



## 12<sup>th</sup> International Conference on CANDU Fuel

“CANDU Fuel: Safe, Reliable & Flexible”

## 12<sup>ième</sup> conférence internationale sur le combustible CANDU

“Combustible CANDU: sûr, fiable, polyvalent”

Holiday-Inn Waterfront Hotel  
2 Princess St, Kingston,  
ON K17 1A2

2013, September 15 - September 18

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Although all efforts have been made to include accurate information about the authors and papers in this conference, errors and omissions may occur due to the information available at the time of publishing.

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## OFFICE OF THE MAYOR

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September 15-18, 2013

On behalf of Kingston City Council, I am pleased to welcome you to Kingston, Canada's *First Capital*. We are delighted to be the host city for the 12<sup>th</sup> international Candu Fuel Conference.

I trust that the topics discussed at this conference will be informative and helpful to the daily tasks you perform each day. I hope you enjoy the fellowship of your peers, the concepts and ideas discussed by the presenters, and all that Kingston has to offer!

During some of your free time I hope you find the chance to explore our city, Eastern Ontario's best kept secret. I can confidently claim that our city-wide shopping, dining, and cultural attractions are second to none. There are dozens of museums, galleries and historic sites to investigate. You will be amazed at how much there is to see and do in Kingston!

Please take some time to visit the Tourist Information Office on Ontario Street (telephone, toll free 1-888-855-4555) to find out more information on Kingston's many amenities and attractions.

Thank you for your selection of Kingston as your destination and best wishes for an enjoyable weekend.

Sincerely

Mark Gerretsen,  
Mayor

MG/rp

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### MAYOR MARK GERRETSEN

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Corporation of the City of Kingston



where history and innovation thrive



## “CANDU Fuel: Safe, Reliable and Flexible” “Combustible CANDU: sûr, fiable, polyvalent”

On behalf of the Organizing Committee, it is our pleasure to welcome each of you to the 12th International Conference on CANDU Fuel. The international nuclear community continues to grow with innovations and ideas and remains adaptable, motivated and responsive to industry needs. CANDU fuel, and its inherent flexibility, continues to present viable options to meet industry challenges. The world of CANDU fuel is an exciting area. We will continue to meet and bring inspired people together in conferences like this.

This conference is presented by the Canadian Nuclear Society, in co-operation with the International Atomic Energy Agency. The conference is also sponsored by eleven organizations with delegates in attendance from eight countries (Argentina, Austria, Canada, India, Korea, Romania, Sweden and the United States of America).

We are proud to have several distinguished guests attending the Welcoming Reception on Sunday night. The Plenary and Technical Sessions commence on Monday morning and continue through Wednesday afternoon. We have received many technical papers, with eight speakers invited for the Plenary Session. The Monday luncheon will feature a presentation on the use of a neutron imaging technique at the Royal Military College of Canada. The Award Committee has endorsed the nomination of two individuals to be presented with 2013 CNS CANDU Fuel Technology Awards at the Tuesday luncheon. The Tuesday night banquet will be held on a 1000 Islands cruise boat.

We're transforming the way we operate to continuously improve our ability to provide safe, reliable and flexible CANDU fuel. Our nuclear community has continued to meet the challenges of our field and excel. We should all be very proud of where we are today and excited about where we are headed.

Before I close, I'd like to thank each of you for attending our conference and bringing your expertise to our gathering. You, as a member of this international community, have the vision, knowledge, wherewithal and experience to help us pave our way into the future. You are our greatest asset; we cannot accomplish what we do without your expertise. Throughout this conference, I ask you to be engaged, proactive and help us develop the future of the international CANDU fuel industry. My personal respect and thanks is extended to each of you.

Respectfully,

Paul Chan

Conference Chair, 12th International Conference on CANDU Fuel  
Professor, Royal Military College of Canada



# Conference Information

## General Information

Kingston, Canada's first capital city, is playing host to this premier event for CANDU Fuel, here, at the Holiday-Inn Waterfront Hotel. This 12th International Conference will provide the best forum for Canadian and international experts of the nuclear industry involved in design, R & D, fabrication, operation, modelling, safety analysis and regulation. This conference will allow you to listen to experts, present your innovations, discuss research, network with your peers and perhaps renew old acquaintances.

## Organizing Committee

Conference Chair: Dr. Paul K. Chan (RMC)

Conference Secretariat: Ms. Maria Iligan (RMC)

Technical Program Committee Chairs: Dr. Hugues Bonin (RMC) & Mr. Mark Floyd (AECL)

Technical Program Secretary: Dr. Emily Corcoran (RMC)

Sponsorship: Dr. Paul K. Chan (RMC)

Award Committee Chair: Dr. Brent Lewis (UOIT University)

Treasurer: Dr. Benjamin Rouben (CNS)

Venue & Facilities Co-ordinator: Maj. Paul Hungler (RMC)

Registration Chair: Mr. Bob O'Sullivan (CNS)

Tour and Guest Program Co-ordinator: Ms. Kathy Nielsen (RMC) & Maj. Paul Hungler (RMC)

Photographer: Mr. John Perreault (RMC)

## Conference Hotel

Holiday-Inn Waterfront Hotel  
2 Princess St Kingston, ON KL7 1A2

## Collaborators

Atomic Energy of Canada Limited, Chalk River  
International Atomic Energy Agency

## Sponsors

AMEC - Nuclear Safety Solutions

Cameco Fuel Manufacturing Inc.

Canadian Nuclear Safety Commission

Canadian Nuclear Society

Candesco - Division of Kinectrics Inc.

CANTECH Associates Inc.

CANDU Energy Inc.

General Electric - Hitachi

Ontario Power Generation

Power Workers' Union

Royal Military College of Canada

Stern Laboratories Inc.

UniTech Services Group

# Program at a Glance

## SUNDAY

EVENING

**REGISTRATION AND RECEPTION**

## MONDAY

MORNING

**PLENARY SESSION**

AFTERNOON

**SESSION 1**  
Modelling & Computer Code Development – I  
*Bellevue North Room, floor 6*

**SESSION 2**  
Safety & Operational Margin Improvement – I  
*Bellevue South Room, floor 6*

## TUESDAY

MORNING

**SESSION 3**  
Fabrication  
*Bellevue North Room, floor 6*

**SESSION 4**  
Performance, Reliability & Operating Experience – I  
*Bellevue South Room, floor 6*

AFTERNOON

**SESSION 5**  
Advanced Fuel Cycles  
*Bellevue North Room, floor 6*

**SESSION 6**  
Design  
*Bellevue South Room, floor 6*

**SESSION 7**  
Spent Fuel Bays Operations  
*Bellevue South Room, floor 6*

## WEDNESDAY

MORNING

**SESSION 8**  
Safety & Operational Margin Improvement – II  
*Bellevue North Room, floor 6*

**SESSION 9**  
Modelling & Computer Code Development – II  
*Bellevue South Room, floor 6*

**SESSION 10**  
Performance, Reliability & Operating Experience – II  
*Bellevue North Room, floor 6*

# Schedule

## SUNDAY

September 15

### Islandview Ballroom, floor 6

19:00 - 20:00: Registration and Reception Started

20:00 - 20:15: Royal Military College Welcome Ceremony with Highland Dancers

20:15 - 20:45: Welcome Speeches

20:45 - 21:30: Registration and Reception Ended

## MONDAY

September 16

### Plenary Session

#### Bellevue Room, floor 6

08:00 - 08:15: Welcoming/opening addresses

08:15 - 08:45: Overview of Activities on CANDU Fuel in Argentina.  
*Alvarez L. & Valesi J.*

08:45 - 09:15: Critical Heat Flux and Heat Transfer Enhancement in Nuclear Fuel Bundles – A Review of the Past 50 Years.  
*D. Groeneveld*

09:15 - 09:45: An Integrated Approach for Safer, Productive and Reliable PHWR Fuel Manufacturing at NFC.  
*Saibaba N.*

09:45 - 10:15: IAEA Activities on Fuel and Fuel Cycles for PHWRs.  
*Basak U. & Dyck G.*

### 10:15 - 10:30 Coffee Break

10:30 - 11:00: Advanced Fuel Development at Atomic Energy of Canada Limited - What does the Future Hold for CANDU Fuels?  
*Kupferschmidt W.*

11:00 - 11:30: Implementation of Modified 37-Element Fuel Bundle at the Darlington Nuclear Generating Station – An Overview.  
*Hughes H.*

11:30 - 12:00: Fuel Performance in Aging CANDU Reactors – A Quick Overview of the CNSC Regulatory Oversight Activities of the Past 15 Years and of the Lessons Learned.  
*Couture M.*

12:00 - 12:30: CANDU Fuel Options: Practical Adaptability.  
*Hopwood J.*

### Lunch

12:30 - 12:45: Group Photo

12:45 - 14:00: Lunch in the Islandview Ballroom, floor 6

13:40 - 14:00: Luncheon Presentation by Major Paul Hungler “The SLOWPOKE-2 Nuclear Reactor at the Royal Military College of Canada: Applications for the Canadian Armed Forces”

### Technical Sessions Start

**Modelling & Computer Code Development – I**  
*Chairs: Lembit Sihver and Elena Sorin*  
Bellevue North Room, floor 6

14:00 - 14:25: Post-Irradiation Particle Emissions from CANDU Fuels and their Nuclear Forensics Applications.  
*Sellers M, Kelly D. & Corcoran E.*



# Schedule

**14:30 - 14:55: Optimization of the Fuel Assembly for the Canadian Supercritical Water-Cooled Reactor (SCWR).**

*French C., Chan P. & Bonin H.W.*

**15:00 - 15:25: FAST: A Combined NOC and Transient Fuel Model for CANDU Fuel.**

*Prudil A., Lewis B.J. & Chan P.*

**15:25 - 15:45: Coffee Break in the Islandview Ballroom, floor 6**

**15:45 - 16:10: UO<sub>2</sub> Fuel Oxidation.**

*Lewis B.J. & Iglesias F.*

**16:15 - 16:40: Numerical Verification/Validation of the Theory of Coupled Reactors for Deuterium Critical Assembly, Using MCNP5 and Serpent Codes.**

*Hussein M., Lewis B.J. & Bonin H.W.*

**16:45 - 17:10: Development of a 3-D Finite Element Model to Examine Fuel Bundle Behaviour Under Post-Dryout Heat Transfer Conditions.**

*Krasnaj C., Chan P.K. & Wowk D.*

**17:15 - 17:40: Feasibility Study of Modelling a CANDU Fuel Element Using a Multiphysics Object-Oriented Simulation Environment.**

*Gamble K. & Chan P.K.*

**Safety & Operational Margin Improvement – I**

*Chairs: Relu Istrate and Ismail Cheng*

**Bellevue South Room, floor 6**

**14:00 - 14:25: Beyond CANLUB-Graphite: An Improved Alternative Coating Development.**

*Farahani M., Ferrier G.A., Chan P.K., Pant A. & Corcoran E.C.*

**14:30 - 14:55: Heat Transfer Enhancement at Supercritical Pressures.**

*Eter A., Groeneveld D., Tavoularis S. & Onder N.*

**15:00 - 15:25: Consideration of Subchannel Area of a 37-Element Fuel to Enhance CHF.**

*Park J.H. & Jung J.Y.*

**15:25 - 15:45: Coffee break in the Islandview Ballroom, floor 6**

**15:45 - 16:10: Fuel Behavior During Large Breaks in the Primary Heat Transport Circuit.**

*Zalog C. & Istrate E.-R.*

**16:15 - 16:40: Aging Effect on the Fuel Behaviors for CANDU Fuel Safety Analysis.**

*Jung J.Y., Bae J.H. & Park J.H.*

**16:45 - 17:10: Assessing the Impact of the 37M Fuel Bundle Design on Fuel Safety Parameters.**

*Shaheen K., Shawkat M., Popescu A., Hasanein H. & Albasha H.*

**17:15 - 17:40: Post-Irradiation Examination of the 37M Fuel Bundle at Chalk River Laboratories (AECL).**

*Armstrong J., Daniels T. & Montin J.*

# TUESDAY

September 17

**Fabrication**

*Chairs: Jung-Gu Lee and Masoud Shams*

**Bellevue North Room, floor 6**

**08:30 - 08:55: Optimization of Dissolution Process Parameters for Uranium Ore Concentrate Powders.**

*Misra M., Reddy A.L.V., Tiwari S.K., Venkataswamy J., Setty D.S., Saibaba S. & Saibaba N.*

# Schedule

**09:00 - 09:25: Optimization of Process Parameters in Precipitation for Consistent Quality UO<sub>2</sub> Powder Production.**  
*Tiwari S.K., Reddy A.L.V., Venkataswamy J., Misra M., Setty D.S., Saibaba S. & Saibaba N.*

**09:30 - 09:55: Pellet Fabrication Development of Annular Pellets for Internally Cooled Annular Fuel.**  
*Bergeron A. & Hamilton H.*

**09:55 - 10:15: Coffee break in the Islandview Ballroom, floor 6**

**10:15 - 10:40: Application of Be-Free Zr-Based Amorphous Sputter Coatings as a Brazing Filler Metal in CANDU Fuel Bundle Manufacture**  
*Lee J.-G., Lee M.-K., Rhee C.-K. & Park C.-H.*

**10:45 - 11:10: Metallurgical Structure Modification of UO<sub>2</sub> Pellet during Sintering.**  
*Santra N., Sinha T.K., Singh A.K., Sairam S., Saibaba S. & Saibaba N.*

**11:15 - 11:40: Status of the Beryllium Replacement Project.**  
*Corcoran E., Daniels T., Harmsen J., Lu E., Onderwater T., Palleck S., Pant A. & Dimayuga I.*

**Performance, Reliability & Operating Experience – I**  
*Chairs: Uddharan Basak and Ho Chun Suk*  
**Bellevue South Room, floor 6**

**08:30 - 08:55: Design of a Molybdenum Based Oxygen Sensor to Assist in the Characterization of Defective CANDU® Nuclear Fuels.**  
*Barry R.A., Scott J. & Corcoran E.C.*

**09:00 - 09:25: A Statistical Assessment of CANDU Fuel Manufacturing Parameters and their Impact on In-Reactor Performance.**  
*Cunning T., Chan P., Pandey M. & Pant A.*

**09:30 - 09:55: Irradiation Behaviour of Th-Pu and U-Pu MOX Fuels.**  
*Mishra P., Jathar V.P., Shriwastaw R.S., Singh H.N., Satheesh P.M., Kondejkar P.B., Mallick G.K., Singh J.L. & Anantharaman S.*

**09:55 - 10:15: Coffee break in the Islandview Ballroom, floor 6**

**10:15 - 10:40: Fuel Deposits, Chemistry and CANDU Reactor Operation.**  
*Roberts, J.*

**10:45 - 11:10: Optimizing In-Bay Fuel Inspection Capability to Meet the Needs of Today's CANDU Fleet.**  
*St-Pierre J. & Simons B.*

**11:15 - 11:40: Regulatory Review of the CANDU Fuel Modification Program in Canada.**  
*Guo, Y.*

## Lunch

**12:00 - 14:00: Lunch in the Islandview Ballroom, floor 6**

**13:30 - 14:00: Presenting the CNS Fuel Technology Awards**

## Advanced Fuel Cycles

*Chairs: Hazen Fan and Steve Livingstone*  
**Bellevue North Room, floor 6**

**14:00 - 14:25: DME-221 Thoria Fuel: Fabrication, Irradiation Testing and Post-Irradiation Examination.**  
*Corbett S., Hamilton H., Floyd M., Harrison N. & Livingstone S.*

# Schedule

**14:30 - 14:55: Thoria Irradiation and Post-Irradiation Examination Experience at AECL.**

*Livingstone S. & Floyd M.*

**15:00 - 15:25: Fuel Performance Modeling for Proposed Th Based Canadian SCWR Fuel.**

*Bell J.S. & Chan P.*

**15:25 - 15:45: Coffee break in the Islandview Ballroom, floor 6**

**15:45 - 16:10: Simulating Reactor Core Configurations of a CANDU 6 Fuelled with Thorium and Natural Uranium.**

*Golesorkhi S. & Kaye M.*

**16:15 - 16:40: Safety Assessment to Support NUE Fuel Full Core Implementation in a CANDU Reactor.**

*Laurie T., Fan H.Z., Siddiqi A., Rouben D., Li Z.P. & Cottrell C.*

## Design

*Chair: Luis Alvarez and Gord Hadaller*

**Bellevue South Room, floor 6**

**14:00 - 14:25: Impact of the 37M Fuel Design on Reactor Physics Characteristics.**

*Perez R. & Ta P.*

**14:30 - 14:55: Silicon Carbide TRIPLEX Materials for CANDU Fuel Cladding and Pressure Tubes.**

*Feinroth H., Markham G., Ales M. & Montgomery M.*

**15:00 - 15:25: Results of Qualification Program Performed to Prepare 37M Fuel for Use in Darlington Nuclear Power Stations.**

*Van Lochem R., Hadaller G. & Daniels T.*

**15:25 - 15:45: Coffee break in the Islandview Ballroom, floor 6**

## Spent Fuel Bays Operations

*Luis Alvarez and Gord Hadaller*

**Bellevue South Room, floor 6**

**15:45 - 16:10: Improvements in In-Bay Irradiated Fuel Inspection Planning & Analysis at Bruce Power.**

*Millar D., Stark R. & St-Pierre J.*

**16:15 - 16:40: FLASHPOINT – A Tool to Routinely Calculate the Heat Load in the Irradiated Fuel Bays.**

*Vyskocil E.*

## Island Cruise

**17:30 Sharp: Embarking the 1000 Islands Cruise Boat**

# WEDNESDAY

September 18

## Safety & Operational Margin Improvement – II

*Chairs: Thomas Krause and Nudurupati Saibaba*

**Bellevue North Room, floor 6**

**08:30 - 08:55: Examining the Viability of Ultrasonic Inspection of Discharged CANDU® Fuel Bundles.**

*Krause T., Huang W. & Lewis B.J.*

**09:00 - 09:25: The Effect of Oxidized UO<sub>2</sub> on Iodine Induced Stress Corrosion Cracking of Fuel Sheathing.**

*Quastel A., Corcoran E. & Lewis B.J.*

**09:30 - 09:55: Comparison Between Zircaloy Oxidation in Steam and Air surroundings.**

*Shawkat M., Hasanein H., Ali M., Parlatan Y. & Albasha H.*

# Schedule

**09:55 - 10:15: Coffee break in the Islandview Ballroom, floor**

**Performance, Reliability & Operating Experience – II**  
*Chairs: Nudurupati Saibaba and Thomas Krause*  
**Bellevue North Room, floor 6**

**10:15 - 10:40: Review of Zircaloy Oxidation Behaviour.**  
*Iglesias F. & Lewis B.J.*

**10:45 - 11:10: On-Line Fuel and Control Rod Integrity Surveillance in BWRs.**  
*Sihver L., Larsson I., Loner H., Grundin A., Helmersson J.-O. & Ledergerber G.*

**11:15 - 11:40: Assessment of Causes for Degrading Fuel Performance at Darlington NGS.**  
*Judah J. & Goodchild S.*

**Modelling & Computer Code Development – II**  
*Chairs: John Roberts and Glenn Archinoff*  
**Bellevue South Room, floor 6**

**08:30 - 08:55: IAEA Programme to Support Development and Validation of Advanced Design and Safety Analysis Codes.**  
*Choi, J.H.*

**09:00 - 09:25: Benchmarking a Fission-Product Release Computer Program Containing a Gibbs Energy Minimizer.**  
*Barber, D., Lewis B.J. & Chan P.K.*

**09:30 - 09:55: Analysis of Fuel End Temperature Peaking.**  
*Xu, Z., Jiang, Q., Lai, L. and Shams, M.*

**09:55 - 10:15: Coffee break in the Islandview Ballroom, floor 6**

**10:15 - 10:40: Advanced CFD Simulations of Turbulent Flows Around Appendages in CANDU Appendages in CANDU Fuel Bundles.**  
*Abbasian F., Hadaller G. & Fortman R.*

**10:45 - 11:10: Modeling Coupled Bending, Axial, and Torsional Vibrations of a CANDU Fuel Rod Subjected to Multiple Frictional Contact Constraints.**  
*Fadaee M. & Yu S.*

**11:15 - 11:40: The Other Metallic Phase in Spent Fuel ~ A Thermodynamic Evaluation of the Quaternary System U-Pd-Rh-Ru ~.**  
*Wang L.C. & Kaye M*

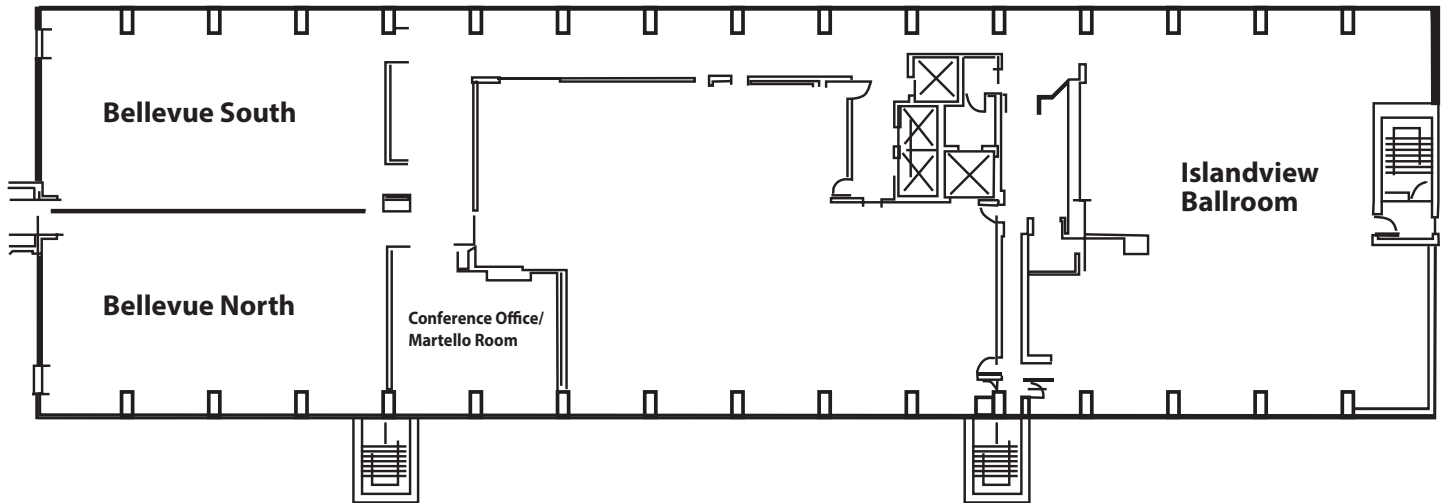
## Lunch

**12:00 - 14:00: Lunch in the Islandview Ballroom, floor 6**

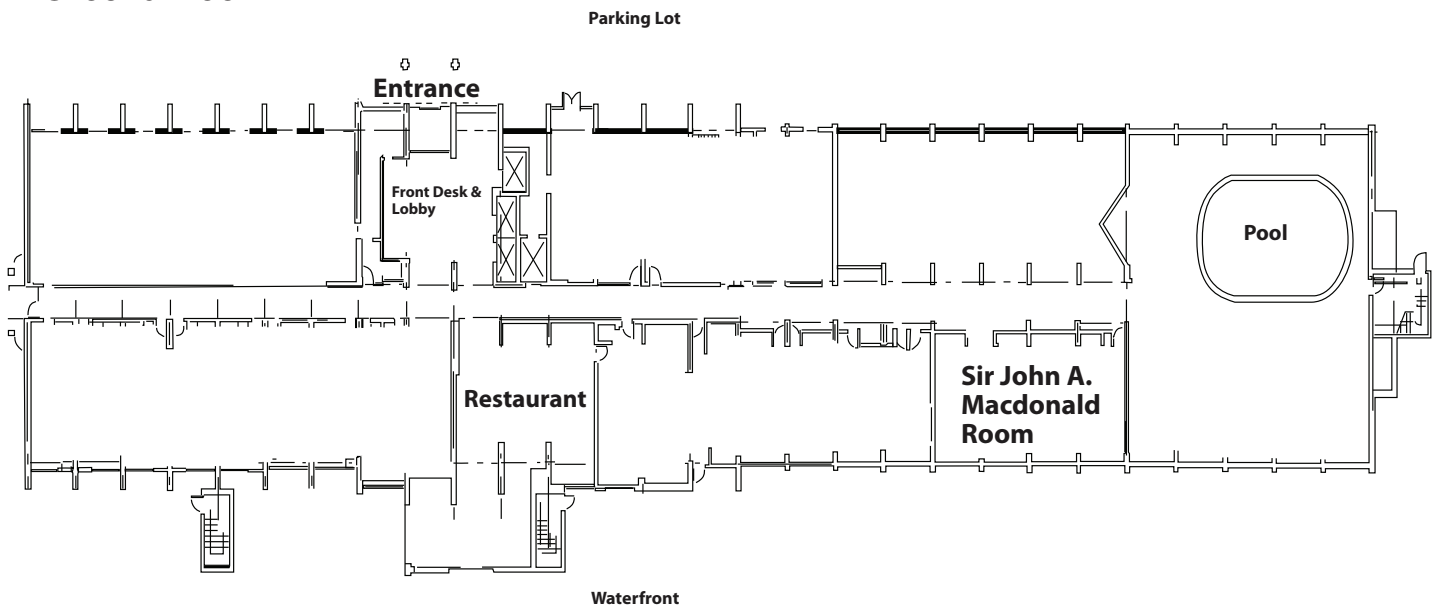
**13:30: Conference Ended and Hotel Checkout**

# Holiday-Inn Waterfront Hotel Level Floorplan

## Floor 6



## Ground Floor











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