwater in Washington, Oregon, California, and Arizona. Most of these assessments were risk-based closures of UST sites in support of voluntary actions of two major oil companies or the U.S. Department of Defense. Also provided senior review of a risk-based remediation at a petroleum terminal site in Oregon.

Directed a risk assessment of petroleum compounds in soil and groundwater at a state Superfund site in Washington. Risks were considered for commercial use of the site as well as for potential exposure to nearby users of private wells. The assessment included a detailed toxicity evaluation of volatile and semivolatile chemicals in gasoline and diesel. Site-specific cleanup action levels were recommended depending on various engineering controls.

Assessed risks associated with PAHs and petroleum hydrocarbons in soil from underground storage tanks at an industrial site in Massachusetts. This risk assessment provided the state regulatory agency with sufficient scientific justification to approve a limited cleanup for the protection of workers.

For the City of Seattle, directed a review and assessment of risks to public health and aquatic life due to urban storm water discharges in the Seattle area. Lead and petroleum hydrocarbon compounds such as PAHs were the main concerns.

Provided senior direction and review of a contingency plan for incineration of oil-soaked waste and debris associated with oil spill cleanup in Alaska. This work was performed for a major petroleum consortium in response to regulatory requirements.

Multiple Chemical Sites/Issues

Project manager for a contract with Oak Ridge National Laboratory to write toxicity review documents for chemicals in support of U.S. EPA Integrated Risk Information System database of toxicity criteria for risk assessment.

Directed a health risk assessment for the Queensland government in Queensland, Australia (of a high-profile site known as Australia's Love Canal), involving a residential area built over an area with previous mining and industrial and municipal disposal activities. The most visible source of concern was the appearance of acid oil sludge at the surface of yards built over mining pits filled with refinery wastes. Chemicals of concern included lead, PAHs, PCBs, cyanide, and chlorinated benzenes in groundwater, surface water, soil, and air.

Examined the nature and extent of underground contamination at an abandoned naval shipyard in northern California converted for residential use. Evaluated the potential for adverse health effects to future residents from long-term exposure to petroleum hydrocarbons, lead, and other metals. Developed and implemented surface flux chamber sampling to measure volatile chemical emissions from soil. Derived cost-effective, risk-based cleanup levels, which were approved by the California Department of Health Services.

Served as an expert for the State of New Jersey regarding health risks associated with a major urban park. Evaluated health risks associated with residual levels of chromium from chromite ore processing, petroleum-related chemicals, lead and other metals, PCBs, and pesticides. Effectively demonstrated the lack of a scientific basis for the opposing expert's report.

Directed human health and ecological risk assessment of lead, PAHs, and explosive chemicals at a former industrial munitions facility. The site encompassed a large woodland area, including small lakes and a salmon stream, and bordered a wildlife refuge and river delta. Ecological concerns included both potential aquatic effects and risks to burrowing animals in the upland areas.

Retained as an environmental toxicology expert by Whatcom County, Washington, in a legal action filed by the county to cease storage of hazardous and solid waste on a property located within a primary watershed. Evaluated the potential chemical hazards at the property that might threaten the watershed.

Directed projects for EPA's Technical Enforcement Support program. Responsibilities included direction of risk assessments for EPA and oversight of potentially responsible parties conducting risk assessments at various sites.

Professional Affiliations

- Society of Toxicology
  – Vice President, Nanotoxicology Specialty Section 2011
  – Program Committee Chair, Nanotoxicology Specialty Section 2011
  – Vice President Elect, Nanotoxicology Specialty Section 2010
  – Webinar Committee; Nanotoxicology Specialty Section 2009-2010
  – Continuing Education Committee 2002–2004

- Society of Environmental Geochemistry and Health
  – Councilor 2002–2010

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Group Vice President, Health

Professional Profile

Dr. Elizabeth L. Anderson is the Group Vice President of Exponent Health. Prior to joining Exponent, Dr. Anderson was President and CEO of Sciences International, a health and environmental consulting firm. She specializes in risk assessment as a basis for addressing the complex problems related to public health and the environment for national and international companies and governments.

Dr. Anderson has over 25 years of experience in working both within government institutions and for corporate entities. For the U.S. Environmental Protection Agency (EPA), she co-authored the first Federal policies to adopt risk assessment and risk management as the basis for setting health protective policies and guidelines for conducting carcinogen risk assessment. She founded and directed the Agency's Carcinogen Assessment Group and the central risk assessment programs for 10 years. Also, she has worked extensively on international risk assessment issues to address human health and ecological consequences of exposure to environmental toxicants, including for private companies, governments, the World Health Organization, and the Pan American Health Organization.

Dr. Anderson is a founder and past-President of the Society for Risk Analysis, regularly serves on peer review panels for Public Agencies and Institutions, has participated in numerous national and international commissions and organizations concerned with risk based issues, and has lectured and published widely in the field of risk assessment. She was also Editor-in-Chief of the journal, *Risk Analysis: An International Journal*, from 1998–2008.

Dr. Anderson is a Fellow of the Academy of Toxicological Sciences and the recipient of numerous awards including Twentieth Century Distinguished Service Award, Ninth Lukacs Symposium (1999), Outstanding Service Award, Society for Risk Analysis (1997), Jerry F. Stara Memorial Award (1994), SES Bonus for Outstanding Performance, (1984), EPA Gold Medal for Exceptional Service (1978), Kappa Kappa Gamma National Achievement Award (1974), and a William Author Mattox Merit Scholarship (1962). She also holds a patent and continues her professional activities through memberships in American Association for the Advancement of Science; American College of Toxicology; New York Academy of Sciences; Society for Risk Analysis; and Society of Toxicology.

Academic Credentials and Professional Honors

Ph.D., Organic Chemistry, The American University, 1970
M.S., Organic Chemistry, University of Virginia, 1964
B.S., Chemistry, College of William and Mary, 1962

Presidential Recognition Award, Society for Risk Analysis, 2006
The 2006 International Achievement Award, The International Society of Regulatory Toxicology and Pharmacology, 2006
Fellow, Academy of Toxicological Sciences
Twentieth Century Distinguished Service Award, Ninth Lukacs Symposium, 1999
Outstanding Service Award, Society for Risk Analysis, 1997
Jerry F. Stara Memorial Award, 1994
SES Bonus for Outstanding Performance, 1984
EPA Gold Medal for Exceptional Service, 1978
Kappa Kappa Gamma National Achievement Award, 1974
William Author Mattox Merit Scholarship, 1962

Patent

Patent #3,738,011: Thickness-scratch testing device, 1973 (with E. Brown).

Publications

Welt M, Anderson EL, Menzie C. Chapter 9. Changing Perspectives on Chemical Product Risks. In: Product Liability. ABA Publishing: Chicago, IL, 2011; 187–223.

Anderson EL. The evolution of risk assessment and management at the USEPA: A 40th anniversary reflection. HERA 2010; 16(6): November–December.

Anderson EL, Lowe K, Turnham P. Cancer Risk Assessment: Chemical Carcinogenesis, Hazard Evaluation, and Risk Quantification. John Wiley & Sons, Inc., 2010.

Welt M, Anderson EL. Changing perspectives on chemical product risks. The John Liner Review 2009; 23(2), Fall.

Reiss R, Anderson EL, Cross CE, Hidy G, Hoel D, McClellan R, Moolgavkar S. Evidence of health impacts of sulfate and nitrate-containing particles in ambient air. Inhal Toxicol 2007; 19:419–449.

Pepelko W, Seckar J, Harp PR, Kim JH, Gray DG, Anderson EL. Worker exposure standard for phosphine gas. Risk Anal 2004; 24(5):1201–1213.

Anderson EL, St Hilaire C. The contrast between risk assessment and rules of evidence in the context of international trade disputes: Can the U.S. experience inform the process? Risk Anal 2004; 24(2):449–459.

Anderson EL. The red book in context: Science at the center. Hum Ecol Risk Assess 2003; 9(5):1197–1202.

Reiss R, Anderson EL, Lape JF. A framework for assessing risk to children. Risk Anal 2003; 23:1069–1084.

Anderson EL. Assessing the risk of terrorism: A special collection of perspective articles. Risk Anal 2002; 22(3):401.

Subramaniam RP, Golden SL, Kral P, Turim J, Anderson EL. An exploratory study of variations in exposure to environmental tobacco smoke in the United States. Risk Anal 2001; 2(3):561–574.

Anderson EL, Goldman S, Kral P, Subramaniam R, Turim J. Risk assessment of indoor air pollutants. In: Proc. 4th Princess Chulabhorn International Science Congress: Chemicals in the 21st Century. The Chulabhorn Research Institute, Bangkok, Thailand, November 28–December 2, 1999.

Hattis D, Anderson EL. What should be the implications of uncertainty, variability, and inherent 'biases'/'conservatism' for risk management decision-making? Risk Anal 1999; 19(1).

Moolgavkar SH, Luebeck EG, Anderson EL. Estimation of unit risk for coke oven emissions. Risk Anal 1998; 8(6).

Moolgavkar SH, Luebeck EG, Anderson EL. Air pollution and hospital admissions for respiratory causes in Minneapolis-St. Paul and Birmingham. Epidemiology 1997; 8(4):364–370.

Moolgavkar SH, Luebeck EG, Hall TA, Anderson EL. Air pollution and daily mortality in Philadelphia. Epidemiology 1995; 6(5):476–484.

Moolgavkar SH, Luebeck EG, Hall TA, Anderson EL. Particulate air pollution, sulfur and daily mortality: A reanalysis of the Steubenville data. Colloquium on particulate air pollution and human mortality and morbidity, Irvine, CA. J Inhalat Toxicol 1994; 7:35–44.

Anderson E, Deisler PF, McCallum D, St. Hilaire C, Spitzer H, Strauss H, Wilson JD, Zimmerman R. Key issues in carcinogen risk assessment guidelines. Risk Anal 1993; 14(4).

Chrostowski PC, Hartley S, Foster SA, Anderson EL. Human health risks associated with asbestos abatement. Risk Anal 1991; 2(3).

Voytek P, Anver M, Thorslund T, Conley J, Anderson EL. Mechanisms of asbestos carcinogenicity. J Am Coll Toxicol 1990; 9(5).

Anderson EL, Chrostowski PC, Vreeland JL. Risk assessment issues associated with cleaning up inactive hazardous waste sites. In: Integrating Insurance and Risk Management for Hazardous Wastes. Kunreuther H, Gouda MUR (eds), Kluner Academic Publishers: Boston, 1990.

Anderson EL, Chrostowski PC, Vreeland J. Risk assessment for use in groundwater management. Risk Assessment for Groundwater Pollution Control, American Society of Civil Engineers, 1990.

Voytek P, Anver M, Thorslund T, Conley J, Anderson EL. Mechanisms of asbestos carcinogenicity. J Am Coll Toxicol 1990; 9(5):541–550.

Anderson EL. Scientific developments in risk assessment: Legal implications. Columbia J Environ Law 1989; 14(2).

Anderson EL, Chrostowski PC, Foster S. Calculating the risks. Solid Waste & Power 1988; 2(3):40–47.

Anderson EL, Henry CJ. Risk assessment/risk management as a toxic control strategy. World Conference on Large Lakes, Mackinac Island, Michigan. In: Toxic Contamination in Large Lakes, Vol. III, Sources, fate, and controls of toxic contaminants. Schmidtke NW (ed), Lewis Publishers, 1988.

Anderson EL. The risk analysis process. Vol. 3, pp. 3–17. In: Contemporary Issues in Risk Analysis, Carcinogen Risk Assessment. Travis CC (ed), Plenum Press, 1988.

Anderson EL. Perspective on risk assessment of carcinogens. Banbury Report 31: Carcinogen risk assessment: New directions in the qualitative and quantitative aspects. Cold Spring Harbor Laboratory, pp. 281–294, 1988.

Bridgen PJ, Anderson EL. Processes and parameters involved in risk assessment for environmental release of biotechnology products. Annual Meeting of the Society for Risk Analysis, Washington, DC, 1986.

Anderson EL, Albert RE, Kamely D. Risk assessments/risk management for environmental uses of biological agents. Invited paper for Banbury Conference on Genetically Altered Viruses and the Environment, Cold Spring Harbor Laboratory, April 28-May 1, 1985. Published in Banbury Report No. 22, p. 33.

Anderson EL. Quantitative approaches in use in the United States to assess cancer risks. Invited paper, 2nd Conference of the Scientific Group on Methodology for the Safety Evaluation of Chemicals, World Health Organization, Rome, Italy, July 12-16, 1982. Published in Methods for Estimating Risks of Chemical Injury: Human and Nonhuman Biota and Ecosystems, SCOPE 1985; 26:405–436.

Anderson EL, Ehrlich AM. New risk assessment initiatives in EPA. Toxicol Indust Health 1985; 1(4):7–22.

Anderson EL, Chu M, Dourson M, DeRosa C. Methodology for ranking the degree of hazard associated with exposure to carcinogens and other toxic chemicals. In: Proc. Symposium on Chemical Emergency Preparedness, Center for Human Health and Ecology, Pan American Health Organization, Metepec, Mexico, July 23–27, 1984.

Anderson EL. The use of quantitative approaches to assess cancer risks. Carcinogen Assessment Group of the U.S. Environmental Protection Agency. Risk Anal, 1983.

Albert RE, Lewtas J, Nesnow S, Thorslund TW, Anderson EL. A comparative potency method for cancer risk assessment: Application to diesel particulate emissions. Risk Anal, 1983.

Anderson EL. Are society's epidemiological needs being met? Invited paper for the Symposium on Epidemiologic Methods for Occupational and Environmental Health Studies, Washington, DC, December 2–5, 1979. Published in Methods and Issues in Occupational and Environmental Epidemiology, Ann Arbor Science Publishers, 1983.

Anderson EL. Risk assessment and regulatory approaches to carcinogens. Proc. FDA Symposium of Risk/Benefit Decisions and the Public Health, 1978.

Albert RE, Train RE, Anderson EL. Rationale developed by the Environmental Protection Agency for the assessment of carcinogen risks. J Natl Cancer Inst 1977; 58:1537.

Hawkins WM, Lutz RE, Anderson EL. Tetrasubstituted 2,5-hydrofuranols and their anomerism. J Org Chem 1970; 35:2934.

Hanson RB, Foley PJ, Anderson EL, Aldridge MH. The thermal cleavage of selected aldehyde hydrazonium salts. J Org Chem 1970; 35:1735.

Foley PJ, Anderson EL, Dewey FM. Synthesis of hydrazonium salts. J Chem Engineer, Data 1969; 14:272.

Books

Anderson EL, Albert RE. Risk assessment and indoor air quality. Monograph. A Volume in the Indoor Air Research Series. CRC Lewis Publishers, 1998.

Selected Invited Presentations (Health Risk Assessment and related topics)

Anderson EL. Biomonitoring in public health protection and regulatory decision-making: PFOA as a case study. Presented at the Second World Congress on Risk, Guadalajara, Mexico, June 10, 2008.

Anderson EL. Precautionary measures lead to widely varying international guidance levels for perfluorooctanoic acid (PFOA): The implications of biomonitoring. Presented at the Second World Congress on Risk, Guadalajara, Mexico, June 10, 2008.

Anderson EL. Risk assessment—A historical perspective from policy to public health. Presented at The George Washington University Medical Center, Washington, DC, March 17, 2004.

Turnham P, Anderson EL, Turim J. Dermal absorption of PCBs in non-aqueous carriers. Poster presented at the 2003 Annual Meeting of the Society for Risk Analysis, December 9, 2003.

Anderson EL. The role of risk assessment in resolving world trade disputes. Presented at the World Congress on Risk Assessment, Brussels, Belgium, June 24, 2003.

Anderson EL. Environmental risk assessment: past, current, future. Conference: Theories And Practices in Toxicology and Risk Assessment. Keynote speaker. Sponsored by Tri-Services Toxicology (AFRL/HEST, NHRC/TD, USACEHR), USACHPPM, AFSOR; USEPA, NCEA; ATSER, Division of Toxicology; NIOSH; and FDA, Cincinnati, OH, April 15–18, 2002.

Anderson EL. The contrast between risk assessment and proof of causality, and the fundamental principles of evidence of each. Workshop: Risk Assessment in the Context of Trade Disputes: How Well Can the Scientific Principles Incorporated into the Resolution of Science-Based Trade Disputes? University of Michigan, Ann Arbor, MI, November 1, 2001.

Anderson EL. Risk assessment: The evolution of a science and its use. Yale University, October 30, 2001.

Anderson EL. The challenge of risk assessment. Eco-Informa 2001: Environmental Risk and the Global Community. Argonne National Laboratory, Argonne, IL, May 14, 2001.

Anderson EL. Environmental forensics: Applying effective scientific methods to decrease cost and liability. IBC USA 3rd Annual Executive Forum, Washington, DC, June 26–28, 2000.

Anderson EL. Risk assessment of indoor air pollutants. 4th Princess Chulabhorn International Science Congress: Chemicals in the 21st Century. The Chulabhorn Research Institute, Bangkok, Thailand, November 28–December 2, 1999.

Anderson EL. Toxicology symposium: agriculture and preservation of water quality: General principles of risk assessment. The Brazilian Society of Toxicology, Sao Paulo, Brazil, March 15–18, 1999.

Anderson EL. Current issues in health risk assessment. International Society for Risk Analysis, Health Risk Assessment: Current issues. 11th Annual Symposium, Williamsburg, VA, October 26–28, 1998.

Anderson EL. Faculty, risk assessment and risk management in environmental law. ALI-ABA Course of Study, October 8–9, 1998.

Anderson EL. Seminar on modern environmental management; risk assessment as a decision making tool, Salvador, Brazil, May 1998.

Anderson EL. The role of uncertainty, variability, and bias in environmental risk management. 8th Engineering Foundation Conference on Risk Based Decision Making in Water Resources, Santa Barbara, CA, October 12–17, 1997.

Anderson EL. Overview of carcinogen and noncarcinogen risk assessment: Historical perspective. International Society for Risk Analysis, Health Risk Assessment: Current issues. 10th Annual Symposium, October 6–8, 1997.

Anderson EL. Coming of age—Risk based environmental decision making. The McLain program in environmental studies, Washington College, September 27, 1997.

Anderson EL. Applications of quantitative risk assessment to environmental health. Guest faculty for the 1997 summer institute in risk management in environmental health and protection, New York University, New York, NY, 1997.

Anderson EL. Risk-based analysis. 2nd Annual Environmental Law Forum, Pennsylvania Bar Institute, Harrisburg, PA, March 20, 1997.

Anderson EL. Risk-based decision making in the environmental arena: An overview. 26th Annual Conference on Environmental Law. American Bar Association, Section of Natural Resources, Energy, and Environmental Law, Keystone, CO, March 13–15, 1997.

Anderson EL. Analysis of risks to human health. Washington Operations Research/ Management Science Council, topics in risk analysis, Arlington Campus of George Mason University, Arlington, VA, November 1996.

Anderson EL. Sources of information for uncertainty analyses: Case studies, risk assessment issues—The probabilistic approach. University of California Extension, Santa Barbara, CA, March 28, 1996.

Anderson EL. Overview of risk assessment and risk management as a tool for environmental decision making, risk assessment, risk management and risk communication: Expanding the dialogue on environmental management—An international seminar. Sao Paulo, Brazil, November 7–9, 1995.

Anderson EL. Origins of quantitative risk assessment for cancer. International symposium sponsored by the Collegium Ramazzini on preventive strategies for living in a chemical world. Washington, DC, November 4, 1995.

Anderson EL. Risk-based decision making engineering foundation conference. Santa Barbara, CA, October 13, 1995.

Anderson EL. Overview of carcinogen and noncarcinogen risk assessment methods. Society for Risk Analysis annual course on new horizons in risk assessment. Arlington, VA, August 29, 1994.

Anderson EL. 12th institute in risk management in environmental health and protection. Guest faculty. New York University, New York, NY, May 17, 1994.

Anderson EL. Risk assessment in environmental decisions. Environmental Policy Issues Seminar, U.S. Office of Personnel Management, Denver, CO, July 21, 1993.

Anderson EL. Crossroads of humanity series, round table forum. The Medical University of South Carolina, Kiawah Island, SC, July 18–21, 1993.

Anderson EL. Risk characterization, environmental and occupational risk assessment: What it means to the mining industry. The American Mining Congress, Fairfax, VA, July 13, 1993.

Anderson EL. Quantitative risk assessment: Introduction to approaches and methods. Guest faculty. 11th Annual Summer Institute in Risk Management in Environmental Health and Protection, New York University, New York, NY, June 2, 1993.

Anderson EL. Using risk assessment to deal with health issues that would be barriers to sustainable development. Governor's Conference, from Rio to the Capitols: State Strategies for Sustainable Development, Louisville, KY, May 26, 1993.

Anderson EL. Risk assessment guidance at Superfund sites. Chemical Manufacturers Association's Superfund Health Risk Assessment Task Group and Remedy Selection Work Group, Washington, DC, April 13, 1993.

Anderson EL. Quantitative risk assessment II: Models and methods. Guest faculty, 10th Annual Summer institute in Risk Management in Environmental Health and Protection, New York University, New York, NY, June 9, 1992.

Anderson EL. Overview of carcinogen and noncarcinogen risk assessment methods. Society for Risk Analysis Annual Course on New Directions in Risk Assessment, Arlington, VA, April 13, 1992.

Anderson EL. Human health assessment: An overview. Seminar on Social, Economic, Biologic and Legal Basis for Dealing with Environmental Problems, Santiago, Chile, April 1992.

Anderson EL. Cancer risk assessments: An overview. Advanced Research Workshop on Oncogene and Transgenics Correlates of Cancer Risk Assessments, North Atlantic Treaty Organization and U.S. National Science Foundation, Athens, Greece, October 7–11, 1991.

Anderson EL. Quantitative risk assessment (with applications to hazardous waste management). Guest faculty. 9th Annual Summer Institute in Risk Management in Environmental Health and Protection, New York University, June 1991.

Anderson EL. Advances in carcinogen risk assessment with potential lessons for risk assessment for reproductive effects. Symposium on Risk Assessment of Prenatally-Induced Adverse Effects, Berlin, Germany, May 1991.

Anderson EL. New directions in risk assessment. Workshop, Society for Risk Analysis, Bethesda, MD, May 1991.

Anderson EL. Risk assessment approaches and application for regulation of exposure to potential carcinogens. U.S.-Japan cooperative cancer research program seminar on scientific basis for carcinogenic risk assessment of experimental carcinogens, Kauai, HI, March 1991.

Anderson EL. Annual Meeting, American Association for the Advancement of Science. Women in Science, Washington, DC, February 1991.

Anderson EL. Professional conference on industrial hygiene: Risk assessment—Future directions and impact on health and environment. Keynote speaker, American Academy of Industrial Hygiene, Vancouver, BC, Canada, October, 1990.

Anderson EL. Changing roles. 17th Annual Michigan Industrial Hygiene Society Mini-Conference, Troy, MI, October, 1990.

Anderson EL. Session Chairman. HAZ MAT/International '90, Toxic air pollutants: Current Issues, Atlantic City, NJ, June 1990.

Anderson EL. Risks associated with hazardous waste. The Wharton School of the University of Pennsylvania, Philadelphia, PA, May 1990.

Anderson EL. New directions in carcinogen risk assessment. Workshop, Society for Risk Analysis, Bethesda, MD, May 1990.

Anderson EL. Risk assessment and risk management. Keynote speaker, International symposium and the 1st Pan Pacific Cooperative Symposium on Industrialization and Emerging Environmental Health Issues, Kitakyushu, Japan, October 1989.

Anderson EL. International Symposium on Environmental Risk Assessment and Risk Management, Seoul, Korea, October 1989.

Anderson EL. Conference on the price of zero risk and zero waste. The Wharton School of the University of Pennsylvania, Philadelphia, PA, October 1989.

Anderson EL. Blue Ribbon International Symposium on Incineration of Municipal Solid Waste. United States Conference of Mayors, Washington, DC, September, 1989.

Anderson EL. Comparison of traditional health risks and risks associated with industrial development. Conference on Environmental Mutagens, Guadalajara, Mexico, July 1989.

Anderson EL. Conducted summer session on science, risk and the law of toxics. Vermont Law School 1989 Summer Session, South Royalton, VT, June 1989.

Anderson EL. 7th Annual Summer Institute in Risk Management in Environmental Health and Protection. Guest faculty, New York University, New York, NY, May 31, 1989.

Anderson EL. Risk assessment of non-ionizing radiation. Electromagnetic Energy Policy Alliance Annual Meeting, Alexandria, VA, April 13, 1989.

Anderson EL. The risk analysis process. Workshop on Carcinogen Risk Assessment, Society for Risk Analysis, Washington, DC, April 3–5, 1989.

Anderson EL, Thorslund TW, Chrostowski PC, Charnley G. Scientific trends in risk assessment research. Association of the Bar of the City of New York, Environmental Law Committee, New York, NY, 1988.

Anderson EL. Conference on Risks of Toxic Substances in Developing Countries: Implications for women and children. Bangkok, Thailand, November 18–20, 1988.

Anderson EL. A defense view of risk assessment. 1988 Fall Annual Meeting. American Bar Association, Section of Litigation, Washington, DC, October 21, 1988.

Anderson EL. The 1988 Washington conference on risk assessment. The Center for Energy and Environmental Management, Alexandria, VA, September 1988.

Anderson EL. Lecture on models for dose-response estimation and low-dose extrapolation. 6th Annual Summer Institute in Risk Management in Environmental Health and Protection, New York University Graduate School of Public Administration, New York, NY, June 1988.

Anderson EL. Seminar on risk assessment of resource recovery plants. 1988 United States Conference of Mayors Annual Conference, Salt Lake City, UT, June 1988.

Anderson EL. Limitations of the risk assessment process: Factors which affect the utility and credibility of the assessment process. Session Chairman. Gordon conferences, Wolfeboro, NY, June 1988.

Anderson EL. Scientific trends in risk assessment research. International symposium on chemical mixtures: Risk assessment and management. Cincinnati, OH, June 1988.

Anderson EL. Participated as rapporteur at the Only One Earth Forum Series. May 1988.

Anderson EL. Managing hazardous materials. Workshop on PCBs, dioxins, and similar materials. Rene Dubos Center for Human Environments, New York, NY, 1988.

Anderson EL. Risk assessment issues associated with cleaning up inactive hazardous waste sites. Conference Info, May 1988.

Anderson EL. Conference on Risk Assessment and Risk Management Strategies for Hazardous Waste Storage and Disposal Problems. Wharton School, University of Pennsylvania, Philadelphia, PA, 1988.

Anderson EL. Seminar on recent trends in health risk assessment: Impact on risk assessment of resource recovery projects. 1988 United States Conference of Mayors Annual Conference, Washington, DC, March 1988.

Anderson EL. The risk analysis process. Workshop on carcinogen risk assessment, Society for Risk Analysis, Washington, DC, March 1988.

Anderson EL. Lecture on scientific trends in risk assessment research. Association of the Bar of the City of New York Seminar on Risk Assessment in Environmental Law, New York, NY, February 1988.

Anderson EL. Risk assessment of suspect carcinogens. Keynote speaker, 2nd U.S.-Japan workshop on risk assessment/risk management, Osaka, Japan, 1987.

Anderson EL. Perspective on risk assessment of carcinogens. Banbury Conference on New Directions in the Qualitative and Quantitative Aspects of Carcinogen Risk Assessment, Cold Springs Harbor, NY, October 1987.

Anderson EL. Lecture on use of risk assessment in the evaluation of the public health impacts of toxic chemicals. Risk analysis in environmental and occupational health with emphasis on carcinogenesis, Harvard School of Public Health, Cambridge, MA, September 1987.

Anderson EL. Lecture on carcinogen risk assessment. New York University, Graduate School of Public Administration, June 1987.

Anderson EL. Lecture on extension of risk assessment methodology to biotechnology applications. NATO Advanced Research Workshop on Risk Analysis Approaches for Environmental Releases of Genetically Engineered Organisms, Rome, Italy, June 1987.

Anderson EL. Panel discussion: Risk assessment and insurability issues. International Symposium on Forecasting, Boston, MA, May 1987.

Anderson EL. Lecture on the risk analysis process. Workshop on Carcinogen Assessment, Society of Risk Analysis, National Academy of Sciences, Washington, DC, April 1987.

Anderson EL. Comments on medical issues in toxic tort cases, risk assessment, cancer, and immunological injuries. ABA Risk Assessment Panel. American Bar Association Section of Natural Resources Law, Chicago, IL, April 1987.

Anderson EL. Roundtable discussion on risk communication and the public's right to know. International Life Sciences Institute, Advisory Panel for Risk Communication, March 1987.

Anderson EL. The role of risk assessment in dealing with environmental pollution problems. Panel member, The Wharton School of the University of Pennsylvania, Philadelphia, PA, March 1987.

Anderson EL. Seminar on risk assessment and risk management. Meeting of Subcommittee on Information Coordination (SIC) of the Committee to Coordinate Environmental Health and Related Programs, National Institutes of Health, January 20, 1987.

Anderson EL. The assessment of air contaminants: The science vs. the art. HazMat West Conference, Long Beach, CA, December 4, 1986.

Thorslund TW, Charnley G, Anderson EL. Innovative use of toxicological data to improve cost-effectiveness of waste cleanup. Presented at Superfund '86: Management of Uncontrolled Hazardous Waste Sites, Washington, DC, December 1–3, 1986.

Anderson EL. Seminar Series on Risk Assessment. The Center for Energy and Environmental Management, Secaucus, NJ, November 19, 1986.

Anderson EL. Research needs to support risk assessment. In retrospect. Annual Meeting of the American College of Toxicology, Philadelphia, PA, November 17, 1986.

Anderson EL. Risk assessment and incineration. Michigan Air Pollution Control Association, Dearborn, MI, November 12, 1986.

Anderson EL. Risk assessment of biologically altered agents. Society for Risk Analysis Annual Conference, Boston, MA, November 10–11, 1986.

Anderson EL. Exposure assessment in a regulatory setting: The significance of protective assumptions in the absence of real data. American Petroleum Institute, Houston, TX, October 30, 1986.

Anderson EL. Workshop on evaluating toxic tort litigation liabilities. Natural Resources Section of the American Bar Association, Arlington, VA, October 29, 1986.

Anderson EL. Workshop on pragmatics of risk assessment. Society of Toxicology, Bethesda, MD, October 28, 1986.

Anderson EL. Seminar series. The Center for Energy and Environmental Management, Dallas, TX, October 27, 1986.

Anderson EL. Risk assessment forum on risk assessment and the workplace: Policy and practice. American Industrial Hygiene Association, George Mason University, Fairfax, VA, October 24, 1986.

Anderson EL. Risk assessment of chemical waste. Hazardous Waste Conference, Pennsylvania Chamber of Commerce, Valley Forge, PA, October 16, 1986.

Anderson EL. Lecture series on risk analysis in environmental health with emphasis on carcinogenesis. Harvard School of Public Health's Continuing Education Program, Boston, MA, September 4, 1986.

Anderson EL. Risk assessment at uncontrolled hazardous waste sites. American Institute of Chemical Engineers Annual Meeting, Boston, MA, August 25, 1986.

Anderson EL. Risk assessment and hazardous waste management: The impact of biomedical and exposure assumptions on meeting acceptable concentration goals. HAZTECH International, Denver, CO, August 14, 1986.

Anderson EL. Recent advances in risk assessment. The 4th Annual Summer Institute in Risk Management in Environmental Health and Protection, New York University Graduate School of Public Administration, New York, NY, June 1986.

Anderson EL. Risk assessment/risk management applied to air toxics. Air Pollution Control Association, Minneapolis, MN, June 22, 1986.

Anderson EL. Risk assessment/risk management training session. Maine Board of Environmental Protection, Portland, ME, June 6, 1986.

Anderson EL. Workshop on research needs in risk analysis. National Research Council, National Academy of Science, Washington, DC, June 2, 1986.

Anderson EL. Conducted course on hazardous chemical management and emergency response. 1st meeting of Caribbean Countries on toxic materials and pesticides, Pan American Health Organization, Bridgetown, Barbados, May 20–23, 1986.

Anderson EL. Chemical risk assessment: Methods and applications. University of California, Los Angeles, Los Angeles, CA, May 2, 1986.

Anderson EL. Cancer risk assessment in a regulatory setting. Annual Meeting of the Operations Research Society of America, Los Angeles, CA, April 14–16, 1986.

Anderson EL. The risk analysis process. Workshop on risk assessment/risk management: Carcinogenesis. Society for Risk Analysis, National Academy of Science, Washington, DC, April 7–9, 1986.

Anderson EL. Chemical risk assessment: the need for research. DuPont's Haskell Laboratories, Wilmington, DE, March 12, 1986.

Anderson EL. Roundtable discussions on risk communication and the public's right to know. Risk Science Institute, Atlanta, GA, December 15, 1986.

Anderson EL. Risk assessment and risk management of cadmium exposures in the U.S. 5th International Conference on Cadmium, International Lead/Zinc Research Organization, San Francisco, CA, February 4–6, 1986.

Anderson EL. Risk assessment of toxic chemicals: A decade of experience. Speaker for the Federal Water Quality Association and the Water Pollution Control Federation, February 1986.

Anderson EL. Annual environmental information exchange. Sponsored by the American Air Pollution Control Association, the U.S. Environmental Protection Agency, and the Society for Mechanical Engineers. Research Triangle Park, NC, December 1985.

Anderson EL. Risk assessment methods for uncontrolled releases of chemicals. Conference on risk analysis in developing countries, World Health Organization and National Science Foundation, Hyderabad, India, October 1985.

Anderson EL. Presented President's address on a decade in risk assessment and a paper on risk assessment as it is practiced at the federal and state level, with emphasis on areas for improvement, October 1985.

Anderson EL. Annual Meeting on Improving Risk Management, Society for Risk Analysis, Alexandria, VA, 1985.

Anderson EL. Lecture series on carcinogen risk assessment and risk management. Harvard School of Public Health's Continuing Education Program, Boston, MA, September, 1985.

Anderson EL. Symposium on risk assessment. Chemical Manufacturers Association, Washington, DC, September 1985.

Anderson EL. Risk assessment methods applied to issues in developing countries: Environmental health risk assessment. Pan American Health Organization, Mexico City, Mexico, August 1985.

Anderson EL. The use of risk assessment at the state level. National Governors Association Council on Environmental Health, Washington, DC, July 1985.

Anderson EL. Assessing risk associated with chemicals. The Toxicology Forum, Aspen, CO, July 1985.

Anderson EL. Research needed to support risk assessment of exposures at superfund and hazardous waste sites. The Centers for Disease Control, Atlanta, GA, July 1985.

Anderson EL. The use of risk assessment in the federal government. Distinguished Scholars Program, American Association for the Advancement of Science, Washington, DC, June 1985.

Anderson EL. Lecture series on risk assessment and public health. 3rd Annual Summer Institute, Graduate School of Public Health, New York University, New York, NY, June 1985.

Anderson EL. Symposium on health and environmental risk assessment. Brooks Institute, Washington, DC, June, 1985.

Anderson EL. Annual Summer Symposium on the Evaluation of Health Data for Toxic Chemicals. Mid-Year Meeting on Risk assessment, Chemical Specialties Manufacturers Association, Chicago, IL, May 1985.

Anderson EL. Symposium on risk assessment. American Industrial Health Council, Washington, DC, May 1985.

Anderson EL. Conference on risk assessment. The American Medical Association, Atlanta, GA, May 1985.

Anderson EL. Risk assessment methods. Mid-Year Briefing Program of the American Industrial Health Council, Washington, DC, May 1985.

Anderson EL. Risk assessment of regulatory implications. 14th Annual Conference on the Environment, Risk Assessment and the Law. Airlie House Conference, The American Bar Association, Warrenton, VA, May 1985.

Anderson EL. Risk assessment of agricultural chemicals. Public Health and Toxicology Committee Meeting, National Agricultural Chemicals Association, Washington, DC, May 1985.

Anderson EL. Risk assessment of potential effects associated with release of genetically altered mechanisms. Banbury Conference on Genetically Altered Viruses and the Environment, sponsored by EPA, Banbury Center, Cold Spring Harbor Laboratory, Long Island, NY, April 1985.

Anderson EL. Executive workshop on risk analysis in the federal regulatory process. American Society of Mechanical Engineers, Washington, DC, April 1985.

Anderson EL. Risk analysis: Invited lecture series on health risk assessment. Stanford University, Palo Alto, Stanford, CA, April 1985.

Anderson EL. Prevention 85: Assessing risks in a hazardous world, Atlanta, GA, March 1985.

Anderson EL. Symposium on acceptable risks/society's gamble. Public television series. Rutgers University, New Brunswick, NJ, March, 1985.

Anderson EL. Toxics management in the Chesapeake Bay. Seminar sponsored by the Virginia Institute of Marine Science and the Virginia Water Pollution Control Association, Gloucester Point, VA, March, 1985. Member, Board on Toxicology and Environmental Health Hazards. National Research Council/National Academy of Sciences, Washington, DC, March, 1985.

Anderson EL. Symposium on new issues in regulatory toxicology and health risk assessment. Society of Toxicology, San Diego, CA, March, 1985.

Anderson EL. Semi-annual meeting of committee on toxicology. National Research Council/National Academy of Sciences, Washington, DC, March, 1985.

Anderson EL. Chemical product risk reduction. Seminar sponsored by Executive Enterprises, Washington, DC, February 1985.

Anderson EL. Seminar on understanding environmental risks. Department of Environmental Toxicology and Public Service Research and Dissemination, University of California, Davis, CA, January 1985.

Anderson EL. National symposium on chemical emergencies. Pan American Health Organization, Sao Paulo, Brazil, December 1984.

Anderson EL. U.S.-Japanese workshop on risk assessment/risk management. Vanderbilt University and Tsukuba University under the U.S.-Japanese Cooperative Program, Tsukuba Science City, Japan, October 1984.

Anderson EL. Lectured on risk assessment. Institute of Public Health, Tokyo, Japan, November 1984.

Anderson EL. Lectured on risk assessment. Mie University School of Medicine, Tsu City, Mie-Ken, Japan, November 1984.

Anderson EL. Risk assessment/risk management seminar. Sponsored by the Institute of Occupational and Environmental Health, Japan School of Medicine, Kitakyushu, Japan, November 1984.

Anderson EL. Conducted risk assessment/risk management Seminar. Sponsored by the Republic of Korea Environmental Agency, Seoul, Korea, November 1984.

Anderson EL. Lectured on risk assessment. Institute of Environmental Research, Yonsei University School of Medicine, Seoul, Korea, November 1984.

Anderson EL. Lectured on risk assessment. Japanese Environmental Agency, Tokyo, Japan, November 1984.

Anderson EL. The future of formaldehyde. Seminar sponsored by the Consumer Federation of America, Washington, DC, November 1984.

Anderson EL. Symposium on risk assessment. EPA, Cincinnati, OH, October 1984.

Anderson EL. Seminar on risk analysis on environmental health with emphasis on carcinogenesis. Harvard School of Public Health, Boston, MA, September 1984.

Anderson EL. Conference on risk analysis. Advisory Council Seminar, Electric Power Research Institute, Monterey, CA, August 1984.

Anderson EL. Symposium on chemical emergency preparedness. Pan American Center for Human Ecology and Health, Pan American Health Organization, Metepec, Mexico, July 1984.

Anderson EL. Summer Institute in Risk Management. New York University, New York, NY, June 1984.

Anderson EL. Risk management and environmental decisions. Federal Water Quality Association, Washington, DC, May 1984.

Anderson EL. Lecture on risk assessment. Wharton School of Business, University of Pennsylvania, Philadelphia, PA, April 1984.

Anderson EL. Executive session on the environment, regulation, and risk. Harvard University, Boston, MA, March 1984.

Anderson EL. 11th Annual Energy Conference on Risk, Media, and the Public. WATTec, Knoxville, TN, February 1984.

Anderson EL. Principles in evaluating carcinogenesis data for environmental pollutants. Food Safety/Risk Assessment Committee, International Life Sciences Institute, Washington, DC, February 16, 1983.

Anderson EL. Carcinogenesis from the environment to the gene oncogenesis. Cold Spring Harbor Laboratory, Long Island, NY, November 19–21, 1982.

Anderson EL. Risk assessment and public policy. Symposium on Health Risk Assessment. Sponsored by the National Association of Science Writers and Women in Government, National Academy of Sciences, Washington, DC, November 18, 1982.

Anderson EL. The evolutionary process of carcinogen risk assessment in EPA: Future trends. Conference on the Reagan/Gorsuch EPA—Its Impact on Industry. Sponsored by the Center for Energy and Environmental Management and "Inside EPA," Washington, DC, November 8–9, 1982.

Anderson EL. Risk assessment for environmental toxicants. Science and Technology Conference for Government Executives, The Brooks Institute, Williamsburg, VA, November 5, 1982.

Anderson EL. Risk for progeny associated with prenatal exposures to chemicals, editor. World Health Organization meeting, Geneva, Switzerland, October 1982.

Anderson EL. Symposium on risk assessment. Speaker and session chairman, Annual Meeting of the American Chemical Society, Kansas City, KS.

Anderson EL. The Scientific Group on Methodology for the Safety Evaluation of Chemicals Within the Framework of the International Program for Chemical Safety. Speaker and workshop participant, World Health Organization, Leningrad, USSR, July 12–16, 1982.

Anderson EL. Practical application in risk assessment. American Mining Congress Risk Assessment Seminar, University of California, Berkeley, CA, June 29, 1982.

Anderson EL. Low dose high consequence risk assessment. Panel Member at annual Meeting of the Society for Risk Analysis, June 18, 1982.

Anderson EL. Practical applications of risk analysis: The Environmental Protection Agency experience. The Food and Drug Law Institute, Washington, DC, June 14, 1982.

Anderson EL. Workshop participant to advise the Georgetown University Medical Center on issues relevant to setting up their Health Policy Institute, Belmont, MD, May 2, 1982.

Anderson EL. Issues and concepts of risk assessment. Session chairman, Annual meeting of the Biostatistics Society, Texas A&M University, San Antonio, TX, March 14–17, 1982.

Anderson EL. Participant and chapter editor for risk assessment for World Health Organization Workshop on methods for the integrated evaluation of risks for progeny associated with prenatal exposure to chemicals, Prague, Czechoslovakia, November 30–December 6, 1981.

Anderson EL. The role of risk assessment in the regulation of carcinogens. University Center for International Studies, University of Pittsburgh, PA, November 3–4, 1981.

Anderson EL. EPA risk assessment for carcinogens. Assembly of Life Sciences Committee on the Institutional Means for Assessment of Risks to Public Health, Washington, DC, October 13, 1981.

Anderson EL. Workshop on low-dose extrapolation, biological and statistical implication of the ED01 study and related data base, Mt. Sterling, OH, September 13–16, 1981.

Anderson EL. Strengths and weaknesses of current risk assessment methods. Conference on Risk Assessment in Regulating Health and Safety, The Brooks Institute, Washington, DC, May 1, 1981.

Anderson EL. Risk assessment as a basis for regulations. University of North Carolina, Chapel Hill, NC, April 8, 1981.

Anderson EL. Risk assessment. Seminar for Presidential Management Program. U.S. Environmental Protection Agency, February 24, 1981.

Anderson EL. The use of scientific data in evaluating environmental carcinogens: The need for balance. Symposium on Genotoxic Effects of Airborne Agents, Brookhaven National Laboratory, Upton, NY, February 11, 1981.

Anderson EL. Symposium on health risk analysis, Session chairman. Oak Ridge National Laboratory Life Sciences Series, Gatlinburg, TN, October 27–30, 1980.

Anderson EL. Risk assessment: A look to the future. Gordon Conference, Plymouth, NH, July 1980.

Anderson EL. Quantitative risk criteria and goals for public health protection. Nuclear Regulatory Commission, Advisory Committee on Reactor Safeguards, Washington, DC, December 1979.

Anderson EL. The role of risk assessment in the regulation of carcinogens. NATO Advanced Research Institute on in vitro Toxicity Testing of Environmental Agents, Monte Carlo, Monaco, September 1979.

Anderson EL. In addition, from 1979 to 1981, invited lecturer on cancer and risk assessment policies at a number of universities, including: University of Cincinnati, January 5, 1979; Hood College, November 1979; University of Wisconsin, November 1979; Williams College, February 1981; University of North Carolina, February 1981; and North Carolina State University, October 1981.

Editorships and Editorial Review Boards

Editor-in Chief, Risk Analysis: An International Journal. Two, 5-year appointments effective January 1999–2008.
Editorial Board for the journal *Human and Ecological Risk Assessment*; appointed 1994–present.

Memberships and Science Advisory Boards/Panels

Chair, Publications Committee, Second World Congress on Risk, 2008.

Board Member, Toxicology Education Foundation, appointed 2005.

Member, Advisory Council for the College of Arts and Sciences, The American University, appointed 2005.

Engineering Foundation Board, University of Virginia, appointed 2005.

EPA Review Panel, "Future Directions in Homeland Security Research," Washington, DC, April 8, 2004.

Member, Division Review Committee, Risk Reduction and Environmental Stewardship, Los Alamos National Laboratory, appointed 2003.

Council Member, Virginia Institute of Marine Sciences, College of William and Mary, Williamsburg, VA, 2003–present.

EPA Review Panel, "Stakeholder Workshop on Priority-Setting Criteria for the Integrated Risk Information System Agenda," Arlington, VA, March 4, 2003.

Member, Scientific Technical Advisory Council, Federal Commission for Sanitary Risk Protection, Ministry of Health, Mexico, appointed July, 2002. Dr. Anderson is one of two international members.

National Science Foundation, Workshop on Interdisciplinary Research in Decision and Risk Analysis, Arlington, VA, July 17–18, 2002.

Peer Review Committee, "Assessment and Recommendations for the South Carolina Air Toxics Standard," July 2000.

Peer Review Committee, EPA's EMPACT Metro Area Grants Program, July 1999, 2000.

Appointed to Cardinal Bank Board of Directors. 3-year appointment effective July 1999–2003.

Member of External Evaluation Group, Los Alamos National Laboratory, March 1999–2004.

Appointed by National Research Council (NRC) and the Commission on Life Sciences, Board on Environmental Studies and Toxicology, as member of the NRC Committee on Assessment of Risks from Remediation of PCB-Contaminated Sediments, 1999–2001.

Chair, Peer Review of the Office of Risk Assessment and Cost Benefit Analysis, U.S. Department of Agriculture, January 1999.

Peer review committee, Environmental Monitoring for Public Access and Community Tracking (EMPACT), National Center for Environmental Research and Quality Assurance, U.S. Environmental Protection Agency, 1999.

Blue Ribbon Advisory Board, Steering Committee, Florida Atlantic University Environmental Business Management Program, 1998.

Executive Advisory Board of Directors, University of Virginia, School of Engineering and Applied Sciences, Northern Virginia Graduate Degree Program in Systems Engineering, 1998–2005.

George Mason University Women's Advisory Board, 1998–2001.

Senior Biomedical Research Service (SBRS) Credentials Committee, Food and Drug Administration, 1998.

Chair, External Review Committee, United States Department of Agriculture, Office of Risk Assessment and Cost-Benefit Analysis. Selected by the Society for Risk Analysis, 1998.

External Review Committee, Los Alamos National Laboratory, Department of Energy, appointed 1998.

Board of Scientific Counselors, Committee to Review the National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency, 1998.

Peer Review Committee, Exploratory Research Program, Environmental Chemistry, U.S. Environmental Protection Agency, 1997 and 1998.

Peer Review Committee, Exploratory Research Program, Environmental Physics, U.S. Environmental Protection Agency, 1997.

Department of Defense Peer Review Committee, Strategic Environmental Research and Development Program (SERDP), 1997.

Chair, Peer Review Committee, Risk Assessment Guidelines For Combustion Sources, U.S. Environmental Protection Agency, 1996.

Peer Review Committee, Center for Risk Assessment, U.S. Environmental Protection Agency, 1996.

Dean's Advisory Council for the School of Engineering and Applied Science at the University of Virginia, 1996-present.

Board of Trustees, Wildfowl Trust of America, appointed 1994–1997.

External Advisory Board, Center for Risk Management of Engineering Systems, University of Virginia, 1987–present.

Advisory Board of the Wildfowl Trust of North America, appointed 1993.

New York Power Commission Advisory Panel to recommend research programs to evaluate risk associated with electric and magnetic fields, 1990.

Risk Assessment Review Panel for the State of New Jersey, appointed 1988.

Member of Panel of Experts, evaluating risk analysis activities of four federal agencies, Program Evaluation and Methodology Division, General Accounting Office for House Committee on Science and Technology, February 1986

Charter Member, Society for Risk Analysis (member of steering committee to establish society, 1980); member of editorial board, *Risk Analysis*; elected council member, 1981; president, 1984-1985; chair, conferences and workshops committee, 1996–1998.

Member, Subcommittee on Risk Analysis, Health and Environmental Research Advisory Committee, Department of Energy, 1985.

EPA Representative to the National Cancer Advisory Board, 1982–1985. Member, interagency risk management council, cabinet council committee; chairman, committee to develop guidelines for assessing reproductive risk.

Member, Principles for Evaluating Health Risks to Progeny Associated with Exposure to Chemicals During Pregnancy, International Program for Chemical Safety (IPCS) committee editorial staff, World Health Organization, Geneva, Switzerland, 1984.

Member, interagency regulatory liaison group, work group on risk assessment (work group published the article, scientific bases for identification of potential carcinogens and estimation of risks, JNCI 63:242, 1979); chairman of the work group, 1980.

Member, Risk Analysis Liaison Committee, National Academy of Sciences/National Science Foundation (under P.L. 96-44).

Member, National Academy of Sciences/Food and Drug Administration advisory committee on institutional means for assessment of risk to public health (under H.R. 7591).

Professional Affiliations

- Academy of Toxicological Sciences
- American Association for the Advancement of Science
- American College of Toxicology
- New York Academy of Sciences
- Society for Risk Analysis
- Cosmos Club
- Society of Toxicology
- Executive Women in Government
- The International Alliance for Women

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David G. Hoel, Ph.D.
Principal Scientist

Professional Profile

Dr. David G. Hoel is a Principal Scientist in Exponent's Health Sciences Center for Epidemiology, Biostatistics, and Computational Biology. He has more than 40 years of experience in the fields of epidemiology, statistics, and risk analysis. He is internationally known for his work in risk assessment and has served on and also chaired numerous committees for the WHO and the U.N. as well as the U.S. National Academy of Sciences, the NIH, the EPA and the FDA. For over 20 years, Dr. Hoel was at the National Institute of Environmental Health Sciences, where he directed the Division of Risk Assessment, which included the Laboratories of Biochemical and Molecular Toxicology, as well as the Branches of Epidemiology and Statistics. This Division focused on the development of quantitative methods of estimating human health risks from environmental and occupational exposures. In addition to working with asbestos and chemicals, he is especially active in the area of radiation risk assessment. He has also been involved with issues of adverse outcomes of pharmaceuticals.

Dr. Hoel has published more than 175 papers and chapters in the general area of statistics and risk assessment. He also has been active in studies conducted by the National Research Council of the National Academy. These studies have included reports on beryllium, depleted uranium, dioxin/agent orange, radiation effects in space travel, and radiation dose reconstruction from atomic testing. He has also testified to Congress on several occasions, most recently to the Senate on tricholoethylene and perchlorate. For the last 15 years, he has taught doctoral students as well as clinical fellows at the Medical University of South Carolina, where he is a Distinguished University Professor. The courses he has taught have been in the areas of advanced methods in epidemiology, cancer epidemiology, and risk assessment. His doctoral students have taken positions in industry, universities, and government.

Academic Credentials and Professional Honors

Ph.D., Statistics, University of North Carolina at Chapel Hill, 1966
A.B., Mathematics and Statistics, University of California, Berkeley (with highest honors), 1961

U.S. Public Health Service Postdoctoral Traineeship in Preventive Medicine, Stanford University, 1966–1967

Member, National Academies' Board on Radiation and Nuclear Studies 2008–2010
National Associate, National Academy of Sciences and National Research Council, 2001
Fellow, American Association for the Advancement of Science, 1997
Ramazzini 1994 Award Recipient for "Contributions to Scientific Knowledge on the Oncogenic Effects of Nuclear Radiation"
Westinghouse Distinguished Scientist, 1993–2004
Member, Institute of Medicine, National Academy of Sciences, 1988

Mortimer Spiegelman Gold Medal Award, American Public Health Association, 1977
Fellow, American Statistical Association, 1974

Academic Appointments

Distinguished University Professor, Medical University of South Carolina, 1998–present
Clinical Professor, Department of Radiology, University of South Carolina School of Medicine, 2000–2009
Professor and Chairman, Department of Biometry and Epidemiology and Associate Director for Epidemiology, Hollings Cancer Center, Medical University of South Carolina, 1993–1997
Adjunct Professor, Department of Biostatistics, University of North Carolina, Chapel Hill, 1970–1993

Publications

McGreevy KM, Lipsitz SR, Linder JA, Rimm E, Hoel DG. Using median regression to obtain adjusted estimates of central tendency for skewed laboratory and epidemiologic data. J Clin Chem, in press.

Gebregziabher M, Hoel DG. Applications of the Poly-k statistical test to life-time cancer bioassay studies. J Hum Ecol Risk Assess, in press.

Wilson DA, Diel JH, Hoel DG. Lung fibrosis and lung cancer incidence in Beagle dogs that inhaled $^{238}PuO_2$ or $^{239}PuO_2$. Health Phys 2009; 96:493–503.

Little MP, Hoel DG, Molitor J, Boice Jr JD, Wakeford R, Muirhead CR. New models for evaluation of radiation-induced lifetime cancer risk and its uncertainty in the UNSCEAR report. Radiat Res 2008; 169:660–676.

Baker PJ, Hoel DG. Meta-analysis of standardized incidence and mortality rates of childhood leukemia in proximity to nuclear facilities. Eur J Cancer Care 2007; 16:355–363.

Reiss R, Anderson EL, Cross CE, Hidy G, Hoel D, McClellan R, Moolgavkar S. Evidence of health impacts of sulfate and nitrate containing particles in ambient air. Inhal Toxicol 2007; 19:419–449.

Adelman AS, Groves FD, O'Rourke K, Sinha D, Hulsey TC, Lawson AB, Wartenberg D, Hoel DG. Residential mobility and risk of childhood acute lymphoblastic leukemia: An ecological study. Br J Cancer 2007; 97:140–144.

Hoel DG. Ionizing radiation and cardiovascular disease. Ann NY Acad Sci 2006; 1076:309–317.

Baker GS, Nakamura T, Hoel DG. Comparison of two models of cancer risk estimation: A statistical analysis. Eur J Oncol 2006; 11:165–176.

Bronley-Delancey A, McMillan DC, McMillan JM, Jollow DJ, Mohr LC, Hoel DG. Application of cryopreserved human hepatocytes in trichloroethylene risk assessment: Relative disposition of chloral hydrate to its carcinogenic and non-carcinogenic metabolites. Environ Health Perspect 2006; 114:1237–1242.

McGreevy KM, Hoel B, Lipsitz SR, Hoel DG. Impact of nutrients on insulin-like growth factor-I, insulin-like growth factor binding protein-3 and their ratio in black and white males. Pub Health Nutr 2006; 10:97–105.

McGreevy KM, Lipsitz SR, Bissada NK, Hoel DG. Impact of race and baseline PSA on longitudinal PSA. Int J Cancer 2006; 118:1773–1776.

Priest ND, Hoel DG, Brooks PN. Relative toxicity of chronic irradiation by 45Ca ß- particles and 242Cm à- particles, with respect to the production of lung tumours in BA/Ca mice. Radiat Res 2006; 166:782–793.

Makie T, Adcock D, Lackland DT, Hoel DG. Pulmonary abnormalities associated with occupational exposures. Am J Indust Med 2005; 48:365–372.

McGreevy KM, Hoel B, Lipsitz SR, Bissada, NK, Hoel DG. Racial and anthropometric differences in insulin-like growth factor I (IGF-I) and insulin-like growth factor binding protein-3 (IGFBP-3) levels. Urology 2005; 66:587–592.

Starr TB, Goodman JI, Hoel DG. Uses of benchmark dose methodology in quantitative risk assessment. Regul Toxicol Pharmacol 2005; 42:1–2.

Heath Jr, CW, Bond PD, Hoel DG, Meinhold CB. Residential radon exposure and lung cancer risk: Commentary on Cohen's county-based study. Health Phys 2004; 87:647–655.

Baker GS, Hoel DG. Corrections in the atomic bomb data to examine low dose risk. Health Phys 2003; 85:709–720.

Nakamura T, Hoel DG. Comparing risks between radiation and dioxin exposure based on two-stage model. Environmetrics 2003; 14:203–211.

Carnes BA, Grahn D, Hoel D. Mortality of atomic bomb survivors predicted from laboratory animals. Radiat Res 2003; 160:159–167.

Creasman WT, Hoel DG, DiSaia PJ. WHI: Now that the dust has settled. A commentary. Am J Obstet Gynecol 2003; 189:621–626.

Nicholas J, Butler G, Davis S, Bryant E, Hoel D, Mohr L. Stable chromosome aberrations and ionizing radiation in airline pilots. Aviation Space Environ Med 2003; 74:953–956.

McGreevy KM, Baron LF, Hoel DG. Clinical breast examination practices among women undergoing screening mammography. Radiology 2002; 224:555–559.

Schubauer-Berigan MK, Baron L, Frey GD, Hoel DG. Breast dose variability in a biracial population undergoing screening mammography. Radiat Protect Dosimetry 2002; 98:417–424.

Schubauer-Berigan MK, Frey GD, Baron L, Hoel DG. Mammography dose in relation to body mass index, race, and menopausal status. Radiat Protect Dosimetry 2002; 98:425–432.

Nicholas JS, Butler GC, Lackland DT, Tessier GS, Mohr LC, Hoel DG. Health among commercial airline pilots. Aviation Space Environ Med 2001; 72:821–826.

Tessier GS, Lam C, Nakamura T, Hoel DG. Two-stage cancer models applied to gamma and neutron exposed mice. Eur J Oncol 2001; 6:297–301.

Radivoyevitch T, Hoel D. Biologically-based risk estimation for radiation-induced chronic myeloid leukemia. Radiat Environ Biophys 2000; 39:153–159.

Nicholas JS, Butler GC, Lackland DT, Hood WC, Hoel DG, Mohr LC. Flight deck magnetic fields in Commercial Aircraft. Am J Ind Med 2000; 38:548–554.

Radivoyevitch T, Hoel DG. Modeling the low-LET dose-response of BCR-ABL formation: Predicting stem cell numbers from A-bomb data. Math Biosci 1999; 162:85–101.

Dinse GE, Umbach DM, Sasco AJ, Hoel DG, Davis DL. Unexplained increase in cancer incidence in the United States from 1975 to 1994: Possible sentinel health indicators? Ann Rev Public Health 1999; 20.

Grosche B, Lackland D, Mohr L, Dunbar J, Nicholas J, Burkart W, Hoel D. Leukemia in the vicinity of two Tritium releasing nuclear facilities: A comparison of the Kruemmel Site, Germany, and the Savannah River Site, South Carolina, USA. J Radiol Protect 1999; 19:243–252.

Hoel DG, Li P. Threshold models in radiation carcinogenesis. Health Phys 1998; 75:241–250.

Nicholas JS, Lackland DT, Butler GC, Mohr LC, Dunbar JB, Kaune WT, Grosche B, Hoel DG. Cosmic radiation and magnetic field exposure to airline flight crews. Am J Indust Med 1998; 34:574–580.

Nicholas JS, Lackland DT, Dosemeci M, Mohr L, Dunbar JB, Grosche B, Hoel DG. Mortality among United States commercial pilots and navigators. J Occup Environ Med 1998; 40:980–985.

Nietert P, Sutherland SE, Silver RM, Pandey JP, Knapp R, Hoel DG, Dosemeci M. Is occupational organic solvent exposure a risk factor for scleroderma? Arthritis and Rheumatism 1998; 41:1111–1118.

Radivoyevitch T, Hoel DG, Chen AM, Sachs RK. Double-strand break misrejoining after X-irradiation: Relating moderate to very high doses by a Markov model. Radiat Res 1998; 149:59–67.

Radivoyevitch T, Hoel DG, Hahnfeldt PJ, Rydberg B, Sachs RK. Recent pulsed fields gel electrophoresis data suggest two types of DSBs. Radiat Res 1998; 149:52–58.

Radivoyevitch T, Hoel DG, Hahnfeldt, Sachs RK. Size distribution of misrejoining DNA fragments in irradiation cells. Math Biosci 1998; 149:107–136.

Daniel DM, Lackland DT, Baron LF, Nixon DW, Garr DR, Gross AJ, O'Brien, Hoel DG. Comparison of white and african-american barriers to mammography: A need for a barrier-specific approach to care. Cancer Prevent Int 1995; 2:3–21.

Gordis L, Berry DA, Chu SY, Fajardo LL, Hoel DG, Laufman LR, Rufenbarger CA, Scott, JR, Sullivan DC, Wasson JH, Westhoff CL, Zern RT. National Institutes of Health consensus development conference statement: Breast cancer screening for women ages 40–49. J Nat Cancer Inst 1997; 89(14):1015–1026.

Hoel DG. Ionizing radiation and cancer prevention. Environ Health Perspect 1995; 103(Suppl. 8):241–243.

Hoel DG, Portier CJ. Nonlinearity of carcinogenesis dose. Environ Health Perspect 1994; 102:109–113.

Davis DL, Dinse GE, Hoel DG. Decreasing cardiovascular disease and increasing cancer among whites in the United States from 1973 to 1987. JAMA 1994; 271:431–437.

Mori H, Nakamura T, Mine M, Kondo H, Okumura Y, Hoel DG. Early mortality of atomic bomb survivors based on house reconstruction survey. Int J Radiat Biol 1994; 65:267–275.

Hoel DG. Questions about radiation and risk estimates that remain after BEIR-V. Radiat Res 1993; 136:137–139.

Davis DL, Bradlow HL, Wolff M, Woodruff T, Hoel DG, Anton-Culver H. Medical hypothesis: Xeno-estrogens as preventable causes of breast cancer. Environ Health Perspect 1993; 101:372–377.

Fung VA, Huff JE, Weisburger EK, Hoel DG. Predictive strategies for selecting 379 NCI/NTP chemicals evaluated for carcinogenic potential: Scientific and public health impact. Fundam Appl Toxicol 1993; 20:413–436.

Hoel DG, Carter R, Ron E, Mabuchi K. The influence of death certificate errors on cancer mortality trends. J Nat Cancer Inst 1993; 85:1063–1068.

Portier C, Clark G, Edler L, Greenlee W, Hoel D, Tritscher A, Lucier G. Ligand/receptor binding for 2,3,7,8-TCDD: Implication for risk assessment. Fundam Appl Toxicol 1993; 20:48–56.

Davis DL, Hoel DG. Figuring out cancer. Int J Health Serv 1992; 22(3):447–453.

Dinse GE, Hoel DG. Exploring time trends in cancer incidence. Cancer Causes Control 1992; 3:409–417.

Huff J, Hoel DG. Perspective and overview of the concepts and value of hazard identification as the initial phase of risk assessment for cancer and human health. Scand J Work Environ Health 1992; 18(1):83–89.

Davis DL, Blair A, Hoel DG. Agricultural exposures and cancer trends in developed countries. Environ Health Perspect 1992; 100:39–44.

Hoel DG, Davis DL, Miller AB, Sondik EJ, Swerdlow AJ. Trends in cancer mortality in 15 industrial countries 1969–1986. J Nat Cancer Instit 1992; 84:313–320.

Piegorsch WW, Carr GJ, Portier CJ, Hoel DG. Concordance of carcinogenic response between rodent species: Potency dependence and potential underestimation. Risk Anal 1992; 12:115–121.

Shimizu Y, Kato H, Schull WJ, Hoel DG. Studies of the mortality of A-bomb survivors. Mortality, 1950–8: Part 3. Non-cancer mortality in the years 1950–85 based on the recently revised doses (DS86). Radiat Res 1992; 130:249–266.

deSerres FJ, Hoel DG. Collaborative study on the genetic toxicology of 2-amino-N6-hydroxadenine (AHA): An exercise in genetic risk assessment. Mutat Res 1991; 253:1–3.

Davis DL, Ahlbom A, Hoel DG, Percy C. Is brain cancer mortality increasing in industrial countries? Am J Indust Med 1991; 19:421–431.

Swenberg JA, Hoel DG, Magee PN. Mechanistic and statistical insight into the large carcinogenesis bioassays on DEN and DMN. Cancer Res 1991; 51:6409–6414.

Hoel DG. An overview of the probable consequences of prolonged inhibition of gastric acid secretion. Res Clinical Forums 1990; 12(1):169–176.

Hoel DG. Assumptions of the HERP index. Risk Anal 1990; 10:623–624.

Hoel DG, Dinse GE. Using mortality data to estimate radiation effects on breast cancer incidence. Environ Health Perspect 1990; 87:123–129.

Davis DL, Hoel DG, Fox J, Lopez A. International trends in cancer in France, West Germany, Italy, Japan, England and Wales, and the United States. Ann NY Acad Sci 1990; 609:5–48.

Davis DL, Hoel DG, Fox J, Lopez A. International trends in cancer mortality in France, West Germany, Italy, Japan, England and Wales, and the USA. Lancet 1990; 336:474–481.

Bailer AJ, Hoel DG. Benzene risk assessments: Review and update. Cell Biol Toxicol 1989; 5(3):287–295.

Bailer AJ, Hoel DG. Metabolite-based internal doses used in a risk assessment of benzene. Environ Health Perspect 1989; 82:177–184.

Piegorsch WW, Hoel DG. Exploring relationships between mutagenic and carcinogenic potencies. Mutat Res 1988; 196:161–175.

Yanagawa T, Hoel DG, Brooks G. A conservative use of historical data for a trend test in proportions. J Japan Stat Soc 1989; 19(1):83–94.

Hoel DG, Haseman JK, Hogan MD, Huff JE, McConnell EE. The impact of toxicity on carcinogenicity studies: Implications for risk assessment. Carcinogenesis 1988; 9:2045–2052.

Pedersen LG, Darden TA, Deerfield DW, Anderson MW, Hoel DG. A theoretical study of the effect of methylation or ethylation at 06-guanine on the structure and energy of DNA double strands. Carcinogenesis 1988; 9:1553–1562.

Hoel DG. Cancer risk models for ionizing radiation. Environ Health Perspect 1987; 76:121–124.

Hoel DG. Radiation risk estimation models. Environ Health Perspect 1987; 75:105–107.

Portier CJ, Hoel DG. Issues concerning the estimation of the TD50. Risk Anal 1987; 7:437–447.

Weinberg CR, Brown KG, Hoel DG. Altitude, radiation, and mortality from cancer and heart disease. Radiat Res 1987; 112:381–390.

Brown KG, Hoel DG. Statistical modeling of animal bioassay data with variable dosing regimens: Example—vinyl chloride. Risk Anal 1986; 6:155–166.

Hoel DG, Yanagawa T. Incorporating historical controls in testing for a trend in proportions. J Am Stat Assoc 1986; 81:1095–1099.

Gold LS, Bernstein L, Kaldor J, Backman G, Hoel DG. An empirical comparison of methods used to estimate carcinogenic potency in long-term animal bioassays: Lifetable vs. summary incidence data. Fundam Appl Toxicol 1986; 6:263–269.

Portier CJ, Hedges JC, Hoel DG. Age-specific models of mortality and tumor onset for historical control animals in the National Toxicology Program's carcinogenicity experiments. Cancer Res 1986; 46:4372–4378, 1986.

Hoel DG. Epidemiology and the inference of cancer mechanisms. Nat Cancer Inst Monogr 1985; 67:199–203.

Hoel DG, Jennrich RI. Life table analysis with small numbers of cases: An example—multiple myeloma in Hiroshima and Nagasaki. J Stat Comput Simul 1985; 20:311–322.

Yanagawa T, Hoel DG. Use of historical controls for animal experiments. Environ Health Perspect 1985; 63:217–224.

Bernstein L, Gold LS, Ames BN, Pike MC, Hoel DG. Some tautologous aspects of the comparison of carcinogenic potency in rats and mice. Fundam Appl Toxicol 1985; 5:79–86.

Bernstein L, Gold LS, Ames BN, Pike MC, Hoel DG. Toxicity and carcinogenic potency. Risk Anal 1985; 5:263–264.

Portier C, Hoel DG. Design of animal carcinogenicity studies for goodness-of-fit to multistage models. Fundam Appl Toxicol 1984; 4:949–959.

Portier C, Hoel DG. Type 1 error of trend tests in proportions and the design of cancer screens. Comm Stat A 1984; 13:1–16.

Poon AH, Hoel DG. Nonparametric estimation of the survival function when cause of death is uncertain. Biometrics 1984; 40:1151–1158.

Brown KG, Hoel DG. Modeling time-to-tumor data: Analysis of the ED01 Study. Fundam Appl Toxicol 1983; 3:458–469.

Brown KG, Hoel DG. Multistage prediction of cancer in serially dosed animals with application to the ED01 study. Fundam Appl Toxicol 1983; 3:470–477.

Portier C, Hoel DG. Low-dose rate extrapolation using the multistage model. Biometrics 1983; 39:897–906.

Portier C, Hoel DG. Optimal bioassay design under the Armitage-Doll multistage model. J Toxicol Environ Health 1983; 12:1–19.

Hoel DG, Kaplan N, Anderson MW. Implication of nonlinear kinetics on risk estimation in carcinogenesis. Science 1983; 219:1032–1037.

Hoel DG, Wakabayashi T, Pike MC. Secular trends in the distributions of the breast cancer risk factors—menarche, first birth, menopause, and weight—in Hiroshima and Nagasaki, Japan. Am J Epidemiol 1983; 118:78–89.

Pike MC, Krailo MD, Henderson BE, Casagrande JT, Hoel DG. 'Hormonal' risk factors, 'breast tissue age' and the age-incidence of breast cancer. Nature 1983; 303:767–770.

Hoel DG. Extrapolation of laboratory data to human health effects. Environ Sci Res 1982; 25:521–526.

Hoel DG. Statistical measures of risk. Drug Metab Rev 1982; 13:829–838.

Kato H, Brown CC, Hoel DG, Schull WJ. Studies of the mortality of A-Bomb survivors. Report 7. Mortality, 1950–1978: Part II. Mortality from causes other than cancer and mortality in early entrants. Radiat Res 1982; 91:243–264.

Hoel DG. Carcinogenic risk. Risk Anal 1981; 1:63–64.

Hoel DG. Statistical issues in toxicology. Selected Papers, Society for Industrial & Applied Mathematics. Environmetrics 1981; 81:248–257.

Hogan MD, Hoel DG. Estimated cancer risk associated with occupational asbestos exposure. Risk Anal 1981; 1:67–76.

Haseman JK, Hoel DG, Jennrich RI. Some practical problems arising from the use of the gamma multi-hit model for risk estimation. J Toxicol Environ Health1981; 8:379–386.

Hoel DG. Incorporation of background in dose-response models. Proc. Symposium on Extrapolation of Laboratory Toxicity Data to Man: Factors Influencing the Dose-Toxic Response Relationship, April 1979. Fed Proc 1980; 39:73–75.

Yanagimoto T, Hoel DG. Comparisons of models for estimation of safe doses using measures of the heaviness of tail of a distribution. Ann Inst Stat Math B 1980; 32:465–480.

Anderson MW, Hoel DG, Kaplan NL. A general scheme for the incorporation of pharmacokinetics in low dose risk estimation for chemical carcinogenesis: Example—vinyl chloride. Toxicol Appl Pharmacol 1980; 55:154–161.

Hoel DG. Animal experimentation and its relevance to man. Proc. US-Japan Conference on Biostatistics in the Study of Human Cancer, May 1978. Environ Health Perspect 1979; 32:25–30.

Hoel DG. Sequential methods in genetic risk assessment. Genetics 1979; 92: s195–s198.

Hoel DG. Statistical approaches to toxicological data. Proc. 5th Symposium on Statistics and the Environment, NAS. Environ Health Perspect 1979; 32:267–271.

Haseman JK, Hoel DG. Statistical design of toxicity assays: Role of genetic structure of test animal population. J Toxicol Environ Health 1979; 5:89–101.

Schoenfelder CA, Hoel DG. Properties of the Neyman-Scott carcinogenesis model at low dose rates. Math Biosci 1979; 45:227–246.

Hogan MD, Chi P, Hoel DG, Mitchell TJ. Association between chloroform levels in finished drinking water supplies and various site-specific cancer mortality rates. J Environ Pathol Toxicol 1979; 2:873–887.

Guess HA, Hoel DG. The effect of dose on cancer latency period. J Environ Toxicol 1977; 1:279–286.

Hoel DG, Weiss GH. Properties of noise emitted by vehicular queues. Transport Res 1977; 11:39–44.

Simon R, Hoel DG, Weiss GH. The use of covariate information in the sequential analysis of dichotomous response experiments. Comm Stat A 1977; 6:777–788.

Hoel DG. Statistical extrapolation methods for estimating risks from animal data. Ann NY Acad Sci 1976; 271:418–420.

Crump KS, Hoel DG, Langley CH, Peto R. Fundamental carcinogenic processes and their implications for low dose risk assessment. Cancer Res 1976; 36:2973–2979.

Hoel DG, Weiss GH, Simon R. Sequential tests for composite hypotheses with two binomial populations. Royal Stat Soc 1976; 38:302–308.

Chase GR, Hoel DG. Serial dilutions: Error effects and optimal designs. Biometrika 1975; 62:329–334.

Hoel DG, Weiss GH. A clinical trial design with a fixed maximum number of failures. Comm Stat 1975; 4:429–436.

Hoel DG, Gaylor DW, Kirschstein RL, Saffiotti U, Schneiderman MA. Estimation of risks of irreversible, delayed toxicity. J Toxicol Environ Health 1975; 1:133–151.

Hoel DG, Sobel M, Weiss GH. Comparisons of sampling methods for choosing the best binomial population with delayed observations. J Stat Comput Simul 1975; 3:299–313.

Simon R, Weiss GH, Hoel DG. Sequential analysis of binomial clinical trials. Biometrika 1975; 62:195–200.

Crump KS, Hoel DG. Mathematical models for estimating mutation rates in cell populations. Biometrika 1974; 61:237–252.

Haseman JK, Hoel DG. Tables of Gehan's generalized Wilcoxon test with fixed point censoring. J Stat Comput Simul 1974; 3:117–135.

Beauchamp JJ, Hoel DG. Some investigations and simulation studies of canonical analysis. J Stat Comput Simul 1973; 2:197–209.

Hoel DG, Crump KS. Estimating the generation time distribution of an age-dependent branching process. Biometrics 1973; 30:125–135.

Patel KM, Hoel DG. A generalized Jonckheere K-sample test against ordered alternatives when observations are subject to arbitrary right censorship. Comm Stat 1973; 2:373–380.

Patel KM, Hoel DG. A nonparametric test for interaction in factorial experiments. J Am Stat Assoc 1973; 68:615–620.

Hoel DG. An inverse stopping rule for play-the-winner sampling. J Am Stat Assoc 1972; 67:148–151.

Hoel DG. A representation of mortality data by competing risks. Biometrics 1972; 28:475–488.

Hoel DG, Walburg Jr. HE. Statistical analysis of survival experiments. J Nat Cancer Inst 1972; 49:361–372.

Hoel DG, Sobel M, Weiss GH. A two-stage procedure for choosing the better of two binomial populations. Biometrika 1972; 59:317–322.

Hook GER, Bend JR, Hoel DG, Fouts JR, Gram TE. Preparation of lung microsomes and a comparison of the distribution of enzymes between subcellular fractions of rabbit lung and liver. J Pharmocol Exper Therap 1972; 182:474–490.

Hoel DG. A method for the construction of sequential selection procedures. Ann Math Stat 1971; 42:630–642.

Hoel DG, Mitchell TJ. The simulation, fitting, and testing of a stochastic cellular proliferation model. Biometrics 1971; 27:191–199.

Hoel DG. A simple two-compartmental model applicable to enzyme regulation. J Biol Chem 1970; 245:5811–5812.

Hoel DG. On the monotonicity of the OC of an SPRT. Ann Math Stat 1970; 41:310–314.

Hoel DG. Some modifications and applications of Wald's OC formula. Ann Inst Stat Math 1970; 22:65–75.

Crump KS, Hoel DG. Some applications of renewal theory on the whole line. J Appl Prob 1970; 7:734–746.

Gaver Jr. DP, Hoel DG. Comparison of certain small-sample Poisson probability estimates. Technometrics 1970; 12:835–850.

Kastenbaum MA, Hoel DG, Bowman KO. Sample size requirements: One-way analysis of variance. Biometrika 1970; 57:421–430.

Kastenbaum MA, Hoel DG, Bowman KO. Sample size requirements: Randomized block designs. Biometrika 1970; 57:573–577.

Hoel DG. Discussion of engineering analysis of experimental data by Robert P. Benedict. ASME Trans 1969; 91:130.

Hoel DG, Mazumdar M. A class of sequential tests for an exponential parameter. J Am Stat Assoc 1969; 64:1549–1559.

Hoel DG. Closed sequential tests of an exponential parameter. Biometrika 1968; 55:387–391.

Hoel DG. Sequential testing of sample size. Technometrics 1968; 10:331–341.

Hoel DG, Mazumdar M. An extension of Paulson's selection procedure. Ann Math Stat 1968; 39:2067–2074.

Hoel DG. The number of k-simplices in the mth barycentric subdivision of an r-simplex. Am Math Monthly 1967; 74:819–820.

Books Edited

Hoel DG, Vouk VB, Butler GC, Pekall DB (eds). Methods for Estimating Risk of Chemical Injury: Human and Nonhuman Biota and Ecosystems, SCOPE /SGOMSEC 2. Proceedings of Workshop on Quantitative Estimation of Risk to Human Health from Chemicals, Rome, Italy, 1982.

Hoel DG, Merrill R, Perera F (eds). Banbury Report 19: Risk Quantitation and Regulatory Policy. Proceedings of the Banbury Conference on Risk Quantitation and Regulatory Policy. Cold Spring Harbor Laboratory, 1985.

Blot W, Hirayama T, Hoel DG. Statistical Methods in Cancer Epidemiology. Proceedings of a Conference of the U.S.-Japan Cooperative Cancer Research Program, 1985.

Davis D, Hoel DG. Trends in Cancer Mortality in Industrial Countries. New York Academy of Sciences, 1990.

Yanagawa, Hoel DG. Biostatistics in Cancer Risk Assessment. Scientist, Inc., Tokyo, 1991.

De Serres FJ, Hoel DG. 2-Amino-N^6-hydroxyadenine: A collaborative study on the genetic toxicology of 2-amino-N^6-hydroxyadenine. Mutation Research, Vol. 253, 1991.

Mohr L, Nixon W, Hoel DG. International Case Studies in Risk Assessment and Management. The Medical University of South Carolina Press, 1998.

Regens J, Travis C, Hoel DG. Multimedia Modeling and Risk Assessment. The Medical University of South Carolina Press 1999.

Extrapolation of Radiation-Induced Cancer Risks from Nonhuman Experimental Systems To Human. National Council on Radiation Protection and Measurements, NCRP Report No. 150, 2005. (Chairman Members include Carnes B, Dedrick R, Fry RJM, Grahn D, Griffith W, Groer P, Preston RJ).

Book Chapters

Yanagawa T, Hoel DG. Incorporating geographic distribution into the expected number of deaths in a comparative study. pp. 25–32. In: Statistical Science and Data Analysis. Matsusita K et al. (eds), 1993.

Portier CJ, Hoel DG, Kaplan NL, Koop A. Biologically based models for risk assessment. In: Complex Mixtures and Cancer Risk. Vannio H, Sora M, McMichael AJ (eds), International Agency for Research on Cancer Scientific Publications, No. 104.Lyon, France, 1990.

Hoel DG. Statistical aspects of chemical mixtures. pp. 369–377. In: Methods for Assessing the Effects of Mixtures of Chemicals, SGOMSEC3. Vouk VB, Butler GC, Upton AC, Parke DV, Asher SC (eds), J. Wiley & Sons Limited, New York, NY, 1987.

Hoel DG, Landrigan PJ. Comprehensive evaluation of human data. pp. 121–129. In: Toxic Substances and Human Risk, Principles of Data Interpretation. Tardiff RG, Rodricks JV (eds), Plenum Press, New York, NY, 1987.

Kaplan N, Hoel DG, Portier CJ, Hogan MD. An evaluation of the safety factor approach in risk assessment. pp. 335–346. In: Developmental Toxicology: Mechanisms and Risk. Banbury Report 26, Pratt RM, McLachlan JA, Markert CL (eds), Cold Spring Harbor Laboratory, Cold Spring Harbor, NY, 1987.

Hogan M, Hoel DG. Utilizing scientific data in assessing human cancer risk associated with chemical exposure. pp. 201–282. In: Report: Chemical Carcinogens: A Review of the Science and Its Associated Principles. U.S. Interagency Staff Group on Carcinogens, Environmental Health Perspectives, Volume 67, 1986.

Hoel DG. The incorporation of pharmacokinetics in low-dose risk estimation. pp. 205–214. In: Toxicological Risk Assessment, Volume I. Clayton D, Krewski D, Munro I (eds), CRC Press, Boca Raton, FL, 1985.

Hoel DG. Dose-response in radiation carcinogenesis: Animal studies. pp. 93–103. In: Epidemiology and Quantitation of Environmental Risk in Humans from Radiation and Other Agents: Potential and Limitations. Castellani A (ed), Plenum Press, London, 1985.

Hoel DG, Preston DL. Dose-response in radiation carcinogenesis: Human studies. pp. 105–122. In: Epidemiology and Quantitation of Environmental Risk in Humans from Radiation and Other Agents: Potential and Limitations. Castellani A (ed), Plenum Press, London, 1985.

Hoel DG. Mathematical dose-response models and their application to risk estimation. pp. 347–359. In: Methods for Estimating Risk of Chemical Injury: Human and Nonhuman Biota and Ecosystems, Scope 1985/SGOMSEC 2. Vouk VB, Butler GC, Hoel DG, Pekall DB (eds), J. Wiley and Sons, New York, NY, 1985.

Portier CJ, Hoel DG, Van Ryzin J. Statistical analysis of the carcinogenesis bioassay data relating to the risks from exposure to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. pp. 99–119. In: Public Health Risks of the Dioxins. Lowrance WW (ed), Rockefeller University, New York, NY, 1984.

Hoel DG. Conditional two sample tests with historical controls. pp. 229–236. In: Contributions to Statistics: Essays in Honour of Norman L. Johnson. Sen PK (ed), North Holland Publishing Company, Amsterdam, 1983.

Hogan MD, Hoel DG. Extrapolation to man. pp. 711–731. In: Principles and Methods of Toxicology. Hayes AW (ed), Raven Press, New York, NY, 1982.

Hoel DG, Crump KS. Waterbourne carcinogens: A scientist's view. pp. 173–195. In: The Scientific Basis of Health in Safety Regulations. Crandell R, Lave L (ed), The Brookings Institute, 1981.

Gaylor DW, Hoel DG. Statistical analysis of carcinogenesis data from chronic animal studies. pp. 97–111. In: Carcinogens in Industry and Environment. Sontag JM (ed), Marcel Dekker, New York, NY, 1981.

Yanagimoto T, Hoel DG. Measures of the heaviness of tail of estimation of safe doses. Pp 347–357. In: Recent Developments in Statistical Inference and Data Analysis. Matusita K (ed), North Holland Publishing Company, New York, NY, 1980.

Hoel DG. Low-dose and species-to-species extrapolation for chemically induced carcinogenesis. pp. 135–145. In: Banbury Report 1: Assessing Chemical Mutagens: The Risk to Humans. McElheny VK, Abrahamson S (eds), Cold Spring Harbor Laboratory, Cold Spring Harbor, NY, 1979.

Hoel DG. Some problems in low dose extrapolation. pp. 1391–1396. In: Origins of Human Cancer, Volume 4, Book C. Hiatt HH, Watson JD, Winsten JA (eds), Cold Spring Harbor Laboratory, Cold Spring Harbor, NY, 1977.

Hoel DG, Sobel M, Weiss GH. A survey of adaptive sampling for clinical trials. pp. 29–61. In: Perspectives in Biometrics. Elashoff RM (ed), Academic Press, New York, NY, 1975.

Hoel DG. Some statistical aspects of experiments for determining the teratogenic effects of chemicals. pp. 375–381. In: Statistical and Mathematical Aspects of Pollution Problems. Pratt J (ed), Marcel Dekker, Inc., New York, NY, 1974.

Chand N, Hoel DG. A comparison of models for determining safe levels of environmental agents. pp. 681–700. In: Reliability and Biometry. Proschan F, Serfling RJ (eds), SIAM, Philadelphia, PA, 1974.

Hoel DG, Weiss GH. A comparison of methods for choosing the better of two negative exponential lifetime distributions. pp. 619–636. In: Reliability and Biometry. Proschan F, Serfling RJ (eds), SIAM, Philadelphia, PA, 1974.

Published Presentations

Hoel DG. Multistage models of carcinogenesis and their implications for dose-response models and risk projections. pp. 123–126. Proceedings, International Conference on Radiation Effects and Protection, Mito, Japan, March 18–20, 1992.

Hoel DG. A balanced approach to risk assessment. pp. 305–311. Proceedings, Toxicology and Industrial Health, Volume 7. Tsuchiya K, Lee SD, Grant LD, Mehlman MA (eds), IXth UOEH International Symposium and First Pan Pacific Cooperative Symposium, Kitakyushu, Japan, 1991.

Ellett WH, Hoel DG, Cooper RD. BEIR V estimates of excess cancer mortality. pp. 309–314. Proceedings, Statistics of Human Exposure to Ionizing Radiation Workshop, Oxford, England, 1990, Radiation Protection Dosimetry, Volume 36, 1991.

Hoel DG. Extrapolation models of animal toxicity data to man. pp. 4-95 to 4-103. Proceedings, Environmental Risk Assessment: How New Regulations Will Affect the Utility Industry. Hoch RJ (ed), Electric Power Research Institute, Palo Alto, CA, 1981.

Hoel DG. Human risk assessment based on laboratory animal studies. pp. 22–24. Proceedings, Second Joint US/USSR Symposium on the Comprehensive Analysis of the Environment, U.S. Environmental Protection Agency, Washington, DC, 1975.

Hoel DG. Statistical models for estimating carcinogenic risks from animal data. pp. 285–291. Proceedings, 5th Annual Conference on Environmental Toxicology, AMRL-TR-74-125, Washington, DC, 1974.

Hoel DG, Sobel M. Comparisons of sequential procedures for selecting the best binomial population. Proceedings, Sixth Berkeley Symposium on Probability and Statistics 4:53–69, 1971.

Prior Experience

Professor and Chairman, Department of Biometry and Epidemiology and Associate Director for Epidemiology, Hollings Cancer Center, 1993–1997
Director, Division of Biometry and Risk Assessment, National Institute of Environmental Health Sciences, 1981–1993
Acting Director, National Institute of Environmental Health Sciences and also the National Toxicology Program, 1990–1991
Associate Director, Radiation Effects Research Foundation, Japan, 1984–1986
Visiting Scientist, Epidemiology Department, Radiation Effects Research Foundation, Japan, 1979–1980
Acting Scientific Director, National Institute of Environmental Health Sciences, 1977–1979
Chief, Biometry Branch, National Institute of Environmental Health Sciences, 1973–1981
Mathematical Statistician, National Institute of Environmental Health Sciences, 1970–1973
Adjunct Professor, Department of Biostatistics, University of North Carolina, Chapel Hill, 1970
Statistician, Oak Ridge National Laboratory, 1968–1970
Senior Mathematician, Westinghouse Research Laboratories, 1967–1968

Project Experience

Conducted an evaluation of laboratory and epidemiological studies since the publication of the National Academy of Sciences' report on the Biological Effects of Ionizing Radiation (BEIR VII) has been completed. The project was developed and sponsored by the Electric Power Research Institute (EPRI). The report of the findings and conclusions has been peer reviewed and the report will be released this year.

Contributed to the Exponent project on evidence of health impacts of sulfate and nitrate containing particles in ambient air. Results were published in the literature.

Evaluated the primate studies of early developmental effects of methyl chloride for the American Forest Products Association (AFPA). Besides analysis, presentations were made to the EPA administration.

A reanalysis of the Harvard Railroad Workers Study of lung cancer and diesel exhaust was carried out for Health Effects Institute in Boston. This related to attempts by the US EPA and Cal EPA to develop exposure standards for diesel exhaust. A committee report was published by HEI.

Assessed the potential risks of prolonged inhibition of gastric acid inhibition for Glaxo Pharmaceuticals and attended Glaxo sponsored meetings in London and Florence with the proceedings published (Elder J (Ed.): Profound Gastric Acid Suppression: Long Term Safety Risk? Res Clinical Forums 1990; 12(1).

Advisory Appointments

National Academy of Sciences:

Subcommittee on Margin of Safety and Extrapolation of the Safe Drinking Water Committee, 1976–1977
Panel on Low Molecular Weight Halogenated Hydrocarbons of the Coordinating Committee for Scientific and Technical Assessments of Environmental Pollutants, 1976–1977
Risk Assessment Subcommittee, Safe Drinking Water Committee, 1978–1979
Committee on Chemical Environmental Mutagens, 1980–1983
Board on Toxicology and Environmental Health Hazards, 1982–1985
Committee on the Biological Effects of Ionizing Radiation (BEIR V), 1986–1989
Committee to Provide Interim Oversight of the DOE Nuclear Weapons Complex, 1988–1990
Committee on Environmental Epidemiology, 1990–1992
Committee on Epidemiology and Veterans Follow-up Studies, 1990–
Committee on Applied and Theoretical Statistics, 1991–1994
Committee on The Health Effects of Mustard Gas and Lewisite, 1991–1992
Committee to Study the Mortality of Military Personnel Present at Atmospheric Tests of Nuclear Weapons, 1993–1994
National Toxicology Program's Science Advisory Board 1994–1996
Committee on the Assessment of Wartime Exposure to Herbicides in Vietnam, 1996–2002
Committee to Review the Health Effects in Vietnam Veterans of Exposure to Herbicides, 1997–2003
Board of the Medical Follow-up Agency, 1996–2001
Commission on Life Sciences, 1999–2000
Advisor, Division on Earth and Life Studies (DELS), 2001–
Medical Follow-up Agency, Patterns of Illness and Care before Deployment to the Persian Gulf War, 2001–2003
Defense Threat Reduction Agency (DTRA), Committee to Review the Dose Reconstruction Program, 2002–2003
Committee on California Agriculture Res. Priorities - Pierce's Disease, 2003–2004
Committee on Evaluation of Radiation Shielding for Space Exploration 2006–2008
Committee on Beryllium Alloy Exposures 2006–2008
Committee on Health Effects of Depleted Uranium 2007–2008
Radiation Effects Research Foundation Science Council 2006–2010
Board on Radiation and Nuclear Studies 2008–2010

World Health Organization and Other International Advisory Groups:

International Agency for Research on Cancer Working Group on the Evaluation of the Carcinogenic Risks to Humans, 1977, 1981, 1982, 2009
Subcommittee of International Commission for Protection against Environmental Mutagens and Carcinogens (ICPEMC) October, 1977–1982
Environmental Mutagenesis and Carcinogenesis Panel, US-Japan Cooperative Medical Science Program, NCI; 1987–1992
Advisory Committee on The Radiation Protection of the Public from Radioactive Residues in Kazakhstan, International Atomic Energy Agency United Nations 2003–2005
Scientific Councilor: Radiation Effects Research Foundation (Hiroshima) 2006–2011

U.S. Environmental Protection Agency Advisory Committees:

Administrator's Pesticide Policy Advisory Committee, EPA, 1976
Carcinogen Assessment Group, EPA, 1977
Work Group on Health Effects Risks of the EPA Science Advisory Board's Committee on Research Strategies, 1987–1988
EPA's FIFRA (pesticide) Science Advisory Panel 1993–
EPA's Science Advisory Board's Radiation Advisory Committee 1993–1995
Chairman, EPA's Expert Panel Review of Benzene Risk Assessment, 1997
EPA's Science Advisory Board's Radiation Advisory Committee, 1996–
EPA's Science Advisory Board's Environmental Health Committee, 1997–2004
EPA's Science Advisory Board's Environmental Health Committee, TCE Health Risk Assessment: Synthesis and Characterization Review Panel, 2002
EPA's Expert Panel Review of Perchlorate, 2002
EPA's Expert Panel Review of Asbestos, 2003
EPA's Expert Panel Review, Supplemental Guidance for Assessing Cancer Susceptibility from early-life Exposure to Carcinogens" (SGACS), 2003
Board of Scientific Counselors' Subcommittee on Human Health Research 2008–

Non EPA Advisory Panels

International Agency for Research on Cancer Working Group on the Use of Mechanistic Data to Evaluate the Carcinogenicity of Chemicals to Humans, 1991
Chairman, Subcommittee on Estimation of Risks of Irreversible, Delayed Toxicity of the DHEW Committee to Coordinate Toxicology and Related Programs, 1975
Scientific Advisory Board of the National Center for Toxicological Research, 1977–1980
Ad Hoc Working Group to Develop Radioepidemiological Tables, NIH, 1984
Chairman, Research Needs Subcommittee of the Committee to Coordinate the Environment and Related Programs, U.S. Public Health Service, 1990–1991
Office of Technology Assessment Advisory Panel on Aging Nuclear Power Plants: Life Attainment, License Renewal, and Decommissioning, Congress of the United States, 1992
Interagency Staff Group for Development of OSTP Carcinogen Document, Office of Science and Technology Policy, 1983–1984

DOD's Breast Cancer Research Program Integration Panel, 1995–1996
NIH's Consensus Development Panel on Breast Cancer Screening in Women Ages 40-49, 1997
FDA's Transmissible Spongiform Encephalopathies Advisory Committee, 1997–2000
Consultant, FDA's Center for Biologics Evaluation and Research (CBER), 2004–2008
U.S. Consumer Product Safety Commission's Chronic Hazard Advisory Panel, 1999–
Scientific Advisory Committee of the Electric Power Research Institute's (EPRI) Environmental Risk Analysis Program, 1994–1995
Scientific Committee 89 (non-ionizing radiation), National Council on Radiation Protection and Measurements (NCRP), 1994–1995
Scientific Advisory Board, Environmental Health Foundation (EHF), 1994–1998

Editorships and Editorial Review Boards

Associate Editor, Journal of Statistical Computation and Simulation, 1972–1978
Associate Editor, Journal of the American Statistical Association, 1973–1979
Member, Editorial Board of the Journal of Toxicology and Environmental Health, 1975–1979
Member, Editorial Board of Communications in Statistics, Part B - Simulation and Computation, 1977–1979
Member, Editorial Board of the Journal of Environmental Pathology and Toxicology, 1979–1980
Member, Editorial Board of Fundamental and Applied Toxicology, 1981–1986
Member, Editorial Board of Environmental Health Perspectives, 1973–2000
Member, Editorial Advisory Board of Journal of Statistical Computation and Simulation, 1978–
Member, Editorial Board of the IMA Journal of Mathematics Applied in Medicine and Biology, 1983–1988
Section Editor, Journal of Environmental Pathology, Toxicology and Oncology, 1986–
Contributing Editor, American Journal of Industrial Medicine, 1987–
Associate Editor, Environmental Research, 1987–
Member, Editorial Board of Risk Analysis, 1987–1990
Associate Editor, Journal of Communications in Statistics, 1987 –
Associate Editor, Biological Monitoring: An International Journal, 1988–1990
Member, International Advisory Board, Journal of Environmental Statistics, 1992–1995
Section Editor, Encyclopedia of Biostatistics, 1996–1997
Editorial Board, Environmental and Ecological Statistics, 2004–

Peer Reviewer

- *National Research Council/National Academies*
- *Institute of Medicine*
- *Risk Analysis*
- *Environmental Health Perspectives*
- *British Journal of Cancer*
- *Journal of the National Cancer Institute*
- *American Journal of Epidemiology*
- *Journal of the American Statistical Association*
- *Biometrics*
- *Journal of Statistical Computation and Simulation*
- *Communications in Statistics, Part B - Simulation and Computation*
- *Journal of Toxicology and Environmental Health*
- *Journal of Environmental Pathology and Toxicology*
- *Fundamental and Applied Toxicology*
- *Journal of Mathematics Applied in Medicine and Biology*
- *Journal of Environmental Pathology, Toxicology and Oncology*
- *American Journal of Industrial Medicine*
- *Environmental Research*

Professional Affiliations

- American Statistical Association
- Biometric Society
- Society for Risk Analysis
- Collegium Ramazzini
- American Association for the Advancement of Science
- Radiation Research Society
- Health Phys Society
- Society for Epidemiological Research

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Mark A. Roberts, M.D., Ph.D.
Principal Scientist and Center Director

Professional Profile

Dr. Mark A. Roberts is a Principal Scientist and the Director of Exponent's Health Sciences Center for Occupational and Environmental Health. He is board certified by the American Board of Preventive Medicine in Occupational and Environmental Medicine. He is a Fellow of the American College of Occupational and Environmental Medicine and is a member of the College's Board of Directors. He has a wide range of experiences in clinical occupational and environmental medicine, as well as epidemiological studies of health complaints in communities and industrial settings. Dr. Roberts' corporate experience includes management of global health issues, clinical services, product liability issues, medical surveillance, fatality investigations, and health benefit plan consultations. His experience in the health, safety, and health benefits arena are especially significant given the rising costs associated with employee benefits and the importance of productivity issues in the workplace.

Dr. Roberts' professional training and experience covers a broad spectrum from public health to corporate medicine. His 17 years of experience in the Oklahoma State Department of Health brings practical public health expertise involving infectious disease and environmental health issues. From 1990 to 1998, he was Assistant/Associate Professor at the Medical College of Wisconsin's Department of Preventive Medicine. While there, he taught courses in the MPH Distant Learning Program and provided onsite support to Milwaukee based companies (Miller Brewery, Aldridge Chemical, Wisconsin Centrifugal, and Harley Davidson). From 1998 to 2003, he was the Associate Corporate Medical Director and was promoted to Corporate Medical Director of BP. He has also served on the Agency for Toxic Disease Registry (ATSDR) Board of Scientific Advisors. He has directed large-scale communication efforts relative to public health issues as well as worked with corporations to communicate health risks of products and manufacturing processes. Dr. Roberts has extensive experience in dealing with the public, both in public meeting forum as well as interviews with the media (radio, TV and newspapers).

Academic Credentials and Professional Honors

M.D., University of Oklahoma, College of Medicine, 1986
Ph.D., Biostatistics and Epidemiology, University of Oklahoma, 1979
M.P.H., Biostatistics and Epidemiology, University of Oklahoma, 1974
M.Ed., Higher Education, Student Personnel Services, University of Oklahoma, 1972
B.S., Zoology, University of Oklahoma, 1971
A.S., Pre-Veterinary Medicine, Murray State College, 1969

05/08

Licenses and Certifications

American Board of Preventive Medicine, Occupational Medicine (1991–present);
Medical License: Oklahoma No. 16402 (1988–present), Wisconsin No. 31165 (1990–present), Illinois No. 0036-098014 (1998–present)

Publications

Articles

Clarke C, Mowat F, Kelsh, M, Roberts M. Pleural plaques: A review of diagnostic issues and possible non-asbestos factors. Archives of Environmental and Occupational Health 2006; 61:4.

Roberts MA. Invited Article, Wisconsin Public Health Association Newsletter, Milwaukee, WI, March 1994.

Roberts MA, O'Brien M. Public health and the environment: Where do we go from here? Invited Article, Wisconsin Public Health Association Newsletter, Milwaukee, Wisconsin, March 1994.

Felsenfeld A, Roberts M. A report of fluorosis in the United States secondary to drinking well water. JAMA 1991; 265(4):486–488.

Tacket C, Barrett T, Mann J, Roberts M, Blake P. Wound infection caused by Vulnificus, a marine vibrio, in inland areas of the United States. J Clin Microbiol 1984; 19:97–99.

Morton D, Saah A, Silberg S, Owens W, Roberts M. Lead absorption among children of employees in a lead related industry. Am J Epidemiol 1982; 115(4):549–555.

Vernon A, Thacker S, Roberts M, Mallonee J, Beauchamp H. Rabies in Oklahoma: An epidemiologic view of the problem in animals. J Okla State Med Assoc 1982; 76(8):293–299.

Helmick C, Vernon A, Schwartz S, Ward M, Roberts M. Rabies in Oklahoma: Report of a human case. J Okla State Med Assoc 1982; 76(8):287–292.

Bernard K, Roberts M, Sumner J, Winkler G, Mallonee J, Baer G, Chaney R. Human diploid cell rabies vaccine. JAMA 1981; 247(8):1138–1142.

Saah A, Mallonee J, Tarpay M, Thornsberry C, Roberts M, Rhoades E. Relative resistance to Penicillin in Pneumococcus: A prevalence and control study. JAMA 1980; 243(18):1824–1827.

Book Chapters

Hudson TW, Roberts MA. Corporate response to terrorism. In: Clinics in Occupational and Environmental Medicine, Terrorism: Biological, Chemical and Nuclear 2003; 2(2):389–404.

Roberts MA. Role of aviation in the transmission of disease. In: Fundamentals of Aerospace Medicine, Second Edition, 1996, 33:1003–1015.

Presentations

Roberts MA. Emerging health issues in welding. Chicago Section AIHA and Northeastern IL Chapter of ASSE, Palatine, IL, November 16, 2005.

Roberts MA. What's the next deep pocket mass tort to hit the automotive industry? Product Liability-Hot Topics Seminar for Defense Counsel, Troy, MI, September 14, 2005.

Roberts MA. Diagnosing and proving manganese exposure. ACI Second National Forum on Welding Rod Litigation, Chicago, IL, June 20, 2005.

Roberts MA. Welding rod litigation: A primer on the legal and medical/science issues. DRI Telephone Conference, Chicago, IL, March 8, 2005.

Roberts MA. Epidemiological issues in welding fume exposure. Mealey's Welding Rod Litigation Conference, New Orleans, LA, November 15, 2004.

Roberts MA. Diagnosing and proving manganese exposure. Mealey's Welding Rod Litigation Conference, West Palm Beach, FL, October 8, 2004.

Roberts MA. Silica: Complex made simple. Ohio Association of Civil Trial Attorneys Asbestos & Silica Litigation Conference, Cleveland, OH, September 29, 2004.

Roberts MA. epidemiological issues in welding fume exposure. Harris Martin Welding Rods Conference, San Francisco, CA, June 16, 2004.

Roberts MA. Basic safety and health for occupational health practitioners. Veterans Affairs Medical Center, Little Rock, AR, September 12, 1997.

Roberts MA. Summer and vacation safety. Milwaukee Area Safety Council, Milwaukee, WI, May 2, 1997.

Roberts MA. Indoor Air complaint evaluations: An update. Central States Occupational Medicine Association, Milwaukee, WI, September 28, 1996.

Roberts MA. Health problems associated with pesticide contaminated well water. Conference on Common Rural and Agricultural Health Problems, sponsored by the Marshfield Clinic, Madison, WI, May 9, 1996.

Roberts MA. Multiple chemical sensitivity. Wisconsin State Association of Occupational Health Nurses, 8th Annual Meeting, Invited Speaker, Egg Harbor, WI, October 4, 1995.

Roberts MA. Psychological factors in occupational medicine and rehabilitation. Milwaukee Psychiatric Hospital, Invited Speaker, Contemporary Issues in Mental Health and Addiction Medicine, Milwaukee, WI, September 6, 1995.

Roberts MA. The clinical importance of sick building syndrome. University of Oklahoma College of Medicine, Department of Family Medicine, Grand Rounds, Oklahoma City, Oklahoma, August 24, 1995.

Roberts MA. Bloodborne pathogens: The standard and its implementation. Milwaukee Area Medical Directors' Association, Milwaukee, WI, May 18, 1995.

Roberts MA. Plugging occupational and environmental concepts into medical schools. ACOEM Session #137, Integrating Environmental Health into Medical School Curricula, Las Vegas, NV, April 28–May 5, 1995.

Roberts MA. Update on the clinical and epidemiological aspects of indoor air complaints. Indoor Air Quality Seminar, Madison, WI, January 19, 1995.

Roberts MA. ADA issues in the hospital setting. St. Mary's Hospital Administrative Staff, Milwaukee, WI, January 11, 1995.

Roberts MA. Occupational health: Resolve to reform. Keynote Address, Southeastern Wisconsin Association of Occupational Nurses Annual Meeting, Milwaukee, WI, May 11, 1994.

Roberts MA. Biological monitoring from the industrial viewpoint. American Occupational Health Conference, Chicago, IL, April 15–22, 1994.

Roberts MA. Biological monitoring. Session Moderator, American Occupational Health Conference, Chicago, IL, April 15–22, 1994.

Roberts MA. Sick Building Syndrome: fact or fantasy? Milwaukee Area Medical Directors' Association, Milwaukee, WI, January 23, 1994.

Roberts MA. Occupational medicine in the hospital setting. Medical Grand Rounds Williamsport Hospital and Medical Center, Invited Speaker, Williamsport, PA, April 16, 1993.

Roberts MA. Community TB control: The good, the bad and the ugly. American Lung Associations' Conference, TB in the '90s: An Aberration or an Epidemic? Invited Speaker, Madison, WI, October 16, 1992.

Roberts MA. Effects of the Americans with Disability Act on industry. Wisconsin State Association of Occupational Health Nurses, 6th Annual Meeting, Invited Speaker, LaCrosse, WI, October 8, 1992.

Roberts MA. Business partnership opportunities in occupational and environmental medicine. Discussion Leader, Governor's Forum on Technological Transfer and Business Partnerships, Milwaukee, WI, September 24, 1992.

Roberts MA. Trials and tribulations of occupational medicine in primary care. Family Health Plan's 8th Annual Family Practice Symposium, Invited Speaker, Milwaukee, WI, August 5, 1992.

Roberts MA. Health and safety in the health care workplace. Krukowski and Costello, S.C., Guest Speaker, Oconomowoc, WI, June 6, 1992.

Roberts MA. Strategic planning for the Americans with Disabilities Act. Hospital Council of Greater Milwaukee Area, Co-Director, March 31, 1992.

Roberts MA. Workplace standards applied to the non-workplace population. American College of Occupational Medicine, State of the Art Conference, St. Louis, MO, October 31, 1991.

Roberts MA. Social, political and legal aspects of environmental health. American College of Occupational Medicine, State of the Art Conference, Seminar Director, St. Louis, MO, October 28, 1991.

Roberts MA. Risk communication: challenge of today's society. Oklahoma Public Health Association Annual Meeting, Tulsa, OK, April 4, 1991.

Roberts MA. Drug testing in the workplace. 21st Annual Winter Refresher Course for Family Physicians, Milwaukee, WI, January 21, 1991.

Roberts MA. Environmental medicine: Fact or fantasy. Oklahoma College of Occupational Medicine, 15th Annual Fall Educational Meeting, Edmond, OK, November 2–3, 1990.

Roberts MA. Environmental epidemiology in relation to occupational medicine. Midwestern Medical Director's Association Insurance Medicine, Wausau, WA, October 26, 1990.

Roberts MA. Putting environmental health back in public health. South Carolina Public Health Association Annual Meeting, Myrtle Beach, SAC, May 24, 1990.

Roberts MA. Board certification in occupational medicine. Industrial Epidemiology Forum, Salt Lake City, UT, May 1990.

Roberts MA. Occupational health team members and resources. Practical Approaches to Occupational Medicine, Oklahoma City, OK, March 3, 1990.

Roberts MA. Environmental aspects of economic development: realities vs. perceptions. Leadership Oklahoma 1990, Ponca City, OK, March 2, 1990.

Roberts MA. Balancing public health and environmental health. Oklahoma Society of Professional Sanitarians, Oklahoma City, OK, October 12, 1989.

Roberts MA. Issues and decisions in environmental health. University of Oklahoma Academy of Retired Professors, Norman, OK, September 26, 1989.

Roberts MA. Indoor air pollution—Update. University of Tulsa Division of Continuing Education and the Center for Environmental Research and Technology, Oklahoma City, OK, May 8–9, 1989.

Roberts MA. On the other side of the fence. 74th Meeting, American Occupational Health Conference, Boston, MA, April 29–May 5, 1989.

Roberts MA. Occupational health and epidemiology. University of Oklahoma, College of Public Health, Alumni Day, Oklahoma City, OK, 1989.

Roberts MA. A Human rabies case in Oklahoma. 32nd Annual Southwest Conference on Diseases in Nature Transmissible to Man, Austin, TX, March 25–26, 1982.

Roberts MA. A serosurvey of Brucella canis antibody titers in dogs and their owners. 30th Annual Southwest Conference on Diseases in Nature Transmissible to Man, Temple, TX, March 27–28, 1980.

Roberts MA. Foodborne illness incidence and investigation. National Society of Professional Sanitarians' Annual Meeting, Springfield, MO, November 1–3, 1979.

Roberts MA. Geographical and ecological distribution of Rocky Mountain Spotted Fever in Oklahoma. 27th Annual Southwest Conference on Diseases in Nature Transmissible to Man, Austin, TX, March 10–11, 1977.

Roberts MA. Preliminary report on a statewide rabies pre-exposure Prophylaxis Program. The International Northwestern Conference on Diseases in Nature Communicable to Man, Boise, ID, August 12–14, 1974.

Posters

Lindeman J, Roberts M, Simpson D. The Educator's Portfolio: Beta testing of the computerized version. Electronic Poster Session, 28th Annual STFM Spring Conference, New Orleans, LA, 1995.

Roberts MA, Lindemann J, Simpson D, Tyborski M. Results of beta testing of the computerized version of the Educator's Portfolio. 33rd Annual Research in Medical Education Conference, Association of American Medical Colleges, Boston, MA, October 30–November 1, 1994.

Roberts MM, Parks TJ, Wertsch JJ, Roberts MA. Ulnar sensory responses in the elderly. American Academy of Electromyography, Annual Scientific Meeting, San Francisco, CA, September 30–October 1, 1994.

Roberts MM, Parks TJ, Wertsch JJ, Roberts MA. Median, ulnar, and radial sensory responses in the elderly. American Academy of Electromyography, Annual Scientific Meeting, San Francisco, CA, September 30–October 1, 1994.

Roberts MA, Lindemann J, Simpson D, Tyborski M. Computerization of the Educator's Portfolio. Central Group on Educational Affairs, Innovations in Medical Education, Central Region Research in Medical Education, Chicago, IL, April 22, 1994.

Roberts MA. TOMES/CCIS computerized information systems. Health Information Technology Symposium, Medical College of Wisconsin, Milwaukee, WI, November 8, 1990.

Abstracts

Hegmann KT, Greaves WW, Moore SJ, Roberts MA. Case-control study of respiratory and reproductive symptoms at an automobile parts manufacturing facility. Society for Epidemiological Research, Miami Beach, FL, June 15–18, 1994.

Reports/Surveys/Projects

Roberts MA, Kitscha D. Evaluation of indoor air quality in a public school setting: A case control study. Kenosha, WI, October 1996.

Roberts MA, Kitscha D. Evaluation of Respiratory complaints associated with metal milling processes. Milwaukee, WI, August 1996.

Fischer LJ, Bolger PM, Calson GP, Jacobson JL, Knuth BA, Radike MJ, Roberts MA, Thomas PT, Wallace KB, Harrison KG. Critical review of a proposed uniform Great Lakes Fish Advisory Protocol. Michigan Environmental Science Board, Lansing, MI, September 1995.

Roberts MA, Cohen S. Utility of health surveillance in a petroleum refinery employee cohort, Milwaukee, WI, April 1994.

Roberts MA, Cohen S. Cancer mortality studies of a petroleum refinery employee cohort. Milwaukee, WI, January 1994.

Roberts MA, Kitscha D, Blessinger J. Cohort Mortality study update of employees at the Velsicol Chattanooga Plant 1943-1992. Milwaukee, WI, 1994.

Roberts MA. Investigation of suspected building associated Illness in a public school building. Milwaukee, WI, December 1993.

Roberts MA. Medical waste disposal in the state of Wisconsin: A report of the special committee on medical waste disposal. Report to the Wisconsin Legislature, PUBL-AM-068-91, Madison, WI, October 23, 1991.

Greaves WW, Roberts MA, Moore SJ. Investigation of employee health. Modine Manufacturing Company, Emporia, KS, November 1990.

Roberts, MA, Walker F. Cancer cluster investigation in Ponca City Oklahoma. Oklahoma State Department of Health, Oklahoma City, OK, 1988.

Prior Experience

Positions Held

- Corporate and Associate Corporate Medical Director and Regional Medical Advisor for North America, BP, Inc., London UK, 1998–2003
- Associate Corporate Medical Director, Amoco Corporation, Chicago, IL, 1997–1998
- Medical Director, Medical College of Wisconsin, occupational Health Clinic, 1996–1997
- Associate Professor, Medical College of Wisconsin, Department of Preventive Medicine, Milwaukee, WI, 1996–1997
- Medical Consultant, Rowan & Blewitt, Inc., Washington, DC, 1995–1997
- Acting Chairman, Assistant Professor, Residency Programs Director, Assistant Professor; Medical College of Wisconsin, Department of Preventive Medicine, Milwaukee, WI, 1994–1997
- Medical Director, Employee Health Services, Miller Brewery, Aldrich Chemicals, St. Mary's Hospital and Wisconsin Bell, Milwaukee, WI, 1991–1997
- Medical/Environmental Epidemiologist, Consultant Environmental Epidemiologist, State Epidemiologist, and Staff Positions; Oklahoma State Department of Health, Oklahoma City, OK, 1972–1990

Boards and Directorships

- Member, Board of Directors, American College of Occupational and Environmental Medicine, Chicago, Illinois, 2008–present
- President, Medical Directors Club of Chicago, Chicago, Illinois, 2006–2007
- Treasure, Medical Directors Club of Chicago, Chicago, Illinois, 2005–2006
- Member, Institute of Medicine of Chicago, Chicago, Illinois, 2004–present
- Member: Board of Directors, Vysis, Inc., Downers Grove, IL, 2001–2002
- Member, Board of Directors, American College of Occupational and Environmental Medicine, Chicago, Illinois, 2000–2007
- Member, Board of Scientific Counselors, Agency for Toxic Substances and Disease Registry, Atlanta, Georgia, 1995–1998
- Member, Institutional Strategic Plan Task Force, Education Task Force for the Medical College of Wisconsin, Milwaukee, Wisconsin, 1995–1996

- Member, Rehabilitation Center Task Force, Medical College of Wisconsin, Milwaukee, Wisconsin, 1995–1996
- Chairman, Commission on Environmental and Occupational Health, State Medical Society of Wisconsin, Madison, Wisconsin, 1994–1998
- Member, Great Lake Fish Consumption Advisory Protocol Panel, Michigan Environmental Science Board, Lansing, Michigan, 1994–1998
- Chairman, Committee on Liaison with Governmental Agencies, Council on External Affairs, American College of Occupational and Environmental Medicine, Arlington Heights, Illinois, 1993–1997
- Member, Environmental Medicine Committee, American College of Occupational and Environmental Medicine, Arlington Heights, Illinois, 1992–present
- Member, Public Health Committee, Medical Society of Milwaukee County, Milwaukee, Wisconsin, 1991–1996
- Member, Commission on Environmental and Occupational Health, State Medical Society of Wisconsin, Madison, Wisconsin, 1991–1994
- Representative of the State Medical Society, Wisconsin Hospital Association's Task Force on Environmental Issues, Madison, Wisconsin, 1991–1998
- Special Committee on Medical Waste Disposal, Wisconsin Department of Natural Resources, Madison, Wisconsin, 1991–1992
- Member of Public Health Advisory Forum, Wisconsin Department of Health and Social Services, Division Health, Madison, Wisconsin, 1991–1993
- Health Studies Review Group, Agency for Toxic Substances and Disease Registry, Division of Health Studies, Atlanta, Georgia, 1990–1995

Editorships

- Editor, Oklahoma Communicable Disease Bulletin, a weekly publication covering current topics of public health interest, 1977–1982

Post-Graduate Training

- Research Fellow in Occupational Medicine Program University of Oklahoma, Health Science Center Oklahoma City, Oklahoma, 1989–1990
- Resident Occupational Medicine Program University of Oklahoma, Health Sciences Center, Oklahoma City, Oklahoma, 1987–1989
- Intern, Family Medicine, University of Oklahoma, Health Sciences Center, Oklahoma City, Oklahoma, 1986—1987

Professional Affiliations

- American College of Occupational and Environmental Medicine
- Chicago Area Medical Directors Association
- The Institute of Medicine of Chicago
- State Medical Society of Illinois
- American Medical Association

CLEAR CREEK ASSOCIATES

MICHAEL ALTER, R.G., P.G.

Title

Principal Hydrogeologist

Expertise

Mine Water Management
Aquifer Studies/Remedial Investigations
Environmental Permitting Support
Pit Lakes
ARD and Contaminant Fate Analyses

Academic Background

M.S., Geology, Arizona State University, 1994
B.S., Geology, Virginia Polytechnic Institute and State University, 1992

Registration

Registered/Professional Geologist: Virginia (2009) No. 1814; Arizona (1998) No. 33261; Pennsylvania (2009) No. 4867; AIPG CPG (2010)

Experience

Clear Creek Associates, Leesburg, Virginia from August 2009
Clear Creek Associates, Tucson, Arizona 1999 to 2009
Dames & Moore Group, Tucson, Arizona 1997 to 1999
Dames & Moore Inc., Phoenix, Arizona 1995 to 1997

Michael (Mike) Alter is a Principal Hydrogeologist who specializes in managing large-scale aquifer and remedial investigation studies and groundwater supply and development programs. His recent focus has been assisting clients with hydrogeologic and groundwater issues pertaining to mining and industrial operations. His mining related expertise includes geochemistry of mine materials and solutions, mine facility siting, mine pit hydrology and pit lake geochemistry, regulatory guidance for mining projects, permit acquisition, and mine contaminant transport in bedrock and basin-fill settings. Mr. Alter has worked on mine water management and hydrogeologic studies at various North American mining sites since 1995.

Mine-Related Project Experience

Cyprus Tohono Corporation, Groundwater Remedial Investigation, Cyprus Tohono Mine, Tohono O'odham Nation, Arizona (since 2001)
Mr. Alter has served as the technical lead and Remedial Investigation (RI) Manager for Remedial Investigation of mining-related groundwater impacts at the Cyprus Tohono Mine, an inactive copper mine in Central Arizona since 2001. A primary component of this characterization and remediation project involves an evaluation of the generation, fate, and transport of radionuclides, including uranium and its decay elements, in mine materials, soil, and groundwater. Mr. Alter was responsible for constructing and using a groundwater and contaminant transport model to simulate radionuclide transport at the Site. Mr. Alter also managed field investigations associated with the groundwater RI, including the siting, design, and construction oversight of over 60 monitor wells. Also responsible for preparing RI scope of work and related RI planning documents, including plans for groundwater monitoring, quality assurance, and health and safety.

Conceptual Site Hydrogeologic Model Development, Climax Molybdenum, Henderson Mill, Henderson, Grand County, Colorado
Mr. Alter is responsible for developing a conceptual site hydrogeologic model of an existing mill tailings impoundment for a metals mine located in the Colorado Front Range. The location of the site above 9,000 feet contributes to high winter snowpacks and large spring surface runoff, creating a challenging setting for water management. Mr. Alter completed a review of the site geology and hydrogeology and is using this information to develop a plan for future monitoring at the site.

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MICHAEL ALTER, R.G.

Asarco Inc, Hayden Smelter, Hayden, Arizona
Mr. Alter is currently providing environmental permitting support for groundwater permitting to accommodate continued operations at Asarco's Hayden Mill and Smelter facility, in Hayden, Arizona

Historical Operations Assessment of Potential Groundwater Impacts, New Cornelia Mine, Ajo, Arizona (2007-2008)
Technical lead and project manager during completion of review of historical operations and an assessment of potential groundwater impacts, including Technologically-Enhanced Naturally Occuring Radionuclides, in the area of the New Cornelia Mine in Ajo, Arizona.

Phelps Dodge Mining Company, Multiple Locations (2004)
As subcontractor to engineering consulting firm, Mr. Alter conducted analysis of community water systems operated by PDMC to identify potential in-well or new well strategies to bring each water utility into compliance with future arsenic standard. Evaluations were performed for water systems in Ajo, Baghdad, and Sierrita. For each site, Mr. Alter developed list of potential well rehabilitation and well siting alternatives.

Pinal Creek Group, Claypool, Arizona (2000-2002)
Project Manger for the siting, design, and installation of three deep production wells, two domestic wells, and two deep exploratory borings. The production wells were installed to meet local water supply needs. Each of the three completed production wells yielded high-quality water at rates that exceeded expectations.

Mine Development/Water Supply Development, Freeport-McMoRan Miami Operations, Claypool, Arizona (2007 – 2008)
Project Manager for the installation and testing of three new water wells to support Miami Smelter operations. Well designs were prepared based on the results of exploration drilling conducted in 2001. Each well met production goals.

Mine Development/Water Supply Investigation, Lone Star Mine, Safford, Arizona (2007 – 2008)
Senior Hydrogeologist for study to evaluate the feasibility of developing a groundwater supply to support a future mine in southeastern Arizona. The objective was to characterize the potential of a local bedrock aquifer to supply water for mine operations.

Permitting Support for Mine Development Feasibility Study, Freeport-McMoRan Copper Queen Branch, Bisbee, Arizona (2007 – 2008)
Project Manager for preparing an Aquifer Protection Permit (APP) application that would accommodate resumed mining operations at the Copper Queen mine.

Permitting Support for Mine Development Feasibility Study, New Cornelia Mine, Ajo, Arizona (2007 – 2008)
Project Manager for preparing an Aquifer Protection Permit (APP) application that would accommodate resumed operations at an inactive Arizona copper mine.

Pit Hydrology Study, Freeport-McMoRan Bagdad Mine, Bagdad, Arizona (2006)
Project Manager for hydrogeologic study of the Bagdad mine pit. The objective was to evaluate the effectiveness of on-going mine pit dewatering activities. Field activities to date included test well drilling and analysis, groundwater quality sampling, isotopic analyses, and various aquifer tests comprising both falling head tests and long-term pumping and

CLEAR CREEK ASSOCIATES

MICHAEL ALTER, R.G.

recovery tests.

Morenci District Fresh-Water Supply Development Project (1996-1998)
Served as field manager on groundwater investigation and water resources development project to identify 10,000 additional gallons per minute of fresh water to be used for mining operations. Responsibilities included supervising multiple drilling subcontractors and a field team of up to 10 geologists. Directed the siting, drilling, installation, and aquifer testing of over 40 test wells and 15 production wells.

Professional Affiliations

Arizona Geological Society (Past President 2003)
American Institute of Professional Geologists
Arizona Hydrological Society
Society of Mining, Metallurgy, and Exploration, Inc.
Virginia Water Well Association
Arizona Water Well Association

Certifications

MSHA – New Miner (Surface Metal/Nonmetal)
MSHA – Annual Refresher Training
OSHA – 40 Hour HAZWOPER Training
OSHA – 8 Hour Health and Safety Supervisor
OSHA – 8 Hour HAZWOPER Refresher Training

4 PLANS FOR MEETING STATEMENT OF NEEDS

The relatively short timeframe for completing this project will require efficient use of the expertise of the project team. Many of the topics of the Statement of Needs could be the subject of their own individual projects, and we view such a level of effort as outside the scope of this project and inconsistent with timeframe for meeting the needs of the Workgroup. For this reason, we will use the experience and expertise of our staff to focus our efforts on advising the Workgroup on the key issues that will need to be addressed by regulations and guidance for uranium mining, milling, and waste management in Virginia. Particular emphasis will be placed on identifying aspects and, if appropriate, gaps in existing Federal, state, and international regulations and guidance that may need to be addressed to meet the special environmental setting of Virginia.

In order to meet the timeframe of the project, most of the tasks required by the Statement of Needs will be performed in parallel and will be scheduled to be completed so that particular tasks can be reviewed during the monthly Workgroup meetings. Figure 4-1 provides a tentative schedule for completion of tasks based on our assessment of their regulatory priority and complexity. This proposed schedule will be discussed and, if necessary, revised based on discussions at the kickoff meeting. This schedule assumes that a contract is awarded by April 30, 2012

Specific items in the Statement of Needs are reproduced below followed by the proposed approach to the study for the items.

TASK A

III. A. Statement of Needs—Initial Literature Analysis and Recommendations

To conduct research and provide a report that:

1. Virginia & Other Relevant Studies: Utilizing summary information prepared by the Uranium Working Group agencies from the existing Virginia uranium mining studies (that is, National Academy of Sciences/National Academies Press [NAS/NAP], Virginia Beach, Roanoke River Basin, Chmura, as well as other relevant studies), and make recommendations relevant to the Board of Health's mission to protect public health and the environment. The summary should include, but not be limited to: uranium milling and mining, public drinking water systems, private wells, cisterns, springs, and recreational water issues, human and animal health (including occupational and reproductive health; teratogenesis; mutagenesis; carcinogenesis; unintentional injury; chronic disease; and toxic exposures (both acute and chronic), silicosis, and other unusual occurrences of diseases of public health concern with special attention to vulnerable populations such as infants and children).

a) Review available scientific literature on: 1) epidemiologic studies measuring long-term effects of exposures to radioactive materials and toxic substances as might be encountered in mining operations of the type proposed for Virginia; 2) limitations of available studies and recommendations of public health experts on design of relevant studies.

Statement of Needs	Project Week																								
	30-Apr	7-May	14-May	21-May	28-May	4-Jun	11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug	20-Aug	27-Aug	3-Sep	10-Sep	17-Sep	24-Sep	1-Oct	8-Oct	15-Oct
Kickoff Meeting																									
Task A: Initial Literature Review and Recommendations			X																						
Task B: Ongoing Technical Advice and Assistance to Commonwealth of Virginia Staff Statement of Needs																									
Task B1: Adequacy of Existing Statutes and Regulations							X																		
Task B2: Characterization of Existing Data and Worksheet Development										X															
Task B3: Development of Monitoring Plans													X												
Task B4: Evaluation of Waste Disposal, Environmental Impact Statement, ALARA, and Financial Assurance																	X								
Task B5: Evaluation of NRC Regulations																				X					
Task C: Assist VDH in Preparing and Presenting Reports			M				M			M			M			M			M				M		
Task D: Assist VDH in Formulating a Draft Conceptual Regulatory Framework																			X						
Draft Final Report																						X			
Final Report																									X

	Work Period
X	Presentation to Workgroup
C	Conference call or on-site meeting
M	Workgroup Meeting

Figure 4-1. Tentative Schedule for Completion of Tasks

b) Assist VDH with development of surveillance and epidemiologic studies to evaluate short and long term health effects associated with mining. Studies must include consideration of sources for accurate, valid baseline levels of materials of concern in the environment and in animals and humans.

2. Existing Regulatory Programs: Compares existing uranium mining and milling regulatory programs including Nuclear Regulatory Commission (NRC), any agreement state programs, and international programs (such as Canada and France) and recommends provisions from within those regulatory programs that are relevant to the Board of Health's mission as described above. Identify where additional requirements may be appropriate to accommodate Virginia-specific population density, rainfall, climate, water table levels, and unique geography.

3. International Emerging Standards: Summarizes pertinent information and studies from such groups as the International Atomic Energy Agency, the World Nuclear Association, etc. and provides recommendations based on this review that are relevant to the Board of Health's mission as described above, including modern best international practices and other emerging standards and technologies. Identify internationally accepted best practices that can be implemented to mitigate the risk of radioactive releases, discussing technologies available to reduce emissions and maintain a focus on pollution prevention and reduction, including strategies for emergency hazards enumerated in the Commonwealth of Virginia Emergency Operations Plan.

Approach to Meeting the Stated Needs

CNWRA and Exponent team members have extensive experience coordinating with NRC in the development of new regulations and guidance related to the nuclear fuel cycle, uranium processing, and radioactive waste disposal. The team is well prepared to conduct the literature review and analysis based on extensive experience researching, synthesizing, and summarizing chemical hazard and safety information, potential health and environmental exposures and risks of metals and other chemicals, emerging national and international regulatory guidance and standards, and technologies for pollution prevention and reductions. The team's approach to meeting the needs of the Virginia Department of Health (VDH) would capitalize on this experience to identify and review pertinent scientific literature and to actively work with and assist VDH with development of studies related to long-term exposure to hazardous chemicals and radionuclides and related to baseline levels of these hazards. We plan to develop an optimal combination of search terms to be used in multiple electronic search engines as well as other important data sources. Our focus will be on elucidating the differences between common uranium mining regions (typically sparsely-populated regions with arid climates) and the population and climate in Virginia. The team's extensive experience with existing regulatory programs in the United States and around the world will facilitate an intercomparison of these regulatory programs. In particular, the team would provide guidance on the implementation of current regulations in Virginia, which has a higher population density and a non-arid climate than typical uranium mining and milling sites.

A scientific literature review will be conducted to obtain epidemiologic and toxicological studies that examine acute, subchronic, and chronic effects of exposures (or other consequences of mining) to radioactive materials and toxic substances during potential uranium mining operations in the state of Virginia. This plan will involve developing an optimal combination of search terms to be used in multiple electronic search engines as well as other important data sources. This process will be conducted in stages, the first of which will be to review the available site information and relevant reviews and studies (e.g., 2012 National Research Council report on uranium mining in Virginia) to identify a list of key constituents for searching

the scientific and regulatory literature. For many of the likely substances of concern from uranium mining (e.g., uranium and other metals such as arsenic, radiation, as well as silica, particulate matter, diesel exhaust), we have considerable knowledge and experience with the scientific literature related to health effects and applicable regulatory guidance (e.g., EPA framework for metals risk assessment; guidance on bioavailability for metals; EPA 2011 Exposure Factors handbook; ATSDR toxicological profiles). For many of the substances, we expect that our literature search will focus on the most recent literature and on specific issues related to Virginia uranium mining to ensure that our assessment is current and Virginia-environment-specific.

The team's synthesis of key findings will be based on an evaluation of, but not limited to, Virginia's uranium milling and mining; public drinking water systems (including water recycling projects and water treatment methods); private well water quality and systems; cisterns; springs; recreational water use and potential problems; the health and well-being of humans and animals which includes workers' health as well as reproductive health (e.g. birth defects, developmental disorders, spontaneous abortion, low birth weight, preterm birth, infertility); teratogenesis; mutagenesis; carcinogenesis; accidents or unintentional injury; infectious and chronic disease as well as rare disease occurrences/outbreaks; and short- and long-term toxic exposures. Particular attention will be given to vulnerable human populations (e.g. infants, children, pregnant women, immunocompromised patients, the elderly). Relevant documents identified will be stored in a bibliographic database and will be maintained on a secure network.

Limitations of the available studies will be highlighted in our health and epidemiologic assessment. Issues regarding study design, measurement of exposure and disease occurrence, biases, statistical analyses, control for confounding, generalizability of study findings, and causality will be addressed and included in any interim report and the final report deliverable. In addition, of importance for many of the substances emitted by uranium mining, as noted in EPA's Metals Framework guidance, is that exposure and risks should be assessed with consideration of the natural occurrence and exposures to these substances. Exponent has had substantial experience in distinguishing in biomonitoring and environmental exposure assessments, whether exposures are in excess of expected background or baseline levels, and the potential source of exposures. Similarly, epidemiological studies need to evaluate incidence of diseases in excess of expected rates or include relevant controls. Based on our comprehensive assessment, Exponent will provide expert opinions and recommendations to the Virginia Board of Health for design of more rigorous studies to fulfill its mission to protect the public health.

Federal regulations for milling, which are enforced by the NRC, are not specific to the type of climate in which the mill is located. Our group will examine the regulations as these may relate to the risk to public health and the environment in the Virginia climate . The CNWRA and Exponent team has considerable experience in evaluating population exposures to hazardous chemicals and radionuclides and has compared regulatory approaches in the United States with those from other countries, including France, Sweden, and Canada. By working closely with VDH staff, the team would provide recommendations that are relevant to the VDH's mission of developing adequate regulations and implementing them..

Task A Deliverable

The deliverable for Task A will be a white paper summarizing the team's recommendations, including recommendations for performing epidemiological studies. The report will include a description and possible additions to the existing regulatory program in Virginia. Finally, the report will summarize the results of international studies that are pertinent to regulation of

mining and milling in Virginia. The due date for the white paper will be three (3) weeks after the contract award date.

Task B

III. B. Statement of Needs—Ongoing Technical Advice and Assistance to Commonwealth of Virginia Staff

1. Coordinate with VDH staff and be available to attend at least monthly progress meetings to develop analyses of the following items and to develop and provide a final report. The Contractor must be available to meet with VDH staff, either face-to-face or via conference calls, as needed to develop interim deliverables and the final report that:

a) Compares the Commonwealth's existing statutes and regulations to recommendations in the initial report (referenced in Part I above);
b) Identifies areas where VDH's existing regulations might need to be modified or expanded to ensure protection of public health and the environment;

c) Recommends changes (including statutory changes) to meet these needs.

d) Evaluation must include a review of the following:

1) Waterworks Regulations (12VAC5-590 et seq.);

2) Disease Reporting and Control Regulations (12VAC5-90-90 et seq.) (requirements for reporting by healthcare providers and laboratories);

3) Private Well Regulations (12VAC5-630 et seq.) Develops conceptual framework and initial project costs to determine the impact on quantity and quality of water in private wells and springs and recommended procedures for replacing or remediating affected supplies. Framework should be capable of characterizing an inventory of impacted wells, springs, recreational waters and cisterns.

4) Facilitate the stakeholder process, including any potentially inspected regulated community (at least 5 statewide meetings with separate final report) to gauge concerns and identify possible solutions concerning regulation of public water supplies and private wells as to water quality and quantity.

5) Regulations concerning recreational use of waters (campgrounds, summer camps, etc.).

e) Determines and characterizes available data (including national and Virginia-specific data) on potential health outcomes related to exposures of concern. Determines if current reporting requirements and laboratory testing capability cover chemicals likely to be encountered in mining operations under consideration. Determines if current tobacco use surveillance is adequate for establishing baseline data for rates of lung cancer, silicosis, and radon-associated health problems using standard epidemiological analytic methods. Determines whether other available data is sufficient to establish baseline rates for conditions of concern (e.g., current silicosis reporting data) or if retrospective or other studies are indicated to determine baseline rates. Evaluate and propose changes to cancer, congenital malformation reporting if necessary.

f) Develop and test case report investigation worksheets and other documents for local Health Department and Central Office use in any necessary investigations for relevant health outcomes.

g) Determine locus of responsibility for the long-term monitoring of adverse health effects ensuring worker health and safety as well as additional recommended monitoring.

h) Monitoring work spaces, monitoring exposures for mine workers, tracking of worker cumulative exposures, adequacy of existing MSHA regulations and comparisons with international standards for radon and radon daughters.

i) Develops a recommended framework for environmental, human health and animal health monitoring so that data can be maintained in compatible systems for analyzing health effects, including long term monitoring.

j) Determines potential impacts (if any) on cisterns and onsite sewage systems.

III. B. 2. Statement of Needs—Water Quality Monitoring

a) Water Quality Monitoring plan for surface waters, including but not limited to:
1) Human health risks associated with chemical toxicity;
2) Human health risks associated with radiological toxicity; and,
3) Human health risks associated with consumption of affected animal and marine populations.

b) Water Quality Monitoring plan for groundwater, including but not limited to:
1) Human health risks associated with chemical toxicity;

2) Human health risks associated with radiological toxicity;

3) Human health risks associated with consumption of affected animal and marine populations; and,

4) The potential impact on groundwater quality and quantity as these affect public wells, private wells and springs.

c) Adequacy of Virginia's Water Quality Standards for groundwater and surface waters, and Virginia's Waterworks Regulations as they relate to human health outcomes:

1) To address water-soluble radionuclides or absorbed chemicals;

2) To address the potential for undiluted tailings liquids to exceed existing Safe Drinking Water Act standards for uranium; and,

3) To address the potential for revised Public Drinking Water System's monitoring schedules for radiological contaminants and other hazardous substances within potentially impacted areas.

d) Evaluate the existing standards for the safe disposal of mine waste as it pertains to human health.

e) Evaluate necessary components of full environmental impact analysis.

f) Methods for incorporating "As Low As Reasonably Achievable" (ALARA) standards into Commonwealth regulations, like those that exist for radiological protection.

g) Recommendations for compliance period financial assurance mechanisms providing for minimization of long-term impacts to water resources and necessary remediation.

h) Recommendations for environmental monitoring, including but not limited to:
1) Required components of an environmental monitoring plan;
2) Recommended goals to include in an environmental monitoring plan; and,
3) Recommended baseline and characterization data needed.

i) Evaluation of NRC regulations for milling and tailings management given state-specific climate (e.g., rainfall) and hydrologic considerations.

Approach to Meeting the Stated Needs

We have approached Task B (i.e., Items III.B.1 and III.B.2 in the RFP) by dividing the task into five concurrent tasks, each addressing a specific issue. Each task will result in a white paper that addresses the needs relevant to that section.

Task B1: Adequacy of Existing Statutes and Regulations

This task will address the needs stated in the RFP under Sections III. B.1.a, B.1.b, B.1.c, and B.1.d. The team will coordinate with VDH staff to compare the Commonwealth's existing statutes and regulations and to identify and recommend changes to areas where VDH's existing regulations require modification or expansion. The evaluation will include a review of Waterworks Regulations (12VAC5-590 et seq.); Disease Reporting and Control Regulations (12VAC5-90-90 et seq.); and Private Well Regulations (12VAC5-630 *et seq*.).

During its review, the team will use its extensive experience coordinating with NRC in the development of new regulations and guidance related to the nuclear fuel cycle, uranium processing, and radioactive waste disposal to efficiently identify gaps in current Virginia regulations and to provide straightforward, implementable recommendations for filling these gaps.

Members of the team will also support the stakeholder process by attending all statewide stakeholder meetings, either in person or via telephone or video conference. A separate summary report on the stakeholder meetings will be prepared as part of Task B1, and the work for Task B1 will be performed in coordination with Task C.

Task B1 Deliverables

Two deliverables will be produced for Task B1. The first deliverable will be a white paper summarizing the recommendations of the team following review of existing Virginia regulations and statutes. The white paper will be developed in coordination with VDH staff. The due date for the white paper will be based on the timing of the stakeholder meeting addressing the topics covered under Task B1.

The second deliverable for Task B1 will be a summary report on the stakeholder meetings held throughout the state. The due date for the meeting summary will be October 15, 2012.

Task B2: Characterization of Existing Data and Worksheet Development

This task will address the needs stated in the RFP under Sections III. B.1.e and B.1.f. The team will coordinate with VDH staff to evaluate the testing requirements and laboratory capabilities to cover chemicals that are likely to be produced by uranium mines and mills. The ability to establish baseline rates of associated health effects will be determined or if other studies are

needed. The current method of reporting cancer and congenital malformation will be evaluated. Finally, recommendations will be developed for use by local health department and central office use.

During its review, the team will use its extensive experience in performing literature surveys to efficiently characterize the available data. The data will be analyzed and recommendations for further study will be provided, if necessary. Because of the strong focus of Task B2 on chemical hazards, it is estimated that Task B2 will be supported primarily (90 percent) by Exponent staff.

Task B2 Deliverables

For Task B2 a white paper summarizing the findings of Task B2 will be produced. The white paper will be developed in coordination with VDH staff. The white paper will include all case report investigation worksheets and other documents that were developed for this task. The due date for the white paper will be based on the timing of the stakeholder meetings described in Task B1.

Task B3: Development of Monitoring Plans

This task will address the needs stated in the RFP under Sections III. B.1.g, B1.h, B.1.i, B.2.a, B.2.b, B.2.c, and B.2.h. The team will review the existing monitoring program currently in place and make recommendations on additions or improvements to the program, if necessary. Recommended requirements of the monitoring plan will be clearly delineated, including the components of the plan, the goals of the plan, and identification of needed baseline and characterization data. A framework for environmental and human and animal health monitoring will be developed to support monitoring of the uranium mine and mill in conformance with state and federal regulations and statutes.

During its review, the team will use its extensive experience in developing and evaluating monitoring programs to evaluate the current program. A framework will be developed to ensure that the Virginia monitoring program meets or exceeds the requirements for monitoring effluents from uranium mines and mills.

Task B3 Deliverables

The deliverable for Task B3 will be a white paper that summarizes the findings of Task B3. The white paper will be developed in coordination with VDH staff. The due date for the white paper will be based on the timing of the stakeholder meetings described in Task B1.

Task B4: Evaluation of NRC Regulations Given State-Specific Climate

This task will address the needs in stated in the RFP under Section III.B.1.c. The team will evaluate NRC regulations for milling and tailings management in light of the difference in climate between Virginia and arid climates, where most uranium mills and tailings piles are located. The evaluation will focus on the adequacy of NRC regulations to protect public health in the Virginia climate. It is estimated that Task B3 will be supported only by CNWRA staff.

Task B4 Deliverables

The deliverable that will be produced for Task B4 is a white paper that discusses the potential impacts of uranium mines and mills on cisterns and onsite sewage systems. The white paper

will be developed in coordination with VDH staff. The due date for the white paper will be based on the timing of the stakeholder meetings described in Task B1.

Task B5: Existing Standards for Water Management, ALARA, and Financial Assessment

This task will address the needs stated in the RFP under Sections B.2.d, B.2.e, B.2.f, and B.2.g. The team will

- Evaluate existing standards for the safe disposal of mine waste and its potential impact on human health,
- Evaluate the necessary components of a full Environmental Impact Analysis,
- Determine methods for incorporating ALARA standards into Commonwealth regulations, and
- Make recommendations for compliance period financial assurance mechanisms.

The team will use its extensive experience in waste disposal, environmental impact statements, ALARA, financial assurance mechanisms, and knowledge of federal regulations to develop recommendations for the listed topics. The recommendations will be based on current federal regulations and national and international standards.

Task B5 Deliverables

The deliverable that will be produced for Task B5 is a white paper that discusses the potential Existing standards for mine waste disposal and impacts to human health, an outline for a full Environmental Impact Analysis for uranium mining in Virginia, and recommendations for financial assurance mechanism to cover the compliance period for a uranium mine and mill. The white paper will be developed in coordination with VDH staff. The due date for the white paper will be based on the timing of the stakeholder meetings described in Task B1.

Summary of Task B Deliverables

The deliverables for Task B consist of a series of white papers summarizing the recommendations of the team, including recommendations for performing epidemiological studies. A final report will include summaries of the white papers and possible additions to the existing regulatory program in Virginia. The final report will summarize the results of international studies that are pertinent to regulation of mining and milling in Virginia. The due date for the final report is October 15, 2012.

TASK C

III. C. Statement of Needs—Assist VDH in Preparing and Presenting Reports

The Contractor will assist VDH in preparing and presenting information and assist in VDH staff's presentations.

Task C: Assist VDH in Preparing and Presenting Reports

This task will address the needs stated in the RFP under Section III. C. The CNWRA/Exponent team will assist the VDH in preparing and presenting reports at stakeholder meetings. The CNWRA/Exponent team will rely on its extensive experience in preparing presentations and reports and in delivering quality, succinct oral presentations. It is estimated that Task C will be supported equally by CNWRA and Exponent staffs.

Task C Deliverables

No deliverables are anticipated for Task C.

TASK D

III. D. Statement of Needs—Assist VDH in Formulating a Draft Conceptual Regulatory Framework

> *Discuss the reports and recommendations enumerated above with VDH and assist staff in implementing findings/recommendations into a draft conceptual regulatory framework that would address VDH-issues for the entire life-cycle compliance period of milling projects in Virginia, as well as other impacted Commonwealth of Virginia regulations.*

Task D: Assist VDH in Preparing and Presenting Reports

This task will address the needs stated in the RFP under Section III. D. The CNWRA/Exponent team will assist the VDH in formulating a draft conceptual regulatory framework. This task will tie together Tasks A, B, and C and make recommendations for a conceptual regulatory framework.

Task D Deliverables

No deliverables are anticipated for Task D.

5 PROPOSED PRICING SCHEDULE

Southwest Research Institute proposes to conduct the Uranium Study according to the Statement of Needs for a Grand Total Price of $806,971.

6 ATTACHMENT B: SUBCONTRACTING PLAN

ATTACHMENT B

Small Business Subcontracting Plan

Definitions

Small Business: "Small business " means a business, independently owned or operated by one or more persons who are citizens of the United States or non-citizens who are in full compliance with United States immigration law, which, together with affiliates, has 250 or fewer employees, or average annual gross receipts of $10 million or less averaged over the previous three years.

Women-Owned Business: Women-owned business means a business concern that is at least 51% owned by one or more women who are citizens of the United States or non-citizens who are in full compliance with United States immigration law, or in the case of a corporation, partnership or limited liability company or other entity, at least 51% of the equity ownership interest is owned by one or more women who are citizens of the United States or non-citizens who are in full compliance with United States immigration law, and both the management and daily business operations are controlled by one or more women who are citizens of the United States or non-citizens who are in full compliance with the United States immigration law.

Minority-Owned Business: Minority-owned business means a business concern that is at least 51% owned by one or more minority individuals or in the case of a corporation, partnership or limited liability company or other entity, at least 51% of the equity ownership interest in the corporation, partnership, or limited liability company or other entity is owned by one or more minority individuals and both the management and daily business operations are controlled by one or more minority individuals.

All small businesses must be certified by the Commonwealth of Virginia, Department of Minority Business Enterprise (DMBE) by the due date of the solicitation to participate in the SWAM program. Certification applications are available through DMBE online at www.dmbe.virginia.gov (Customer Service).

Offeror Name: Southwest Research Institute

Preparer Name: Eva G. Carpenter **Date:** March 28, 2012

Instructions

A. If you are certified by the Department of Minority Business Enterprise (DMBE) as a small business, complete only Section A of this form. This shall not exclude DMBE-certified women-owned and minority-owned businesses when they have received DMBE small business certification.

B. If you are not a DMBE-certified small business, complete Section B of this form. For the proposal to be considered and the offeror to be declared responsive, the offeror shall identify the portions of the contract that will be subcontracted to DMBE-certified small business in Section B.

Section A

If your firm is certified by the Department of Minority Business Enterprise (DMBE), are you certified as a (**check only one below**):

_____ Small Business

_____ Small and Women-owned Business

_____ Small and Minority-owned Business

Certification number:_____ Certification Date:_____

Section B

Populate the table below to show your firm's plans for utilization of DMBE-certified small businesses in the performance of this contract. This shall not exclude DMBE-certified women-owned and minority-owned businesses that have received the DMBE small business certification. Include plans to utilize small businesses as part of joint ventures, partnerships, subcontractors, suppliers, etc.

B. Plans for Utilization of DMBE-Certified Small Businesses for this Procurement

Small Business Name & Address DMBE Certificate #	Status if Small Business is also: Women (W) Minority (M)	Contact Person, Telephone & Email	Type of Goods and/or Services	Planned Involvement During Initial Period of the Contract	Planned Contract Dollars During Initial Period of the Contract
Clear Creek Associates 6155 E. Indian School Rd. Ste. 200 Scottsdale, Arizona 85251 Certificate # 697428	S	Doug Bartlett Dbartlett@clearcreekassociates.com 703-777-4863	Prepare letter reports Tasks 1–4, literature review, attend meetings, review potential threats	Prepare letter reports Tasks 1–4, provide summary of best practices, prepare report	$26,200
Total $					$26,200

7 ATTACHMENT C: STATE CORPORATION COMMISSION FORM

ATTACHMENT C

STATE CORPORATION COMMISSION FORM

Virginia State Corporation Commission (SCC) registration information. The offeror:

☒ is a corporation or other business entity with the following SCC identification number: F1431420 **-OR-**

☐ is not a corporation, limited liability company, limited partnership, registered limited liability partnership, or business trust **-OR-**

☐ is an out-of-state business entity that does not regularly and continuously maintain as part of its ordinary and customary business any employees, agents, offices, facilities, or inventories in Virginia (not counting any employees or agents in Virginia who merely solicit orders that require acceptance outside Virginia before they become contracts, and not counting any incidental presence of the offeror in Virginia that is needed in order to assemble, maintain, and repair goods in accordance with the contracts by which such goods were sold and shipped into Virginia from offeror's out-of-state location) **-OR-**

☐ is an out-of-state business entity that is including with this offer an opinion of legal counsel which accurately and completely discloses the undersigned offeror's current contacts with Virginia and describes why those contacts do not constitute the transaction of business in Virginia within the meaning of § 13.1-757 or other similar provisions in Titles 13.1 or 50 of the Code of Virginia.

****NOTE**** >> Check the following box if you have not completed any of the foregoing options but currently have pending before the SCC an application for authority to transact business in the Commonwealth of Virginia and wish to be considered for a waiver to allow you to submit the SCC identification number after the due date for offers (the Commonwealth reserves the right to determine in its sole discretion whether to allow such waiver): ☐

8 SIGNED ADDENDA

VIRGINIA DEPARTMENT OF HEALTH
OFFICE OF PURCHASING AND GENERAL SERVICES (OPGS)
109 GOVERNOR STREET
RICHMOND, VIRGINIA 23219

March 16, 2012

ADDENDUM NUMBER (2) TO ALL BIDDERS/OFFERORS:

Reference:	RFP 1200001-999
Commodity:	91843
Dated:	March 5, 2012
For Delivery To:	Commonwealth of Virginia Department of Health Office of Purchasing and General Services (OPGS) Attn: Daniel Wilborn, Contract Officer 109 Governor Street 12th Floor, Room 1214 Richmond, VA 23219-0331
Bid/Proposal Due:	April 4, 2012
Pre-bid/proposal Conference:	March 16, 2012

The above is hereby changed to read:

1. Questions: Question concerning this RFP will be accepted until 4:00 p.m. March 20, 2012. Questions must be submitted by e-mail to Daniel Wilborn daniel.wilborn@vdh.virginia.gov and Linda Bumgarner linda.bumgarner@vdh.virginia.gov including questions asked during the pre-proposal conference.

Note: A signed acknowledgment of this addendum must be received at the location indicated on the IFB/RFP either prior to the bid/proposal due date and time or attached to your bid/proposal. Signature on this addendum does not substitute for your signature on the original bid/proposal document. The original bid/proposal document must be signed.

Sincerely,

Daniel Wilborn, CPPO, VCCO, VCO
Procurement Manager, OPGS
Phone: (804) 864-7519

Southwest Research Institute
Name of Firm

Signature/Title

3/19/2012
Date

OPGS Form 102 1 of 1 Rev 04/10

VIRGINIA DEPARTMENT OF HEALTH
OFFICE OF PURCHASING AND GENERAL SERVICES (OPGS)
109 GOVERNOR STREET
RICHMOND, VIRGINIA 23219

March 16, 2012

ADDENDUM NUMBER (2) TO ALL BIDDERS/OFFERORS:

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Bid/Proposal Due:	April 4, 2012
Pre-bid/proposal Conference:	March 16, 2012

The above is hereby changed to read:

1. Questions: Question concerning this RFP will be accepted until 4:00 p.m. March 20, 2012. Questions must be submitted by e-mail to Daniel Wilborn daniel.wilborn@vdh.virginia.gov and Linda Bumgarner linda.bumgarner@vdh.virginia.gov including questions asked during the pre-proposal conference.

Note: A signed acknowledgment of this addendum must be received at the location indicated on the IFB/RFP either prior to the bid/proposal due date and time or attached to your bid/proposal. Signature on this addendum does not substitute for your signature on the original bid/proposal document. The original bid/proposal document must be signed.

Sincerely,

Daniel Wilborn, CPPO, VCCO, VCO
Procurement Manager, OPGS
Phone: (804) 864-7519

Southwest Research Institute
Name of Firm

Manager Dept. Earth, Material and Planetary Sciences
Signature/Title

3/19/2012
Date

OPGS Form 102 1 of 1 Rev 04/10

VIRGINIA DEPARTMENT OF HEALTH
OFFICE OF PURCHASING AND GENERAL SERVICES (OPGS)
109 GOVERNOR STREET
RICHMOND, VIRGINIA 23219

March 26, 2012

ADDENDUM NUMBER (3) TO ALL BIDDERS/OFFERORS:

Reference:	RFP 1200001-999
Commodity:	91843
Dated:	March 5, 2012
For Delivery To:	Commonwealth of Virginia Department of Health Office of Purchasing and General Services (OPGS) Attn: Daniel Wilborn, Contract Officer 109 Governor Street 12th Floor, Room 1214 Richmond, VA 23219-0331
Bid/Proposal Due:	April 4, 2012
Pre-bid/proposal Conference:	March 16, 2012

The above is hereby changed to read:

1. Questions and Answers: Questions that were submitted are answered is the Question and Answers document attached.
2. Attendance lists for vendors that attended the pre-proposal are attached.
3. Bid/Proposal Due Date: Has been changed to April 5, 2012 at 2:00 pm.

Note: A signed acknowledgment of this addendum must be received at the location indicated on the IFB/RFP either prior to the bid/proposal due date and time or attached to your bid/proposal. Signature on this addendum does not substitute for your signature on the original bid/proposal document. The original bid/proposal document must be signed.

Sincerely,

Daniel Wilborn, CPPO, VCCO, VCO
Procurement Manager, OPGS
Phone: (804) 864-7519

Southwest Research Institute / CNWRA
Name of Firm

Signature/Title

3/26/2012
Date

OPGS Form 102 1 of 1 Rev 04/10