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23 November 2021

RE: Warragamba Dam Raising: Environmental Impact Statement – Chapter 27: Water quality

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NAME OF APPLICATION: Warragamba Dam Raising
ASSESSMENT TYPE: State Significant Infrastructure
APPLICATION NUMBER: SSI-8441

I wish to provide comments in response to the Draft Environmental Impact Statement for the Warragamba Dam Raising project (Reference No. 30012078, 10 September 2021). My comments relate specifically to Chapter 27: Water Quality.

The principal 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 Dam be managed and maintained in a manner that reliably produces high quality drinking water and minimises water quality risks.

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.*”

Shortcomings relating to the assessment of risks associated with water quality in Chapter 27 of the draft EIS

In my opinion, there are a number of important shortcomings in the Chapter 27 (Water Quality) of the Draft EIS. These are described below.

Secretary’s Environmental Assessment Requirements: Water Quality not met in full.

The Secretary’s Environmental Assessment Requirements in relation to water quality and set out in Table 27-1. Among these, is the requirement that the Proponent must:

> *“(b) identify and estimate the <u>quality and quantity of all pollutants</u> that may be introduced into the water cycle by source and discharge point and describe the nature and degree of impact that any discharge(s) may have on the receiving environment, including consideration of all pollutants that pose a risk of nontrivial harm to human health and the environment*”

The fact that this requirement has not been fully met is clearly acknowledged on Page 27-10, where it is stated:

> "*The infrequent and variable operation of the FMZ and the difficulty in quantifying changes in upstream catchments also presents limitations in assessing any changes in pollutant loads. Consequently, no meaningful load assessment of pollutants was able to be undertaken. However, pollutant load data from the previous studies and the geomorphology assessment (Appendix N2) has been presented*".

Surrogate events selected to provide an indication of expected water quality impacts from operation of the FMZ are not effective surrogates.

Water quality concerns relating to the operation of the flood mitigation zone are partially described in Section 27.2.3 (Page 27-3):

> *"The operation of the flood mitigation zone (FMZ) would result in an increase in the extent and duration of temporary inundation of the upstream catchment. These catchment areas contain landscapes, vegetation and soils which do not currently experience inundation and consequently there would be the potential for changes in water quality while they are inundated. In the longer term, repeated occurrences of inundation may permanently alter the landscapes, vegetation and soils which may give arise to additional impacts such as erosion. However, both the frequency and period of temporary inundation of new catchment areas would be very low in comparison to the permanent full supply level (FSL) – and therefore any water quality impacts would generally be short-term".*

The selection of surrogate inflow events, intended to represent the impacts from the operation of the FMZ is described in Section 27.2.4.1 (Page 25-5), and proposed to provide a "conservative assessment":

> *"A suitable wet weather surrogate event to assess the impact of the filling of the FMZ would have the following features:*
>
> - *the water level in the dam would be at least 12-16 metres below FSL which is similar to the depth of the FMZ when full*
> - *the event would result in the filling of the dam to FSL (or just above FSL) with minimal or no spilling*
> - *appropriate water quality data was available.*

It should be noted that this is a conservative assessment as the landscape beneath FSL is devoid of vegetation and generally consists of bare earth or deposited sediment – which may contribute higher levels of turbidity and nutrients during filling, compared to the FMZ which would not be devoid of vegetation".

In some aspects, this logic is correct. It is certainly true to say that vegetation protects soil catchments from erosion. The difference between a vegetated and a freshly denuded catchment can be starkly observed following bushfires or intensive forestry.

However, I don't believe this is a reasonable representation of the catchment below the full supply level (FSL) of Warragamba Dam. Catchment below the FSL cannot be considered to have been recently denuded and thus highly prone to fresh erosion. This is land that has been inundated many times (every time Warragamba Dam has been full or close to full).

For much of this area, there will be little or no soil at all, but instead bare rock exposed. Bare rock is not highly susceptible to erosion in the same way that a freshly denuded soil catchment would be. Thus, this is really not a conservative surrogate at all, but instead represents a much more stable catchment than that which would be encountered between the FSL and FMZ.

Surrogate estimations of pollutant loads are given in Section 27.3.2.4 (Page 27-30). It is stated there:

"There is limited available information on pollutant loads from the upstream catchment. Two catchments of predominantly pristine bushland in the Warragamba area, were monitored over the period from late 1997 to early 2001 (Hollinger and Cornish 2001). The results from the monitoring are presented in Table 27-10 and indicate that pollutant loads from these forested catchments are low in comparison to other land uses".

However, this is also not a reasonable surrogate analysis of a pollution load that may be expected to be produced by the extreme flooding and sudden inundation of the FMZ. The 'surrogate' pollution loads presented in this section of the document were derived from long-term intermittent rainfall and runoff. This is mostly relatively gentle rainfall, which causes very different physical circumstances and runoff patterns to sudden flooding. Long-term intermittent rainfall percolates down into the soil matrix and much of it flows beneath the surface to waterways. In contrast, floods are characterised by water levels above the soil surface, so pollutants can be transported much more quickly and freely to waterways. In this case, the pollutant loads can be expected to be very different (and much greater) than the pollution loads that would be associated with long term intermittent rainfall.

Management of raw water quality for drinking water via the regional raw water supply.

Current practices for managing raw water quality for drinking water are described in Section 27.5.2.3 (Page 27-41). Most of the information here relates to 'monitoring', which is valuable, but doesn't itself protect water quality.

The fourth dot-point refers to "regional raw water supply for drinking water purposes system", and states the following:

> "*regional raw water supply for drinking water purposes system – There is an extensive system of dams, weirs, canals, pipelines, and tunnels which supply raw water supply for drinking water purposes to various water filtration plants in the Sydney, Illawarra and Shoalhaven regions. If the water quality in Lake Burragorang is not suitable as raw water supply for drinking water purposes, alternative sources can temporarily supply Prospect Water Filtration Plant including the Upper Nepean dams, Shoalhaven dams and Prospect Reservoir. However, Warragamba and Orchard Hills filtration plants would still rely on water from Lake Burragorang*".

It is important not to overlook the final sentence from the above paragraph. While Prospect Water Filtration Plant can draw raw water from multiple sources, this advantage does not apply to customers who rely on water from the Warragamba Water Filtration Plant or the Orchard Hills Water Filtration Plant. As stated, Lake Burragorang (Warragamba Dam) is the only raw water source available to these plants, so no risks are mitigated by access to a regional raw water supply.

Management of raw water quality for drinking water by variable offtake levels

Section 27.5.2.3 (Page 27-41) then continues to describe a further raw water quality management strategy:

> "*Management of raw water supply for drinking water purposes at Warragamba Dam is shown in Figure 27-9. When the flood inflows are colder than the water in Lake Burragorang, they sink to the bottom of the lake and the water supply outlet screens are raised to avoid lower quality flood inflows. Conversely when the flood inflows are warmer than the water in the lake, the outlets are lowered to avoid the lower quality flood inflows*".

This passage describes a very important water quality risk management strategy that is employed by WaterNSW. This strategy relies on considerable stratification of the water in Lake Burragorang. This occurs when there is a major temperature difference between cold water toward the bottom of the lake and warmer water toward the top. Since warmer water is less dense than cold water, it remains somewhat segregated from deeper water. This stratification can enable poor quality water to be avoided by targeting the depths with the best quality water for raw water supply.

However, what is not stated as that significant temperature stratification generally only occurs during summer. In the cooler winter months, stratification can be much more minor, with similar water temperature across the depth profile of the lake. Under these circumstances, mixing between depths is much more difficult to avoid, especially if there are turbulence-inducing events, such as large inflows or high winds.

Only recently (October 2021), Sydney Water customers experienced a 'taste and odour' water quality event, from water sourced from Warragamba Dam. It was reported that high winds had caused mixing in the dam, which caused cyanobacterial-produced substances (including the chemical geosmin) to be mixed from the surface, into depths of the water column. This illustrates that the ability to draw water from multiple depths to manage water quality is not failure-proof. Indeed, it is most likely to fail under the same circumstances that might produce an east-coast low weather event and the flooding of the FMZ.

Risks associated with natural organic matter (NOM) in dam water

Risks associated with increased generation of natural organic matter (NOM) in dam water are described and assessed in Table 27-16:

Table 27-16. Upstream water quality risk assessment

Summary of risk	Factors to consider	Overall impacts and risk without mitigation	Mitigation measures	Residual risk with mitigation measures
Increased generation of NOM in dam water from inundated vegetation and soils – which in turn may increase concentration of trihalomethanes in chlorinated drinking water. Trihalomethanes have been suggested to cause cancer	▪ cancer risk from THMs in drinking water not clear ▪ existing NOM concentrations low ▪ the generation of NOM from soils and vegetation is determined by period of inundation. The frequency and duration of inundation with the Project is low ▪ threshold period for establishment of microbiological communities and significant NOM generation 15+ days ▪ non-deciduous woody vegetation has a low rate of generation of NOM.	**Likely Impacts** – Small increases in NOM concentrations in raw water supply for drinking water purposes after operation of FMZ **Risk Assessment** Consequence – Health major Likelihood – Rare *Overall risk – Medium*	▪ monitoring ▪ sourcing raw water supply for drinking water purposes from other dams ▪ adjusting treatment processes at WFPs ▪ use of multi-level offtake.	Consequence – Health negligible Likelihood – Rare *Overall risk – Low*

These risks are far from being fully characterised. The author of this risk assessment appears to assume that the key risk associated with NOM is the production of trihalomethanes in chlorinated water, and then states “cancer risk from THMs” in drinking water not clear” as a factor to consider.

Trihalomethanes are not monitored as closely as they are because of cancer risks specifically associated with these chemicals. Instead, trihalomethanes are monitored since they are considered to provide a useful surrogate measure of a much larger range of disinfection by-products in drinking water. Many of those additional chemicals are known to be carcinogenic (eg, N-nitrosodimethylamine). Furthermore, there is strong epidemiological evidence available to indicate strong associations between the presence of trihalomethanes in drinking water and adverse health outcomes including bladder cancer. Focusing on the health risks associated with trihalomethanes specifically reveals a lack of understanding of public health issues associated with drinking water disinfection byproducts.

The ’Factors to consider’ also refer to the fact that “the generation of NOM from soils and vegetation is determined by period of inundation” and state that “the frequency and duration of inundation with the Project is low”. This point is not highly relevant. The low frequency between floods is what enables NOM to build up in the FMZ and thus is a contributing factor to the high loads. But a more important fact is not the frequency of flood events, but the duration for which elevated NOM may persist in Lake Burragorang. Modelling will need to be undertaken to estimate this, but elevated concentration of

NOM could well persist for months or even years following a major inundation of the FMZ. So this should not be characterised as a short or infrequent event.

High concentrations of NOM are likely to be associated with several water quality impacts which are not even identified in this Draft EIS. Most importantly, influx of leaves and other organic matter to waterways following flooding is well-known to be a cause of deoxygenation and ‘blackwater’ events. In recent years, such events have occurred on the Murray River and the Hunter River, following flooding events.

When organic matter, such as leaves, are washed into waterways in large mass, they are subsequently biodegraded by aerobic bacteria. As these aerobic bacteria consume the organic matter, they also consume dissolved oxygen from the water. This can cause oxygen concentrations to plummet leading to major fish kills and numerous water quality impacts.

The water quality impacts can include the production of foul tastes and odours due to the presence of reduced sulphur and other compounds. The low oxygen concentrations can also solubilise minerals from the catchment, including iron and manganese. These minerals will be re-oxidised as the water treatment plant (consuming chlorine), which can lead to many water quality difficulties including the production of discoloured water.

Both residual NOM and the presence of other chemically reduced substances can lead to excessive consumption of chlorine at the water treatment plant. This adds to costs since additional chlorine is required, but also produces further disinfection byproducts. Furthermore, the presence of these substances in drinking water makes it more difficult to maintain a safe disinfection residual as the treated drinking water is being distributed to customers. These complications lead to elevated risk of exposure to pathogenic substances (such as Cryptosporidium, Giardia and bacteria) in drinking water.

Even while misunderstanding the risks associated with disinfection byproducts and overlooking the risks associated with deoxygenation and blackwater events, the overall impacts and risk without mitigation have been rated as “Medium”. This is significant since mitigation measures identified all have significant limitations, as described above.

Risks associated with sediment (turbidity) in dam water

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Risks associated with Increased erosion of inundated areas resulting in increased turbidity and raw water supply for drinking water quality issues are also described and assessed in Table 27-16:

Summary of risk	Factors to consider	Overall impacts and risk without mitigation	Mitigation measures	Residual risk with mitigation measures
Increased erosion of inundated areas resulting in increased turbidity and raw water supply for drinking water quality issues	▪ the majority of sediment and nutrient loads originate from upstream catchment ▪ the frequency and duration of inundation with the Project is low allowing vegetation to regenerate or colonise between events ▪ existing turbidity is low.	**Likely Impacts** – Increases in water turbidity due to erosion **Risk Assessment** Consequence – Legal Medium (Breach of raw water supply for drinking water purposes agreements) Likelihood – May occur *Overall risk – High*	▪ implementation of the National Parks EMP ▪ continued implementation of other erosion management programs in the upper catchment ▪ use of the multi-level offtake ▪ sourcing raw water supply for drinking water purposes from other dams ▪ adjusting processes at water treatment plants.	Consequence – Legal Minor (Breach of raw water supply for drinking water purposes agreements) Likelihood – Possible under exceptional circumstances *Overall risk – Low*

The risks associated with increased turbidity are likely to be high and have been rated this way without mitigation. As with elevated NOM, it is stated that a factor to consider is the “frequency and duration of inundation with the Project is low allowing vegetation to regenerate or colonise between events”. However, time between events is also a potential exacerbating factor since it allows increased opportunity to turbidity associated with decaying organic matter to build up in the FMZ.

The mitigation measures include “implementation of the National Parks EMP” and “continued implementation of other erosion management programs in the upper catchment”. While these are important activities, they will not be effective in controlling sediment loads following an event such as a bushfire in the catchment.

Other mitigating factors include “use of the multi-level offtake” and “sourcing raw water supply for drinking water purposes from other dams”. However, as described above these both have limitations and thus are not universally applicable or reliable.

The suggestion that high turbidity loads can be managed by “adjusting processes at water treatment plants” is also highly optimistic. A major elevated turbidity load would cause significant challenges for the ongoing operation of water filtration plants.

Risks associated with nutrients in dam water

Risks associated with leaching of nutrients from inundation of soils and eutrophication/water quality issues are identified in Table 27-16:

Summary of risk	Factors to consider	Overall impacts and risk without mitigation	Mitigation measures	Residual risk with mitigation measures
Leaching of nutrients from inundation of soils and eutrophication/water quality issues	▪ the leaching of nutrients from soils is determined by period of inundation. The frequency and duration of inundation with the Project is low	**Likely Impacts** – Small increases in soluble nitrogen concentrations	▪ implementation of the National Parks EMP ▪ use of the multi-level offtake	Consequence – Environment Minor (algal bloom) Likelihood – Unlikely
	▪ threshold period for establishment of microbiological communities and significant phosphorus generation 20+ days ▪ soils in catchment generally nutrient poor.	**Risk Assessment** Consequence – Environment Minor (algal bloom) Likelihood – May occur *Overall risk – Medium*	▪ sourcing raw water supply for drinking water purposes from other dams ▪ adjusting processes at Water Treatment Plants.	*Overall risk – Low*

Factors listed to consider include "the leaching of nutrients from soils is determined by period of inundation. The frequency and duration of inundation with the Project is low" and "threshold period for establishment of microbiological communities and significant phosphorus generation 20+ days".

However, again these factors are not highly relevant as mitigating factors. The long periods between flooding events in the FMZ only allows the increase opportunity for nutrients to build up in decaying vegetation. The period that is required for P-consuming organisms to grow is also irrelevant since once P enters the lake the residence time could be many months or even years. Previous evidence has shown that Lake Burragorang is susceptible to cyanobacterial blooms, including the major bloom which occurred in 2007, following heavy winter rainfall.

Risks associated with nutrients in dam water

Risks associated with increased concentrations of pathogens in dam water leading to increased human health risks are identified in Table 27-16:

Summary of risk	Factors to consider	Overall impacts and risk without mitigation	Mitigation measures	Residual risk with mitigation measures
Increased concentrations of pathogens in dam water leading to increased human health risks	▪ pathogen levels are very low in the dam and generally below detectable levels ▪ the frequency and duration of inundation with the Project is low ▪ native animal faeces have low levels of pathogens ▪ existing feral animal control programs.	**Likely Impacts** – Small increases in pathogen concentrations **Risk Assessment** Consequence – Health Medium Likelihood – Possible *Overall risk – Medium*	▪ implementation of the National Parks EMP ▪ use of the multi-level offtake ▪ sourcing raw water supply for drinking water purposes from other dams ▪ adjusting processes at water treatment plants	**Risk Assessment** Consequence – Health Medium Likelihood – Rare *Overall risk – Low*

These risks align with the occurrence of the Sydney Water crisis in 1998. A large rainfall event occurred at that time, washing accumulated pathogens (Cryptosporidium and Giardia) into the Lake. All of the mitigation measures identified to manage this risk were also available at that time. An Inquiry conducted in the wake of the Sydney Water crises led to the establishment of the Sydney Catchment Authority (since merged with another agency to become WaterNSW). Thus, the organisation largely exists for the purpose of taking these risks very seriously and implementing effective measures to control them.

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.

Yours sincerely,

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