nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

September 2003

NWMO BACKGROUND PAPERS
8. WORKSHOP REPORTS

8-2 WORKSHOP ON THE TECHNICAL ASPECTS OF NUCLEAR FUEL WASTE MANAGEMENT

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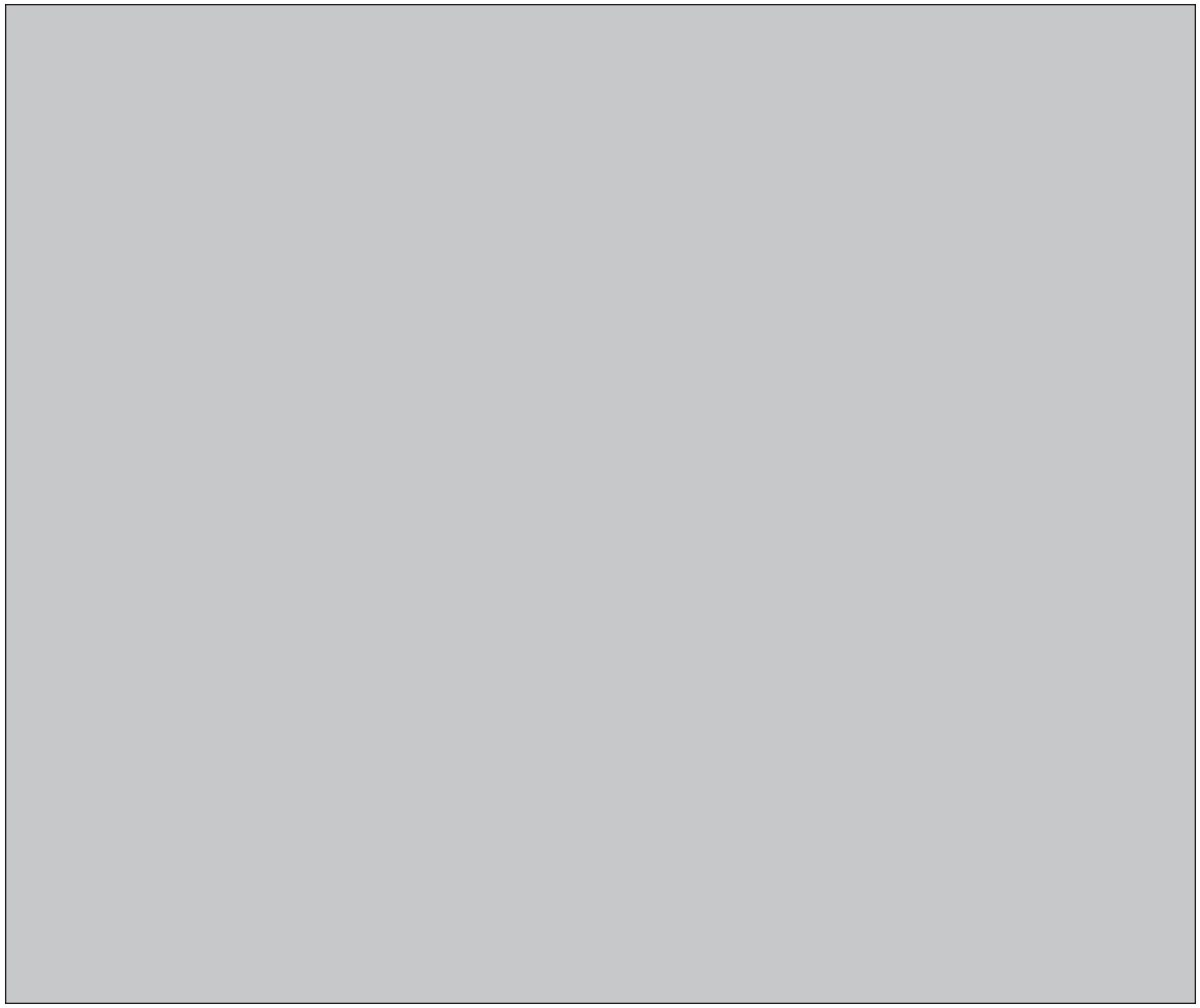

WORKSHOP ON THE TECHNICAL ASPECTS OF NUCLEAR FUEL WASTE MANAGEMENT

INTRODUCTION

This meeting was organized by the McMaster Institute for Energy Studies to assist the NWMO in its mandate to stimulate a wide ranging public discussion on nuclear waste management issues. Based on the Nuclear Fuel Waste Act (NFWA) of November 15, 2002, the NWMO is required to assess approaches to the long-term management of nuclear fuel waste and to recommend a suitable management plan. The act requires that the NWMO assess at least three distinct options:

- Deep geological disposal
- Storage at nuclear reactor sites
- Centralized storage above or below ground.

The primary purpose of this workshop was to identify the key issues, questions and concerns that need to be addressed from a technical perspective if the above mandate is to be met. The meeting was attended by 50 to 60 participants from various universities, nuclear energy organizations, and technical and consulting companies with a wide range of expertise, interests, and commitments.

The context of the meeting was set by a plenary address by Phil Richardson of Enviros Consulting (UK). This address reviewed the many different international proposals and scenarios for dealing with nuclear waste management. Without attempting to prejudice the discussions to follow, he divided these scenarios into categories defined by the present level of international interest expressed in each of them.

Subsequently, the workshop divided into separate morning and afternoon sessions to deal with (in the morning)

- Active versus passive approaches to waste management;
- The technology and time horizons involved in the various management options;
- A discussion on whether nuclear fuel should be considered waste or not.

In the afternoon, the morning deliberations were used as a template for more detailed technical discussions on the following;

- On-site and off-site storage

- Permanent disposal options;
- Fuel reprocessing

Each of these sessions was charged with the following mandate;

- The identification of the key issues pertaining to the particular approach or option;
- The definition of approaches required to address the issues identified;
- The specification of the questions that need to be addressed by the NWMO with respect to the technical aspects of nuclear fuel waste management.

The conclusions from these discussions were then presented and discussed more widely in morning and afternoon plenary sessions. Here, the key issues and concerns raised and discussed at the workshop are summarized.

ACTIVE versus PASSIVE

In general terms storage can be seen as an active option and disposal as a passive one. More specifically, however, all options are initially active and become passive to varying degrees with time. The extent to which this transition from active to passive occurs defines the storage option and whether, in the longer term, it metamorphoses into permanent disposal, where permanent disposal means the foregoing of retrieval.

Regardless of the eventual recommendations of the NWMO to Parliament, the active management of spent fuel at reactor sites will be required in the immediate future. Accordingly, utilities have designed storage casks and implemented plans to store spent fuel. An eventual decision either to continue on-site storage or to proceed to off-site storage or permanent disposal will influence the decision on the type of storage cask used; i.e., whether it is designed for transportation, storage or permanent disposal.

The following key issues were defined;

- While the expertise to implement and maintain active options may presently exist, will this be the case in the longer term? For instance, after a long period of interim storage will the expertise to revive a specific active option in a safe and cost effect manner still exist?
- Will those institutions responsible for the implementation of an option be sufficiently durable and vigilant to achieve the objectives of a long term active management plan that may initially be put in place?
- If a decision is made to adopt a highly active option such as reprocessing following a period of less active short term storage will the industry be

sufficiently durable, and the expertise well enough developed to implement it in an efficient manner?

- What will be the consequences in terms of cost, public and worker safety, and challenges to the environment of initiating an active option only to find it rendered unacceptable by evolving political and social attitudes?

Considering the nature of the spent fuel, any decision to adopt a longer term active management option should be based on economic, social risk and environmental assessments. A strategy for an on-going risk analysis is also necessary.

Of the three options that must be considered by the NWMO, storage at reactor sites must be considered an active option requiring on-going monitoring and risk assessment. Centralized storage or permanent disposal would be initially more active options, since additional features such as site construction and security and waste transportation would be involved. Eventually the management plans for both options, especially the permanent disposal option, would become more passive.

TECHNOLOGY AND TIME HORIZONS

A key conclusion from these discussions was that it is already inevitable that the dominant management mode over the next 50 to 100 years will be storage even if the recommended mode is permanent disposal. This conclusion is based on reasonable estimates of times required to complete the necessary social and technical procedures for the implementation of a permanent disposal plan. These estimates were based on the following allowances:

- 10 years for site selection;
- 10 years for site assessment and approval;
- 10 years for construction and licensing;
- 30 to 50 years for waste emplacement and on-site operations.

Based on these estimates, the very earliest waste could be placed in long term off-site storage or in a permanent disposal site would be approximately 30 years. Current dry storage methods are expected to last 50 years or more, so there is no technical urgency to implement a permanent disposal plan. Given the presently existing uncertainties about the long term future of nuclear power, this inevitability can be considered fortuitous, since it offers considerable leeway in the decision making process, allowing either the adoption of a second fuel cycle via reprocessing or a step-wise progression from storage to permanent disposal over a longer timeframe.

A second conclusion based on these estimates is that storage and disposal are not necessarily distinct options, but a staged approach to permanent disposal allowing

retrievability for 100 years or more depending on the specific time sequence of chosen events. Since there is no foreseeable limitation to on-site storage capacity, a number of storage refurbishment cycles can be envisaged, allowing on-site management of the wastes for 200 to 300 years. The possibility of on-site storage for such a protracted period has been considered by Ontario Power Generation. This suggests that there is no economic driving force for the introduction of a costly centralized storage facility, unless it is intended to operate the facility for times in excess of such refurbishment cycles.

One consideration when deciding on an optimum period of storage is the rate of decay of radioactivity within the fuel. The dangerous gamma radiation fields will decay to effectively innocuous levels over a period of 300 to 1000 years, which coincides with the likely periods for on-site (200 – 300 years) and central storage ($\geq$ 1000 years). This means that fuel management will be an active process (more or less active depending on the storage location and method chosen).

There are pros and cons to this situation. Such an active scenario may be deemed socially attractive, since waste would be under surveillance during its most toxic period. However, it could also be deemed unacceptable, since the fuel would be more susceptible to risks of various kinds and would remain accessible until it had achieved a more benign state that would facilitate its handling and possible further processing for weapons purposes.

Thus, while there may be no economic driving force for central storage or disposal, there could be a social one, depending on the public's perception of the dangers associated with spent fuel. There is the possibility that long term storage will be perceived as a reluctance of the nuclear industry to deal with its wastes, thereby conferring on future generations an unjustified burden. This could induce public pressure to close down the nuclear industry.

IS NUCLEAR FUEL WASTE OR A SLIGHTLY DEPLETED RESOURCE?

It was agreed that, according to the normal industrial definition, used fuel should not be considered waste. It is, in reality, a degraded (or poisoned) resource and should be considered no differently to other industrially produced materials that can potentially be recycled for resource recovery. Any decision on whether it should be recycled (or reprocessed, to use accepted nuclear terminology) should be based on criteria similar to those which would be applied to any other potentially recyclable industrial product. These criteria would be based on accepted economic, social and political principles and assumptions.

Before any decision on reprocessing is taken, a number of key issues need to be considered:

- To commence reprocessing is to engage in a very active technology that is acknowledged to be difficult. A well-defined, publically explained purpose for undertaking the procedure would have to be offered. Would the primary purpose of reprocessing be, (a) to initiate a second fuel cycle using retrieved fissile/fertile material; (b) to produce a more benign waste form that would facilitate the disposal process; or (c) a combination of both?

- Would a decision to initiate a second fuel cycle make economic sense in Canada, given the existing uncertainties over nuclear power and the fact that Canada is the world's primary producer of the raw uranium resource?

- If the primary purpose is to initiate a second fuel cycle, how would the decision be perceived internationally, given that some countries presently capable of reprocessing are reconsidering the option?

- Is there a technical case to support the claim that reprocessing would produce a more benign or readily handled waste form?

- Since to commence reprocessing is to take the first steps in producing nuclear weapons, consideration must be given to the issue of weapons proliferation and the potential security and terrorist risks that this would introduce.

- Given the indecision over the future of nuclear power and the viability of on-site storage, is a decision on whether or not to reprocess necessary in the near future (20 to 30 years)?

STORAGE OPTIONS

A number of key issues were identified:

- The need for a clear definition of the meaning and purpose of storage;

- The need to decide the location of one or a number of storage sites;

- The technical and security issues surrounding repackaging (the placing of spent fuel bundles in new casks) and transportation;

- The need to determine whether there are time and/or spatial restraints on specific storage technologies;

- The question of whether Canada has any international responsibilities for CANDU used fuel inventories, since CANDU reactors have been sold internationally.

Definition of Storage

Fuel storage can be considered either as an interim solution or as a first step to final disposal. One possible purpose for storage is to bridge a gap between a primary fuel cycle and a second one based on recycled (reprocessed) fuel. Such an option would be short term and would allow time for the present uncertainties over the future of nuclear power to be resolved. The need for short term storage appears inevitable (see above), and presently available technologies appear adequate to guarantee safe storage for well beyond 50 years.

A second purpose of storage is as a first step on the route to permanent disposal. Given that the choice, assessment and licensing of a permanent disposal scenario and site will take a considerable length of time, storage for this purpose could be required for a long time. It is essential that the technology for interim storage be robust and demonstrated to be safe, especially if there is a possibility that storage is the first step to disposal.

The Storage Location

There are two clear possibilities; (i) storage at presently existing nuclear reactor sites (on-site storage); (b) storage at one, or more, centralized locations (off-site storage).

On-site locations are already determined by the location of the reactors generating the used fuel. Presently, fuel is stored at these sites, either in storage pools at the reactor location, or in above-ground dry storage containers within the reactor site exclusion zone. Considerable study has gone into the design and performance assessment of the dry storage process, and safe storage for ≥ 50 years seems reasonably assured. However, since most Canadian reactors are close to significant urban populations, the question of security and public acceptability of on-site storage become issues.

Off-site storage is not, to date, an option that has received major attention. It would appear to be one step along the pathway to permanent disposal. It would also be more expensive than on-site storage, since the period of storage would be longer and advanced technologies closer to those considered for permanent storage would need to be developed. A major geological/ecological study of potential sites would have to be undertaken. The development of an off-site location would have the advantage of centralizing storage potentially making site security, maintenance and monitoring easier. The size of this advantage would depend on the nature, location, and management of the site. For instance, while security would be enhanced by underground storage at a remote location, the ability to monitor would be made more difficult.

Both on-site and off-site storage would require an active monitoring program. One suggestion was to develop the monitoring techniques, but to make the monitoring process independent of the nuclear industry. This would allow the public, through its own chosen technical representatives, to decide whether storage was a safe maintainable option.

Repackaging and Transportation

While presently existing on-site technologies for wet and dry storage can be considered adequate for well beyond 50 years, any longer period of on-site or off-site storage would require that the waste be repackaged in new casks. Opinion was that this would be required approximately every 100 years. This seems an expensive and involved procedure, especially if the nuclear option had by then been abandoned. If, however, an initial period of storage was a first step to permanent disposal, then it would have the advantage of allowing advances in materials technology and, hence, the adoption of an advanced package technology. This advanced technology could then allow further extended storage or permanent disposal, depending on prevailing opinions and attitudes at the time.

If the decision is to proceed with off-site storage, then it would be necessary to transport the waste from the reactors to the central storage site. Package designs for transportation have been considered internationally and robust designs are available. Consequently, the primary concerns with transportation would be route selection and security not technical issues.

Time and Spatial Constraints

Available on-site storage space appears adequate for the anticipated volumes of used fuel from present reactor operations, and a minimum period of 30 to 50 years of on-site storage appears inevitable. Thus, there is no immediate technical need to decide on alternative storage options. Given the undecided future of the industry, this is a significant benefit. Even if new reactors were built, this 30 to 50 year period would not be reduced, since, presumably, they would be built with wet and dry fuel storage capacities at least equal to those of the presently operating reactors. As the end of that period was approached the issues of repackaging with advanced technologies, transportation and central storage site location would become of more immediate concern.

Importing Spent Fuel

As a primary uranium producer and exporter of CANDU reactors and technology, it may be to Canada's benefit to repossess spent fuel wastes as a possible recyclable resource or as an international service to facilitate its disposal and prevent weapons proliferation. While the economic incentive could be large, significant ethical and social issues would arise. On the technical front such a decision could pose a challenge to available storage space (presumably off-site space).

Key Concerns

There is the possibility that a storage site initially defined as temporary could become permanent. This would present licensing and social issues, particularly for on-site storage, since the original site licensing agreements which specified storage would only be temporary.

- While it might be possible to design a remote central storage site, on-site storage sites are dictated by reactor location. Some of these sites are in urban areas undergoing substantial population growth. As a consequence, the public perception of the acceptability of these sites could change as development progressed.

- If new nuclear reactors are constructed, on-site storage facilities would proliferate. This could have a significant impact on security and public perceptions of safety and, hence, on their licensing.

- To date, no debate has taken place on whether a large number of on-site storage facilities will be more acceptable to the public than a single centralized location.

- Who should control the site monitoring; the utilities responsible for the waste or an independent regulatory body or organization?

- To date, no debate has taken place on whether or not it is acceptable for Canada to accept spent fuel produced off-shore.

DISPOSAL OPTIONS

The distinction between long-term off-site storage and permanent disposal will not necessarily be clear to the public. This would not be surprising, since the two are not opposing options, and a flexible policy of storage followed by disposal is a technically attractive one. However, in building flexibility into storage/disposal options, the boundaries between the two could become confusing. It was suggested that one simple way to make this distinction clear is to define storage, in whatever form it is adopted, as a management option which always retains the possibility of retrieval, whereas disposal precludes the possibility of retrieval except under emergency conditions. While this definition may appear clear, it does not address the factors controlling a decision to dispose of, rather than store, the spent fuel. The main factors controlling such a decision are likely to be economic and social.

To date, only one permanent disposal option has been seriously considered; deep disposal in the Canadian Shield, the option developed by AECL/OPG and reviewed in the Seaborn report. There is a concern that the sheer volume of information available on this option will preclude the serious consideration of viable alternatives, especially since the Seaborn report found the technical case for Canadian Shield disposal acceptable. In addition,

much of the information and understanding of these geological formations was developed collaboratively with the Swedes and Finns, and the Finnish decision to proceed with disposal deep in granite may prove a persuasive precedent.

A key issue for any permanent disposal site (or underground storage site for that matter) will be the cost and time required to characterize the site to the degree required to justify its acceptance. Economically, this makes the choice of an alternative to granitic disposal in the Canadian Shield difficult. Thus, economic practicality suggests that the consideration of alternative geologic formations should focus on those for which some international experience is already available. These formations include, consolidated clays (Belgium, Switzerland), salt domes (Germany) and arid desert environments (USA).

For economic reasons, scientific and technical investigations must be focused on a small number of possible sites. This introduces a dilemma. Is the process of site evaluation and selection started by designating a specific region and then looking for a site within it, or is it started by targeting one specific kind of site and then looking for a region which contains one?

However, it was noted that support for disposal sites in Sweden and Finland, and for a low level waste repository in Deep River (Ontario), shows that support for a storage/disposal site is more likely in a presently existing nuclear community than elsewhere. Thus, there is a strong possibility that social criteria will be at least as important as technical ones in the site selection process.

As reviewed by Richardson in his plenary address, number of other options exist but presently generate only marginal interest internationally. Despite this it would be prudent to maintain a watching brief on these options, especially the possibility of transmutation.

Key Concerns

- If on-site disposal is chosen as a viable option, then existing licensing agreements defining these sites as temporary would need to be renegotiated.

- Given the previous focus on, and intense study of, granitic sites within the Canadian Shield, how will the NWMO achieve its mandate to evaluate other sites to a degree that will allow their feasibility as alternative sites to be comparatively evaluated?

- For economic reasons, scientific and technical investigations must be focused on a small number of possible sites. How will the NWMO approach the need to balance the gathering of technical information for site selection against the procurement of public approval?

- Can this dilemma be at least partially preempted by clearly defining technical and social criteria that define what will be an acceptable site before site investigations begin?

- It is not clear that a meaningful non-intrusive monitoring program can be designed for deep geologic disposal.

FUEL REPROCESSING

It was acknowledged that, presently, reprocessing of used fuel is not an available technology in Canada, and its association with the first steps in producing weapons is firmly rooted in the public's mind. This apparent disadvantage is offset by the fact that reprocessing opens up a wide range of possibilities for fuel management. Not only does it introduce the possibility of a second fuel cycle to enhance the nuclear option, it also increases the options available for storage and disposal.

It introduces the possibility of a reduction in volume of the waste. By separating the highly radioactive fission products from the low activity alpha emitters, it introduces the possibility of separate waste streams. The highly active fission products could be incorporated into a waste form with a much smaller volume than the original fuel wastes. Their disposal would then require much smaller facilities. The residual low activity "waste" would be much more benign and its storage and disposal might be more easily and less contentiously achieved.

To date, the economic viability of this last argument is untested. It was agreed that, for reprocessing to become a viable option the economic need for a second fuel cycle would have to be demonstrated.

While strictly not a fuel reprocessing procedure, transmutation is a technology that is being investigated to convert the spent fuel waste to a more innocuous form using elemental transformations induced in the fuel by bombardment with energetic particles such as neutrons or protons. It is presently the subject of research programs in a wide range of countries. Despite its potential, it remains an unproven practical method for waste management. However, given the inevitability of many years of storage of spent fuel wastes, there is ample opportunity for progress in the research underway, and developments in this area should be monitored.

Key Concerns

- Since reprocessing technology does not presently exist in Canada, should it be built or should the option be adopted using off-shore facilities?

- The advantages to be gained by volume reduction and the introduction of dual waste streams are not presently well defined.

- It would be necessary to address the issues of cost, operating safety and security, and weapons proliferation.

SUMMARY OF GENERAL CONCLUSIONS

- The boundaries between storage and disposal are not well defined, and one can view fuel waste management as a flexible set of options encompassing short term on-site storage, longer term central (off-site) storage and permanent disposal. This flexibility is an asset considering the present uncertainties surrounding the nuclear power option.

- Storage of spent fuel is a less expensive option to build and operate and allows the fuel to be more readily retrieved. However, it requires active management and monitoring, and a societal commitment by future generations.

- Of the two possible storage options, on-site at reactor locations and off-site at a central facility, the second may be more secure but could make retrieval more difficult and costly.

- Permanent disposal is a more costly option, initially requiring active management to ensure safety and security, but becoming a passive option once achieved. The societal obligations of future generations would be minimal, but fuel retrieval would be very expensive.

- On-site storage is inevitable, at least for the next fifty years or more, irrespective of any decision made on longer term storage or disposal options. This necessity is based on reasonable estimates of the time required to assess, select, license and construct a longer-term storage or final disposal site.

- This inevitability leaves considerable leeway for the decision-making process on long-term management.

- A fifty-year period of storage leaves a number of options open for the future. These include, (i) a further extended storage period; (ii) permanent disposal; (iii) fuel reprocessing to initiate a second fuel cycle. The chosen option would depend on economic factors and public attitudes at the time.

- Spent fuel management should not be considered in isolation of other nuclear fuel cycle issues, such as reactor decommissioning wastes.

- Nuclear fuel wastes should not be judged by a different standard to that used in the consideration of other industrial wastes.

**WORKSHOP ON THE TECHNICAL ASPECTS
OF NUCLEAR FUEL WASTE MANAGEMENT**

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WORKSHOP ON THE TECHNICAL ASPECTS OF NUCLEAR FUEL WASTE MANAGEMENT

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Speakers and Facilitators

ELIZABETH DOWDESWELL
Elizabeth Dowdeswell has had an extensive career in government, education and international affairs. She has served as Executive Director of the United Nations Environment Program, permanent representative to the World Meteorological Organization, principal delegate to the Intergovernmental Panel on Climate Change and Canadian Chair of the Great Lakes Water Quality Board. Throughout, her focus has been on bringing the public into public policy making. A former Assistant Deputy Minister of Environment for Canada, Ms. Dowdeswell has been a member of numerous Canadian and international boards, advisory panels and commissions.

DAVID JACKSON
David P. Jackson is currently Adjunct Professor of Engineering Physics at McMaster University where he teaches nuclear engineering courses. Since early 2001 he has been a primary player in establishing the University Network of Excellence in Nuclear Engineering, a consortium of universities and industry with the objective of preserving and enhancing nuclear education and research in Canadian universities. In addition to the technical aspects of his field, he is also interested with the broader issues of the management of technological systems and public communications with applications to the nuclear area. David is a research associate of the University of Ottawa's Program on Research in International Management and Economy and was a member of McMaster's theme school on Science, Technology, and Public Policy where he taught a course on Science and Technology in the Media and co-managed a Consensus Conference on municipal waste options for the city of Hamilton. He is coauthor with Hans Tammemagi of Unlocking the Atom:the Canadian Guide to Nuclear Technology, published in 2002, a book intended to explain to the layperson a broad gamut of nuclear technologies. Having obtained his Ph.D. in Engineering Physics from the University of Toronto in 1968, David then joined Atomic Energy of Canada Ltd. as a scientist at Chalk River Laboratories doing research in particle solid interactions phenomena including plasma-wall interactions. He has held a number of university and visiting scientist positions including a year as visiting scientist at the Max Planck Institute in Germany. In 1982, as manager, he initiated the fusion breeder blanket program at Chalk River Laboratories for the Canadian Fusion Fuels Technology Project (CFFTP) and became Manager, Fusion in 1985. From 1987-1997 he was Director of Canada's national fusion program and was the federal official responsible for CFFTP and the CCFM laboratory at Varennes, Quebec. David has represented Canada on a number of senior international committees including the International Fusion Research Council of the International Atomic Energy Agency of which he served as chair from, 1993 to 1998. With support from Natural Resources Canada, he continues to represent Canada on the International Energy Agency's Fusion Power Coordinating Committee. He was a member of the federal government's Panel on

Energy Research and Development from 1985 to 1997. He is a past President of the Canadian Nuclear Society, a Director of the Canadian Nuclear Association and a former member of the Partnership Group on Science and Engineering. Now consulting on nuclear and energy topics through his company David P. Jackson and Associates Limited, in 1999 he designed, coordinated and wrote a successful proposal to the Canadian Foundation for Innovation to establish an Institute for Applied Radiation Sciences based around the McMaster Nuclear Reactor.

DONALD LUSH
Donald Lush entered the consulting industry in 1973 after completing his Ph.D. in the study of movement of radio-labelled organic materials through groundwater and surface water systems. He has extensive experience in the evaluation of human activities on the natural environment. His experience ranges from domestic activities such as work with the Canadian Nuclear Safety Association and Ontario Power Generation, to international involvement including association with multilateral organizations (OECD, IEA), and in several countries including the US and Germany.

ROBERT MORRISON
Robert Morrison is a senior research associate and an adjunct research professor at Carleton University. From 1980 to 1997 he was Director General of Uranium and Nuclear Energy at Natural Resources Canada (NRCan). Since 1997 he has consulted for NRCan, Ontario Power Generation, the Department of Foreign Affairs and International Trade and the Organization for Economic Co-operation and Development. He has a degree in engineering physics from McGill University and a doctorate in experimental physics from the University of Paris.

DEAN MOUNTAIN
Dean Mountain, Director of the McMaster Institute for Energy Studies, is Professor of Finance and Business Economics at McMaster University. He obtained his Ph.D. in Economics from the University of Western Ontario in 1979. His principle areas of expertise and research interest are in energy/electricity economics and applied econometrics. Dean has over twenty years of professional and academic experience in the areas of electricity and energy economics, load research, statistical analyses of demand management programs, evaluation of new electricity rate
structures, and the building of aggregate and end-use electricity and energy forecasting models. He has consulted extensively in these areas. His clients have included Ontario Hydro, Manitoba Hydro, Nova Scotia Power Corporation, Consumers Gas, Centra Gas Manitoba Inc., Electricity Independent Market Operator of Ontario, Hydro One Networks Inc., Natural Resources Canada and Environment Canada.

PHIL RICHARDSON
Phil Richardson has a BSc in Geology from Hull University. He is a Chartered European Geologist and a Fellow of the Geological Society. Phil has over 27 years experience, including 13 years in the coal mining industry. He became an independent consultant in 1988, and has built up a detailed knowledge of national radioactive waste management programmes and a reputation as an independent reviewer of deep geological disposal. He

took up a senior position as a Principal Consultant with Enviros Quantisci in 1999, and is now a Technical Manager at Enviros Consulting. Phil has advised Local and State Governments and national agencies in the United Kingdom, United States, Sweden, Japan, and Germany on global radioactive waste disposal issues, and currently maintains a subscription-based website supplying information on 18 national radioactive waste management programmes and nuclear site remediation. Within Enviros, Phil works on a wide range of projects dealing with public and stakeholder involvement and participation in siting hazardous facilities, as well as other technical issues related to geoscientific aspects of radioactive waste management and disposal.

DAVID SHOESMITH

David Shoesmith is a Professor in the Department of Chemistry and specializes in research on the electrochemistry of materials and corrosion science. He has held this appointment since June 1, 1998. He presently holds the Natural Sciences and Engineering Research Council and Ontario Power Generation (NSERC/OPG) Industrial Research Chair in Nuclear Fuel Disposal Chemistry. Previously, he worked for Atomic Energy of Canada Ltd for 25 years, achieving the rank of principal scientist. Since 1980 he has been an active researcher in the Canadian Nuclear Waste Disposal Program, and is an international expert on waste container/waste package issues. He is an elected fellow of the International Association of Corrosion Engineers (1996) and the Canadian Society for Chemistry (1985). He has won awards from the Electrochemical Society (Lash Miller), the Canadian Society for Chemistry (Manitoba Chemist of the Year), and Atomic Energy of Canada (Discovery Award). He has written over 120 refereed publications and approximately 90 technical and commercial reports. Approximately half of these publications are in the area of Nuclear Waste Disposal Studies. David's current research interests include Nuclear waste disposal studies on fuel, containers and cladding; Modeling of corrosion processes in consolidated media (soil, concrete, etc); Localized corrosion of metals and alloys; Hydrogen in metals; Properties of thin films on materials; and Neutron reflectometry.

MAMDOUH SHOUKRI

Mamdouh Shoukri has served as McMaster University's Vice-President, Research & International Affairs, since July 1, 2001. Before becoming the Vice-President, Mamdouh was the Dean of the McMaster's Faculty of Engineering since 1994 and, prior to that, served as the Chair of the Department of Mechanical Engineering for four years. An expert in energy conversion and utilization, nuclear reactor thermal-hydraulics and nuclear safety research, he came to McMaster in 1984 after seven years in the nuclear industry with Ontario Hydro. He is a fellow of the Canadian Society for Mechanical Research and a consultant to a number of Canadian and U.S. companies.

Currently, Mamdouh is responsible for all research activities within McMaster University and for the aggressive pursuit of new partnerships, nationally and internationally, designed to capitalize on McMaster's significant research strengths.

Established in 1887, McMaster University is one of Canada's top research-intensive universities with an international reputation for innovation and excellence. It offers undergraduate and graduate programs to more than 17,000 full and part-time students in business, engineering, health sciences, humanities, science and social science.

Workshop Participants

GEORGE BEREZNAI

George Bereznai is Professor and Dean of the School of Energy Engineering and Nuclear Science at the University of Ontario Institute of Technology, in Oshawa. George received the PhD degree from McMaster University in 1972, and subsequently worked for Ontario Hydro in the area of nuclear training simulators. Between 1995 and 2001 he was Atomic Energy of Canada Limited's Chair Professor in Nuclear Engineering at Chulalongkorn University in Bangkok, Thailand, where he was responsible for the planning and delivery of a nuclear human resources development project that included courses in nuclear waste management.

CAROLE BURNHAM

Carole Burnham is the Principal at Carole Burnham Consulting, providing strategic and advisory services in climate change, sustainable development and environmental and hazardous waste management. In Carole's extensive career in the environment, she has worked in consulting, academic research, government and industry.

Carole was Ontario Hydro's first corporate environmental director, where she was responsible for Canada's first public corporate environmental report, for the introduction of a corporate environment management system, for the drafting of a plan for the management of used nuclear fuel and for the introduction of emission reduction trading in Ontario. She also served as the Ontario Ministry of Environment's PCB task force leader, developing guidelines for the regulation of mobile PCB destruction facilities in Ontario. In her role as Director, Resource Recovery and Recycling, at Hatch, she expanded Hatch's practice in technology development, evaluation and commercialization of metals recovery.

Carole has organized conferences, appeared before commissions and co-authored numerous papers on environmental issues. Her diverse career has provided her with an extensive knowledge and understanding of the effects on the environment of metals and minerals, electrical generation facilities and hazardous waste management facilities.

A Fellow of the Air and Waste Management Association and a Diplomate of the American Academy of Environmental Engineers, Carole is a Past Chair of the Canadian Environment Industry Association.

LUIGI COTESTA

Luigi Cotesta obtained a Bachelor of Science in Civil Engineering from the University of Ottawa in 1997 and has since been involved with the Mining Innovation, Rehabilitation and Applied Research Corporation (MIRARCO). He has worked on various projects related to the Geotechnical

and Mining Engineering fields, involving field investigations, design of new laboratory/field testing methods, 3-D numerical modeling, 3D visualization, data integration techniques and computer programming/software development. Recently he has helped pioneer the use of Virtual Reality (VR) in the minerals industry for decision-making and is currently the Manager of MIRARCO^Òs Mining Exploratorium; the mineral industry's first collaborative immersive Virtual Reality Laboratory (VRL)

designed to allow multi-disciplinary teams to understand complex datasets, while improving the overall quality of decision-making. Luigi's main research interests lie in n-dimensional visualization techniques and he is currently involved in the second phase of Ontario Power Generation's 3D Geoscience Visualization program, one of 17 studies conducted for the Deep Geologic Repository Technology Program (DGRTP).

KEN DORMUTH

Ken Dormuth is Director of Environmental Affairs and Technology for Atomic Energy of Canada Limited. He is a graduate of the University of Saskatchewan and the University of Alberta, where he specialized in theoretical physics. He joined AECL in 1971 as a reactor physicist and mathematical analyst where his work included modeling the behaviour of radioactive materials in the atmosphere and groundwater. He led the development of a risk assessment methodology for radioactive waste disposal. He held positions as a manager and senior manager of R&D related to nuclear waste disposal. From 1994 to 1998, Ken was Director of AECL's Nuclear Fuel Waste Management Program. In this position, he led AECL's participation as the proponent in the public review of the nuclear fuel waste disposal concept under Canada's Federal Environmental Assessment and Review Process. Ken has served on numerous international committees and study groups related to nuclear waste management and environmental aspects of nuclear power. He has been the Canadian representative on the Joint Technical Committee of the NEA International Stripa Project, the Canadian representative on the Waste Technology Advisory Committee of the IAEA, and the Canadian Project Director for a cooperative program of waste management research under an agreement between the United States and Canada.

PETER FLAVELLE

Peter Flavelle is the Senior Specialist in the Wastes and Geoscience Division of the Canadian Nuclear Safety Commission (formerly the Atomic Energy Control Board, AECB). His compliance verification and assessment work in the fields of geochemistry, hydrogeology, materials science, computer modeling, pathways analysis and waste management have been sufficiently diverse and interesting to have kept him with the nuclear regulator for the past twenty years. For the previous five years, Peter was seconded from Atomic Energy of Canada Ltd. to the National Hydrology Research Institute of Environment Canada, where he developed and implemented hydrogeologic and hydrogeochemical field testing procedures and equipment as part of the Canadian Nuclear Fuel Waste Management Program. Prior to that, for three years he held various contract and term positions doing environmental studies with the Glaciology Division of Environment Canada and with the Canada Center for Remote Sensing. Having graduated from Carleton University in 1975 with an Honours BSc in Physical Chemistry, Peter undertook graduate studies in geochemistry at Carleton University part-time after joining the AECB.

DANIEL FUNG

Daniel Fung is a Chemical Engineer with more than twenty eight years of experience. His areas of expertise are in nuclear waste, environmental management, decommissioning and regulatory affairs. In addition, he has experience in project management, primarily in the power generation and radioactive waste management field, and environmental

assessments and studies. Some of Mr. Fung's recent experience includes: co-ordination of, and negotiation on, project licensing/approval activities, the preparation of nuclear regulatory agency (CNSC) submissions for licensing of non-reactor safety materials such as high and low-level nuclear wastes. Specific projects include the Canadian Nuclear Fuel Waste Management Program, the CEAA EA and licensing of the Bruce Used Fuel Dry Storage Project, the Pickering Used Fuel Dry Storage Project and the Decommissioning of the Bruce Heavy Water Plant, Impact Analysis of CNSC Proposed Regulations and Regulatory Documents, CSA Proposed EA Standards for compliance with the CEAA, and the Lakeview Ash Management Study for a disposal site. Furthermore, Daniel has been a research engineer which has given him experience in initiating, designing and monitoring studies involving air, water and land environmental control for the two iron ore processing plants at Sept-Iles, P.Q. and Labrador City, Nfld. as well as for the research into and later operation of the flotation process in the 1000 ton per hour commercial plant for processing iron ore.

ROBERT GADSBY

Robert Gadsby has over 30 years of experience in the Canadian nuclear industry and has served in a wide variety of senior management positions with Atomic Energy of Canada Limited (AECL), during the period 1972 – 2003. Most recently, Robert was General Manager, Waste Management and Decommissioning – with responsibility for directing the development of AECL's Canadian and international waste management service business (including AECL's cooperative programs with the IAEA and other international waste management organizations, and recent Canadian initiatives in Russia to support the G-8 Global Partnership program). From its commencement in 1994, he was responsible for the leadership of AECL's Plutonium Disposition Initiatives – which involved the concept of turning "swords into plowshares" – working with the US Department of Energy and the Russian Ministry of Atomic Power on the possibility of fabricating CANDU MOX fuel from surplus weapons plutonium, for consumption in Canadian CANDU reactors. Robert lived for three years (1990-1993) in South Korea, as AECL's Vice President and Senior Representative, during the period when AECL successfully completed the contract negotiations and started construction on three new CANDU reactors for the Wolsong site. Following his return to Canada, he served as Deputy to the President of AECL's CANDU division, and also served as Vice President, for theYear 2000 Program for AECL. Born in Hamilton, Ontario, Robert received his Bachelor of Science degree in Physics from McMaster University in 1971 and his Master of Science degree in Nuclear Physics, in 1972.

MEL GASCOYNE

Mel Gascoyne has a BA (Chemistry), MSc (Environmental Sciences), both from Lancaster University (UK) and a PhD (Geology) from McMaster University. From 1982 to 1998 he worked on geochemical aspects of nuclear fuel waste disposal for AECL in Pinawa, MB and became a Senior Scientist in 1993. Now a geological consultant he specializes in water and rock chemistry and its application to nuclear waste disposal. In the last five years since leaving AECL Mel has been involved in a number of consulting contracts for document review, report preparation, isotopic and dissolved gases analysis

of groundwaters, short course presentation, and laboratory analytical methods. His clients include the British Geological Survey, SKB (Sweden), POSIVA OY (Finland), Ontario Power Generation, AECL (Canada), the US Dept. of Energy (Yucca Mountain Project), Duke Engineering (Canada), and NOVA Chemicals (Canada).

ELISE HERZIG

Elise Herzig was appointed Director Commercial Operations of the McMaster Nuclear Reactor ("MNR") in July 1996 with the mandate to create and implement a turnaround strategy for MNR's commercial operations. In this capacity she has positioned MNR as a viable business entity and world class centre with a unique combination of facilities, skills and people filling the needs of industry, research and student learning. Some accomplishment highlights include the Establishment of MNR as the second largest global supplier of Iodine I -125; Collaboration with industry/academic research partners towards the creation of McIARS - the McMaster Institute of Applied Radiation Sciences; and Negotiation for disposal of highly enriched uranium spent fuel to the United States Department of Energy.

Prior to this, Elise worked for eleven years as a consultant for a broad range of private and public sector organizations across Canada . Having worked in Canada, Europe and the United States she was a member of the Advanced Manufacturing Sectoral Advisory Group on International Trade (SAGIT) and is currently a member of the Medical and Health Care Products and Services SAGIT.

DOUG HINK

Doug Hink has twenty-seven years experience in the Canadian and international nuclear industry. He has held a range of positions at the executive level including Vice President, Strategic Development for Atomic Energy of Canada Limited (AECL). In this role he was responsible for corporate planning and business strategy, including waste management programs. He is also experienced in international business development, project management, and engineering for nuclear power projects. Doug has also worked in the private sector, most recently in the water treatment industry developing new environmental remediation applications and point of use water systems. Through his own business he currently advises clients on strategic planning, business development, and project management issues.

PAUL HOUGH

Having started as a metallurgical engineer with a focus on high temperature materials, Paul has spent a number of years in industrial research, ending up with Eldorado Nuclear in Ottawa. However, over the last 15 years or more, he has strayed into other areas. These include heading up the Science & Technology Div of the Library of Parliament, working with the Royal Society of Canada, and conducting lobbying efforts for research funding as the Executive Director of the Canadian Federation of Biological Societies. The understanding that he has gained over the years of the legislative process, the functioning of government and the intricacies of the university world in Canada, provides a solid base for him at the CNSC to provide advice on policy, regulatory and legislative issues. Paul's experience has also underscored the necessity of any regulatory agency to be engaged with its community and to be seen as a dynamic organization.

AAMIR HUSAIN
Aamir Husain is a senior engineer/scientist at Kinectrics, Toronto, Canada. He has a PhD from the Chemical Engineering Department at McMaster University in Hamilton, Canada. Aamir has extensive experience in a variety of nuclear applications including waste management, gamma spectrometry and decontamination.

MIHAELA ION
Mihaela Ion is a senior analyst with Candesco Research Corporation, Toronto. Her areas of expertise include safety and licensing, and environmental analysis for nuclear facilities. She has been involved extensively in the assessment of the radiological consequences and effects on general population during normal operation and in case of potential accidents at various nuclear power plants and research facilities (e.g., Iter fusion facility). Mihaela graduated in 1991 with a BSc/MSc degree in Power Engineering from the University "Politehnica" of Bucharest, Romania. In 1999 she received the MSc degree in Nuclear Engineering from the University of Missouri-Columbia, USA, and is currently a PhD candidate at the Nuclear Science and Engineering Institute, USA.

THEO KEMPE
Theo Kempe is a member of the Long-term Waste Management Technology Department of Ontario Power Generation (OPG), and has 28 years experience in the nuclear industry in Canada and the UK. She has been involved in a number of studies of management of used fuel and high-level waste, and currently has responsibilities in the areas of safety and regulatory requirements, and transportation system studies. She has also contributed to the safety assessment and licensing of OPG's current storage and transportation systems.

FRANK KING
Frank has a Master's Degree in Nuclear Power Engineering and has worked for Ontario Hydro/Ontario Power Generation since 1972 in reactor design and safety assessment, risk assessment and in nuclear waste management. He is currently Director, Nuclear Waste Engineering and Technology and is responsible for a range of technical issues dealing with transportation, processing, storage and disposal of Ontario Power Generation's used nuclear fuel, and low and intermediate level radioactive waste.

MICHAEL KRIZANC
Michael Krizanc is a Communications Assistant with the Nuclear Waste Management Organization. Prior to joining the NWMO, he was an energy policy advisor to the Government of Ontario. He is trained as a broadcast journalist and had a lengthy career in radio and television news.

JOHN KRASZNAI
John Krasznai has over 25 years of experience in nuclear plant chemistry control, the development of chemical cleaning and decontamination processes, safe tritium handling practices, and the characterization of radioactive wastes for processing, storage and disposal.

In 1996 John developed a patented process for Waste Oil Decontamination. He holds a Ph.D. in Inorganic Chemistry and a B.Sc. in Chemistry and Physics, and is the author of over 20 scientific publications in international journals and conferences.

STEPHEN LINDLEY

Stephen Lindley is Director of the SNC-Lavalin Engineers and Constructors (SLE&C) Environment Group and Manager of the Environmental Assessment and Planning Department. Stephen has over 21 years experience in environmental assessment/ management. He has managed and participated in a broad variety of large and small-scale multidisciplinary environmental projects for a variety of public and private sector undertakings, both in Canada and internationally.

In Waste Management. some of his recent (mostly domestic) project experience includes Project Manager with Interim Waste Authority (IWA) Landfill Site Search for Metropolitan Toronto/York Region; Steetley Quarry Products Inc. South Quarry Landfill Expansion Environmental Assessment Study; Waste Management Master Plans and Landfill EAs for West Nipissing Area (Sturgeon Falls), Port Colborne/Fort Erie, and the Town of Caledon.

He was Environmental Manager for many others, including Dufferin County, Durham Region, Waterloo Region, Peel Region, Grey-Owen Sound Region; and Collingwood Area, and Project Manager for the Redland Quarry Products Inc. South Quarry Landfill Project, including Expert testimony before the Consolidated Hearings (Joint) Board.

In other areas, he has been Project Manager, Hwy 407 East Partial and West Extension Environmental Assessment (CEAA), permitting/approvals and construction inspection/supervision; Environmental Manager, Environmental Assessment (CEAA) and permitting/approvals for the Collingwood to Alliston Water Supply Pipeline Project; Project Manager, Integrated Shoreline Management Plan (Tommy Thompson Park to Frenchman's Bay) for the Metropolitan Toronto and Region Conservation Authority; and Project Manager, City of London Southside Pollution Control Plant Schedule "C" Class EA; permitting and approvals (provincial and federal); effluent outfall design; water quality studies/modeling and City-wide PCP system effluent review.

With the First Nations, Stephen was Project Manager, Kaska Tribal Council, Yukon Territory, Infrastructure Strategy; Environmental Manager, Attawapiskat First Nation Flood Control Project; Environmental Assessment (CEAA), permitting and approvals for a 275 km transmission Line from Moosonee to Attawapiskat First Nations; and Third Party Review of Faro Mine Closure Strategy and Water License Application on behalf of the Kaska Tribal Council, Yukon Territory.

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In Mining, he was Environmental Manager and/or technical resource (EAs, environmental management plans, closure plans), for a variety of mine feasibility studies and design programs, including Agrium Phosphate (Canada), Rosia Montana Gold (Romania), Las Cristinas Gold (Venezuela), Jacobina Gold (Brazil, Taldy Bulak Gold (Kyrgysztan), Voisey's Bay Nickel (Canada), Diavik Diamonds (Canada), Rosia Montana Gold Project Environmental Assessment and Mine Closure Plan (2002).

Mr. Lindley is also an Adjunct Professor within the Lassonde Mineral Engineering School at the University of Toronto.

LEO M. LOWE
Leo Lowe is a Principal and Senior Health and Environmental Physicist at SENES (specialists in energy, nuclear and environmental sciences) Consultants Limited. He has 25 years experience in studies of occupational and environmental radioactivity, exposure pathways analysis, and risk assessment. He has performed radiation dose and risk calculations (both for humans and non-human biota) on numerous projects ranging from the environmental impact studies of the world's highest grade uranium mines and exposures in high level nuclear waste repositories, to studies on exposure to elevated levels of naturally occurring radioactive materials (NORM). His experience includes risk communication with workers and members of the public, and critical analyses of various proposed occupational and environmental standards for radioactivity in Canada, the United States and overseas. He has also served as an expert consultant to the International Atomic Energy Agency on the environmental implications of radioactive waste produced by the Jordanian phosphate industry. Leo is a former Director of the Canadian Radiation Protection Association and has contributed to more than 40 papers on environmental and occupational radioactivity and risk.

ED MALLETT
Ed Mallett is the President and CEO of OCETA, the Ontario Centre for Environmental Technology Advancement. He began as Director for OCETA in 1993 when it was still in the conceptual stage. He was one of the key members to develop the proposals and documents necessary to obtain approval and support from the federal and provincial governments. The majority of Ed's career was spent working for ICI Canada where he held senior management positions in Research, Corporate Planning, Business Development, and Production. Also, as group President of Specialty Chemicals, he was directly responsible for several businesses including Chemical Distribution, Water Treatment Chemicals, Oilfield Services, and served as a Director of Tricil Waste Management during its period of most rapid growth. After leaving ICI, Ed acted as a consultant for Canadian Venture Founders, a new venture fund centralized on start-up and early stage technology organizations, and was President of Turbotak Technologies Inc. Born in Barrow-in-Furness, England, Ed's educational background consists of a BSc Honours and a PhD in Chemistry obtained at Manchester University in England.

MALCOLM MARTINI
Malcolm Martini is a planner and economist with 38 years of consulting experience. He served as manager of Acres Economics and Planning Division and also served as a project manager in their environmental assessment group. While at Acres Malcolm was involved various types of energy projects ranging from hydro-electric, to gas installations in both Canada and internationally. He was in charge of the regional planning aspects of the Three Gorges Project in Chin, and was responsible for the environmental planning and consultation work for the relocation of low level radioactive soils in the Malvern Area. For the last six years Malcolm has been an associate and a Senior Environmental Specialist with SENES Consultants Limited. There he has worked on the EAs for the Pickering Restart, and the Bruce, Darlington and Pickering Used Fuel Dry Storage

facilities. Mr. Martini coordinated the EA for the Whiteshell Decommissioning study and worked on the EA for the decommissioning of the Bruce Heavy Water Plant.

DOUGAL R. MCCREATH

Dougal McCreath has 40 years of worldwide experience as a consultant, teacher and researcher in geotechnical engineering for civil, mining and environmental projects. He has been involved for many years with issues concerning nuclear waste storage and disposal. Recent involvement has included being a member of the federal government (CEAA) Seaborn Panel from 1996 to 1998 for review of the AECL concept for disposal of high-level waste in Canada; member of the federal government (FEARO) Kirkwood Panel from 1993 to 1996 for review of the decommissioning of uranium mine tailings at Elliot Lake, Ontario; and a member of the Subsurface Advisory Team (SAT) to Environment Canada from 1990 to 1995 for technical review of the environmental assessment of AECL's high-level waste disposal concept.

Dougal is the author of over 50 technical publications, primarily in the field of rock engineering, and in 2001, he was elected as a Fellow of the Engineering Institute of Canada.

MOHAMED MOLEDINA

Mohamed Moledina has 30 years experience with CANDU Systems Process design, construction, commissioning, and operation of CANDU power plants. Some of his experience includes Senior Design Engineer with Ontario Power Generation (OPG); Nuclear Waste Management Division - Bruce and Pickering Used Fuel Dry Storage Facilities and Waste Transportation; Product Manager with OPG-Isotope Sales Group Detritiation Services and Management of tritiated and cobalt-60 wastes from pharmaceutical research and sterilization; Senior Design Engineer assigned to ITER Project by OPG to undertake Design of Detritiation System and Tritium Handling Systems; and Engineering Supervisor with an AECL,CANDU Fuel Reprocessing Design Study in High Level Liquid Waste (HLLW) Vitirfication and Storage Design Study to compare CANDU fuel reprocessing cost with European fuel reprocessing cost.

JOHN NEATE

John Neate is an experienced executive providing leadership and clear vision in both the private and public sectors. Since 1997, his skills and expertise have been used by organizations to help them achieve sustainable objectives while anticipating and adapting to change. During this period, he has provided advisory services to the United Nations Environment Programme (UNEP) International Environmental Technology Centre (IETC) in Japan, the United Nations University International Network on Water, Environment and Health (UNU/INWEH), the Commission for Environmental Cooperation (CEC), Technology Early Action Measures (TEAM) of the Canadian Climate Change Action Fund, Environment Canada, the Canadian Department of Foreign Affairs and International Trade (DFAIT), Canada's Natural Sciences and Engineering Research Council (NSERC), the Ontario Centre for Environmental Technology Advancement (OCETA), and the Globe Foundation. From 1990 to 1997, he was

responsible for building a private sector employee-owned technology research, development and services company with over 100 employees that was acquired by a publicly-traded firm in the fall of 1997. Prior to this, he served as the energy and scientific policy advisor for Canada's Environmental Protection Service and was the principal investigator on energy supply alternatives for the Ontario Royal Commission on Electric Power Planning. His working experience across Canada and internationally in over twenty countries demonstrates his ability to mobilize resources and create positive alliances. He has considerable experience as a hands-on manager in solving complex challenges related to energy and water infrastructure, innovative technology applications, resource management, and project development. John has a Bachelor of Science Degree from McGill University and a Master's Degree in Environmental Studies from York University.

GABRIELE OGUNDELE

Gabriele Ogundele has been with Ontario Hydro Research Division/Ontario Power Generation/Kinectrics for over 15 years where he has been engaged in corrosion-related activities and materials performance. He has been involved in a number of laboratory investigations on the integrity of engineering materials, and providing solutions to materials' degradation under various environmental and operational conditions. Gabriele is also engaged in various studies pertinent to the understanding of the corrosion mechanisms affecting underground nuclear waste and dry storage containers. Specific activities include: laboratory evaluation of various corrosion mechanisms such as corrosion fatigue, stress corrosion cracking, and erosion corrosion on component materials, for input into 'fitness-for-service' guidelines; developing specialized testing apparatus; conducting failure analysis on damaged components in thermal and nuclear plants.

SRIDHAR RAMAMURTHY

Sridhar Ramamurthy is a Senior Research Scientist at Surface Science Western (SSW), an analytical laboratory located within the University of Western Ontario, London, Ontario, Canada. Sridhar is a Materials Scientist with research interests in the areas of corrosion and electrochemistry. He is the leader of corrosion research group at SSW and is currently involved in several research projects in this area. As a sub-contractor to the Ontario Power Generation and Kinectrics Inc., he was involved in the investigation of the underdeposit corrosion behaviour of oxygen free phosphorous doped (OFP) copper samples exposed to the Standard Canadian Shield Saline Solution (SCSSS). In addition, he has also been involved in the surface analysis/electrochemical characterization of nuclear materials used in steam generators and pressure tubes. Finally, he is also responsible for performing short-term industrial contract work related to the failure analysis of industrial materials, especially those containing a coating/oxide layer.

WAYNE RICHARDSON

Since 1998 Wayne Richardson has been the Director of the Canadian Federal Government's Climate Change Technology Early Action Measures (TEAM) initiative. Since 1998 TEAM's investment of $95 million partnered with the private sector and other governments to create a total investment of over $930 million in leading edge

climate change mitigation technologies. TEAM was honoured with the distinguished Canadian government "Head of the Public Service Award" in December 2000 for "Excellence in Policy". During 1997, he was Special Advisor to the Director General, Environmental Technology Advancement Directorate in Environment Canada. He provided leadership on technology funding and commercialization issues, and on privatization and alternative service delivery. Wayne spent 1996 in the private sector, as President, North American Environmental Services/Enviro-Tech Sciences Inc. NAES was a consortium of Canadian companies focused on developing business in the US DOE and US DOD site remediation market. Prior to 1996, he spent 16 years in a variety of policy and technology positions with Environment Canada including: Manager, Technology Transfer Office; Senior Corporate Policy Advisor; Departmental Coordinator, Energy R&D; Programme Engineer, Oil & Gas Production and Refining. His time with the federal government followed several years in Toronto as Senior Environmental Scientist with the Ontario Environment Ministry's Great Lakes Unit. Responsibilities included design, execution and interpretation of major scientific studies of the Lake Ontario nearshore, interaction of water intakes and outfalls on Lake Ontario, including nuclear and thermal power generation plant plume studies, and the first major international ecosystem survey of the St. Lawrence River between Lake Ontario and Quebec. Prior to this he was an engineer/planner with the Toronto Harbour Commissioners. Wayne is a graduate of the University of Toronto, with a degree in Mechanical Engineering and postgraduate studies in Human Environmental Systems. He lives and works in Ottawa, Canada and is a Professional Engineer.

SEAN RUSSELL

Sean Russell is the Manager, Long-term Waste Management Technology Department, with over twenty years experience in the assessment of radioactive waste management facilities and health physics-related activities at Ontario Power Generation Inc. Sean has been involved in the Canadian programs for the management of used fuel (UF) and low and intermediate-level waste (L&ILW;) since the 1980s. He is responsible for the definition, planning, prioritization and co-ordination of the safety assessment, geoscience and repository engineering development activities for the long-term management of UF and L&ILW.

STEVE SHEPPARD

Steve Sheppard is Vice President and senior ecotoxicologist with ECOMatters Inc., and is a Professional Agrologist (P.Ag) and a Canadian Certified Environmental Practitioner (C.C.E.P.). He is also the Editor-in-Chief of the Journal of Environmental Radioactivity and was previously Editor-in-Chief of the Canadian Journal of Soil Science. His research places emphasis on contaminant exposure pathways and ecotoxicology, much of it directed to support assessment modelling. He has over 100 referred journal publications in seven major topic areas: ecotoxicology, environmental assessment, radioecology, radionuclide behaviour, contaminant exposure pathways, soil science and agronomy. His book "Advances in Earthworm Ecotoxicology" is widely recognised as summarising the most recent developments on this topic. His Ph.D. and M.Sc. were in soil science and plant nutrition, and his B.Sc. was in physical sciences. A few of his recent projects include: determining ecotoxicology endpoints for radionuclides for the French nuclear

waste agency ANDRA; evaluating behaviour and impacts of U for the Canadian nuclear regulator CNSC; review and parameterisation of a dynamic model of 14C behaviour in the Loire River for Electricité de France; measurement and interpretation of dose to transport workers in Canada for the CNSC; quantitative risk assessments for decommissioning of Whiteshell labs for Atomic Energy of Canada Limited; radiological dose estimates for the ecological effects review of Ontario Power Generation (OPG) Darlington NGS; a model of terrestrial pathways for the revised OPG derived release limit model; a biosphere model of 36Cl using specific activity concepts for ANDRA; a revised soil model for nuclear waste disposal assessments for OPG; and review and parameterisation of a cold-biospheres model of nuclear fuel waste disposal assessments for ANDRA. In addition to scientific work, Steve is the Executive Director of the Canadian Society of Agronomy and the Registrar and Office Manager of the Canadian Society of Soil Science.

LES SHEMILT

Les Shemilt received a B.A.Sc. (Hon.) in Chemical Engineering and a Ph.D. in Physical Chemistry from the University of Toronto, and an M.Sc .in Chemistry from the University of Manitoba. As well as several years in industry with Defence Industries Limited, he has held professorships at the University of British Columbia, at the University of New Brunswick where he founded the Department of Chemical Engineering, and at McMaster University where he served for ten years as Dean of Engineering, in 1987 becoming a Professor Emeritus.. He has also been Visiting Professor at universities in Switzerland, Great Britain, India, Australia and Japan, and was an external examiner at the University of the West Indies.

Les Shemilt was the founding Chairman of the New Brunswick Research and Productivity Council, served as Science Advisor to the Province of New Brunswick, and on the National Research Council of Canada 1966-9. He was President of the Chemical Institute of Canada in 1970-1, and the Vice-President of the Academy of Science of the Royal Society of Canada in 1991-2. He has received the Fellowships of several professional societies, most notably the Royal Society in 1985 , and the Canadian Academy of Engineering in 1987 (as a Founding Fellow). From 1979 to 1996 he was Chairman of the Technical Advisory Committee to Atomic Energy of Canada Limited on the Nuclear Fuel Waste Management Program, has twice led reviews of the Swedish program on nuclear waste disposal, and has been involved in major international consultative efforts related to the same field. He has served as consultant to several Canadian industries and government departments.

Les Shemilt's fields of research have been primarily in applied thermodynamics, mass transfer, and electrochemical and corrosion engineering in which he has supervised 50 masters and doctoral theses, published over 80 papers and a number of contributed chapters to reference works, and edited several scientific volumes. For 18 years he was Editor of the Canadian Journal of Chemical Engineering, and is now Honorary Editor. He has received numerous awards and medals, both national and international, and has been the recipient of three honorary doctorates. In 1991 he was appointed an Officer of the Order of Canada.

ROBERT SLATER

Robert Slater has been a key player in environmental issues for over 30 years both in Canada and internationally. He was the Senior Assistant Deputy Minister in the Department of Environment for the federal government for eight years and also held three positions at the Assistant Deputy Minister level in the fields of Environmental Conservation, Policy and Environmental Protection. He was also the Director General for the Ontario region of the Department where he served for six years as Chairman of the International Joint Commission's Great Lakes Water Quality Board. His early career involved working as a teacher in West Africa, as Technical Services Manager for a water pollution control company in North America and Europe, and as founder of an environmental consulting organization in Canada. He was Vice-Chairman of the World Environment Centre based in New York, where he served on the Board for almost twenty years. In 1996, he was the first recipient of the Nortel Award for Career Contribution from the Association of Professional Executives of the Public Service of Canada. He holds degrees from Imperial College of the University of London. He is currently President of Coleman, Bright and Associates, an organization providing strategic advice to the private and public sectors and individuals.

DONALD WILES

Don Wiles is a Professor (Retired, September, 1990) with the Chemistry Department, Carleton University. His education includes: M.Sc. 1950 Chemistry, McMaster University; Ph.D. 1953 Nuclear Chemistry, M.I.T., Cambridge, Mass; PDF 1953-55 Kjemisk Institutt, University of Oslo. His recent teaching positions include: 1959-1963Assistant Professor, Carleton University; 1963 – 1969 Associate Professor, Carleton University; 1965 - Visiting Scientist Institute for Atomic Physics, Bucharest, Romania; 1969 - Professor, Carleton University; 1969 - 1970 Visiting Scientist, Institut für Heisse Chemie Kernforschungzentrum Karlsruhe, Germany; 1971-1975 Consultant, Applied Chemistry Department Brookhaven National Laboratory; 1993 - Visiting Professor, ANSTO, Lucas Heights, Australia; 1979-1987 Chairman,Chemistry Department, Carleton University; 1990 - Consultant, Atomic Energy Control Board (Canada); 1990 - Consultant, Environment Canada (Nuclear Waste Disposal) FEARO, SRG; 1995 - Consultant, Missouri Department of Natural Resources; and 1996-1997 Visiting Professor, Universitas Cenderawasih, Jayapura, Irian Jaya, Indonesia.