Keynote speech at the Water NZ annual conference: 'Science and the water issues of today and tomorrow'

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Good morning. I would like to thank Peter Whitehouse from Water New Zealand for inviting me here today and Water New Zealand for hosting this conference. I have looked at the conference programme with interest and it seems like a commendable mix of topics associated with the intersection of water issues with science & technology.

I would also like to acknowledge Ngāi Tahu and His Worship, Mayor Bob Parker, for taking time out from dealing with the earthquake to open the conference. Water is vital resource that, as you will have noticed, raises issues and sparks debate everywhere. In New Zealand, these issues seem to crystallise in Canterbury first –sometimes even before the rest of the country realises there is an issue. So it is therefore most fitting that this conference is being held in Canterbury. And it is gratifying that local community leaders recognise the importance of the issues that will be discussed here over the next couple of days. If we are to unravel these issues sensibly, it is essential that inter-disciplinary and technical dialogue occurs between the scientists, engineers, policy makers, modellers, economists and managers who are grappling with these issues. Thank you for your support.

Similarly, I would like to acknowledge the participation of Tom Lambie (the Environment Canterbury Commissioner) and my fellow keynote speakers at this conference; Kerry McDonald (who is, among other things, President of the New Zealand Directors Institute and a Board Member of the New Zealand branch of the World Wildlife Fund) and Joe Flynn (CEO of the Water Industry Alliance). It's good to have you here.

My name is Stephen Goldson. I am primarily an entomologist and have spent most of my career at Lincoln in AgResearch and its precursor organisations, most recently as Chief Scientist. Much of this has been working on the suppression of some of our worst exotic forage pest species using biological control agents. I have also had the odd excursion into science policy and strategy. More latterly, I have developed a strong interest in ways to enhance New Zealand's border biosecurity and am currently the Executive Director of a multi-organisational Centre of Research Excellence called Better Border Biosecurity, or "B3".

About a year ago, the Chief Science Adviser to the Prime Minister, Professor Sir Peter Gluckman, asked if I could assist part-time and I currently spend thirty percent of my time as his strategist. I advise mainly on environmental issues and CRIs as Sir Peter's background has been very much in the biomedical area, particularly in paediatric medicine.

During the course of this work with Sir Peter, we have both become extremely aware of issues around water, climate, and the interaction between the two. How could we not?
Before I say anything else, I must acknowledge my science colleagues who really are water scientists. I would like to assure the audience today that I am definitely not one. Neither am I a climate scientist. So you are probably asking what I am doing here? Really my job today is to highlight the importance and value of the contribution that water scientists can make to informing debate, anticipating what may be coming our way, and making suggestions of what we could do about it.

The perfect storm?

We live at an interesting time in human history. At no other time has science and technology had such a profound positive impact on human lives and society, improving our lifestyles and increasing our life expectancy. Internationally, however, we also face a burgeoning global population at the same time that climate change appears set to significantly alter water, and therefore food, availability in many highly populated regions.

Even without climate change, the world has always had droughts, and therefore people short of water in some areas. We tacitly accept that there are currently around 500 million people, around 8% of the world's population, who are considered to be "chronically short of water" – even if we may not fully grasp the implications for those people. But now we are starting to see the signs of significant water stress closer to home as well. In Australia, unsustainable water and land management has already led to, among other things, severe soil salinity problems over large areas of what have traditionally been Australia's most productive landscapes. Climate change is likely to both exacerbate these types of existing issues, and create more.

And we are starting to see concern around water use, water quality and droughts here in New Zealand. That this is occurring is in itself a cause for concern. New Zealand enjoys regular rainfall and high quality water. We are currently ranked second of 149 nations in the Freshwater Quality portion of the international Environmental Performance Index. In this Index, Freshwater Quality is an aggregate measure based on data for the five commonly evaluated water quality factors; dissolved oxygen, pH, conductivity, and the nutrients nitrogen and phosphorus.

At the same time, however, we have significant and increasing non-point source pollution of our waterways, primarily from nitrogen, phosphorus and E.coli. As you will already be aware, high levels of nitrogen and phosphorus allow increased plant growth. This can result in oxygen levels in a body of water becoming too low to sustain life –initially at night, when the increased population of aquatic plants go into oxygen deficit and it starts to absorb oxygen from the surrounding water. E.coli, of course, is a bacteria that lives in the lower gut of warm-blooded species, and is therefore indicative of the presence of faecal material. Inside the human gut, most strains of E.coli confer benefits such as production of vitamin K2 and exclusion of harmful pathogens. More virulent strains, however, can cause diseases such as gastroenteritis, urinary tract infections, neonatal meningitis and septicaemia.

Even in natural areas, around a third of our waterways fail to meet Ministry of Health recommendations for recreational activities, let alone drinking, because of these three pollutants. These are the waterways we can no longer safely fish from or swim in. Contamination is often from bovine or human effluent, or from unsustainable land management practices. In pastoral and urban areas, this percentage of waterways with

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unacceptable water quality rises substantially. That we have such an obvious and systemic problem with nitrogen and phosphorus pollution, and still rank second in an international Index that includes these factors, is rather telling. In addition to the contamination issues, here in Canterbury, and to a lesser extent in some other parts of New Zealand, we even have heated debate surrounding water allocation.

Environment Canterbury (the Canterbury Regional Council) has mapped the water allocation status of groundwater zones of Canterbury (link: http://www.ecan.govt.nz/services/online-services/monitoring/groundwater-allocation/pages/zone-map.aspx). The red zones on this map show where the total amount of groundwater drawdown currently allocated exceeds the allocation limit for that zone. The yellow zones show where the total amount of groundwater use currently allocated is 80% of the limit. And the white zones show where the total amount of groundwater currently allocated is less than 80% of the allocation limit.

Given the politics surrounding groundwater allocation in Canterbury, I feel obliged to note that, due to small scale variations within zones, effects of excess drawdown will be noticeable at some localities even within zones that have not reached the overall allocation limit for the entire zone. Conversely, it is possible that there may be some locations, within some zones that are at or above maximum allocation limits, at which it may be sustainable to extract more groundwater. However, given the importance of the issue, and given that these current allocation limits are based on the best reliable information available to date, my opinion as a scientist is that it would be prudent to rigorously test such contentions **prior** to using them to inform either policy or management decisions.

This, of course, raises the issue of where the burden of proof should lie. Should applicants have to prove beyond reasonable doubt that further abstraction will not have a significant effect? In which case, what happens if effects are not found due to insufficiently thorough, or insufficiently robust, investigation? Or should the relevant regulatory authority have to prove that further extraction will have an impact before they can reject an application? In which case, at what point would applicants collectively consider that a regulatory authority had sufficiently reliable evidence to justify their application being rejected -or for an existing use right to be reduced or withdrawn? This is a significant issue in its own right and I will touch on it only briefly, from the perspective of achieving sustainable evidence-based policy, in a few minutes.

Suffice to say, at this point, that a reasonable level of effort has gone into understanding Canterbury's groundwater resources. As a result, effects such as vertical flow, pumping-induced leakage and nitrate contamination from intensified land-use are beginning to be better understood, although this does not make them any less important or less urgent to address. Optimal water allocation on finer, intra-aquifer zone scales will require further work, as will longer term issues, such as the effects of contamination and drawdown within Canterbury's more slowly recharged "fossil aquifers". In summary, even in New Zealand, where we are blessed with, at least from a global perspective, abundant and clean water, battle lines are being drawn over its use and management.

In addition, climate change pressures look set to have a significant impact on global water resources. Areas where reduced water availability is predicted include the Mediterranean basin, western USA, southern Africa, and north-eastern Brazil. Other effects of climate change on water availability and use include salination of groundwater supplies, exacerbated effects of pollution and changed weather patterns leading to changes in the distribution and frequency of floods and droughts. Indeed, in 2009, Professor John Beddington, the UK Chief Science Advisor,

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described the interaction of climate change with increased demands of a growing global population for food, water and energy as "The Perfect Storm". And while our unique position and climate means that this may actually benefit New Zealand in some ways in the very short term, no country will be immune from these effects in the longer term. This emerging crisis raises two issues; obligations and opportunities.

Obligations

First and foremost, we must work with other countries to reduce greenhouse gas emissions. This applies in New Zealand as much as any other country in the world. It is all very well to point out that we are a small country and that, as a nation of only four million people, we emit only a tiny portion of the world's greenhouse gases. But, with annual greenhouse gas emissions of around 19 tonnes per capita CO_2-equivalent, we are still, on a per capita basis, one of the heavier greenhouse gas emitters. And even on a national basis, greenhouse gas emissions, as a percentage of nation-wide 1990 levels have been increasing at a faster rate than most of the European and American markets we wish to export to. We are a trading nation, dependent on our brand and good name, and our trading partners are unlikely to allow us to deny our greenhouse gas obligations just because we have a low population density. And, given that much of our national branding centres around New Zealand's environmental quality, we must demonstrate application to this issue. Indeed, some work in this area is already underway - particularly from those working in the fields of *(1)* scientific research, *(2)* engineering and technology development, *(3)* economic policy and *(4)* social and environmental policy.

(1) Scientific research

In terms of scientific research, New Zealand has invested considerable hope and money in the role of science in reducing green house gas emissions. In particular, there is intense interest in methane –a greenhouse gas that is twenty-one times more potent than carbon dioxide. This gas is produced by our numerous ruminant farm animals and consequently it contributes around over a third of this country's greenhouse gas emissions. New Zealand is the only developed nation with a greenhouse gas profile where methane contributes anywhere near this percentage of emissions.

Research into methane is focused around the newly-opened New Zealand Agricultural Greenhouse Gas Research Centre in Palmerston North. The Centre is a partnership between AgResearch, DairyNZ, Landcare Research, Lincoln University, Massey University, NIWA, Plant & Food Research, the Pastoral Greenhouse Gas Research Consortium (PGgRc) and Scion. The Centre will also play a key role in New Zealand's science input into the world-wide initiative, the Global Research Alliance (GRA), announced in Copenhagen last year. The rumen is inhabited by an astonishingly diverse and immensely complex community of microbes, including bacteria, protozoa (single-celled animals), fungi, archaea (mostly organisms that produce methane, called methanogens) and viruses. One millilitre of rumen fluid contains more microbes than the whole world's human population.

Taken together, these microbes are unique in their ability to digest the fibrous parts of plants, which the host animals cannot do on their own. In doing so, however, they produce methane as a by-product and this methane is burped out by the host. Research around ruminant emissions will be aimed at reducing the amount of methane that is produced - perhaps by persuading the methanogens to produce something more useful that the cows can digest. Other areas of research include farming methods that have the potential to significantly increase the carbon storage capacity of our soils, farming systems that can continue to rely on

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natural rainfall and sunshine in the face of a changing climate (including the development and use of water-efficient forage), and energy efficient systems such a minimum tillage agriculture.

(2) Engineering and technology development

In terms of engineering, while fuel efficient transport still has a way to go, there has been accelerated progress in recent years. In Australia and the United Kingdom, engineers and architects have been working together to design zero-emission homes. Technologies such as communication-enabled Smart Metres have the potential to allow power companies, and their customers, to better manage demand patterns and overall consumption. Concrete manufacturing, traditionally a high carbon-emitting activity, may be able to be developed so it sequesters carbon instead. And, with governments in a number of countries developing national economic development strategies specifically targeting this potentially lucrative growth area, we can expect more advances in the near future.

(3) Economic policy

Economic programmes include the much-discussed Emissions Trading Scheme. Home insulation subsidies to retrofit insulation into older, poorly insulated homes are currently in place and there have also been changes, albeit gradual ones, to the Building Code to ensure new homes are better insulated and more water efficient.

(4) Social and environmental policy

Social and environmental policy has resulted in both educational programmes to encourage behaviour changes, such as walking school buses and enviro-schools, and increased investment into programmes such as recycling, public transport and cycle-ways in some localities. Yet, despite these efforts, greenhouse gas emissions continue to rise. And most commentators are speculating that any stabilisation of the rate of greenhouse gas emissions is only due to the recent financial crisis and resulting global recession. More progress, integrated from across multiple disciplines, is urgently needed. The same applies to adaptation strategies. Latent climate change, driven by existing atmospheric greenhouse gas concentrations, means that some changes and challenges associated with climate change are probably already inevitable, even if we cut emissions to zero tomorrow. We need to be ready for these challenges.

Opportunities

The second issue, however, are the potential opportunities. Water, which already gives New Zealand a competitive advantage in the primary production sector, will become even more valuable. This is most fortunate because, as a country we do not have the diverse mineral wealth or easily accessible oil that has driven economic growth in major economies such as the USA and Middle Eastern nations. We do not have a large internal economy and we are relatively remote from markets. Such factors may have led to New Zealand's lack of large-scale pharmaceutical and electronics industries, such as those found in Asia, the USA and Europe. That said, New Zealand has produced extraordinary niche industries, often linked to agricultural technology and its connection to the availability of abundant, clean water. Although the commonplace occurrence of water in New Zealand means that we sometimes overlook it as an important resource, a large part of our economy is based on exporting 'virtual water'.

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The term ‘virtual water’ is an economic concept that refers to the amount of water it takes to produce goods and services. It takes, for example, around 1,000 litres of water to produce one litre of milk, 960 litres to produce a litre of wine and 300 litres to produce 1 litre of beer.

The original development of the Virtual Water concept is credited to Israeli economists as a way of assessing the relative worth of different types of exports to their economy. Was it worth, for example, exporting water-intensive oranges? Or could this scarce water be more profitably used to develop other sectors of Israel’s economy? So, if New Zealand has a competitive advantage via exporting virtual water, and climate change is likely to increase this advantage, how are we managing this increasingly valuable, but vulnerable, resource?

The value of robust research

This is a large area and, as a scientist, I have no particular ability to address the inevitable political and social issues. Rather, I’d like to explore some of the ways in which science, research and technology can inform and support sustainable water management. As I have said, New Zealand has some significant issues when it comes to water. These include:

- Increasing demand from a growing population. (For example, in areas such as Canterbury, groundwater resources already appear to be over-allocated in some places. Similarly, the increasing complexity in the provision of water supply to large urban populations is another example of why issues around demand are highlighting the need for comprehensive, long term planning.)

- The effects of droughts in Northland, the East Coast and Marlborough. The health impacts, economic impacts and use limitations within both urban and rural waterways due to pollution. (For example, the previously mentioned proportions of waterways, even within “natural areas”, that are unsafe for recreational activities. And polluted freshwater runoff affecting marine ecosystems and industries, such as aquaculture.)

- Disrupted freshwater food-chains due to widespread structural barriers to fish migration.

- Changes in land-use potentially altering local hydrology to the point where it affects adjacent freshwater and marine systems. (For example, pine forests planted in coastal dune systems increasing the levels of evapotranspiration to the point where this noticeably affects water runoff into dune lakes, and potentially also beach habitats).

Many of these issues are caused or exacerbated by a dairying industry that has experienced very rapid growth in recent years. As a nation, we can’t retreat from dairying, and the industry has many positive impacts. But we can, and should, do a lot more research into the unintended negative impacts of a flourishing, water-intensive dairy industry and how to avoid or, at the very least, off-set them. These kinds of controversies can only be untangled by research –and the type and quality of the evidence required is difficult to obtain. This is not the kind of evidence that can be obtained through public opinion or from opposing experts presenting their site-specific effects assessment of some local proposal at a Council Hearing or in Environment Court. Focus groups are no substitute for science and, as the old saying goes, “the plural of anecdote isn’t data”.

While science can’t create policy, it certainly needs to inform it. And, in order to achieve optimal management of New Zealand’s water resources, both policy and management needs

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to be informed by reliable, robust, relevant and up to date knowledge. This type of knowledge can only be obtained through long-term, non-commercial, scientifically-robust research programmes with stable funding and management. New Zealand unfortunately doesn't have a large capacity in this area, but there is one important programme I would like to mention, this being the National State of the Environment Monitoring Programme. The National State of the Environment Monitoring Programme provides information on environmental indicators, including regional water use and allocation, river water quality, lake water quality, groundwater quality and recreational water quality[26]. Although it is run by the Ministry for the Environment, multiple councils and research organisations feed data into it.

One of the programmes is The National Rivers Water Quality Network. This is a long term programme run by the National Institute of Water & Atmospheric Research. Over the last twenty years, monitoring of seventy-seven sites on 35 large rivers around New Zealand have provided a robust insight into the attributes and long term trends of our waterways. Issues identified or quantified by the National Rivers Water Quality Network programme include topsoil loss, public health impacts related to water quality, macro-invertebrate diversity and changes in pollution sources.

More broadly, the State of the Environment Monitoring Programme needs standardising and streamlining, in particular so as to provide sufficient support to contributing organisations to ensure that the local and regional data they provide are sufficiently consistent, robust, in the right areas and of the right format, to build on national databases. Certainly though, the overall State of the Environment concept is still a good start and worth building on.
The importance of information gained from these kinds of basic research and monitoring programmes cannot be over-estimated. Firstly, it informs policy and identifies information gaps. One example of new research in this area is a series of three core projects initiated by the Cawthorne Institute. These projects seek, among other things, to develop a robust methodology for prioritising stream restoration budgets and to tease out optimal environmental flow regimes in order to help inform water allocation decisions.

The use of evidence-based policy to inform local, sustainable management approaches

The application of good evidence-based policy stimulates the kinds of resource management responses we will hear more about over the next couple of days; such things as aquifer recharge management, inflow management, sewage treatment, maintenance of drinking water quality, and wastewater management. In the future, at conferences such as this one, we may well be discussing things such as methods for extracting phosphorus, and even nitrogen, from dairy effluent before it reaches our streams, and ways of recycling it back onto our farms. We may also be discussing more equitable, sustainable, and cost-effective ways of accessing and managing water in our built environments and urban areas.

Research to inform national and international economic and social policy

Social and economic tools to inform and influence consumer behaviour, such as Water Footprint labelling on products, with Water Footprints being the aquatic sister of Carbon Footprints, may help to further inform and extend this debate. Water Footprint Assessments are one tool being advocated by UNESCO and WWF to assess the impact of foreign imports on water availability in the source country. It looks not only at where virtual water imports are coming from, but also the impact that exporting this virtual water has on the exporting country. In an assessment of UK Virtual Water imports that was carried out by the World Wildlife Fund in 2008, New Zealand was assessed as exporting a lot of virtual water to the UK,

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but having low water stress. In contrast, South Africa exports a similar amount of virtual water to the UK, but has water stress levels that are several orders of magnitude greater.

This raises ethical issues around the effect that virtual water-intensive imports can have on exporting countries, particularly the more vulnerable populations within those countries. Water Footprint labelling is being lobbied for by non-government agencies as a way to better manage the effects of increasing international trade involving virtual water by reflecting the relative efficiency (and effects) of producing various commodities in different areas. On the demand side, this type of assessment could potentially lead to a shift in either the type of exports accepted from some countries or, at the producer level, bring about either a shift from cash cropping towards crops that prioritise domestic needs or a shift to more water efficient exports.

Water Footprint analyses may even help to make other governments think differently about non-tariff barriers to trade, such as state-funded subsidies for water-intensive primary production in water-stressed areas. All of these geopolitical considerations work in favour of New Zealand's trading position. In the short term, this advantage is likely to be accentuated further under climate change if predicted changes in water supply in populated areas eventuate. More locally, current research into Water Footprints within New Zealand could assist producers, land managers and regional authorities in addressing efficient crop selection and resource allocation issues, particularly in water-stressed areas such as the Canterbury plains. In future, Water Footprint labelling could also be used to support New Zealand's marketing position in terms of minimising impacts on natural biological systems and ecology.

Conclusion

We live in interesting times. Globally, climate-induced water scarcity and population growth will continue to increase the relative value of water over the foreseeable future. If we understand, value and manage our water resources wisely, New Zealand will be in a good position to develop competitive advantages in water-intensive industries. An integrated, multi-disciplinary and evidence-based approach to policy development is the most likely way of achieving this goal.

Thank you.

ENDS.

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