Roy W. Brown — Curium, VP, Government Affairs & Strategic Alliances

Education, Certifications and Affiliations

- MA, Business Administration, Webster University, 1987
- BS, Radiation Biophysics, University of Kansas, 1978

Years of Experience

- 39 years total
- 30+ years in the nuclear medicine industry
- 9+ years in Health Physics, EHS

Work History

- 2011–present, VP, Government Affairs & Strategic Alliances, Curium Pharmaceuticals (and predecessor companies)
- 2005–2011, President, Nuclear Medicine Solutions, Inc.
- 2002–2005, President, TCI Medical Inc.
- 2000–2002, Consultant
- 1978–2000, Various positions, Mallinckrodt

Relevant Highlights

- Serves on the European Observatory Working Group on Global Research Reactor Scheduling
- Member of the White House Office of Science & Technology Policy Committee on the Supply of Medical Radionuclides
- Serves on several IAEA Coordinated Research Projects on the production of Mo-99, and the Conversion from HEU to LEU for the production of Medical Radionuclides.
- Served on the Department of Energy Nuclear Science Advisory Committee on Isotopes from 2008-2009 and 2014-2015.
- Serves on the Board of Directors for the Education & Research Foundation for Nuclear Medicine

Experience Overview

Roy Brown has more than 30 years of experience in the nuclear medicine industry. He currently serves as the co-Chair of the Council on Radionuclide and Radiopharmaceuticals, Inc. (CORAR) Isotope Supply Committee and as the Chairman of the Board for CORAR. He is a member of the Society of Nuclear Medicine's task force on molybdenum-99 (^{99}Mo), is Curium's representative to the European Nuclear Energy Association's Organization for Economic Cooperation and Development (OECD) Committee on Medical Isotope Supply, serves on the White House Office of Science & Technology Policy Committee on the Supply of Medical Radionuclides, is a member of the European Commission Observatory on the Supply of Medical Isotopes, serves on several International Atomic Energy Agency (IAEA) committees dealing with ^{99}Mo and ^{133}Xe production, is on the European-based Association of Imaging Producers and Imaging Suppliers (AIPES) Reactor and Isotopes Working Group, and serves on the AIPES General Assembly.

Mr. Brown currently serves as the Vice President of Government Affairs & Strategic Alliances for Curium. Curium is the world's largest radiopharmaceutical manufacturer, with manufacturing plants in Maryland Heights, Missouri; Petten, Netherlands; and Saclay, France. Curium holds a broad-scope license for its operation in Maryland Heights. The company also has a bulk ^{99}Mo manufacturing plant in the Netherlands. Mr. Brown's principal responsibility is development of the company's strategy for long-term radionuclide supplies, including ^{99}Mo. He also engages with state and federal legislators, regulatory agencies, and trade associations to educate and advocate on behalf of Curium.

Selected Presentations

"Current Tc-99m Supply Chain Issues and the Effect that LEU Conversion Has Had on the Supply," The Missouri Valley Chapter of SNM Annual Meeting, Overland Park, Kansas, September 16, 2017.

DOE, 2017, "Challenges and Opportunities on the Path to LEU Conversion," U.S. Department of Energy Mo-99 Topical Symposium Meeting, Montreal, Canada, September 11.

NAS, 2017a, "Current and Future Plans for the Production of Mo-99," Russian National Academy of Sciences-U.S. National Academy of Sciences, *Symposium on Mo-99 Production*, Vienna, Austria, July 17.

NAS, 2017b, "Conversion to Low-Enriched Uranium Based Mo-99 Production," Russian National Academy of Sciences-U.S. National Academy of Sciences, *Symposium on Mo-99 Production*, Vienna, Austria, July 18.

NAS, 2017c, "Regulatory Perspectives from a Tc-99m Generator Manufacturer," Russian National Academy of Sciences-U.S. National Academy of Sciences, *Symposium on Mo-99 Production*, Vienna, Austria, July 19.

CME Course, 2017, "Current Tc-99m Supply Chain Issues and the Effect that LEU Conversion has had on the Supply," Continuing Medical Education, Society of Nuclear Medicine Annual Meeting, Denver, Colorado, June 12.

FNMT, 2017, "Molybdenum-99 (Mo-99) Supply Update," 46th Annual Meeting of the Florida Nuclear Medicine Association, Tampa, Florida, May 6.

"The Current Supply of Mo-99," Canadian Medical Isotope Working Leaders Group, Ottawa, Canada, April 3, 2017.

"Update on Curium's Effort to Convert to Low Enriched Uranium," The European Union Observatory on the Supply of Medical Isotopes, Luxembourg City, Luxembourg, March 28, 2017.

"Current Supply Challenges with Mo-99 and Other Medical Radionuclides," American Pharmacists Association Annual Meeting, San Francisco, California, March 25, 2017.

"Mo-99 Production and Effective Control of Xe-133 Emissions Comprehensive Test Ban Treaty Organization," Workshop on Signatures of Man-made Isotope Production (WOSMIP VI), Bariloche, Argentina, November 30, 2016.

Ralph A. Butler, PE — NWMI Senior Advisor

Education, Certifications, and Affiliations

- MS, Nuclear Engineering, University of Missouri – Columbia
- BS, Engineering Management, University of Missouri – Rolla
- U.S. NRC Senior Reactor Operator License (30560), Westinghouse PWR
- Registered Professional Engineer, Missouri (E-20909)
- Member, American Nuclear Society, since 1983
- Past Chair of the National Organization of Test, Research, and Training Reactors (TRTR)

Years of Experience

- 48 years (total)
- 35+ years of nuclear experience

Work History

- 2000 – 2017, MURR
- 1993 – 2000, DOE/DoS
- 1989 – 1992, Consultant (commercial nuclear power)
- 1981 – 1989, Union Electric Company
- 1969 – 1975, US Navy

Relevant Highlights

- Registered professional engineer (PE)
- Former NRC licensed Senior Reactor Operator
- Served on American Nuclear Society Executive Committees for several ANS divisions

Awards

- Recipient, Missouri Honor Award for Distinguished Service in Engineering, University of Missouri College of Engineering, 2008
- Recipient (two times), VP Al Gore's National Performance Review Certificate of Appreciation (Hammer Award)
- Paul Harris Fellow, Rotary International

Experience Overview

Ralph Butler, PE, has over 35 years of nuclear experience in the management, oversight, and operation of Navy, commercial, university, and U.S. Department of Energy (DOE) facilities, both domestic and international. His experience includes power plant and research reactor operations, program management, quality improvement and assessment activities, and independent safety reviews.

Mr. Butler is currently serving as a Senior Advisor to Northwest Medical Isotopes, LLC (NWMI) on the licensing and final design of the Radioisotope Production Facility to be constructed in Columbia, Missouri, near the University of Missouri Research Reactor (MURR).

Relevant Project Experience

University of Missouri Research Reactor Center, Columbia, MO — 2000 – 2017

Executive Director

Responsible for the safe, legal, and efficient operation of the University of Missouri's 10 MW research reactor (MURR), the most powerful university-operated research reactor in the U.S. with a staff of 180. MURR is a multidisciplinary research center with a three-fold mission of promoting interdisciplinary research, providing an education opportunity for students, and providing irradiation and isotope production services to researchers, medical institutions, and private companies worldwide.

U.S. Department of Energy (DOE) and Department of State (DoS), Washington, DC — 1993 – 2000

Program Manager, Argonne National Laboratory

Served as overall program manager of Argonne's Maryland office.

Program Manager, DOE Office of Nonproliferation and National Security

Managed special nuclear material protection, control, and accounting upgrades at four Russian nuclear institutes.

Senior Technical Advisor, DoS

Advised on matters related to two light water reactors being provided to the Government of the Democratic People's Republic of Korea, North Korea.

Consultant, DOE
Domestically conducted management and technical evaluations of DOE nuclear facility operations, radioactive waste management policies, and decommissioning activities for the Office of Environmental Management and Nuclear Safety.

Served as senior advisor to Brookhaven National Laboratory's Reactor Division in the development and implementation of a three-year restart project of the high flux beam reactor and with transition to a new management contract.

Rochester Gas & Electric – Rochester, NY **1990 – 1992**
Consultant
Under contract to manage a $6 million, fixed-price maintenance upgrade project. Responsibilities included design specification research, development of an engineered maintenance analysis relational database, and incorporation of reliability centered maintenance recommendations into enhanced maintenance procedures. As Operations Specialist, duties included performing 10 CFR 50.59 reviews and determining post-maintenance operability testing requirements.

Virginia Power – Richmond, VA **1989**
Consultant, Corporate Nuclear Safety Group
Served as Principal Engineer leading the independent review of a large backlog of safety documents for the Surry and North Anna nuclear plants. Performed special investigations as requested by utility executives for reactor trips, operational events, design changes, and engineering work requests.

Union Electric Company, Callaway Nuclear Plant – St. Louis, MO **1981 – 1989**
Supervising Engineer, Quality Assurance
Directed a group of degreed QA engineers responsible for the assessment and evaluation of the Operations, Instrumentation and Controls, Maintenance, and Work Control departments from a technical and legal aspect.

Control Room Supervisor and Refueling Senior Reactor Operator, Operations Department
Supervised all activities related to the safe, legal, and efficient operation of the reactor systems and equipment within the Callaway Nuclear Plant. Directed operational activities, including scheduling, authorization, and acceptance of work and test activities; training and scheduling of operations personnel; and the review and revision of plant procedures.

Shift Technical Advisor/Engineer, Independent Safety Engineering Group
Provided advanced technical assistance to the operating shift complement during normal and abnormal operating conditions; assisted the operations staff in interpreting and applying the requirements of technical specifications; performed an early review of the planned activities for the upcoming shift to ascertain whether special considerations or precautions were warranted.

Developed the program for the review, evaluation and dissemination of plant and industry operating experience information such as Institute of Nuclear Power Operations (INPO) significant event reports (SER), significant operating experience reports (SOER), and NRC I&E Bulletins and Notices, performed the first Callaway Plant probabilistic risk assessment (PRA), developed procedures for the independent review of various plant departments, and assisted in the development of a listing of reactor trip single point failure components.

U.S. Navy **1969 – 1975**
Machinist Mate First Class, USS SCULPIN (SSN-590)
Qualified Engineering Watch Supervisor and Engineroom Supervisor. Served as Mechanical Division's Leading Petty Officer. Also served as ship's welder and diesel engine petty officer.

Michael R. Corum **Atkins Vice President, Energy (Nuclear)**

Education, Certifications and Affiliations

- MS, Nuclear Engineering, University of Tennessee, 1991
- BS, Nuclear Engineering, University of Tennessee, 1990
- BA, Biology, University of Tennessee, 1981

Years of Experience

- 36 years (total)
- 27 years in the nuclear industry

Work History

- 2001 – Present, Atkins (member of SNC Lavalin Group)
- 1982 – 2001, Various companies

Relevant Areas of Expertise

- Nuclear criticality safety
- Radiation shielding
- Packaging and transportation – Safety analysis report for packaging (SARP) development
- Hazardous analysis
- Reactor core reload analysis
- Integrated safety analysis
- Fault tree analysis
- Qualitative and quantitative methods of hazards assessment

Experience Overview

Michael (Mike) Corum is a subject matter expert with over 27 years of experience in the nuclear industry. His broad experience base in nuclear criticality safety includes expertise in radiation shielding, hazards analysis, packaging and transportation, and core reload analysis. He has extensive experience in both facility support and packaging and transportation (fresh and spent fuel). Additional areas of expertise include integrated safety analysis (ISA), fault tree analysis, qualitative and quantitative methods of hazards assessment, shielding analysis using Monte Carlo N-Particle (MCNP) code, validation and benchmarking of criticality codes, nuclear reactor core design, and reactor physics calculations in support of reload safety analysis efforts. Mr. Corum is an experienced user of MCNP, KENO V.a, KENO VI, the SCALE system (including SAS and CSAS sequences), PHOENIX, and the Advanced Nodal Code (ANC).

Since 2012, Mr. Corum has supported Northwest Medical Isotopes, LLC (NWMI) during development of the construction permit and operating license applications for the NWMI Radioisotope Production Facility (RPF). He also provided regulatory support during Advisory Committee on Reactor Safeguards (ACRS) meetings for the construction permit application. His support includes subject matter expertise in criticality safety, shielding, and ISA. In addition, he provides interface support for natural phenomena hazards, external event analysis, fire hazard analysis, radiation protection, and thermal hydraulics. Mr. Corum became a strategic partner to NWMI for final design phase plan development.

Relevant Project Experience

Atkins, Columbia, SC **2001 – present**

Vice President Operations, Commercial Nuclear and Specialty Engineering Division

Vice President Operations (2004 – 2017) – Performs management oversight for the Atkins Nuclear and Specialty Engineering Division. Responsibilities include business financial oversight, strategic decision making, business development, personnel recruitment, contract negotiation, joint marketing ventures, technical capabilities development, and marketing to prospective clients. Functional groups managed include licensing, commercial nuclear business development, reactor core physics, health physics, shielding, radiation protection, reactor thermal hydraulics, criticality safety, risk assessment, probabilistic risk assessment (PRA), reactor severe accident modeling, fire protection, specialty structural engineering, and GLASS software development.

Core Design Engineer, Westinghouse Electric Co., Pittsburgh, PA (2008 – 2011) – Performed numerous core reload safety analysis calculations for various utility customers while supporting the Westinghouse Core Design group in Pittsburgh. Analyses included moderator temperature coefficient, doppler coefficient and defect, beta-effective, control rod operational limits, shutdown margin, trip reactivity, rod misalignment, dropped rod, dropped bank, single rod withdrawal, rod withdrawal at power, rod bank withdrawal from subcritical, boron dilution accident, post-LOCA (loss of coolant accident) long-term cooling critical boron, rod ejection accident analysis, steam line break analysis, boron design requirements, integral fuel burnable absorber (IFBA) power suppression, locked rotor, and maximum rod power census for LOCA.

Westinghouse Electric Company, Columbia, SC (2004 – present) – Performed numerous nuclear criticality calculations using MCNP to support the nuclear criticality safety evaluation (NCSE) for the boiling water reactor (BWR) fuel bundle inspection area and the fuel assembly storage area. Participated on the design team for the fuel bundle inspection insert and the fuel assembly storage racks. Authored the NCSE for the Columbia Fuel Fabrication Facility (CFFF) BWR fuel bundle inspection area and the fuel assembly storage area to demonstrate double contingency and incorporate requirements of 10 CFR 70.61. Authored numerous other NCSEs in support of the CFFF Criticality Safety Program recovery effort.

Performed criticality accident alarm system placement calculations, immediate evacuation zone (IEZ) evaluation, and dose assessments for workers using MCNP for the CFFF. Provide continuing criticality safety support to the facility.

Cameco, Port Hope, Ontario (2004 – 2005) – Managed the establishment of a comprehensive criticality safety program at the Cameco Port Hope fuel manufacturing facility. Developed the schedule and allocated the resources necessary to complete the program for Cameco. The program scope included formal procedures to define the criticality safety program and NCSEs to document the safety basis for the proposed fissile material operations in the Slightly Enriched Uranium (SEU) Facility. The NCSEs are completed following a hazards assessment involving Atkins and Cameco process engineers, design engineers, operators, and supervisors.

Zircatec Precision Industries, Port Hope, Ontario (2004 – 2006) – Managed the establishment of a comprehensive criticality safety program at the fuel manufacturing facility. Developed the schedule and allocated the resources necessary to complete the program. The program scope includes formal procedures to define the criticality safety program and NCSEs to document the safety basis for the proposed fissile material operations in the SEU facility. The NCSEs are completed following a hazards assessment, directed by Atkins, involving process engineers, design engineers, operators, and supervisors.

Nuclear Fuel Services, Erwin, TN (2001 – 2004) – Performed numerous nuclear criticality calculations using SCALE 4.3 to support the NCSE for the solvent extraction and uranium-aluminum dissolution operations at the Blended Low Enriched Uranium (BLEU) Processing Facility. Authored NCSEs for the new BLEU processing facility solvent extraction and uranium-aluminum dissolution operations to demonstrate double contingency and incorporate requirements of 10 CFR 70.61. Performed shielding calculations using MCNP to support various operations in the new BLEU Processing Facility.

Performed criticality analysis to support licensing of the RAJ-II BWR fresh fuel container. Employed innovative analysis techniques to define acceptable fuel parameter ranges that allow for future fuel design changes without the need for a shipping container license amendment. Authored Chapter 6 of the RAJ-II Safety Analysis Report (SAR).

Westinghouse Electric Company, Columbia SC and Pittsburgh, PA **1992 – 2001**
Engineer/Senior Engineer B/Senior Engineer B, Commercial Nuclear Fuel Division
Performed numerous nuclear criticality analyses to demonstrate double contingency of operations. Supported analyses with KENO V.a/SCALE and MCNP calculations. Also developed fault trees in support of the criticality analyses to demonstrate double contingency protection as part of the ISA process.

Developed methodology for the Wesflex transfer, storage, and transportation cask criticality design effort. Coordinated and served as the lead engineer for the criticality effort for the multi-purpose canister system and the first-of-a-kind criticality analysis for the Temelin fresh fuel transfer containers and spent fuel storage racks. Drafted numerous reports and presented technical information to customers, senior staff, and U.S. Nuclear Regulatory Commission (NRC) and U.S. Department of Energy (DOE) officials.

Provided reload core design services to Westinghouse clients in the commercial nuclear power industry. Performed shielding analyses using MCNP for both transportation casks and nuclear reactor designs.

Westinghouse Savannah River Company, Inc. – Aiken, SC **1991 – 1992**
Engineer
Performed quantitative risk analysis (PRA) and qualitative hazards assessment support for the solid waste disposal facility at the Savannah River Site. Performed numerous risk assessment analyses, led teams, and authored several SARs. Used techniques and analysis methodology learned from the Process Safety Institute courses on qualitative and quantitative methods of hazards assessment. Developed a Monte Carlo approach for accident analysis of helicopter flights over the Solid Waste Disposal Facility.

University of Tennessee – Knoxville, TN **1988 – 1991**
Research Assistant and Graduate Research Assistant

United States Air Force – San Antonio, TX, Sacramento, CA, Merced, CA, Blytheville, AR **1982 – 1988**
Captain – Bombardment Heavy Wing, Strategic Air Command, Blytheville Air Force Base, AR
Wing Instructor, Electronic Warfare Officer (1986 – 1988) – As a member of the Wing Commander's Staff, organized, coordinated, and directed all electronic warfare activity, defensive measures, electronic countermeasures equipment, and electronic combat tactics. Developed and provided training in relation to Operational Readiness Inspections (ORI) and crew combat tactics. Participated in Giant System tests to improve electronic combat systems capability and received a letter of appreciation for contribution.

Training Flight Instructor, Electronic Warfare Officer (1986) – Managed all training activities for the squadron, prepared personnel schedules, and coordinated programs. Cited for excellence at the Squadron Officer School, as one of the prestigious course's outstanding presenters.

Electronic Warfare Officer Instructor (1985 – 1986) – Planned, organized, conducted, and evaluated operational training in relation to interception, analysis, masking, and jamming of enemy electromagnetic activity. Directed airborne defense of the manned bomber leg of the Strategic Air Command's nuclear triad. Maintained mission readiness status by performing combat crew alert duty in support of the global Single Integrated Operational Plan and Emergency War Order operations. Selected to serve as an audit officer for the critical munitions supply accounts.

Navigator/Electronic Warfare Officer (1981 – 1985) – Attained navigator rating and specialized in electronic warfare. Assured quality and continuity of training in Emergency War Order procedures and techniques for B-52 aircraft. Planned, organized, conducted, and evaluated operational training. Developed countermeasures to defeat enemy ground and airborne weapons, command, and control systems. Represented the 97th Bombardment Wing in the annual Bombing and Navigation Competition, and received the highest score by compiling over 50 error-free runs. Received perfect test scores on Strategic Air Command's most difficult evaluations, the ORI and 1st Combat Evaluation Group.

Gary Dunford — AEM Consulting, LLC – Managing Partner

Education, Certifications and Affiliations

- BS, Chemical Engineering, University of North Dakota, 1978

Years of Experience

- 38 years (total)
- 38 years at DOE sites
- 31 years in waste retrieval technologies at DOE sites

Work History

- 2001 – present, AEM Consulting LLC
- 1997 – 2001, WASTREN, Inc.
- 1979 – 2001, Various Hanford Site M&O contractors

Relevant Highlights

- Direct management responsibility for more than $25M of task-based projects for Hanford tank farms, most involved preparing or contributing to technical studies and reports related to Hanford waste retrieval and processing
- 10 years of experience with all aspects of day-to-day Hanford tank farms operations, including waste retrieval and transfer operations
- Key participant in the development of new process models to support baseline case planning for the Hanford River Protection Project mission
- Responsible for a 60-person, multi-organizational project team assigned to complete the Tank Waste Remediation System Final Safety Analysis Report, and to communicate the results to regulators and the public
- Extensive experience in systems engineering, assessments, alternative evaluations, system optimization, and flowsheet development

Experience Overview

Gary Dunford has a strong background in plant operations and providing process engineering support to radioactive/mixed waste facilities. His experience extends into systems engineering applications, flowsheet development, conduct of operations principles, operational readiness activities, safety documentation preparation, and authorization basis implementation. Mr. Dunford is noted for his ability to identify innovative solutions to problems and bring diverse groups together to complete projects. He has worked on projects and is familiar with the various sites within the U.S. Department of Energy (DOE) complex, including the Hanford Site, Idaho National Laboratory, and Savannah River Site.

Mr. Dunford serves as the AEM Consulting, LLC (AEM) Process Engineering Manager supporting Northwest Medical Isotopes, LLC (NWMI), with responsibility for developing the radiochemical separation processes, developing flowsheet conditions, and sizing of process equipment for the NWMI Radioisotope Production Facility. Tasks include preparing process flow diagrams, piping and instrumentation drawings, and process descriptions. He also provides operations and maintenance and a safety analysis perspective to NWMI.

Mr. Dunford served as the Assistant Manager for Facility Operations and was responsible for the daily operations of the Hanford tank farms and readiness activities for special activities and projects. Additionally, his staff successfully installed the Tank SY-101 mixer pump, which mitigated DOE's top priority safety issue at the time.

Mr. Dunford served as the Manager of Tank Farms Plant Engineering, a role that had him overseeing a multidisciplined engineering organization responsible for the plant, process, and design engineering functions for tank farms, grout, and evaporator facilities. He was responsible for upgrades to ensure that major modifications were properly designed, safely installed, formally tested, and systematically turned over, including operational readiness activities.

Mr. Dunford developed, marketed, and implemented a project plan and strategies to complete the Hanford Site's first DOE Order-compliant final safety analysis report. He implemented a prototype risk status and review process to reduce DOE's approval time by half.

Relevant Project Experience

AEM Consulting, LLC – Richland, WA **2001 – present**
Principal
Serves as AEM Process Engineering Manager supporting development of the construction permit and operating license applications for the NWMI Radioisotope Production Facility and submittal of those applications to the U.S. Nuclear Regulatory Commission (NRC). Responsibilities include developing the radiochemical separation processes, developing flowsheet conditions, and sizing of process equipment for the facility.

Prepared or contributed to numerous technical studies and reports related to Hanford waste retrieval and processing, including C Farm 100-series tanks, and the alternatives evaluation for retrievals based on deep sludge gas release events.

Prepared or contributed to numerous technical studies and reports related to Hanford baseline case planning, including the River Protection Project (RPP) waste retrieval mission analysis and the Strategic Initiative Analysis plans. Managed the development of two new models integral to Hanford RPP baseline case planning: TOPSim, a dynamic simulation for modeling waste tank retrieval and processing operations, and the Life-Cycle Cost Model (LCCM).

Westinghouse Hanford Company, Richland, WA **1995 – 1997**
Manager
Final Safety Analysis Report (FSAR) development – Oversaw a multi-organizational team that completed the Tank Waste Remediation System FSAR. Acted as the primary interface with stakeholders, DOE Headquarters, and the Defense Nuclear Facilities Safety Board (DNFSB). Responsible for communicating technical approaches and results to regulators and the public.

Westinghouse Hanford Company – Richland, WA **1993 – 1995**
Manager
Waste tank upgrade, installation, and testing – Responsible for ensuring that major upgrades to support waste systems operation and waste retrieval and transfer were properly designed, safely installed, formally tested, and systematically turned over, including operational readiness activities.

Westinghouse Hanford Company – Richland, WA **1987 – 1993**
Manager, Tank Farms Plant Engineering, and Assistant Manager for Facility Operations
Tank Farms operations and engineering – Co-managed an operating staff of over 400 direct report and matrix support personnel. Sponsored and defended the 242-A Evaporator Safety Analysis Report before DOE Headquarters review teams to support 242-A Evaporator restart efforts. Initiated conduct of operations principles into operations and acquired staff to make a step-change improvement in the conduct of operations throughout operations and maintenance. A highlight of this period was the successful installation of the Tank SY-101 mixer pump, which mitigated DOE's top priority safety issue. Responsible for day-to-day operations and technical support for all tank farms activities, including waste tank retrieval and transfer and waste systems operations.

Rockwell Hanford Operations – Richland, WA **1987 – 1997**
Manager, Waste Concentration, and Manager/Engineer, PUREX Shift Engineering
Waste Concentration Unit – Responsible for providing process engineering support for radioactive liquid waste concentration, interim storage, and transfer. Oversaw the process engineer's design review and startup support for new tank farms construction projects.

PUREX Facility – Responsible for the 24-hour/day process engineering support to the reprocessing facility. Monitored and maintained process chemistry during operations and established facility configurations to support special nuclear materials inventories. Became a Certified Process Engineer for the plant's solvent extraction and plutonium processing systems. Managed a series of engineering and supervisory assignments to support Hanford 200 Area processing facilities.

Nicholas F. Fowler — NWMI Chief Executive Officer

Education, Certifications and Affiliations

- M.S., Industrial Engineering and Engineering Management, Stanford University, 1981
- B.A., Economics, Stanford University, 1980

Years of Experience

- 36 years (total)
- 30 years in executive management
- 13 years as Chief Executive

Work History

- 2010 – present, Northwest Medical Isotopes, LLC
- 2004 – present, Orion Ventures, LLC
  1981 – 2005, Hewlett Packard Company

Honors/Affiliations

- 2014 – present, Oregon State University, Executive Commercialization Advisory Council
- 2014, District Chairman, Boy Scouts of America
- 2013 Entrepreneur of the Year, City of Corvallis
- 2013, Committee of Visitors, National Science Foundation

Experience Overview

Nicholas Fowler is a serial entrepreneur, active angel investor, and technology industry veteran. He currently serves as Chairman and Chief Executive Office of Northwest Medical Isotopes, LLC (NWMI). Mr. Fowler co-founded NWMI in 2010 with a primary mission to provide a domestic, secure, and reliable supply of molybdenum-99 (^{99}Mo) for medical diagnostics for ailments such as cancer, heart disease, and bone and kidney disease.

Beginning in 1981, Mr. Fowler spent 25 years with the Hewlett-Packard Company. As Director and General Manager, he led the creation of several major new businesses, including notebook computers, personal digital assistants, and internet sales and support.

Mr. Fowler was the founder or instrumental in the growth of numerous startup ventures, including Perpetua Power Source Technologies, Inc. (a world leader in thermoelectric technologies), ZAPS Technologies, Inc. (an innovator in optical spectrophotometric technology for the detection of contaminants), Wave Sciences, LLC (innovator in signal processing and officer safety) and TryEco, LLC (inventor of starch based superabsorbent polymers).

Carolyn C. Haass — NWMI Chief Operating Officer

Education, Certifications and Affiliations

- BS, Metallurgical Engineering and Chemistry, Colorado School of Mines, 1984

Years of Experience

- 33 years (total)
- 25 years at DOE sites
- 6 years working with NRC
- 7 years radioisotopes production

Work History

- 2012 – present, Northwest Medical Isotopes, LLC
- 1997 – 2012, Various Hanford Site contractors
- 1991 – 1997, U.S. Department of Energy
- 1985 – 1991, Ebasco, Inc.

Relevant Highlights

- Direct management responsibility for more than $150M of task-based projects for commercial and government nuclear projects
- Extensive experience in systems engineering, assessments, alternative evaluations, system optimization, and flowsheet development
- Responsible for 100+-person, multi-organizational project team, Hanford Tank Farm Pretreatment Project
- Managed and completed two EISs for the Hanford Nuclear Reservation, including Tank Farms and K-Basins
- Direct management responsibility for all environmental requirements, Hanford Tank Farms
- Member of the White House Office of Science & Technology Policy Committee on the Supply of Medical Radionuclides
- Council of Radionuclides and Radiopharmaceuticals Board Member
- Paul Harris Fellow (X4), Rotary International

Experience Overview

Ms. Haass is a senior executive with 30 years of experience in multidisciplinary complex nuclear, chemical, hazardous, and mixed-waste engineering, procurement, construction, and project management projects for both government and private industry. She served as a regulator with the U.S. Department of Energy for more than 10 years. Ms. Haass' expertise includes strategic planning and project management of large complex nuclear and hazardous waste projects; technology development, project design, construction, and operations; developing long-term life-cycle technical, schedule, and cost integrated baselines; and associated risk and issue management. She has extensive communications experience in the nuclear and environmental industry, including day-to-day interface with regulators, safety boards, Congress, stakeholders, tribal nations, public, media, community leaders, and decision makers.

Relevant Project Experience

Northwest Medical Isotopes, LLC (NWMI) – Corvallis, OR **2012 – present**
Chief Operating Officer (COO)

COO and co-founder of NWMI with the charge to design, license, construct and operate a medical radioisotope production facility. Lead and direct all company operations, strategic planning, business development and conflict management with 100+ employees and contract staff. Establish and maintain operating standards, regulatory compliance, and total quality management while maintaining a current level of knowledge of industry-related trends and compliance standards to ensure a cohesive structure within the company.

Consultant, URS Corporation/AECOM and Fluor Corporation – Richland, WA **2001 – 2012**
Consultant

Supported the Hanford River Protection Project (RPP) in strategic planning and the development of new technologies for the cleanup of Hanford tank waste. Developed business strategies/plans for environmental cleanup for DOE sites, including Hanford, Idaho, and Savannah River.

Environmental Compliance and Permitting Manager
Aqueous Separations Engineering Scale Demonstration Facility (ASESDF) project, Idaho National Engineering and Environmental Laboratory – Supported development of an integrated baseline, including technical, cost, schedule, and environmental strategy required for the design, construction, and commissioning of ASESDF. The ASESDF project involved the design-construction of an engineering-scale demonstration of light water reactor (LWR) fuel preparation and leaching, subsequent aqueous separations, and solidification processes. Responsibilities included compliance with RCRA, CAA, CWA, NEPA, and waste incidental to reprocessing (WIR) determination for first cycle raffinates.

Technical Advisor
U.S. Department of Defense (DoD) Chemical Demilitarization/DOE High-Level Tank Waste Treatment –Supported and advised technology development, design, fabrication, commissioning, and testing of processes and equipment; conduct of operations; and ESH&Q projects for the treatment of legacy waste in DoD (chemical demilitarization projects) and DOE Environmental Management (high-level tank waste treatment).

Portage, Inc. – Richland, WA **2001 – 2003**
Office Manager
Responsibilities included development of operations business plan to win and maintain a work backlog of more than $12 million annually for governmental environmental restoration activities, managed over 25 technical and administrative personnel, and procured contracts for both small and large contracts and for all types of contracting mechanisms. Negotiated contract requirements, ensured contract compliance, and completed performance evaluations.

Technical Advisor
Yucca Mountain Environmental Impact Statement (EIS) – Supported preparation and submission of Yucca Mountain EIS for the storage of commercial nuclear power plant spent fuel and immobilized high-level waste generated during the cold war era at DOE sites.

CH2M HILL Hanford Group, Inc. – Richland, WA **1997 – 2001**
Regulatory/Stakeholder and Congressional Affairs Director, DOE Hanford Tank Farms
Supported efforts to cleanup ~56 Mgal of mixed radioactive and hazardous waste in the Hanford tank farms. Responsibilities include:

- Served as principal liaison between regulatory agencies, stakeholders (Federal Facility Agreement and Consent Orders), congressional staff, media, and community leaders for the Hanford tank farms and associated prime contractors
- Developed, led, and integrated ES&H/regulatory, stakeholder, and congressional strategies and issues to ensure project success; consistent and effective communications were maintained to validate strategic mission objectives; and regulatory requirements were being met
- Maintained direct communication with all levels of management, including company presidents and Senior DOE officials
- Managed and provided oversight of media relationships and events
- Developed/maintained relationships with Federal, State, and local officials and community leaders
- Served on the DOE Emergency Operations/Response Team.

Director, Single Shell Tank (SST) Program and Balance of Mission Strategic Planning
Managed program and strategic planning for tank waste retrieval and closure of 149 underground SSTs that contain approximately 40 Mgal of high-level radioactive mixed waste. Project life-cycle costs were estimated to be ~$12–15 billion over 40 years. Specific responsibilities include:

- Formulated strategic plans to meet SST mission closure goals and objectives (e.g., waste retrieval technology development, tank waste retrieval upgrades, risk-based waste retrieval, RCRA closure (seven waste management units)
- Developed project execution plans and project management plans

- Developed life-cycle cost estimates and managed the allocation and prioritization of financial resources to meet mission requirements
- Conducted RCRA remedial investigations to determine the nature and extent of contamination in support of corrective measure studies for all environmental media (e.g., soil, groundwater)
- Implemented project management requirements (e.g., monthly project performance reporting, earned value management system [EVMS], risk management, staffing/human resources)
- Negotiated and monitored over 20 subcontracts (ranging from $100,000 to $5 million)

U.S. Department of Energy (Richland, WA) **1991 – 1997**

Environmental/NEPA Manager, Hanford Tank Farms

- Managed and integrated environmental activities for Hanford tank farms remediation activities, including permitting (RCRA, CWA, CAA), NEPA, regulatory compliance and interface, public involvement/communication, and strategic planning
- Managed and completed 2 EISs and supported development of four additional EISs, and managed completion of 12 environmental assessments (EA) and more than 25 categorical exclusion (CX) determinations for execution of the Hanford cleanup mission
- Developed and implemented communication and public involvement activities
- Maintained strategic interface relationships with key Federal and State decision-makers, congress, stakeholders, tribal nations and media

Pretreatment Facility/Construction Project Acquisition Manager, Hanford Tank Farms

- Managed and oversaw all tank waste infrastructure projects acquisitions (tank farms upgrades and line items) and the initial pretreatment module (pretreatment of Hanford tank waste) supporting the tank waste remediation system (TWRS) mission
- Responsibilities included day-to-day management of project planning, design, and construction activities, including baseline and technical management, contract management and procurement, and life-cycle cost and schedule analysis. Project life-cycle costs were in excess of $1 billion.

EBASCO, Inc. (Lakewood, Co) **1985 – 1991**

Project Engineer, DoD Rocky Mountain Arsenal

Responsible for several projects that were part of a series of multidisciplinary tasks conducted to assess the nature and extent of contamination resulting from over 40 years of various chemical-manufacturing plants. Contaminants included chemical warfare agents, organic solvents, heavy metals, and pesticides. Also:

- Supported development and submission of RCRA remedial investigation for soil and groundwater contamination caused by leaking chemical sewers and contaminated sanitary sewers
- Evaluated and upgraded wastewater treatment system for the removal of organics, pesticides, and fluorides to come into compliance with Federal and State NPDES permit requirements.

Steve Reese, PhD — Irradiation Services Manager

Education, Certifications and Affiliations

- PhD, Radiological Health Sciences, Colorado State University, 1997
- BS, General Science, Oregon State University, 1991

Years of Experience

- 22 years (total)
- 19 years in research reactor operations
- 2 years research scientist at DOE site

Work History

- 1997 – present, Oregon State University
- 1991 – 1993, PNNL

Relevant Highlights

- For the last 12 years, Level 2 for NRC License R-106, as the Director of the OSU Radiation Center
- Responsible for 20-year license renewal, including writing the safety analysis report, for NRC License R-106
- Project coordinator for the conversion from HEU to LEU for license R-106, including safety and accident analyses
- Extensive experience in research reactor operations, including holding Senior Reactor Operators license for 18 years, implementation of the 10 CFR 50.59 change process, and management responsibility for the emergency response plan, physical security plan, and operator requalification plan
- Author of numerous peer-reviewed publications on neutron radiography, special nuclear materials detection, reactor operation, skin dosimetry, reactor dosimetry, and numerical modelling of research reactors

Experience Overview

Steve Reese is the Director of the Oregon State University (OSU) Radiation Center and instructor in the Department of Nuclear Engineering and Radiation Health Physics. The OSU Radiation Center is a multifaceted research facility specializing in research related to the nuclear sciences. The facility houses unique capabilities, including the 1.1 MW Oregon State TRIGA reactor (OSTR), gamma irradiator, thermal hydraulics testing laboratories, radiochemistry laboratories, and extensive radiological spectral and counting equipment. His research focus includes neutron radiography, Monte Carlo N-Particle (MCNP) code, isotope production, and reactor dosimetry.

Dr. Reese also holds a Senior Reactor Operating license for the OSTR. He is certified by the American Board of Health Physics and is a member of the Organization of Training, Research, and Test Reactor Executive Committee. Previously, Dr. Reese served as the Reactor Administrator of the OSTR for seven years. Prior to that, he served as a Research Scientist at Battelle Pacific Northwest National Laboratory. Research activities at Battelle centered on development of a CR-39 automated counting system for low-energy neutron environments and responsibility for nuclear accident dosimetry technical evaluations and measurements.

He has served on several committees that involve reactor operations, utilization, and safety. With respect to safety, he currently holds positions on the Reactor Safety Committee for Reed College, serving as the chairperson from 2006–2008, and the Reactor Operations Committee for the OSTR. These committees perform audits of reactor operations, maintenance and surveillance schedules, emergency planning, Title 10, *Code of Federal Regulations*, Part 50.59 (10 CFR 50.59) screens and evaluations, radiation protection, and experiment review and approval.

Dr. Reese has extensive regulatory and license experience. He was responsible for the coordination, submission, and review of a 20-year NRC reactor license renewal application and a safety analysis report in support of conversion from high-enriched uranium (HEU) fuel to low-enriched uranium (LEU) fuel, both of which were successfully granted/approved in 2008. Additionally, he has a thorough understanding of the process for making modifications to a facility under 10 CFR 50.59.

Reflective of his recognized expertise in research reactor operations, Dr. Reese has served on several federal advisory committees and was requested as a technical expert on several International Atomic Energy Agency (IAEA) missions to support workshops, meetings, or consultancies. He is also active in Test Research and Training Reactors (TRTR), Health Physics Society (HPS), American Nuclear Society (ANS), and American National Standards Institute (ANSI), where he serves on the Research and Advanced Reactor Consensus Committee and is the working group chairperson for two national standards.

Selected Publications

Schickler, R.A., and Reese, S.R., 2017, "Installation of a Second CLICIT Irradiation Facility at the Oregon State TRIGA Reactor," *2017 International Group on Research Reactors Annual Meeting*, Sydney, Australia.

Marcum, W.R., Byfield, P.Y., and Reese, S.R., 2015, "Steady State Thermal Hydraulic Analysis of a Molybdenum Production Element for Implementation in TRIGA® Reactors," *Nuclear Sci and Engr 180*, 123-140.

Schickler, R.A., Marcum, W.R., and Reese, S.R., 2013, "Comparison of HEU and LEU Neutron Spectra in Irradiation Facilities at the Oregon State TRIGA Reactor," *Nuclear Engr and Design 262*, 340-349.

Hartman, M.R., Keller, S.T., Reese, S.R., Robinson, B., Stevens, J., Matos, J.E., Marcum, W.R., Palmer, T.S., and Woods, B.G., 2013, "Neutronic Analysis of the Oregon State TRIGA® Reactor in Support of Conversion from HEU to LEU Fuel," *Nuclear Sci and Eng 174*, 135-149.

Hamby D.M., Lodwick, C.J., Palmer, T.S., Reese, S.R., Higley, K.A., Caffrey, J.A., Sherbini, S., Saba, M., and Bush-Goddard, S.P., 2013, "The New VARSKIN 4 Photon Skin Dosimetry Model," *Rad Prot Dosimetry, 154(3),* 365-363.

Marcum, W.R., Palmer, T.S., Woods, B.G., Keller, S.T., Reese, S.R. and Hartman, M.R., 2012, "A Comparison of Pulsing Characteristics of the Oregon State University TRIGA Reactor with FLIP and LEU Fuel," *Nuclear Sci and Eng 171*, 150-164.

Hamby, D.M., Lodwick, C.J., Palmer, T.S., Reese, S.R., and Higley, K.A., 2011, "VARSKIN 4: A computer Code for Skin Contamination Dosimetry," NUREG/CR-6918, U.S. Nuclear Regulatory Commission, Washington, D.C.

Campbell, L., Misner, A., Smith, L.E., Reese, S.R., Robinson., J.A., 2010, "High Energy Delayed Gamma Spectroscopy for Plutonium Assay of Spent Fuel," IAEA-CN-184/128, International Atomic Energy Agency, Vienna, Austria.

Marcum, W.R., Woods, B.G., and Reese, S.R., 2010, "Experimental and Theoretical Comparison of Fuel Temperature and Bulk Coolant Characteristics in the Oregon State TRIGA® Reactor during Steady State Operation," *Nuclear Engr and Design 240*, 151-159.

Robinson, J.A., Hartman, M.R., and Reese, S.R., 2010, "Design, Construction and Characterization of a Prompt Gamma Activation Analysis Facility at the Oregon State University TRIGA® Reactor," *J Radioanal Nucl Chem 283*, 359-369.

Ashbaker, E., Reese, S.R. and Greenwood, L., 2005, "Characterization of the Neutron Spectra in Various Oregon State University TRIGA® Reactor Irradiation Facilities", Health Physics 89, 74-75.