Submission
No 349

INQUIRY INTO PROPOSAL TO RAISE THE WARRAGAMBA DAM WALL

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Mr Justin Field MLC
Committee Chair

Select Committee on the Proposal to Raise the Warragamba Dam Wall,
Inquiry into the Proposal to Raise the Warragamba Dam Wall

Dear Chair,

Thank you for the opportunity to raise a number of issues in relation to the Proposal to Raise the Warragamba Dam Wall.

The principle role of Warragamba Dam is to provide a secure and reliable source of potable water for residents of Sydney. Lake Burragorang and the catchment that supplies water to it have important parts to play in serving this role. In compliance with the Australian Drinking Water Guidelines and the Framework for Management of Drinking Water Quality, it is essential that Warragamba be managed and maintained in a manner that reliably produces high quality drinking water and minimises water quality risks to public health.

Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines provide guidance on how the supply of drinking water should be managed ‘from catchment to consumer’ to ensure safe drinking water quality. The Guidelines introduce the “Framework for Management of Drinking Water Quality”. The Framework encompasses 12 ‘elements’, of which Element 2 is “assessment of the drinking water supply system”.

Among the important aspects of the drinking water supply system requiring assessment are catchments and source waters. The Guidelines emphasise that “catchment management and source water protection provide the first barrier for the protection of water quality”. Furthermore, they state:

> “*Effective catchment management has additional benefits. By decreasing contamination of source water, the amount of treatment and quantity of chemicals needed is reduced. This may lead to health benefits through reducing the production of treatment by-products, and economic benefits through minimising operational costs.*”

Water Quality Risks from Heavy Rainfall and Catchment Flooding

If the proposed new flood mitigation capacity were ever to be used, this would present significant water quality risks, including risks to public health, for Sydney Water drinking water customers. The likely impacts to water quality should be very carefully assessed before such a project is progressed.

Drinking water catchments contain various particulate and soluble substances, which may be mobilised to waterways by runoff from rainfall (Khan *et al.*, 2015). As a consequence, heavy rainfall and high river flows are commonly associated with elevated turbidity (Goransson *et al.*, 2013) and dissolved organic matter (Hongve *et al.*, 2004; Murshed *et al.*, 2014).

Transportation of particulate organic matter and dissolved organic matter from forested catchments involves a number of mechanisms and controls, which are only poorly understood for large, intense, storm events (Dhillon & Inamdar, 2014). Intensive events may involve mechanisms which may have low relative significance during less intensive events. For example, it has been proposed that intensive rainfall may lead to changes in water pathways in the catchments and thus increased leaching of organic components from the upper soil layer (Hongve *et al.*, 2004).

As a consequence of diminished runoff quality, water quality in lakes or storage reservoirs may also be impacted during heavy rainfall events. For example, the loading and distribution of suspended matter in storage reservoirs exhibit significant differences during wet and dry periods (Wang *et al.*, 2013).

Long-term discharge of turbid water from reservoirs after flood events is a major socioenvironmental problem in many countries. Modelling and simulation studies were recently reported for an important drinking water reservoir for Seoul, Korea (Park *et al.*, 2018). These studies concluded that the ability to control persistent elevated turbidity following an extreme flood was limited, even with a selective withdrawal facility recently installed to control this problem. The fate and transport of high turbidity flows were highly influenced by both the thermal stability of the reservoir and the season in which the flood event occurred. The study found that coping with major future flooding events would require additional countermeasures such as bypassing high-turbidity water (Park *et al.*, 2018).

Water quality researchers have forecast that, with climate change, increased temperature and enhanced biodegradation of soil organic matter will lead to an increase in the production of dissolved organic matter, while flooding and runoff will export it from soil to rivers and lakes (Lipczynska-Kochany, 2018). Quality of the source freshwater is expected to deteriorate and drinking water production may become more expensive (Lipczynska-Kochany, 2018).

Through increased concentration of organic matter in surface runoff and the subsequent necessary increase in chlorine disinfection doses, increased concentrations of disinfection by-products are a likely outcome in final treated drinking waters (Beaudeau *et al.*, 2011). In circumstances where satisfactory disinfection cannot be maintained, excessive rainfall has been a significant contributor to historical waterborne disease outbreaks in developed countries (Curriero *et al.*, 2001; Auld *et al.*, 2004; Hrudey & Hrudey, 2007; Nichols *et al.*, 2009).

Water Quality Risks from Inundation of Previously Non-inundated Areas

A catchment, which is generally not inundated, but may become inundated during rare or occasional circumstances only, is akin to a catchment which has remained relatively dry during an extensive period of drought. During such circumstances, contaminants are known to accumulate (Mosley, 2015). Rainfall following prolonged periods of drought can mobilise heavily accumulated sediment and nutrients in a water catchment, leading to sudden influxes to streams and reservoirs (Wright *et al.*, 2014). In this way, drought-breaking rains can wash off accumulated organic carbon in a large ‘flush’ and organic carbon concentrations may remain elevated in reservoirs for a considerable period of time (Ritson *et al.*, 2014). Slumping of riparian banks is also likely, leading to further release of organic matter and sediment.

During August 1998, an intense low-pressure system off the east coast of Sydney caused heavy rainfall throughout the catchment of Lake Burragorang (Khan *et al.*, 2017). This resulted in high inflows into the lake, causing the storage level to increase from 58% of capacity to full within two weeks. The consequences at the Prospect Water

Filtration Plant included an increase in turbidity, which peaked at >15 NTU (normally < 1 NTU).

One month earlier, following relatively light rainfall, *Cryptosporidium* and *Giardia* had been detected at the water filtration plant and at a supply reservoir within the distribution system. That incident was believed to have been resolved, but the heavy rainfall corresponded with further detections of these pathogens in both the raw and treated water from Lake Burragorang. *Cryptosporidium* and *Giardia* were detected at up to 12,080 and 7,620 (oo)cysts per 100 L in the bulk water pipelines to the water filtration plant (Cox *et al.*, 2003). Due to the high levels of *Cryptosporidium* and *Giardia* present it was necessary to issue three boil water alerts, the first of which prompted the Sydney Water Inquiry (McClellan, 1998).

Various causes for the contamination were proposed, and included a combination of the extreme rainfall and the immediate operational response (McClellan, 1998). The consequences of the rainfall were complicated due to approximately five years of preceding drought, which had allowed an accumulation of faecal matter and other debris in the catchment area's riparian zones. Its relatively simple to conceive how a large normally-dry flood mitigation area could present circumstances for a similar accumulation of contaminants and a sudden release during inundation.

As a result of the Sydney Water Inquiry, 91 recommendations were made to improve catchment management and water supply processes. The adoption of these recommendations saw major legislative changes, including the formation of the Sydney Catchment Authority (now part of Water NSW).

Illustrative Case Study: Tropical Cyclone Marcia at Rockhampton, QLD, 2015

Severe Tropical Cyclone Marcia was a Category 5 cyclone that made landfall at its peak strength over central Queensland, near Shoalwater Bay, on 20 February 2015. The cyclone went on to affect various areas, including Rockhampton, where it became a Category 3 system on the same day.

Fitzroy River Water is a commercialised business unit of Rockhampton Regional Council, responsible for operating water supply assets throughout the region. The major regional water storage is the Fitzroy River Barrage, with an accessible storage volume of 75 GL. Surface water from the Fitzroy River is stored behind the barrage and used to supply the Glenmore Water Treatment Plant, which provides drinking water to Rockhampton.

A few days after the cyclone, it was observed that Alligator Creek, a major tributary of the Fitzroy River, was discharging a very black plume of water into the river and contributing a major portion of the flow in the river. The Alligator Creek catchment has substantial wetlands and low-lying land and it was believed these acted as a retarding basin for rainfall which occurred during the cyclone, slowly releasing flow to the Fitzroy River. This release was highly coloured and had very low dissolved oxygen (approx. 1 mg/L). These characteristics were believed to have been due to organic material being released from the wetlands and surrounding low-lying land. The deoxygenated water was shown to have elevated concentrations of iron and manganese.

Elevated raw water manganese concentrations (<1 mg/L) were first noted downstream at the water treatment plant approximately 12 days after the cyclone. The operators of the water treatment plant struggled to control manganese in the treated water, exceeding the aesthetic guideline value of 0.1 mg/L in the Australian Drinking Water Guidelines for approximately two weeks during March 2015. During this period, there was a sharp spike in customer complaints regarding drinking water colour and taste. There was a short period of less than one day when the treated water manganese concentration exceeded the health guideline value of 0.5 mg/L.

Low dissolved oxygen concentration made treatment at the water treatment plant to remove manganese very difficult, since to treat the water extensive oxidation was required. The approach adopted was to install an aeration system followed by chlorine dosing at the inlet, as well as post-flocculation and pre-filtration. These actions were only partially effective due to the limited detention/reaction times that were available, sub-optimum pH for manganese oxidation and the presence of elevated natural organic matter which led to high chlorine demand.

Water quality recovery was hampered during these weeks due to a lack of rainfall required to flush the impacted water from the Fitzroy River Barrage. Nonetheless, a large volume of black water was released from the barrage gates, equivalent to years' worth of supply for this system.

Risks Exacerbated by Previous Bushfires

If the proposed flood mitigation area has been affected by bushfires in the lead-up to a flood event, this would further impact the integrity of the water catchment. Forest biomass is composed of many elemental substances, including carbon, nitrogen, phosphorous and a diverse range of inorganic species. A major product of bushfires is ash, the particulate material deposited on the ground and consisting of minerals and oxidised organic substances (Bodi *et al.*, 2014). Ash is highly mobile and may be very effectively redistributed from a burned site to surface depressions, foot-slopes, streams, lakes and reservoirs (Bodi *et al.*, 2014).

The major water quality impacts of bushfires are typically experienced after the fire, during subsequent heavy rainfall events (Stanford *et al.*, 2014). Runoff from burnt areas carries considerable quantities of sediment (Moody & Martin, 2009; Silins *et al.*, 2009; Emelko *et al.*, 2011; Smith *et al.*, 2011), as well as soluble nutrients contained in the ash, which can lead to problems for potable water supplies (Bodi *et al.*, 2014; Writer *et al.*, 2014).

Elevated concentrations of nutrients, most notably nitrogen and phosphorus, are the most commonly reported bushfire-derived water quality contaminants (Emelko *et al.*, 2011; Smith *et al.*, 2011). Bushfires in Australia have been shown to increase catchment nitrogen and phosphorus exports by around 5 to 6-fold, peaking at 15 kg ha^{-1} of total combined nitrogen and 2 kg ha^{-1} of phosphorous (Lane *et al.*, 2008).

Forest biomass may also act as a sink for regional urban pollutants, including metallic components of air pollutants. Consequently, forest fires may liberate large quantities of gradually-accumulated contaminants, leading to elevated concentrations of substances, including arsenic, aluminium, cadmium, chromium, iron, lead, mercury, sulphate, chloride, calcium, magnesium, manganese, barium, sodium, and potassium in sediment and local stream flows (Emelko *et al.*, 2011; Smith *et al.*, 2011; Bladon *et al.*, 2014; Costa *et al.*, 2014).

Risks from Altered Hydrodynamics during and After Flooding

Lake hydrodynamics have a major impact on water quality and managing risks at the point of water offtake. Hydrodynamics dictate the residence time of water in the late, as well as the potential for 'short-circuiting' of some inflows.

During a flooding event, there is a high likelihood that the regular hydrodynamics may be disrupted and that water will flow to from different parts of the catchment compared to normal operation. As water drains from newly inundated areas, channels may form, leading to the development of new temporary waterways, draining into the lake at various locations, some of which may not be easy to predict. In some cases, these new waterways may deliver water much closer to the point of drinking water offtake, thus effectively reducing residence time in the lake for this water. This can have significant water quality implications at the water filtration plant.

Limited water quality science capacity at WaterNSW

The WaterNSW science program, focused on water quality science in the Sydney catchment has been significantly diminished over the last decade. Current water quality science skills are focused on issues including carp eradication, cyanobacteria (largely outsourced) and mining. But there is very limited capacity around microbiology and assessing pathogen risks, -the very thing that led to the establishment of the Sydney Catchment Authority following the Cryptosporidium incidents in 1998.

Prior to amalgamation with WaterNSW, The Sydney Catchment Authority had developed the Healthy Catchments Strategy (HCS) to reduce risks to water quality. The organisation had identified the most significant risks in the drinking water catchment in terms of four priority pollutants (pathogens, nitrogen and phosphorous and suspended solids). The risks are classified according to uses and management of land in a tool called the Pollution Source Assessment Tool (PSAT).

PSAT brings together science and technical information, spatial data, modelling, expert knowledge and best management practices to assist in prioritising management activities in the catchments. It analyses the relative risk of the four priority pollutants from 13 land use activities. The relative risk for each pollutant is categorised into four classes ‘very high’, ‘high’, ‘medium’, and ‘low’. The results of PSAT are reported for each module and pollutant at a drainage unit scale. These risk ratings are then used to prioritise intervention programs.

Inflows to Warragamba are monitored and major inflows (which can contain poorer quality water) are tracked to identify potential water quality risks. This is to determine the level at which inflows are travelling within the water column so that offtake levels can be set to draw the best quality water for supply. Real time monitoring is supported by models such as the “Sydney Catchment Authority Reservoir Management System” (SCARMS), which can be used to predict the likely lake behaviour in response to inflows and changing environmental conditions such as weather.

SCARMS is understood to be highly effective for predicting water quantity and physical conditions, such as temperature. It can predict mixing, stratification, and other hydrodynamic behaviours. As such, it can effectively model the fate of a conservative tracer in the lake. However, it has not been calibrated for chemical and biological processes. So it is not anticipated to be particularly useful for predicting nutrient concentrations or their dissipation. This also applies for organic carbon and turbidity. It is unlikely that SCARMS would even be considered for effective modelling or predicting pathogen concentrations.

While SCARMS is an effective and important tool, the limitations of its application should be recognised. The model makes numerous simplistic assumptions, such as assuming the water in the lake is neutral/pristine water with no concentrations of contaminants. This simplicity means that it cannot be expected to make useful predictions under highly unusual circumstances. For example, during the hydrodynamic events that led to the establishment of a large cyanobacterial bloom in 2007, some water quality features, such as turbidity, behaved in a completely unexplainable way.

Given the above, it is my opinion that there is currently limited water quality science capacity at WaterNSW, suitable for modelling, predicting and managing water quality risks that may be established as a consequence of significantly increased flood mitigation capacity for Lake Burragorang (Warragamba Dam).

Conclusion

The potential water quality impacts of a large new flood mitigation area should be taken very seriously. They should be very carefully assessed and accounted for when undertaking any analysis of the costs, benefits and risks associated with the proposed development.

I would be very happy to provide further explanation of any of the issues that I have raised in this submission. Furthermore, I would have happy to provide copies of any of the references cited.

Yours sincerely,

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