18 April 2017

National Water Reform inquiry
Productivity Commission
GPO Box 1428
Canberra City ACT 2601

Submission to the Productivity Commission National Water Reform Inquiry 2017

Thank you for the opportunity to provide a submission to this very important and timely inquiry. This submission addresses the Terms of Reference of the Inquiry as described in the Productivity Commission Issues paper on ‘National Water Reform’ (March 2017). In the context of the Preliminary Framework – national water reform priorities (Issues Paper, Table 1), the focus of this submission is ‘**Water Services – Rural and urban water services are provided efficiently**’. Three specific topics are raised in this submission:

- The importance of **potable water reuse** in urban water supply portfolios;
- The need to improve preparedness to manage **water quality impacts of extreme weather events**;
- The need to better account for changing community expectations regarding **recreational opportunities from urban rivers**.

My Background and Experience

I am an Associate Professor in the School of Civil & Environmental Engineering, where I undertake research and teaching activities in the fields of water quality, drinking water and wastewater treatment, risk assessment and sustainability. I also lead the research stream on trace organic chemicals in water at the UNSW Water Research Centre.

I am a current member of the Water Quality Advisory Committee to the National Health and Medical Research Council (NHMRC) and the Water Quality Technical Advisory Group to the World Health Organization (WHO). On both of those committees, I provide expert advice on many issues associated with water quality and health, including the development and revision of water quality guidelines. In particular, I have made significant contributions to the Australian Drinking Water Guidelines, Australian

Guidelines for Water Recycling and (yet to be released) WHO Guidelines for water recycling for drinking (“potable reuse”).

I am a member of the Australian Water Association (AWA) and current Chair of the AWA specialist Network for Water Recycling. I am also a member of Engineers Australia (MIEAust).

The importance of potable water reuse in urban water supply portfolios

With increasing demands on existing water supplies and limited access to new conventional water resources, some municipalities have begun to intentionally reuse highly treated municipal wastewater effluents to augment drinking water supplies.

Throughout the world, treated and untreated municipal effluents are discharged to waterways including streams and rivers. In many cases, towns and cities downstream draw upon such streams and rivers for municipal drinking water supplies. As such, water that was discharged as treated wastewater is unintentionally reused for drinking water supplies. This practice is commonly termed ‘unplanned’ or ‘*de facto*’ potable reuse, indicating that although it is not usually seen as an intentional water supply strategy, it is nonetheless, a reality in many places (Rice & Westerhoff, 2015).

Planned potable water reuse involves the purposeful addition of highly treated wastewater (i.e., reclaimed or recycled water) to a drinking water supply. The distinction between ‘unplanned’ and ‘planned’ potable reuse is significant since the acknowledgement of intention and more holistic view of the overall urban water cycle has led to changes in implementation (Drewes & Khan, 2011). These changes have included increased attention to health risk assessment and management. In turn, these have led to the incorporation of enhanced or additional water quality treatment barriers in some cases (Drewes & Khan, 2015).

Practices of planned potable water reuse have been categorised as one of either ‘indirect potable reuse’ (IPR) or ‘direct potable reuse’ (DPR). The distinction is made on the inclusion or exclusion of what has been referred to as an ‘environmental buffer’ (Leverenz *et al.*, 2011).

The incorporation of an environmental buffer involves transferring the water, at some appropriate point in the treatment train, to an environmental system such as a surface water reservoir or groundwater aquifer. The environmental buffer may serve a number of functions including storage, dilution and the opportunity for further water quality improvement by natural treatment processes such as sunlight-induced photolysis, biotransformation and natural pathogen inactivation. Furthermore, passing reclaimed water through an environmental buffer has been perceived to be beneficial regarding enhancing public perception of potable water reuse projects. This is achieved, in part, by providing a ‘disconnection’ between sewage as the source of the water and potable use as the final application. Projects that have incorporated the use of an environmental buffer are examples of IPR, while projects that omit any significant environmental buffer have been referred to as examples of DPR (Arnold *et al.*, 2012).

A range of planned potable reuse schemes, employing various natural and engineered treatment processes, have been developed internationally since the early 1960s (Drewes & Khan, 2011). The majority of these projects are examples of IPR schemes. However, there is now a rapidly growing trend toward interest in municipal DPR projects. There are now operational DPR plants in Namibia, South Africa and Texas, USA. Furthermore, there is considerable interest in developing DPR for a number of large cities in California including San Diego and Los Angeles.

The absence of an environmental buffer in a DPR project does not necessarily imply that there is no capacity for storage to buffer variabilities in water supply and demand. However, it would normally imply that such a storage buffer, should it be used, would be ‘engineered’ rather than ‘natural’ (Tchobanoglous *et al.*, 2011). Furthermore, engineered storage buffers of DPR systems would not normally be assumed to provide any additional treatment benefit, as may often be assumed for environmental buffers.

The US EPA Guidelines for Water Reuse describe DPR as follows (US Environmental Protection Agency, 2012):

> *“DPR refers to the introduction of purified water, derived from municipal wastewater after extensive treatment and monitoring to assure that strict water quality requirements are met at all times, directly into a municipal water supply system. The resultant purified water could be blended with source water for further water treatment or could be used in direct pipe-to-pipe blending, providing a significant advantage of utilizing existing water distribution infrastructure.”*

The Guidelines state that DPR may now “be a reasonable option based on significant advances in treatment technology and monitoring methodology in the last decade and health effects data from IPR projects and DPR demonstration facilities”. With specific reference to data collected from a number of US-based IPR projects, the Guidelines conclude that the advanced wastewater treatment processes in place in these projects can meet the required purification level.

The case for including DPR among the various water supply options that may be considered in a particular circumstance is based largely on the potentially advantageous environmental, financial and reliability attributes of DPR compared to some alternatives:

> *“In many parts of the world, DPR may be the most economical and reliable method of meeting future water supply needs. While DPR is still an emerging practice, it should be evaluated in water management planning, particularly for alternative solutions to meet urban water supply requirements that are energy intensive and ecologically unfavorable. This is consistent with the established engineering practice of selecting the highest quality source water available for*

> *drinking water production. Specific examples of energy-intensive or ecologically-challenging projects include interbasin water transfer systems, which can limit availability of local water sources for food production, and source area ecosystems, which are often impacted by reduced stream flow and downstream water rights holders who could exercise legal recourse to regain lost water. In some circumstances, in addition to the high energy cost related to long-distance transmission of water, long transmission systems could be subject to damage from earthquakes, floods, and other natural and human-made disasters. Desalination is another practice for which DPR could serve as an alternative, because energy requirements are comparatively large, and brine disposal is a serious environmental issue. By comparison, DPR using similar technology will have relatively modest energy requirements and provide a stable local source of water."*

The Academy of Technological Sciences and Engineering (ATSE) on DPR

The Australian Academy of Technological Sciences and Engineering (ATSE) recently released a report on the potential future role of DPR as a component of drinking water supply in Australia (Khan, 2013). I was the lead author of that report. The front cover of the report is displayed in Figure 1 and a full copy can be downloaded (free of charge) from the ATSE website: www.atse.org.au

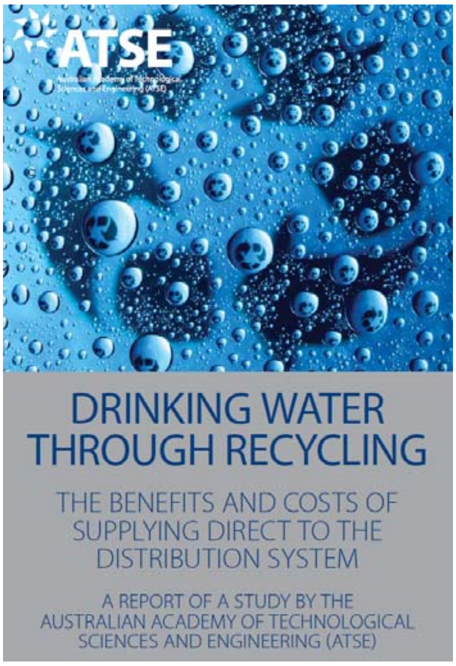


Figure 1 Report on direct potable reuse (DPR) recently produced by the Academy of Technological Sciences and Engineering (ATSE). Available from www.atse.org.au

In undertaking the development of this report, ATSE developed a series of key findings, as presented in the following paragraphs.

> *The science, technology and engineering associated with DPR have been rapidly advancing in recent decades. DPR is growing internationally and will be an expanding part of global drinking water supply in the decades ahead.*
>
> *DPR is technically feasible and can safely supply potable water directly into the water distribution system, but advanced water treatment plants are complex and need to be designed correctly and operated effectively with appropriate oversight. Current Australian regulatory arrangements can already accommodate soundly designed and operated DPR systems.*
>
> *High levels of expertise and workforce training within the Australian water industry is critical. This must be supported by mechanisms to ensure provider compliance with requirements only to use appropriately skilled operators and managers in their water treatment facilities. This will be no less important for any future DPR implementation and to maintain high levels of safety with current drinking water supply systems.*
>
> *Some members of the community are concerned about the prospect of DPR. Planning, decision-making, and post-implementation management processes should acknowledge and respond to these concerns. Public access to information and decision-making processes needs to be facilitated. However, the relative merits of water supply options should, as far as possible, be based on quantifiable or evidence-based factors such as public safety, cost, greenhouse gas emissions and other environmental impacts, as well as public attitudes. There is little value in distinguishing DPR from other water supply options, unless specific proposals are compared using these criteria. Any proposal to consider DPR alongside alternative water supply options should explicitly take account of full life cycle costs, long term sustainability (including pricing) and full costing of externalities.*
>
> *Individual recycling schemes, as with other supply options, will present unique opportunities and risks that need to be systematically identified and managed. In ATSE's view, the Australian Guidelines for Water Recycling provide an appropriate framework for managing community safety and guiding responsible decision-making.*
>
> *Ultimately, water supply decision-making should be based on an objective assessment of available water supply options to identify the most economically, environmentally and socially sustainable solution. While optimum solutions will continue to be case-specific, ATSE is convinced of the technical feasibility and safety of drinking water supply through DPR when properly managed. ATSE considers there may be considerable environmental, economic, and community benefits of supplying highly treated recycled water direct to drinking water distribution systems in appropriate circumstances.*

> *ATSE therefore concludes that DPR should be considered on its merits – taking all factors into account – among the range of available water supply options for Australian towns and cities. Furthermore, ATSE is concerned that DPR has been pre-emptively excluded from consideration in some jurisdictions in the past, and these decisions should be reviewed.*
>
> *Governments, community leaders, water utilities, scientists, engineers and other experts will need to take leadership roles to foster the implementation and acceptance of any DPR proposal in Australia.*

It is proposed that these findings are highly relevant to the considerations of the Productivity Commission in assessing opportunities for optimised urban water supply systems in Australian towns and cities.

The need to improve preparedness to manage water quality impacts of extreme weather events

Extreme weather events include heavy rainfall and floods, cyclones, droughts, heatwaves, extreme cold, and wildfires. Each of these types of events can potentially impact drinking water quality by affecting water catchments, storage reservoirs, the performance of water treatment processes or the integrity of distribution systems.

There is now broad scientific consensus that, with the continuation of greenhouse gas warming over the 21st century, it is very likely that heat waves will occur more often and last longer, and that extreme precipitation events will become more intense and frequent in many regions (IPCC 2014). These climate change impacts will amplify existing risks, and create new risks for natural and human systems. The Intergovernmental Panel on Climate Change (IPCC) has identified important key risks for various global regions, including in some cases, increased drought-related water shortages, as well as increased damage from floods and wildfires (IPCC 2014).

Current evidence indicates global increases in the frequency and magnitude of high temperature extremes, together with more frequent and intense heavy rainfall events in many, but not all, global regions (Goodess, 2013). Consequently, some regions are projected to become more prone to more intense rainfall, while others will become more prone to drought (Cook *et al.*, 2014). Recent evidence suggests that already about 75% of the moderate daily hot extremes, and about 18% of the moderate daily precipitation extremes over land, are attributable to climate change (Fischer & Knutti, 2015). Pacific Ocean *El Nino* events are a prominent feature of climate variability and are associated with severely disrupted weather patterns, leading to tropical cyclones, drought, wildfires, floods and other extreme weather events worldwide (Cai *et al.*, 2012). Recent modelling has revealed evidence for a doubling in *El Nino* event occurrences in the future as a result of greenhouse gas warming (Cai *et al.*, 2014).

Extreme weather events may adversely impact on drinking water supplies in a variety of ways, leading to water quality impacts, including increased concentrations of suspended material, organic matter, nutrients, inorganic substances and pathogenic microorganisms in source waters.

A systematic review identified eighty-seven waterborne outbreaks involving extreme water-related weather events (Cann *et al.*, 2013). Heavy rainfall and flooding were the most common extreme weather events that preceded waterborne outbreaks, which often resulted from the contamination of drinking-water supplies.

Direct impacts to water quality from extreme weather may be relatively simple to identify, but indirect impacts from extreme weather or changing trends over time can be overlooked, especially when they occur months, or even years, after the onset of the particular event. Changes to temperature and precipitation patterns can increase the potential for wildfires, encourage invasive species or increase forest mortality, resulting in both short-term impacts on water quality and long-term impacts to water catchments.

It is possible to design and operate systems to mitigate foreseeable extreme events. Many water quality impacts from extreme weather events may be successfully managed by existing water treatment plants and, therefore, do not lead to water quality impacts being experienced by customers, provided the treatment plants have been adequately designed and are operated for the local circumstances. However, some extreme events may impose additional burdens on treatment facilities, requiring additional power consumption, chemical use, maintenance or waste production. They may also represent an elevated level of source water risk and require additional risk management activities by water utilities, regulators and others to protect customers.

In some cases, extreme weather events can adversely impact water supply systems, such that normal household water services may not be maintained. These circumstances may also have public health impacts. Furthermore, extreme weather events can damage electrical, communication and transportation infrastructure, leaving water supply systems and operations vulnerable to other water quality impacts.

Small scale water services, using surface water resources (rivers and lakes) for drinking water production may be particularly vulnerable to short term events due to their low adaptation capacity, and a relative lack of trained personnel and technical knowledge, compared to major centralised systems.

A summary of water quality and quantity consequences of extreme weather events and possible mitigation strategies is presented in Table 1 (Khan *et al.*, 2015). Australian experience has shown that even when individual weather events may not be considered ‘extreme’, combinations of events can present extreme and difficult-to-predict circumstances (Khan *et al.*, 2017).

Table 1. Water quality and quantity consequences of extreme weather events and possible mitigation strategies (Khan *et al.*, 2015).

Extreme event	**Duration of effect after the event**[1]	**Adverse supply impact**	**Effective mitigation strategies**
Heavy rainfall and floods	Short to moderate	• Increased pathogen and contaminant concentrations • Elevated turbidity due to increased particulate and soluble substances in storm runoff • Sewage system overflows • Decreased disinfection efficacy • Damage to infrastructure, including electrical supply • Staff cut off from treatment plants and other work locations • Very short retention times in reservoirs due to short-circuiting	• Additional or increased disinfection processes • Implementation of enhanced treatment options prior to a forecast event • Issuing of boil water advisories • Alternate delivery of potable water (*e.g.*, tankers) • Supply of point-of-use filtration devices and personal water quality testing kits • Pre-filtration of surface waters prior to intake in drinking water plants • Diversifying water sourcing options
Superstorms and high winds	Short	• Similar to "heavy rainfall and floods" above. • Loss of key staff due to transport difficulties or damage to their own property.	• Similar to "heavy rainfall and floods" above, plus: • Plan to have alternate staff available on call or accessible electronically • Building redundancy into water supply systems, including back-up power generators • Availability of alternate water sources
Drought	Moderate	• Increased nutrient loads after extended period of drought • Large "flushes" of organic carbon once rainfall occurs • Elevated risks of algal and cyanobacterial blooms • Intrusion of saltwater in coastal area groundwater or intrusion of saline groundwater into inland surface water, which can render water unpalatable and require significant treatment changes, and can lead to increased brominated disinfection by-products	• Increased monitoring of surface water reservoirs for signs of algal or cyanobacterial blooms • Diversifying water sourcing options • Additional filtration in early stages of drinking water production
Extreme heat	Short to Moderate	• Elevated risks of algal and cyanobacterial blooms • Accelerated loss of disinfectant residual in distribution system • Early onset of nitrification in chloraminated systems • Increased peak demand	• Diversifying water sourcing options • Careful monitoring and application of disinfectant • Vertical mixing of water supply reservoir • Stricter nutrient management in the catchment

Wildfires	Short to Long	• Destruction of treatment equipment and other hardware • Staff cut off from treatment plants and other work locations • Increased magnitude of storm runoff • Increased nutrient and contaminant loads • Increased organic carbon • Elevated risks of algal and cyanobacterial blooms • Elevated microbial activity and DOC transformation • Presence of fire-fighting chemicals	• Diversifying water sourcing options • Additional filtration in early stages of drinking water production • Activated carbon treatment • Careful monitoring and application of disinfectant • Additional monitoring of contaminants • Prevention of particulate matter entering water-courses (eg straw bales, construction of swales)
Unseasonable extreme cold	Moderate to Long	• Salinisation from de-icing salts • Lake destratification and mixing • Intake ice blockages • distribution system failures	• Careful control of road surface runoff • Enhanced distribution system monitoring and maintenance

[1] short = days to weeks, moderate = weeks to months, long = years.

The Australian water industry has played a leading role in the incorporation of a risk-based management framework to underpin safe and reliable drinking water supply. This was achieved by the development of the Framework for Management of Drinking Water Quality, which first appeared in the 2004 revision of the Australian Drinking Water Guidelines (ADWG). While that Framework is applicable to the management of drinking water quality under all conditions, there is evidence to indicate that a range of extreme weather events pose particular challenges to drinking water quality.

In 2013, Water Research Australia funded a research project to “Identify and assess the water quality risks from extreme events” (WaterRA Project 1063-12). The aim of this project was to undertake research to support the development of specific guidance for the Australian water industry to manage threats to drinking water quality from extreme weather events. The outcomes of this research were presented in the final report for WaterRA Project 1063-12 and a number of scientific journal manuscripts, which are now published from that work (Khan *et al.*, 2015; Deere *et al.*, 2017; Khan *et al.*, 2017).

An important outcome from this work was an industry guideline document, published by Water Research Australia and titled ‘Protecting Drinking Water Quality from Extreme Weather Events’ (**Figure 2**). This document provides evidence-based guidance for Australian water utilities to improve their management of drinking water supplies, to protect against water quality impacts of extreme weather events. The outcomes from this research and the findings presented in the guidance document should be incorporated into future Australian drinking water supply management practices.

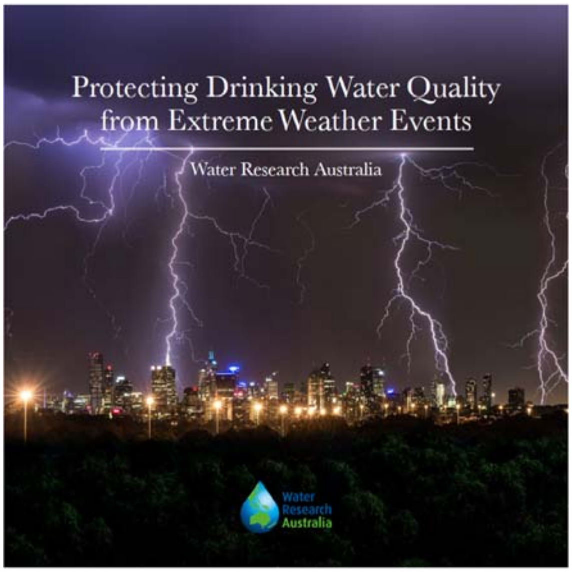


Figure 2 Protecting Drinking Water Quality from Extreme Weather Events – Practical guidance developed by Water Research Australia for Australian drinking water managers.

The need to better account for changing community expectations regarding recreational opportunities from urban rivers

During the last five years, there has been rapidly growing interest, by community members and local governments, in the restoration of previously polluted urban rivers to ‘swimmable’ status. This involves ensuring that water quality, at designated swimming locations is managed to ensure acceptable levels of risk to public health from chemical and microbial water quality contaminants.

Examples of this trend in Australia can be observed in a number of currently active community campaigns. These include the following examples:

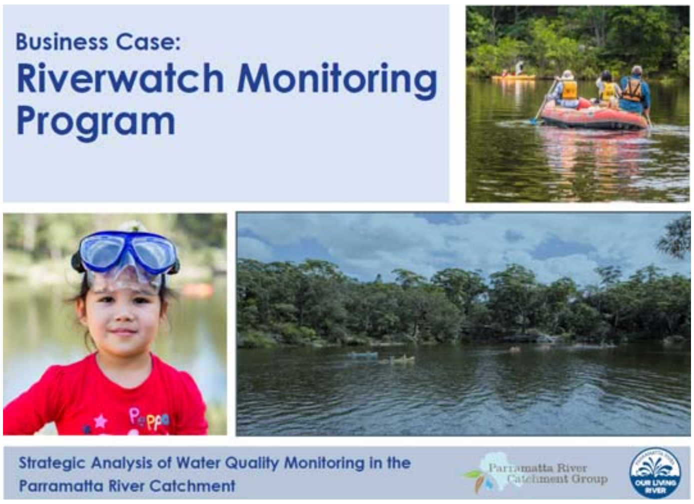
- The “Our Living River” campaign to return parts of the Parramatta River in Sydney to swimmable status by 2025. (http://www.ourlivingriver.com.au/)

- The Yarra Swim Co is leading a push for a swimmable Yarra River in Melbourne, with a focus on reviving the historic swimming ‘Race to Princes Bridge’ (http://www.yarraswim.co/) .

Similar campaigns are active to promote restoration of iconic international rivers for swimming including the Thames River (London), The River Spree (Berlin) and Harbour Baths in Copenhagen. A number of international cities are already enjoying considerable success in restoring previously polluted rivers to swimmable status including the Charles River (Boston).

The Our Living River Campaign, focused on Sydney’s Parramatta River is an initiative of the Parramatta River Catchment Group, which is an association of interested organisations including local governments (Hunters Hill Council, Blacktown Council, City of Canada Bay, City of Ryde, Strathfield Council, Burwood Council, City of Canterbury Bankstown, Cumberland Council, Inner West Council, City of Parramatta, The Hills Shire Council) as well as Sydney Water, NSW EPA and NSW Planning & Environment.

During 2016, the Our Living River Campaign commissioned and published a number of important reports regarding the management of water quality in the Parramatta River. These included a literature review on ‘How should recreational water quality in the Parramatta River be assessed?’ (Khan & Byrnes, 2016a), a Technical Analysis Report on water quality in Parramatta River (Khan & Byrnes, 2016b) and a Business Case for a future Riverwatch Monitoring Program (Parramatta River Catchment Group, 2016) (**Figure 3**).



Business Case:
Riverwatch Monitoring Program

Strategic Analysis of Water Quality Monitoring in the Parramatta River Catchment

Parramatta River Catchment Group

OUR LIVING RIVER

Figure 3 Business case developed by the Parramatta River Catchment Group for the development of a Riverwatch Monitoring Program to support the Our Living River campaign (Parramatta River Catchment Group, 2016)

This trend toward community interest in recreational opportunities from urban rivers was much less visible when Australia’s National Water Initiative was developed (2004) than it is in 2017. Accordingly, this issue did not receive any attention in the documents and policies developed as a consequence. However, it is proposed that this is now a rapidly emerging trend and that the impacts of urban water management decisions on recreational water quality should be afforded significant more attention in the future.

Conclusion

I hope that the Productivity Commission will find the information that I have provided in this submission to be useful for the very important inquiry taking place. I would be happy to provide any further information, including copies of any of the literature or documents referred to in this submission. I look forward to reading the findings and recommendations of this inquiry.

Yours sincerely,

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