Global Access Partners Pty Ltd ABN 74 000 731 420

COMMERCIALISING NANOTECHNOLOGY IN WATER 2006

GAP Forum Report
Melbourne, Australia

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EXECUTIVE SUMMARY

The Global Access Partners (GAP) Forum on 'Commercialising Nanotechnology in Water' was held on the 15th and 16th of June 2006 in Melbourne at the Department of Innovation, Industry and Regional Development.

The Forum brought together 55 participants from 46 organisations *(see List of Participant, page 39)* and was supported by the Victorian Government, Nanotechnology Victoria, CSIRO, University of Melbourne, Victoria University, Australia-Israel Chamber of Commerce and Qantas Airways *(see Partners & Sponsors, page 6).*

The Hon. John Brumby MP, Treasurer of Victoria, opened the Forum with a keynote address *(page 10).* **The Hon. Matt Viney MP**, Victorian Parliamentary Secretary for Innovation & Industry, and **Mr David Gallagher**, Manager of the National Nanotechnology Taskforce, Department of Industry, Tourism & Resources, gave keynote speeches at the Boardroom Session and Workshop respectively *(for the full Forum Programme, see page 32).*

Mr Keith Blakely, Chief Executive Officer of NanoDynamics, Inc. – a leading US manufacturer of nanomaterials and nanotechnology-enabled products - presented at the Forum. An overview of Australian water issues was offered by **Prof John Langford AM**, Director of the Melbourne Water Research Centre.

The Forum sought to identify Australia's most pressing water problems, the nanotechnologies that could address them and aid the development and commercialisation of water nanotechnologies. The key points of the Forum discussions are briefly outlined below:

» **Nanotechnology** is the design, production and application of structures, devices and systems by controlling shape and size at the nanoscale. Eight to ten atoms span one nanometer (nm).

» The future of the world's water and energy supplies pose a range of increasingly pressing problems which developments in nanotechnology may help to address. The demand for clean water for domestic, agricultural and industrial use will increase with population and living standards while global warming may threaten traditional resources.

» Victoria has invested over a billion dollars in water infrastructure and is a leading player in the development of nanotech solutions which will boost the productivity and profitability of agriculture and improve the efficiency of domestic and industrial water provision. 77% of water harvested in Victoria is used for irrigation while Melbourne consumes just 8%.

» **Nanoscale filtration** can greatly improve the efficiency of waste-water treatment and recycling through mechanical or chemical means. **Nanoporous membranes**, with pores below 10 nm, allow the removal of ions while 'ultrafiltration' operates on a scale between 10 and 100 nm. **Magnetic nanoparticles** offer an effective and reliable method of removing heavy metal contaminants from waste water as their relatively large surface area increases their effectiveness. Nanoscale filtration is comparatively inexpensive compared to traditional precipitation and filtration methods and could provide the key to developing affordable large scale desalination of sea water.

» Nanotechnology can improve **energy efficiency** by reducing material and process rates, creating better thermal insulation and enhancing the economic viability of renewable energy sources, particularly **solar cells**. The efficiency of **Hydrogen full cells** is enhanced through the use of nanostructured catalysts comprising carbon supported noble metal particles of 1- 5 nm.

» The development of nanotechnology is hampered by a lack of common international standards and nomenclature. The water industry tends to be conservative, due to the long life of its assets, and **regulatory frameworks** and **economic incentives** may be required to provoke demand for nanotech and its development by commercial companies. Water will remain inexpensive relative to power and waste treatment, and incentives to improve energy efficiency may prove more effective drivers of new water nanotechnology than measures aimed at water alone.

» The "water policy group" identified **market failure across the industry**. Companies and authorities remain unaware of the mechanisms available for developing, exploiting or sharing technology, e.g. the Water Trust funds. Keith Blakely's address highlighted the relationship between water and energy and the opportunities for nanoscale technologies to play a major role in both sectors.

» The "water leadership group" agreed on the existence of **vertical market failure** in terms of new technology in the water industry, in particular, the dissemination of information regarding emerging technologies and society's growing demands for new solutions. The participants foresaw promising commercial opportunities in the establishment of better information, investment and product development systems with the aim of increasing the uptake of these radical new technologies.

» **The National Consultative Committee on Nanotechnology Commercialisation** will provide a forum for Government, Industry and Academia to

drive the adoption of commercial nanotechnology. The goal is to develop practical solutions to existing problems, rather than the development of new technology for its own sake.

» A second **roundtable** was proposed to develop the GAP Forum's outcomes. This event will include laboratory visits and broaden its scope to incorporate a range of international research initiatives. The Roundtable will be held at GE Global Research Centre in Niskayuna, New York State.

(For a detailed summary of the discussions, see Report of the Forum Proceedings, pages 10-31)

DISCLAMER:

This Report represents a wide range of views and interests of the participating individuals and organisations. Statements made during discussions are the personal opinions of the speakers and do not necessarily reflect those of the organisers and sponsors of the Forum.

THE STEERING COMMITTEE

A Steering Committee of industry experts worked for over a year on the content and objectives of the Forum. GAP would like to thank the following people for their contribution and foresight:

Dr Peter Binks
CEO Nanotechnology Victoria

Harry Buskes
Policy Adviser, Business Development Division, Department of Innovation, Industry & Regional Development, Victorian Government

Peter Fritz AM
Group Managing Director, TCG Group, Managing Director, Global Access Partners (GAP)

David Gallagher
Manager, National Nanotechnology Taskforce, Department of Industry, Tourism & Resources

Rob Gell
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Prof John Langford
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Catherine Williams
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Department of Innovation
Industry & Regional Development
Victorian Government

PARTNERS & SPONSORS

'Commercialising Nanotechnology in Water' 2006 was coordinated by Global Access Partners (GAP) Pty Ltd and co-sponsored by the following organisations:

Global Access Partners (GAP)
www.globalaccesspartners.org

Victorian Government
www.iird.vic.gov.au

Nanotechnology Victoria
www.nanovic.com.au

Qantas Airways
www.qantas.com

In-kind support was offered by:

CSIRO Nanotechnology Centre
www.csiro.com

Melbourne Water Research Centre,
University of Melbourne
www.civenv.unimelb.edu.au/research/centres/mwrc.html

Institute of Sustainability & Innovation
Victoria University - http://research.vu.edu.au/ISI

Australia-Israel Chamber of Commerce
www.aicc.org.au

KEYNOTE SPEAKERS

The GAP Forum on 'Commercialising Nanotechnology in Water' 2006 featured two guest speakers – Mr Keith Blakely, CEO of NanoDynamics, Inc., USA, and Prof John Langford AM, Director of the Melbourne Water Research Centre, University of Melbourne.

Keith Blakely is the CEO of NanoDynamics, Inc., the global leader in the commercialisation of nanomaterials and nanotechnology-enabled components and systems. The company was formed in 2002 and has already introduced commercial products for the microelectronics, biomedical, chemical, semiconductor, defense, and alternative energy (fuel cell) markets. NanoDynamics has been featured in the USA Today, Business Week, and on CNBC's Squawk Box and the CBS Evening News.

Mr Blakely is a serial entrepreneur, having started his first company, Advanced Refractory Technologies, Inc. (ART), in Buffalo, NY in 1981 at the age of 24. For the next twenty years, he served as ART's President and CEO, overseeing its growth from a two person operation to over 300 people with two international joint ventures and three domestic facilities. During his tenure, he established relationships with General Motors, Bekaert, Mitsubishi, Westinghouse, McDermott International, United Defense, and many others. The company was recognised as a worldwide leader in advanced materials when it was acquired by a subsidiary of Tyco International in June 2001.

Following the sale of ART, Mr Blakely established a technology management consulting organisation – The InVentures Group – which has provided technology assessments, business planning, and technology commercialization to several organisations, from start-ups to multi-billion dollar firms. The InVentures Group was instrumental in helping the University of Buffalo establish STOR (the Office of Science, Technology, and Economic Outreach) in 2001 and served as the interim Director of Commercialization.

More recently, Mr Blakely founded First Wave Technologies, one of the first private-sector companies in WNY focused on the development and commercialization of pre-incubator technology projects.

Mr Blakely served as the President and COO of TechSys, Inc., a NASDAQ listed company which developed new technologies for portable electric power generation, including solid oxide fuel cells, in collaboration with NASA's Jet Propulsion Laboratory and Adelan Ltd., in Birmingham. He also assisted as the President and CEO in the commercial transition of another nanomaterials company, AP Materials, Inc.

Mr Blakely, who was elected a Fellow of the American Ceramic Society in 2001, received the R&D 100 Award in 1979 and 1985, was NYS Entrepreneur of the Year in 1995, has served on the boards of several public and private organisations, including the Buffalo-Niagara International Trade Council, the Western New York Technology Development Corporation, and the Buffalo Economic Renaissance Corporation. Keith is a native of Western New York and a graduate of SUNY Buffalo.

In November 2003, **John Langford** was appointed a Professorial Fellow at the University of Melbourne, and Director of the newly created Melbourne Water Research Centre. From 1994 to 2003 Professor Langford was inaugural Executive Director of the Water Services Association of Australia, the peak body of the Australian urban water industry. He was Managing Director of the Rural Water Corporation, Victoria's state wide irrigation and rural water authority, from 1989 to 1994. John is Chairman of the Murray Darling Freshwater Research Centre. He also chairs the Advisory Board of the Special Research Centre at Sydney University on the Environmental Impact of Coastal Cities.

Prof Langford has extensive experience in water resource and catchment management, urban and irrigation water supply and in managing research. As Executive Director of the Water Services Association of Australia (WSAA), John built WSAA from its conception into a highly effective industry association with 28 members servicing 14.5 million people in Australia and New Zealand. Prof Langford has worked for Melbourne Water, the United States Department of Agriculture, the Department of Water Resources of Victoria and the Rural Water Corporation. He has served on the Boards of Goulburn Murray Water, the Murray-Darling Basin Commission, the Land Conservation Council, the Australian National Committee on Irrigation and Drainage, the Water Research Foundation, the Environment Council. He is a Churchill Fellow, a Fellow of the Academy of Technological Sciences and Engineering, and a Fellow of the Institution of Engineers, Australia. In October 1999 John was awarded the Peter Hughes Water Award by the Australian Water & Wastewater Association in recognition of his world class contribution to water affairs. He was the Munro Orator for 2000, and in 2003 was awarded a Centenary Medal by the Australian Government for his contribution to environmental science and technology. Prof Langford was awarded an Order of Australia in the 2005 Queens Birthday Honours.

PARTICIPATING ORGANISATIONS

GAP would like to thank the following for their attendance at the Forum:

- ANT - Applied Nano Technologies
- Aqua Diagnostic
- Australia-Israel Chamber of Commerce
- Central Highlands Water
- Centre for Membrane Science & Technology, UNSW
- Copa Water (formerly CDS Technologies)
- CRC for MicroTechnology (Small Technologies Cluster Access Programme)
- CSIRO Manufacturing & Infrastructure Technology
- Deakin University
- Department of Industry, Tourism & Resources, Australian Government
- Department of Innovation, Industry & Regional Development, Government of Victoria
- Department of Sustainability & Environment, Government of Victoria
- Department of the Environment & Heritage, Australian Government
- GBS Venture Partners
- GE Infrastructure, Water & Process Technology
- Gippsland Regional Water Monitoring Partnership
- Grampians Wimmera Mallee Water
- Huntsman Chemicals
- Hydrocon Australasia
- ICGS
- Information City Australia
- Invetech
- Macquarie University
- Melbourne Water
- NanoDynamics, Inc.
- Nanotechnology Victoria
- Office of Science and Technology, Department of Innovation, Industry & Regional Development
- Office of the Deputy Secretary- Business Development, Department of Innovation, Industry & Regional Development
- Office of the Minister for State & Regional Development, State of Victoria
- Pall Corporation
- Technical Strategy Advisors
- RMIT Applied Sciences
- SKM Consulting
- South East Water Limited
- State of Victoria
- Sydney Grammar School
- TCG Group
- University of Melbourne
- University of Technology Sydney
- Victoria University
- Victorian Water Industry Association
- Viva Vlu Pty Ltd
- Wave Energy Desalination Pty Ltd (Energetech)
- Yarra Valley Water

REPORT OF THE FORUM PROCEEDINGS

Keynote Address by The Hon. John Brumby MP, Minister for State & Regional Development, Minister for Innovation, Treasurer of Victoria,

John Brumby welcomed Forum participants and keynote speakers and noted the success of the GAP Congress on Knowledge Capital of November 2005.

He acknowledged that water supply is a major global issue. A billion people, a sixth of the world's population, lack access to clean water and 10 million people, including 2 million children, die every year from tainted supplies. The demand for clean water for domestic, agricultural and industrial use will increase as globalisation enables economic growth in developing countries.

Two of Victoria's key industries, agribusiness and manufacturing, depend on consistent supplies of clean water. Victoria's largest export, processed dairy products, is a major consumer. Quality of life and a relatively clean environment are major assets of Melbourne, Victoria and Australia and their standards must be maintained.

Victoria is emerging from severe drought, its river systems have been degraded in the past and significant changes in water management must be made for the future through demand management, research and development and investment in environmental technologies. These will become a leading international growth market, particularly for developing nations in the Asia/Pacific region. The OECD predict that the global market for environmental goods and services will increase from $430 billion in 2000 to $770 billion by 2010.

Victoria's approach focuses on managing demand and pricing, changing attitudes, utilising market forces and improving infrastructure. Targets include improving the efficiency of irrigation systems by 25% by 2020, increasing Melbourne's water savings by 15% by 2010 and 30% by 2020 and boosting environmental flows to the region's rivers, including an extra 20 billion litres for the Yarra.

'Our Water Our Future', the state water policy released in 2004, aims to secure water supplies for homes, businesses, rivers, farms and the environment for the next 50 years. It sets out 110 initiatives and is already showing results, particularly in demand management, with Victorians now using 20% less water than in the late 1990's per capita and half the 1980's amount.

The 'Pathway to Sustainability' Program has helped Melbourne's top 200 businesses reduce their consumption by 12% through water audit saving plans and efficiency measures, and will be extended to the top 1,000 water using businesses over the next three years.

The State Government is reforming water markets and pricing to help move water from low to high value uses. Agreement has been reached with New South Wales to trade water across state borders. Victoria and New South Wales are talking to South Australia about creating common trading systems between all three states.

Victoria is investing over a billion dollars in water infrastructure, with the Wimmera/Murray pipeline the largest of these schemes. Because of evaporation and leakage, 100 mega litres of water entering an open system produces only 10 at its end, so piping a previously open channel system saves 90 mega litres a year.

The Eildon Dam has been completed and channel automation is proceeding in the Goulburn and Gippsland regions. The 2006/2007 State budget includes $30 million for a new pipeline to secure Bendigo's water supplies and $50 million for Gippsland factories.

Mr Brumby emphasised his role as Minister for Innovation, outlining the state's innovation agenda for which over a billion dollars has been earmarked, including funding for a new range of water technology projects. These include the Urban Water Conservation Demonstration and Research Facility, which researches water quality and its safe use in households, business and agriculture. The Sustainable Aquaculture Systems Project researches water recirculation systems and sustainable aquaculture while a similar programme targets industries using large quantities of water.

Regional economic benefits can be gained through smarter irrigation projects. Wireless technology can increase the water efficiency of the dairy and viticultural industries as, for example, computer technology can measure, to the nearest drop, how much water goes into a single apple tree.

At present only 10% of a tree's crop can be sold as premium export quality at $4 a kilo, with the remaining 90% going for pulp and juice at 40 cents a kilo, but precise watering regimes can boost the premium crop to 50% of the whole. Better technology and applications not only save water, but can greatly increase profitability.

The Australasian Industry Research Centre is developing cleaner production technologies. The Facility for Storm water Biofilter Technologies will design and demonstrate second generation biofilters for rainwater treatment in different environments, such as residential estates, roadsides and water supply catchments.

Nanotechnology is an emerging technology offering radical new functionality, reduced cost and size and improved efficiencies and reliability.

By 2015, the value of nanotech-related products may approach $1.5 trillion in sectors ranging from biotech, pre-processing and energy, advanced manufacturing, construction, to energy and the environment. It will produce huge environmental benefits in terms of water management and treatment by improving filtering, decontamination, desalination, conservation, recycling, analysis and monitoring and sewerage systems.

Victoria has provided hundreds of millions of dollars to support nanotechnology initiatives in universities and industry, including the Victorian Centre for Advanced Material Manufacture and the smaller scale technology clusters. The Australian Small Technologies Alliance is the focal point for networking and collaboration between Victoria's nanotech, micro technology, biotechnology and ICT industries.

Nanotechnology Victoria is leading the drive, its partners including universities such as Deakin, Monash, Melbourne, RMIT, Swinburne and CSIRO. NanoVic is well advanced on initiatives with significant environmental applications, including tests for trace metals and other contaminants and a Biosensor for the analysis of phosphate and nitrates.

Victoria is committed to becoming a centre of excellence in nanotechnology and has hosted and sponsored major industry events such as the Second National Nanotechnology Conference in September 2005 and the 12th International Commercialisation of Micronanosystems Conference in September 2007, the leading international conference on micro/nano technology commercialisation and education.

In closing, Mr Brumby reiterated his support for the GAP Forum, acknowledged the support of the National Nanotechnology Task Force in creating the event and wished participants well in their future endeavours.

"The Role of Nanotechnology in Addressing Critical Global Issues"

Presentation by Mr Keith Blakely
CEO, NanoDynamics, Inc., USA

Keith Blakely outlined nanotechnology's potential to address critical issues such as water and energy supply. Denying it was merely a buzz word or a fad, he argued that technical progress over the last century has been driven by advances in material science and our ability to translate these into commercial products, such as transportation and the automotive and aerospace industries.

Medicine has seen similar advances, with the discovery and development of radioactive isotopes, the ability to synthesize complex organic and inorganic materials, antibiotics, imaging techniques and implantable machines.

No area has seen more interdependency between material science and its progress than electronics and computing. Semiconductor fabrication and integrated circuit production have revolutionised our computational, modelling and predictive capabilities allowing the design, engineering and manipulation of chemical and manufacturing processes to create true 'designer' materials.

Nanotechnology is the culmination of this evolution of interdependency between computing and manufacturing capability, allowing us to both identify the problems facing our planet and create new tools to resolve them.

Mr Blakely said, he had founded *NanoDynamics* in 2002, with the catchphrase "the power of nanotechnology", to focus on its commercial application in key sectors such as energy, the environment, life sciences and electronics. It is not a technology push company, which would develop new materials first and then attempt to find applications, but rather a market pull organisation, which first talks to companies and then seeks to address their needs.

The company has three facilities in the United States: Columbus Ohio, Buffalo New York, and Pittsburgh Pennsylvania. Columbus focuses on water and membrane technology and advanced ceramics. Pittsburgh undertakes life sciences research and product testing while the majority of research and manufacturing is done in Buffalo.

NanoDynamics is a vertically integrated company. Research and development, technology demonstrations and feasibility projects lead to the synthesising of new materials, the manufacture of components and the design, fabrication and assembly of final products.

The company aims to extract value at every level. When a novel material with very broad applications is developed, it is licensed to partners around the world to develop its full range of possibilities.

NanoDynamics currently has two very different products in the marketplace. One is the NDMX golf ball, which minimises hooking and slicing by reducing side spin thanks to its hollow metal core. Its hollow metal core cannot be constructed from conventional materials because standard steel or titanium deforms upon impact by the golf club off the tee. Merely thickening the wall transgresses the ball's legal weight limit, but reducing the size of the metal's grain improves its strength without adding to its weight.

NDMX golf ball

Revolution-50 solid oxide fuel cell

The second product is the Revolution-50 solid oxide fuel cell, which efficiently generates electricity from hydrocarbons, producing only carbon dioxide and water as waste. Nanomaterials throughout its entire architecture allow it to meet its performance metrics. It employs a 50 nanometre coating on a porous ceramic substrate, forming a flat layer bridging the openings between much larger particles, and uses carbon nanotives with a range of filtration and hydrogen storage applications.

Returning to the premise that the two major challenges facing the planet are energy and water, Mr Blakely related expert predictions that global oil consumption will increase by 150 million barrels a day by 2050. Energy has to become affordable and renewable to avoid the political and social problems caused by non-renewable sources today.

Water poses a similar challenge. The world's population, living standards and food production are increasing, putting huge stresses on water resources. China has 20% of the world's population, but only 7% of the world's water. These imbalances do not bode well on the geopolitical scene without new solutions to these problems.

One answer is **water filtration**. Nanoporous filters and low pressure membrane technologies that reduce energy requirements make the economics of **desalination** much more tenable for broad scale application, as do other potential technologies such as nanomagnetics.

Monitoring by nanosensors that detect both quality and quantity of water flows allows better management, while ground based **remediation** of contaminated water has been undertaken in the USA and elsewhere. Nanomaterials can be designed to capture ion specific contaminants in water, allowing soils to recover and ground water to be used more effectively.

Affordable nanoenabled **fertilisers** are being developed to provide more efficient release of soil nutrients while reducing watering requirements.

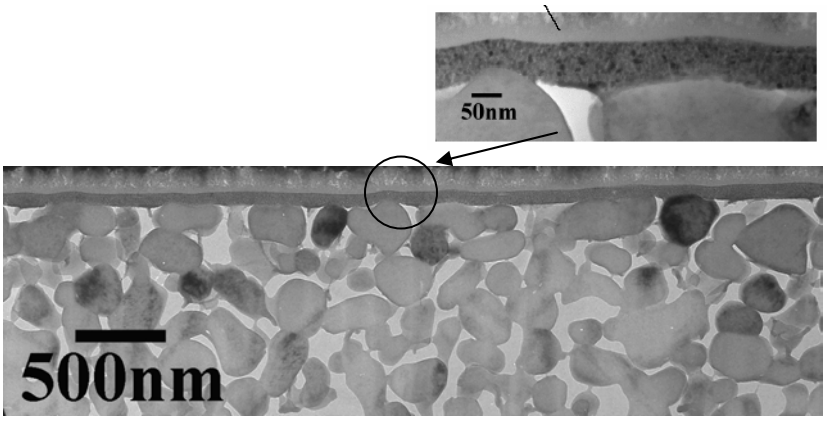
Solid state **thermoelectrics** will greatly reduce the large amount of water used for cooling machinery. They can be used for refrigeration or to convert excess waste heat back to electricity and, as the efficiency of thermoelectrics is dictated by the size of the particles, the ability to maintain nanosized core shell materials has led to significant increases in thermoelectric efficiency.

New coatings have been introduced in the glass industry. PPG are producing a self-cleaning glass that relies upon photocatalytic titanium dioxide. There are many ways to utilise the **photocatalytic** and **anomycrobial** activities of nanoparticulants. One being pursued is the reduction of biofilm in filters in waste water treatment plants which both improves the efficiency of filtration and reduces downtime in maintenance cycles. Domestic dry laundries are being developed and future washing machines will combine heat, light and photocatalytic processes to take care of organic dirt contaminants rather than use water.

Structural innovations include the new field of nanocements, which have improved mechanical properties, cut setting or curing times and use less power and water in their manufacture and deployment. Improved composites allow more efficient wind and wave power generation and are being explored by major energy companies like ADD and General Electric.

An issue with membrane technology is that, as pore sizes are reduced to filter out containments as small as viruses, it becomes difficult to maintain an adequate flow. **High throughput membranes**, 50 nanometres thick, can have pores as small as 2 nanometres, allowing only water molecules through. These require tremendous mechanical support and a completely continuous thin film coating on top.

Such a membrane was developed at Ohio State University and can, in theory, process 100 times more water than conventional membranes of similar pore size. Dramatic improvements in throughput bring dramatic economic improvements.



High Throughput Membrane Technology shown at the Nanoscale

Nanotechnology has the ability to revolutionise purification, desalination and a number of other challenges, but several factors hold back its widespread application. There is a **lack of integration** from materials to components and devices to systems. The industry is comprised of small companies working on one project, e.g. the synthesis of a new material, fabricating a component or the design of a device or system, but few companies can offer the 'total solutions' customers demand.

There remains a **lack of incentives** to deploy these new technologies and materials into the marketplace. End users want to minimise their costs and using more water is cheaper than buying technology to minimise its use. There is no incentive for businesses to research, manufacture and market water efficient technology if there is no demand for it. Even the recent increases in oil prices, which have seen gasoline increase in the USA from $1.25 to $3.50 a gallon in a year, have not proved sufficient to motivate the US government to invest heavily in alternative energy sources.

The **lack of standardisation** is another important factor. Consumers expect electrical goods to be compatible, and manufacturers of electronics understand that chip architecture has to operate with a vast array of end-use applications so the fabrication, design and nomenclature used in these sectors is standardised.

Nanotech is a very new industry so such standards are still to evolve. The lack of accepted definitions and nomenclature, standards for testing and design and health and safety parameters will stymie the economic case for and acceptance of new products and technologies, though these issues are starting to be addressed in the USA.

The annual market for fresh water is worth $300 billion and is growing at double digit rates. The financial markets see water as 'the next oil' and are providing capital to companies with concepts or products that address its availability, production and purification. The current focus on energy has in turn increased interest in water, with 'Google' searches on the topic increasing significantly over the last two years. Four of the top ten cities where 'fresh water' searches were undertaken were Australian. Multinationals, such as General Electric and Dupont, are declaring their interest and acquiring water companies, while the US venture capital community has stepped up its funding of filtration and desalination technology start-ups.

The need is global and there will be numerous niche opportunities, boding well for future access to capital. If venture capitalists felt only companies the size of General Electric could succeed in this business, they would not be providing capital to the innovators.

In conclusion Mr Blakely accepted the difficulty of prioritising water issues, due to the very different nature of local needs around the world, but asserted that nanotechnological solutions to water and energy issues could be developed. The hurdles to be crossed are economic and political, rather than technical, in nature.

Major Opportunities for Nanotechnology

Direct

- **Water filtration**
  - Nanoporous filter and membrane materials
- **Desalination**
  - Low pressure membrane technologies
- **Monitoring**
  - Sensors for quality and quantity of water resources
- **Remediation**
  - Contaminant specific treatments to recover soils

Indirect

- **Fertilizers**
  - Time release and greater efficacy to reduce watering requirements
- **Thermoelectrics**
  - Dramatic reduction in cooling water needs
- **Antimicrobials & photocatalysts**
  - Biofilm reduction in filters; dry laundry processes; "always clean" surfaces
- **Structural**
  - Nanocements using less water; improved composites for wind turbine blades

Presentation by Prof John Langford AM
Director, Melbourne Water Research Centre
University of Melbourne

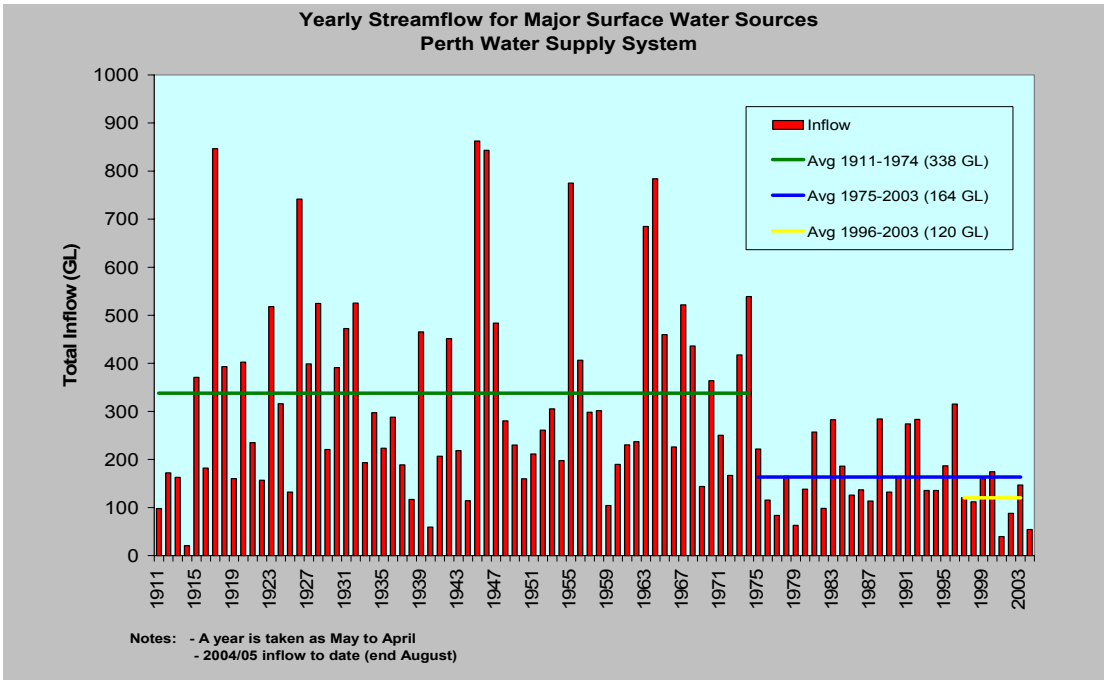
Prof John Langford explained the role of the Melbourne Water Research Centre as a hub to connect skills and finance, rather than a platform for original research. His speech laid out many areas in which nanotechnology could improve water treatment and supply.

He noted that water flow into Perth's reservoirs has halved in the 30 years since 1975, compared to the previous 70. Rainfall has declined 15% in that time, as it has in the Sahara.

The time scales require that action be taken to secure water supplies before it can be proven that climate has permanently shifted, but CO2 concentrations in ice cores taken in Vostok, a Russian Antarctic Base, demonstrate that climate does indeed change.

Alfred Deakin, Australia's second Prime Minister, was quoted as saying *'it's not the quantity of water that determines the resolve, it's the quantity of intelligence supplied'.* Prof Langford said, this observation still applied today, and argued that Australia should invest in intelligence, rather than vast canals in the far north.

Reduced inflows to dams (as at 31 August 2004)



Perth has spent approximately a billion dollars in response to the water issue and is currently building a large desalination plant. Although the 9 year drought in Melbourne is officially at an end, measures must be taken for the future by investing in intelligence. This is the opportunity for Nanotechnology.

Water and energy are inextricably linked, and water utilities are often the largest consumers of energy in a state. Water is intrinsically heavy and therefore costly to transport or pump through filter membranes.

Reducing evaporation from surface water bodies would save vast volumes of water. Lake McCurran, off the Hume Highway in Victoria, is being decommissioned because 44,000 million litres of water currently evaporates from it. Reducing that evaporation is the most efficient way of improving flows in the river. The August 2004 issue of 'The New Scientist', in an editorial entitled 'Running on Empty', argues that water lost to evaporation is genuinely lost to the system, whereas water lost in seepage is often used by other people.

An experimental monolayer was developed in Mansfield in the 1960s to cover water bodies and reduce evaporation, but wind and waves reduced it to a waxy residue on the down side of the reservoir. A solution to this problem remains in the realm of future speculation.

A more accurate means of measurement than elastic sided buckets might be transformational, though a low cost method of calculating ground water flows delivered to irrigators might destroy the economic case for Australia's rice growing industry.

The adoption of domestic water meters has been shown to cut consumption by 25%.

Certain strains of Australian algae produce extremely hazardous toxins and a method of detecting these toxins early, allowing pre-emptive action before a full scale bloom, would be useful.

The concept of **virtual water** is important. A city imports ten times its physical water supply embodied in its food. Every cup of coffee requires eleven hundred cups of water to produce it. A 250 gram steak uses 9,000 litres of water. Any measures taken to improve the efficiency of water use in that chain of production would have an important impact, from irrigation, to cleaning, preservation, transport and handing.

77% of water harvested in Victoria is used for irrigation, Melbourne consumes just 8%. Precise **irrigation** using wireless sensor and control technology could both cut water use and optimise production. Current methods to calculate the crop's status, be it the stomatal openings in the leaves, the movement of sugars and flavouring compounds throughout the plant or cavitation or temperature, are relatively primitive, requiring sensors glued to the leaves.

Wireless system of control would be a significant step forward as the goal of producing premium quality crops requires each plant to be treated individually.

Global warming may produce periods of very high temperatures, severely damaging our productive vineyards. Spraying kaolin, a white clay mineral, onto grapevines can lower their temperature and future nanotechnology may fulfil a similar purpose while reducing the need for harmful fungicides and herbicides.

Public health is the prime purpose of water supply and sanitation systems. It is obviously vital to separate drinking water and effluent waste. Nanotechnology can target specific pathogens, in particular cysts and oocysts such as cryptosporidium. Their hard shells protect them from disinfectants and a technology to weaken those shells would render them vulnerable.

Viruses are another target while the developing world needs simple 'bucket chemistry' to deal with its problems.

The water industry needs to emulate **the food industry** in adopting hazard analysis at critical control points instead of trying to measure every possible pathogen.

The safety of pasteurised milk is measured by its exposure to temperature and similarly water needs a system which measures the operations which inactivate the pathogens, rather than the pathogens themselves.

Checks on microbiological quantity take 24 hours to produce results, by which time it is too late to stop an infection. Measurement of protection in real time allows pre-emptive remedial steps to be made, and warning can be given before anyone is infected.

Current particle counters are a blunt instrument and nanotech has a role to play in improving monitoring performance, as it has in improving the efficiency of commercial water treatment processes in flocculation, filtration and disinfection.

The energy used by South Australia's **sewerage** system has doubled in five years in meeting improved environmental standards on the discharge and recycling of sewerage. Nanotechnology could cut energy costs as well as improve efficiency. Sewerage farms accumulate heavy metals and PCPs and the ability to remove or inactivate them would be significant. Werribee, Melbourne Water's sewerage farm, the second oldest in the world, has a large and unwelcome stockpile of contaminated biosolids accumulated over the last 100 years.

Water efficiency needs to be improved in washing machines, toilets and dish washers. A Melbourne company called Ecowash claim they can wash cars without using water, and nanotechnology in surface coatings might find a use on automobiles. Most **domestic water** is used by taps and toilets and anything which improves their efficiency makes a major difference in saving water and energy.

Australia's water supply is uncertain because its climate is unpredictable. The variation in China's Yangtze between the maximum and minimum recorded flow over a year is about two.

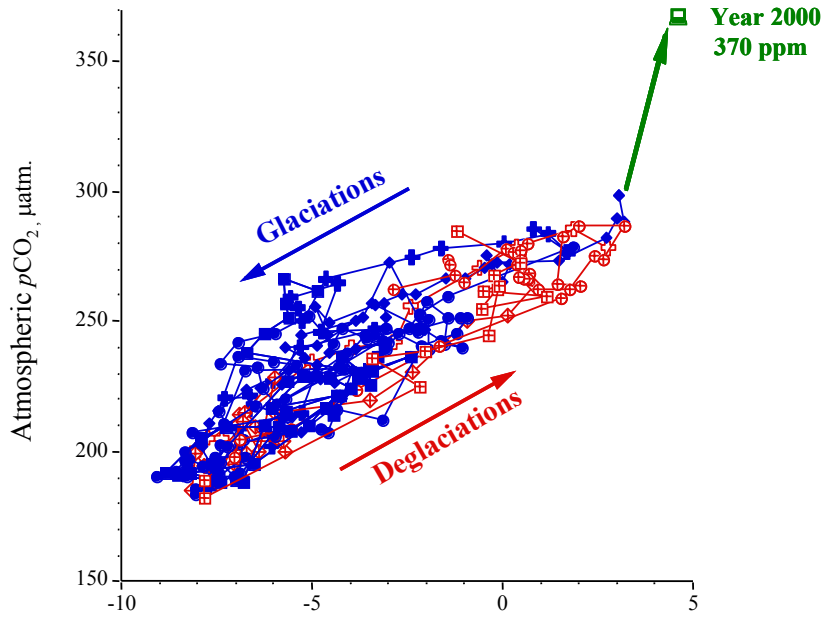
The River Murray is 15 to 1, the Darling River's ratio is nearly 5,000 to 1. The ocean is therefore a much more stable and inexhaustible water supply if low energy desalination can become a reality, linked to renewable energy.

Grey water is the other untapped source. If it can be treated over 'the magic kilometre' then people will accept it. Winperk in Namibia and Singapore are undertaking such schemes.

Australia's coastal cities make it hard to achieve the 'magic kilometre' but the public need to be educated as to its safety and reassured that endocrine disruptors, hormones, pharmaceuticals and other contaminants are removed down to nano quantities.

These are all areas where aggressive improvements in technology could produce radical transformations in the water problems we face, said Prof Langford in conclusion.

Atmospheric CO_2 and Deuterium Temperature Anomalies in the Past 420,000 Years (Vostok Ice Core Data)



IGBP 2000

The discussion focussed on finding commercial nanotech solutions to water problems. Speakers emphasised the need for a holistic approach. They encouraged participation from all interested parties in raising awareness in Government and the water industry regarding Nanotechnology's possibilities. The GAP Consultative Committee could play an important role in bringing key players together to drive the process forward.

Speakers discussed water use by the mineral extraction industry. Mining uses huge quantities, but its major loss is through evaporation. If nanotechnology could reduce the need for water cooling, important savings could be made. Desalination is close to being an economic proposition for use in mining applications on the West Coast of Australia.

Further benefits could accrue from designing out environmentally damaging industrial processes, rather than merely attempting to remedy or ameliorate their damaging impact after the fact. Education through schools, university and public television would help set this process in motion for future generations.

The hope that nanotechnology would develop at the same rate as power and solar cell technology have in the last decade was expressed. It was noted that modern consumers will baulk at jumping out of a cold shower in darkness to save energy. Better technology must produce the desired effects without imposing on people's lifestyles.

It was agreed that integration and communication between different stakeholders and economic and regulatory incentives were required to drive innovation.

The need to take factors beyond the purely economic was raised, with the market seeing a complex interplay between a large number of stakeholders and issues.

Peter Fritz stressed the importance of experts working together to meet shared objectives.

Keith Blakely said, his company had targeted energy as a market opportunity, but stressed that products can be developed with a wide range of spin-off applications. For example, acrylics can improve everything, from floor coverings to nail polish.

If new applications, technologies and materials are developed, businesses will be astute in expanding their application to create new products and make profit. Waste plants can produce methane, which can in turn generate enough electricity to power themselves and return power to the grid. Decentralised systems are the best defence against terrorist attacks on a centralised system.

Mr Blakey advocated selecting a priority product around which to organise. A desalination product, for example, would offer other applications for its membrane technology, which would be taken up by other businesses.

One of the Forum speakers underlined the significance of new limits on extracting water from rivers acting as a spur to new developments. Sewerage farms, for example, cover a large amount of land, which could be utilised for solar panels to power their operations.

Speakers observed that increasing the price of oil, an expensive non renewable resource, would be much more effective in changing behaviour than increasing the minimal price of water, which is itself not going to happen in the short term because of political considerations.

The traditional supply of water from pristine sources is still 30% cheaper than the more environmentally friendly option of recycling because externalities are not factored into the price. Only a change in accounting practise would reflect the true cost of water, but that would in turn increase the price of everything with deleterious political and economic effects.

Tony Kelly, of Yarra Valley Water**,** reiterated that water makes up only 1 – 3% of the total cost of horticultural irrigation schemes. Even if the price of water was doubled, it would still be dwarfed by other production costs, fertiliser bills and labour. Despite its relative unimportance, water bills are a politically contentious issue which politicians are loathe to address. Unlike electricity or telecommunications, most of the cost in water lies in transforming and transporting it around a small, tight physical network. A competitive market cannot be created by duplicating the existing infrastructure. Economic restructuring has greatly increased economic efficiency, but complicates the task of co-coordinating action across a range of institutions. Free market pricing cannot work, additional costs have to be added to the existing system to show the true value of water.

Other speakers noted that inventing technology which lacks a ready market is a sure fire way of losing money. Market drivers had to be created to reward innovation. Prototype technology which greatly reduces the energy costs of desalinated water is available, and major Australian cities such as Sydney are located on the coast, but scepticism and distrust of new technology remains.

The world urgently needs sources of renewable energy, which could then exploit the inexhaustible supply of water in the oceans through affordable desalination, perhaps through using hydrogen, rather than fossil fuels. The world is divided between a billion poor people without access to clean water and people in the developed world willing to pay $3.50 for 100ml of designer bottled water.

Prof John Langford noted that water supply and the price of effluent were more important to a broad range of food industries than materials, electricity, world commodity prices, but that investment is limited by uncertainty over the state of future environmental legislation. Measures can be counter productive, demands that effluent be neutral can instigate negative behaviour, for example, requiring that acid salts be added to alkali waste. Positive behaviour should be reinforced by methods beyond the mere price of water.

Speakers suggested legislative limits on the amount of water which can be taken from the environment, forcing less wasteful use of the resource and making options such as recycling, desalination and storm water more economically attractive.

Large corporations with massive plant investments tend to be the agents of change in the water industry as they cannot risk their businesses, be they breweries or power stations, by running out of water.

The legacy system is to extract water from relatively pristine environments, pipe and chlorinate it to cities and then dump the effluent.

One argument held that the future will inevitably see a dispersed water catchment, treatment and distribution system, as opposed to the huge pipelines run today. Sydney has 26,000 km of pipes in its distribution system. Sydney Water is a pipeline and transport company.

It was counter argued that decentralised home systems will inevitably be uneconomic compared to centralised urban grids. 5,000 homes with septic tanks and $5,000 biofilter systems is not an economic proposition compared to mass municipal treatment. Successful decentralisation exists in the modern distributed telecommunications system and perhaps will in future energy generation, but it was thought government regulations regarding effluent standards would tend to lead to centralised water solutions.

It was observed that many statutory bodies actually cover different physical boundaries, leading to difficulties in co-coordinating policy approaches, although the number of water utilities has fallen from 400 in 1982 to 15 today. Water is already one of the most heavily regulated industries, in every aspect from dam safety to customer service, public health and effluent discharge, and only government incentives and regulation will affect the situation.

"Australian National Nanotechnology Task Force"

Overview by Mr David Gallagher
Department of Industry, Tourism and Resources

David Gallagher thanked GAP for his invitation to the Forum and welcomed its role in turning nanotechnology into business opportunities. He outlined his role in developing options for a National Nanotechnology Strategy over the previous year.

This started with the Prime Minister's Science Engineering and Innovation Council producing a report identifying nanotechnology as an emerging technology which will have substantial impacts on the Australian economy, with water an especially important issue.

There are up to 20 different research groups working in nanotechnology, with many tens of millions of dollars worth of research projects under way. At least 50 companies are using nanotechnology to develop business opportunities and some of Australia's larger companies are active in this area. The Department of Industry provides programs to support innovation, such as 'Commercial Ready', and has been very active in supporting Australian nanotechnology companies.

Mr Gallagher encouraged businesses to use these programmes to support research and development and commercialisation.

Nanotechnology has been a priority of the Inward Investment Agency, 'Invest Australia', which has been active in supporting Australian companies linking with projects overseas. The National Cooperative Research Infrastructure Screen, NCRIS, run out of the Department of Education, Science and Training in Australia, has developed a road map highlighting the importance of nanotechnology in developing major research facilities in characterisation and fabrication.

He highlighted the need to coordinate actions across different areas of government, to look at areas where the uptake of nanotechnology may be inhibited by current policies or circumstances and to develop awareness of community concerns regarding perceived risks involved in the technology.

Mr Gallagher emphasised the need to engage with research institutions and for international engagement in developing global standards in infrastructure and health, safety and environmental laws to encourage mutually beneficial trade.

Dr Simon Wilson's group (facilitator – Dr Stephen Gray) identified agriculture, industry and urban opportunities for minimising water use. Easy to clean nanosurfaces would reduce the amount of water used in CIP cleaning in the dairy industry while nanosurfaces could reduce evaporation in irrigation channels. More intelligent measurement of environmental flow requirements might allow the release of water to the environment in a way which would enable the harvesting of other water for agriculture.

Opportunities exist for recycling between factories, while filtration systems for on-site reuse would create local opportunities. Photocatalysis to reduce contaminants such as organics and surfactants would allow the re-usage of water. Non-water cleaning systems could also be developed. Sensors which can intelligently measure the supply and use of water, or detect salt infiltration and illegal discharge inside a sewer system, would improve management and improve water quality, while global warming may increase the need to harvest rain, store storm water and measure containments in real time.

Other issues included opportunities for local filtration and salt removal to encourage local reuse rather than the traditional long distance pumping of water from country dams to urban settings and minimising hydraulic losses. Nanotechnological approaches to reducing the amount of energy needed to pump water, through reduced friction pipes, would be valuable but may prove physically impractical.

The concept of self-cleaning pipes, or silver nanoparticles inside the water reticulation system to reduce the use of disinfectants was highlighted as a preferred topic for further development.

Prof Greg Leslie's group (facilitator – Dr Peter Binks) looked at the framework needed to encourage the commercialisation of water nanotech. They recognised four sectors of interest: domestic and industrial water consumption, municipal collection and treatment and national agricultural and environmental issues. Each sector has different drivers but any nanotechnology embedded in an asset would have to repay its investment over its lifetime, e.g. silver nanoparticles to prevent bacterial growth in a refrigerator over a span of five to ten years.

A water utility's assets can last for over a century and so policy needs to be compatible with that lifespan. The water industry is notoriously conservative because it must design around long asset lives.

Industry is always looking to reduce costs, but the cost of water is so low relative to its value, that it is hard to generate savings through limiting its use.

Reducing water use will be a by-product of reducing energy and chemical consumption or improving environmental performance. Nanotechnology can reduce reliance on chemicals and energy. A policy framework which encourages reductions in energy and chemicals will therefore encourage nanotech, but it must be compatible with end-users.

Agriculture embodies synergies between energy, nutrients and water that are used to grow food which is imported into the cities and consumed. The return of that water and those nutrients back to the land by silage recycling and nanotechnology should be encouraged.

Government can build a sustainable framework through policy. New South Wales encourages the use of energy efficient lightning by offering free low energy globes in return for energy saving measures. European countries penalise storm water run off from properties, so promoting the adoption of eco-friendly porous outdoor surfaces.

Municipalities respond to regulations. If policy requires utilities to reduce discharge by promoting recycling, it will facilitate the uptake of new technologies while farmers should have incentives to recover the nutrients and water used on their land to minimise waste and run off.

Policy needs to be flexible to address complex issues branching across different sectors with different drivers.

Clive Davenport's Group (facilitator – Dr Terry Turney) discussed future scenarios, including cloud seeding, the effect of city heat islands on local rainfall and industrial onsite recycling of cooling water.

Nanotechnologies such as phylum filtration, non water cleaning and bucket sized thermoelectrics were considered promising as were small scale water flow sensors for agricultural and environmental water monitoring.

Better irrigation technology to minimise waste and evaporation and microclimate control of crops were thought to have the best opportunities for nanobusinesses in the short term.

For filtration to be cost effective, the problems of biofouling, chemical management and energy must be solved, but the problem of take up lies in a lack of incentives, rather than of technology. Regulations are needed as businesses will not adopt water saving technology of their own accord. Any drought-induced interest in water saving evaporates once the emergency ends, so only regulation can drive permanent change.

David Gallagher's group (facilitator – Harry Buskes) favoured international co-operation to solve local problems. Matching a city such as Perth with similar cities overseas would allow expertise and experience to be shared and offer greater commercial opportunities to be exploited. In any international collaboration Australia's interest and benefit should be maintained. Mr Gallagher advocated government support for Australian firms involved in such international collaborations.

Dr Belinda Ferrari's group (facilitator – Dr Sarah Morgan) identified three major water using groups: urban and rural communities and industry; and three major water sources: salt water, waste water and rainwater.

Problems associated with using these sources include its capture, treatment, transportation and reassuring the public regarding its quality. The use of recycled water is determined by community perceptions, rather than logic. Many applications do not require water of potable quality.

Nanotechnology may help urban communities recycle water through membrane filtration, and reassure the public as to its quality by monitoring it for everything, from pathogens to heavy metals, in real time. Recycled industrial water could be used for agricultural irrigation, with losses minimised through closed system delivery and better integration with fertiliser regimes. Domestic and industrial water consumption could be cut through dry technology in cleaning and disinfection.

(For the list of Workshop Topics, see page 38; profiles of Workshop Facilitators are provided on pages 35-37).

Chairman **Dr Peter Binks** emphasised the goal of developing practical solutions to existing problems, rather than developing new technology for its own sake. Regarding the Forum's first day discussions with policy makers, he underlined the need for a holistic approach which linked water and energy use and tied the various water consumption chains together. He noted that the discussions of the first day's sessions had explored priorities while the second day's activities had focussed on practical solutions, including the need to amend the regulatory environment, produce new products and change the current management of water systems.

He said, CEOs responded to direct economic incentives and that the price of water was currently too low for market forces to change standard practises. The price of effluent was a more potent factor, with its deleterious effects on food production, or the environment a more effective driver of potential change. These economic imperatives need to be linked to innovation to create commercial opportunities. Bonds must be forged between those who experience problems and the researchers charged with finding solution to them.

Cedric Israelsohn reiterated the importance of financial incentives to companies and advocated a move away from over reliance on Government leadership and funding.

Harry Buskes believed the problem lay in an information gap, rather than a lack of funding from commercial or government sources. The priority should be with ensuring people with the right knowledge made the right connections.

Other speakers advocated the linking of water management and measures to limit CO2 emissions. Public education programmes to limit time in the shower saves both water and energy and any Government action to reduce CO2 will inevitably also save water. California's Ground Water Replenishment System, the largest indirect potable recycling scheme in the world due to come on line in 2007, was driven by the need to save a million barrels of oil a year otherwise used to pump water from Northern California.

The role of Government in co-coordinating policy was questioned, as current thinking favours reducing the regulatory burden to promote economic efficiency, and any attempt at regulation inevitably provokes opposition from interest groups. The removal of regulatory barriers to new technology offers more opportunity for encouraging change.

Prof John Langford observed that the urban water infrastructure, particularly the small pipe network which accounts for the bulk of investment, is a natural monopoly. Water is heavily regulated in terms of drinking water quality, dam safety, effluent, sewer overflows, continuity of water supply and minimum flows and pressures. The product is remarkably cheap and big urban water utilities are on full cost recovery, making a 5% or 6% real rate of return on a huge asset base. There are no private water utilities responsible for final delivery to customers.

Even if the price of water was doubled, to take account of externalities, it would make no difference because water is still a very cheap product. It is also an extremely political subject. Everybody agrees how precious it is, but any attempt to increase its price meets determined opposition.

Only government action can create a market. The Victorian Government has capped diversions from rivers, as did Bob Carr in New South Wales, but the problem remains as water resources are declining while the population and affluence continue to rise.

Water is an 'A – Z' issue, politically invisible when the dams are full, but provoking a crisis in times of drought. Victoria has suffered nine dry years in succession, causing problems for both cities and farmers with reserves down to 6%, so water is moving up the agenda.

Mandated efficiency standards for appliances are effective. Dual flush toilets came into widespread use because of a mandated standard in Victoria in 1984. Only government action can create the market because water is too cheap for people to save for financial reasons. Farmers will not invest in water efficient technology because it is not economic to do so.

Dharma Dharmabalan observed that water users tended to work in isolation, with no-one looking at the cycle as a whole. He championed decentralisation as a better alternative to the current centralised systems, using multiple sources including groundwater, storm water and rainwater for harvesting, usage and disposal. Nanotechnology could, for example, be used in small waste water treatment plants in housing blocks.

Water companies can be slow to adopt new technology. Victoria's first membrane micro filtration system was built in 1991 with some difficulty because no-one had experience with it. Sydney then adopted it and the take up of micro filtration has increased since then.

Nanotechnology could be used to reduce salinity and water hardness in small towns, but only regulation will push water authorities to take up these technologies.

Wiebke Benze observed that her storm water management company used a detention system to treat rain water which prevented pollution and heavy metals reaching waterways.

However, Mrs Benze said, councils and consulting engineers did not use such systems because they added to costs. Only Government targets would give them an incentive to use it and so encourage further technical development.

Harry Buskes advocated a new approach to education to encourage the decision makers of the future to see issues currently treated as separate, such as energy, soil and water, as inextricably linked.

Alexandra Gilmour explained her design for a dish washer, which uses nanotechnology to constantly purify and filter water and so allows closed system recycling.

Stan Jeffery observed that the Sydney cryptosporidium scare of July 1998 proved a massive boost to the bottled water and home filtration market. Future threats, notably from terrorism, need to be prepared for now, perhaps in co-operation with international partners.

Prof John Langford recalled his grilling by the media during that time as an industry spokesman and that no-one actually fell ill as a result of it.

Bottled water is still a fast growing market, despite being less safe than tap water and 1,000 times the cost.

It is regulated by the Food Standards agency whose microbiological regulations are much looser than the National Health and Medical Research Council and the World Health Organisation's drinking water standards. Water is hard to store and transport, and carries a rich collection of bacteria even after disinfection. Bottled water transported on trucks in the sun is not a healthy alternative to tap water. Regulators reacted to the Crypto scare by over chlorinating the water, which put more consumers off by tainting its taste. If nanotechnology can disinfect water without chlorine or leaving a taste, it has a great future.

Coke-a-Cola succeeded in marketing Amatil as a result of the Sydney Water incident, and make huge profits by buying water for one thousandth of what they sell it for, putting it through a microfilter and using ozone to disinfect it, which does not leave a residual taste.

Peter Fritz thanked the speakers and participants and welcomed Dr Peter Binks as Chair of the National Consultative Committee on Nanotechnology Commercialisation.

In closing the Forum he thanked the sponsors of the event, including the Victorian Government, Nanotechnology Victoria, QANTAS, Global Access Partners and CSIRO, Melbourne Water and the Institute of Sustainable Innovation at the Victoria University and Australia-Israel Chamber of Commerce for their support.

This report on the Forum's proceedings will form a blueprint for the Consultative Committee in terms of developing commercial outcomes and forming a platform for co-operation with Government and businesses.

APPENDICES

PROGRAMME – DAY ONE

Breakfast Session - Thursday, 15 June 2006

The Investment Centre Victoria
ANZ Tower, Level 46,
55 Collins St, Melbourne

8:15am	Registration. Breakfast served	
8:30am	Welcome	**Mrs Catherine Fritz-Kalish** General Manager, Global Access Partners
	Keynote Address	**The Honourable John Brumby MP** Minister for State and Regional Development, Minister for Innovation, State of Victoria
8:45am	Presentations *1st Speaker*	**Mr Keith Blakely** Chief Executive Officer NanoDynamics, USA
	2nd Speaker	**Prof John Langford AM** Director, Melbourne Water Research Centre, The University of Melbourne
9:20am	Roundtable Discussion *Session Chair*	**Dr Peter Binks** Chief Executive Officer Nanotechnology Victoria
10:15am	Break	
10:30am	Discussion continues	
11:25am	Vote of thanks	**Dr Peter Binks** CEO Nanotechnology Victoria
11:30am	Close	

PROGRAMME – DAY ONE

Lunch Session - Thursday, 15 June 2006

The Investment Centre Victoria
ANZ Tower, Level 46,
55 Collins St, Melbourne

12:30pm	Registration	
1:00pm	Lunch served	
1:15pm	Welcome	**Mrs Catherine Fritz-Kalish** General Manager, Global Access Partners
	Keynote Address	**The Honourable Matt Viney MP** Parliamentary Secretary for Innovation & Industry, Department of Innovation, Industry & Regional Development, State of Victoria
1:30pm	Presentations *1st Speaker*	**Mr Keith Blakely** Chief Executive Officer NanoDynamics, USA
	2nd Speaker	**Prof John Langford AM** Director, Melbourne Water Research Centre, The University of Melbourne
2:05pm	Roundtable Discussion *Session Chair*	**Dr Peter Binks** Chief Executive Officer Nanotechnology Victoria
2:30pm	Break	
2:45pm	Discussion continues	
3:25pm	Vote of thanks	**Dr Peter Binks** CEO Nanotechnology Victoria
3:30pm	Close	

PROGRAMME – DAY TWO

Workshop - Friday, 16 June 2006

The Investment Centre Victoria
ANZ Tower, Level 46,
55 Collins St, Melbourne

12:00	Registration	
12:30pm	Welcome	**Mrs Catherine Fritz-Kalish** General Manager, Global Access Partners
	Overview	**Mr David Gallagher** Manager, National Nanotechnology Taskforce, Department of Industry, Tourism & Resources, Australian Government
12:45pm	Presentations	
	1st Speaker	**Mr Keith Blakely** CEO NanoDynamics, USA
	2nd Speaker	**Prof John Langford AM** Director, Melbourne Water Research Centre, The University of Melbourne
1:20pm	Workshop/Lunch	
	Facilitators	**Dr Peter Binks** CEO Nanotechnology Victoria
		Mr Harry Buskes Business Development, Department of Innovation, Industry& Regional Development, Victoria
		Dr Stephen Gray Director, Institute of Sustainability & Innovation, Victoria University
		Dr Sarah Morgan Project Manager, Nanotechnology Victoria
		Dr Terry Turney Director Nanotechnology Centre, CSIRO
2:40pm	Break	
3:00pm	Presentation of outcomes	
3:30pm	Panel Discussion	
	Chairman	**Dr Peter Binks** CEO Nanotechnology Victoria
4:15pm	Vote of thanks	**Mr Peter Fritz AM** Chair of Steering Committee, GAP Forum

Dr Peter Binks
CEO Nanotechnology Victoria

Dr Peter Binks has been Chief Executive Officer of Nanotechnology Victoria Limited since May 2003. Nanotechnology Victoria is a consortium of 4 research organisations focussed on the commercialisation of industrial nanotechnologies. Nanotechnology Victoria currently has three major investments of US$1 million each, a portfolio of over a dozen development activities, and employs 8 professionals. Nanotechnology Victoria will invest around US$4 million in nanotechnology development activities in 2006. Peter was the 1983 Rhodes Scholar for Tasmania, and has a PhD in Theoretical Physics from Oxford University. Peter previously worked with McKinsey & Company, with BHP as General Manager at BHP's Research Laboratory in Melbourne, and with Telstra Mobile as General Manager Strategy and Business Development and Director of Product Marketing. Over the last 12 months Peter has been a leader in the development of Australia's nanotechnology strategy. He participated in the Prime Ministers Science Engineering and Innovation Council Working Party on Nanotechnology, and designed and helped manage the 2nd National Nanotechnology Conference in September 2005. He sits on the Advisory Board for the National Nanotechnology Taskforce, and is a prominent speaker and writer on issues of nanotechnology commercialisation, investment, education, and regulation. These include *Questions Loom Large in Nanotechnology's Tiny World*, an opinion piece in the *Melbourne Age* in September 2003, and *Governing the Invisible: The New Regulatory Frontiers of Nanotechnology* (Graeme Hodge, Diana Bowman and Peter Binks); published in Conference Proceedings for the *Integrated Governance Conference* held in Prato, 26-29 October 2005.

Mr Harry Buskes
Senior Policy Adviser, Business Development, Department of Innovation, Industry & Regional Development

Harry Buskes is a Senior Policy Adviser, Business Development, in the Department of Innovation, Industry and Regional Development for the State Government of Victoria, Australia. Harry has a B.Sc (Hons) in Physics and an MBA from the Melbourne Business School with specialisation in Business Strategy and Technology Management. He is the Department's key emerging technology specialist and representative for nanotechnology, microtechnology and related activities in Victoria. Harry has over 6 years experience in Government in science and technology covering technology commercialisation, the STI Infrastructure Grant Program and catalysing new project areas. Prior to this, Harry had over 20 years experience as a senior researcher and project and business development manager for a multi-national resources company covering a wide range of advanced materials and analytical techniques. A number of his developments have been licensed to US and Australian companies.

Prof Stephen Gray
Director, Institute of Sustainability and Innovation, Victoria University

Prof Gray has 16 years research experience in water and wastewater treatment and sustainable water systems. He has extensive knowledge in the areas of membrane fouling, chemical coagulation, solid/liquid separation processes, surface chemistry and chemical engineering. He has been involved in the development of water treatment processes, such as MIEX resin and the CDS fine solids separator. He has also worked in the field of sustainable water systems, focusing on water and contaminant balance modelling and assessment of alternative water systems. He was the team leader of the CSIRO Urban Water team before recently being appointed the Director of Sustainability and Innovation at Victoria University, where he is establishing a Water Research Centre. He is also a member of the IWA Australia committee and has served on the Editorial Board of the AWA Water Journal.

Dr Sarah Morgan
Project Manager
Nanotechnology Victoria

Dr Sarah Morgan joined Nanotechnology Victoria in September 2005 from the Water Studies Centre, School of Chemistry, at Monash University, accepting a position as Project Manager - Delivery & Sensing.

Sarah is working in the sensing and delivery program on a series of commercial projects involving development of testing, analytical and delivery devices. Sarah is using her expertise in the analysis area, and building an important portfolio of activities in water analysis and environmental nanotechnology applications with Dr Bob Irving. She also supports the nanostructured materials team in several areas involving the development of environmental related projects. Sarah is an outstanding, highly motivated and competent researcher with recent experience in the optimization and assessment of nutrient analysis techniques for portable flow injection analysis instruments. Her knowledge base is the key driver behind the establishment of new projects for NanoVic and its commercial partners in nanoscale detection and water treatment. In her time at NanoVic - which includes a term as a consultant to the Delivery & Sensing team prior to accepting her current position - Sarah has performed some significant work in the application of nanotechnologies to water management issues. She has conducted a major review of the opportunities and challenges in water for both rural and metropolitan authorities, worked with consulting and technical service firms in the industry, and is leading efforts towards a major national forum on nanotechnology and water, to be held in 2006. Sarah is also managing a project to develop nanotechnology-based sensors for the detection of phosphates in water, and is developing targets for the Monash-Swinburne-NanoVic Chemical NanoArrays project. Sarah has an undergraduate degree in Science, from The University of Melbourne. Sarah also has First Class Honours in Science, and a PhD in Environmental/Analytical Chemistry from Monash University. She was awarded a Monash University Graduate Scholarship and was awarded the prize for excellence in oral presentation at the Research and Developments Topics Meeting in 2003. Sarah is an active member of the Royal Australian Chemical Institute (RACI), and regularly attends meetings and activities for the Victorian Branch Analytical Chemistry Group.

Dr Terry Turney
Director
CSIRO Nanotechnology Centre

Dr Terry Turney is Director of CSIRO's Nanotechnology Centre and holds adjunct Professorships at several Australian Universities. Over years he has served with CSIRO, he has been responsible for the development and transfer of numerous nanotechnology-based products to Australian and overseas companies. His training from the University of Sydney and the ANU was as a Chemist, with subsequent interests spanning materials science, synthetic liquid fuels development, mineral processing and polymer composites. He is holder of over 20 patent applications and 80+ publications in these areas.

A Fellow of the Academy of Technological Sciences and Engineering and of the Royal Australian Chemical Institute, he has served on numerous bodies looking at technology issues, including an Australian Prime Minister's Working Group on Nanotechnology in 2005. He is a Director of the Australian Nano Business Forum Pty Ltd, an industry-based group representing the interests of companies in the business of nanotechnology in Australia. Through his current position as Chairman of the Asian Nano Forum, a network organization promoting regional R&D and the economic uptake of nanotechnology within 13 economies in Asia, he has provided advice on commercialization and R&D to several governments in the Asia-Pacific region. Dr Turney maintains an active research profile with interests in industrial ecology, biomimetic materials and nanocomposite materials.

Group I (facilitator - Dr Peter Binks, speaker – A/Prof Greg Leslie)
Frameworks to encourage commercialisation of nanotechnology

- What industry leadership is required to implement technologies for water applications?
- What policy changes are needed to encourage nanotechnology development and ensure Australian industry readiness to embrace new technologies?

Group II (facilitator - Harry Buskes, speaker – David Gallagher)
Leveraging international models

- How can we implement successful methods used overseas (e.g. USA, Israel, South Africa etc.) to the Australian situation?
- What are the market triggers that would make nanotechnology solutions attractive?
- What nanotechnology solutions are the most attractive commercially?

Group III (facilitator - Dr Stephen Gray, speaker – Dr Simon Wilson)
Industrial ecology and water supply management

- Issues of wastewater and loss of water through the supply chain are critical. How can we modify the flows of energy and material through the water industry to achieve 10-20% improvement?
- How can nanotechnology change the logistics of water supply, embedding intelligence into the water management system?

Group IV (facilitator - Dr Terry Turney, speaker – Clive Davenport)
'Technologies of 2030'

- To create a scenario for a fictional water management system of the future using nanotechnology as a tool, based on the requirements provided (e.g. a society where the water price is higher than petrol price, with specific requirements for water recyclability; what are resources available, population rate, etc.).

"Youth Group" (facilitator - Dr Sarah Morgan, speaker – Dr Belinda Ferrari)
Global Framework

- "There is a lot of water on Earth, but it is in the wrong form and in the wrong spots. How do we manage the flow of water into our systems and how do we modify that flow (through nanotechnology, social engineering etc.)?"

Dr Andrew Baker
Associate Director
GBS Venture Partners

Dr Brett Bateup
State Relationship Manager
Victoria CSIRO

Mr David Beale
RMIT Applied Sciences

Mrs Wiebke Benze
Managing Director
Hydrocon Australasia

Dr Peter Binks
CEO Nanotechnology Victoria

Mr Steve Bird
Chief Executive Officer
Victorian Water Industry Association

Mr Keith Blakely
Chief Executive Officer
NanoDynamics

The Hon. John Brumby MP
Minister for State & Regional Development, Minister for Innovation, State of Victoria

Mr Harry Buskes
Policy Adviser, Business Development, Department of Innovation, Industry & Regional Development

Mr Dennis Cavagna
Managing Director
South East Water Limited

Mr Robert Crompton
Executive Director
Information City Australia

Dr Xavier Csar
Innovation Adviser to The Hon. John Brumby MP, Office of the Minister for State & Regional Development, Minister for Innovation

Mr Clive Davenport
Chief Executive Officer
CRC for MicroTechnology
(Small Technologies Cluster Access Programme)

Ms Madeline De Lacy
Account Manager
VIC Department Sales
Copa Water (formerly CDS Technologies)

Mr Andrew Denver
Vice President for Asia
Pall Corporation

Mr Dharma Dharmabalan
Manager, Water Quality & Treatment
Central Highlands Water

Dr Belinda Ferrari
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Gippsland Regional Water
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Dr Terry Turney
Director, Nanotechnology Centre, CSIRO

The Hon. Matt Viney MP
Parliamentary Secretary for Innovation &
Industry, Department of Innovation,
Industry & Regional Development

Ms Catherine Williams
Senior Project Officer
Office of the Deputy Secretary - Business
Development, Department of Innovation,
Industry & Regional Development

Dr Simon Wilson
Water Treatment & Process Engineering
Melbourne Water - Strategy & Planning

Dr Roger Wrigley
Institute of Land & Food Resources
University of Melbourne

Photo Gallery

Day One – Roundtable Discussion

The Hon. John Brumby,
Treasurer of Victoria

Dr Peter Binks, CEO
Nanotechnology Victoria

Keith Blakely
CEO NanoDynamics

Prof John Langford AM
Director, Melbourne
Water Research Centre

Catherine Fritz-Kalish
General Manager
Global Access Partners (GAP)

Photo Gallery

Day Two – Workshop

Group 2
Facilitator – Harry Buskes

Group 1
Facilitator - Dr Peter Binks

Group 3
Facilitator - Dr Stephen Gray

"Youth Group"
Facilitator – Dr Sarah Morgan

Group 4
Facilitator - Dr Terry Turney