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‘Swimmability’: A key element for communities to safely engage with Australian urban rivers

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Abstract. Australia’s largest cities are growing, and this is placing increasing pressure on urban waterways. There is a growing awareness that the quality of life in Australian urban communities is enhanced through the engagement of people with healthy urban rivers. Swimming, boating, and fishing in many Australian urban waterways are popular recreational activities. Swimming and other activities associated with waterways contributes to quality of life in urban communities. Swimming in urban rivers can be risky. Hazards include dangerous currents, aquatic plants, submerged hazards, algal blooms, and unsuitable water quality. In Sydney, Australia’s largest City, swimming is popular in the Hawkesbury-Nepean River. Data from showed that E. coli levels in the river occasionally exceeded safe recreational guidelines for human health. The results are not reported to the public. We believe that it is more important than ever that government, industry and scientific bodies work to protect and improve the water quality of Australian urban rivers as our cities grow. Sharing this information with the community needs to consider education programs, public forums, and timely communication of the current state of local Australian urban rivers regarding their ‘swimmability’.

1. Introduction

Humans, throughout history, have always relied on river systems to thrive. This involves critical needs such as providing drinking water, to powering industry, or providing safe and healthy recreational environments [1]. Whilst the quantity of water is important, it is just as vital that the quality of the water is of a high enough standard that it is safe for any intended purpose, such as primary contact recreational activities [2]. Sydney is Australia’s largest city and it is expected to grow from its current population of 5 million, to 8 million residents over the next 40 years [3]. It aims to achieve this growth whilst also improving the quality of life of its residents, which has been called ‘liveability’ [3]. An element of ‘liveability’ is encouraging residents to embrace their waterways, which are a very popular element in the lifestyle for many of Sydney’s residents. We have used the term ‘swimmability’ to describe the safe use of waterways for recreation.

A key attribute of ‘swimmability’ is having good water quality in waterways for swimming? Swimming is a ‘primary contact’ aquatic recreational activity. Primary contact is defined as activities ‘where the body can be fully immersed and there is the potential to swallow water, and you are in direct contact with the water. This includes surfing, water skiing, diving and swimming’ [4].

‘Swimmability’ is undoubtedly poor and unsafe if waters are contaminated by pathogenic microorganisms that are hazardous for humans. Swimming in untreated waters has been associated with disease outbreaks for swimmers. For example, across USA from 2000 to 2014 there were 4958 disease outbreaks associated with swimming in untreated freshwater and marine waters [5]. The causal



microorganisms were reported to be noroviruses (22%), toxigenic *E.coli* (20%), *Shigella* (13%) and *Cryptosporidium* (13%) [5].

The ‘Guidelines for Managing Risks in Recreational Water’ is widely used in Australia to guide the safe management of aquatic recreation in ocean, estuarine and fresh waters [4]. These guidelines seek to encourage a preventative approach that assesses and minimizes hazards at recreational locations [4].

These Australian guidelines closely followed the approach advocated by the World Health Organization (WHO) [1999] commonly called the ‘Annapolis Protocol’ [6]. The WHO [6] and Australian guidelines [4] classify recreational waters according to health risk, based on the analysis of long-term microbial data. The presence of bacteria, such as *Escherichia coli* (*E. coli*), are used as an indicator microorganism to measure the degree of faecal contamination and the likely presence of pathogens, including bacteria, viruses and protozoa [4-6]. Other microorganisms such as *Enterococci* are also used, particularly for marine and estuarine waters [7].

Water contaminated with elevated levels of *E.coli* has been attributed primarily to the exposure of the water to faecal wastes of warm-blooded animals [4]. Melbourne Water and Victorian EPA advise people not to swim in the Yarra River if the presence of *E.coli* exceeds 500 organisms/100 ml [8]. In Ontario, Canada, guidelines state that in freshwater, a presence of *E.coli* that exceeds 100 organisms/100 ml is a risk to human safety, whilst other regions of Canada state that any presence of *E.coli* below 200 organisms/200 ml [9]. It is ambiguous as to which guideline is appropriate for testing ‘swimmability’.

The ocean beaches of Sydney are world famous and are very popular for swimming, particularly in summer. The NSW Government conducts regular testing and public reporting of ocean beaches under the ‘Beachwatch’ program [10]. The Beachwatch program uses *Enterococci*, which are regarded as a better indicator, than *E.coli*, for the potential presence of pathogens in marine and estuarine waters [4,5,9]. There is no similar program that measures and publicly reports microbial water quality in the freshwater Hawkesbury-Nepean River in western Sydney, despite its popularity for aquatic recreation, including swimming, fishing and boating. We were puzzled by this gap in public health information and it prompted our study.

The aim of our study was to investigate microbial water quality data for popular recreation locations along the freshwater reaches of the Hawkesbury-Nepean River. Our key question was: What is the swimmability of the Hawkesbury-Nepean river, based on microbial water quality, and how does it compare with appropriate guidelines and to the river monitoring conducted for the Yarra River?

2. Methodology

2.1. Study area

The Hawkesbury-Nepean River, or Yandhai in the Aboriginal language, is a river that stretches over 200 km through NSW, draining one of the east coast’s largest catchments. The river performs numerous roles such as habitat for hundreds of native species. It also provides water for agriculture and fisheries, and it also receives treated sewage wastes [11]. The Hawkesbury-Nepean River also provides drinking water for the Sydney Metropolitan area [12]. In addition to these roles, the river also acts as a prime location for recreational activities such as fishing, kayaking, rowing, swimming, picnics, and bird watching, that invigorate the Western Sydney tourism industry, as well as serving local communities [13].

2.2. Data on river faecal bacteria

We sought to compare recent publicly available data on the ‘swimmability’ of two famous Australian rivers, the Yarra River, in Melbourne, Victoria. The other was the Hawkesbury-Nepean River, in the south-western and western suburbs of Sydney, New South Wales. We searched for public information on recent and historic water quality results. In particular, we wanted to compare data on the relative level of faecal bacteria in these two rivers, to compare their ‘swimmability’. Both waterways were chosen as they are regarded as iconic natural assets of Australia’s two largest cities. They are both a

very popular facet of the natural environment of these two fast-growing cities. Both are widely used by urban communities for recreation, including boating, swimming and fishing.

The Yarra River had considerable on-line information available. It has a regularly updated website called 'Yarra Watch' that enabled people to find out the location and current advice on water quality of swimming sites along the river [14]. During the warmer months of the swimming season (December to March) weekly updated results are provided. The information is also made available for the public using social media, and also shared with the media, for example the ABC reported on the swimming in the Yarra River in May 2018 [8,14].

To evaluate the 'swimmability' of the Hawkesbury-Nepean River, we were not able to find and publicly available data. Subsequently we searched for data on swimming sites within the Hawkesbury-Nepean River from many sources. WaterNSW was approached and provided us with water quality data after submitting a formal 'Freedom of Information' request. This data is not normally made available.

As a measure of safe and healthy 'swimmability', we compared the *E.coli* bacteria results in the Hawkesbury-Nepean using the WHO Annapolis protocol [6] to classify recreational waters according to health risk, based on the *E.coli* 95th percentile of many years of data [6]. We also compared the Nepean River *E.coli* results at Penrith Weir in dry weather and wet weather. This location was selected as it was one of the most popular locations on the river for swimming and other forms of aquatic recreation. We classified dry weather as <3 mm rain over preceding seven days and wet weather as >3 mm over preceding 7 days. This was done as it had been observed that faecal pollution of Sydney's ocean beaches worsened after rainfall [7].

To compare Nepean River results to the Yarra River we used the 500 cfu/100 mL warning level used by Victorian EPA / Melbourne Water to alert swimmers that water was unsafe for swimming [8] [14]. We also made comparison to the more stringent guideline (500 cfu/100mL) used by authorities in Ontario Canada [9].

The water samples collected along the Hawkesbury-Nepean River NSW were not collected at a suitable frequency for measuring the microbial water quality as only one sample was taken every month [4]. However, we have presented the available information, collected over five years, to provide some basis for assessing the relative level of faecal bacteria and the 'swimmability' of the river.

3. Results and discussion

Of the seven sites on the Nepean River examined, two of the sites failed to meet the 500 *E.coli*/100 mL threshold on more than 5% of sampling occasion (Table 1). One site was Nepean River at Penrith Weir (Table 1) which failed this guideline for 7.86% of the 89 samples collected over 2013-2018. The other was the Nepean River at Yarramundi (Table 1), which failed this guideline for 6.66% of the 90 samples collected. Both sites are popular locations for aquatic recreation, including swimming, fishing and boating. The most favourable results were found for the Nepean River were recorded at Maldon weir, and it never exceeded the 500 *E.coli*/100 mL level for any samples (2013-18). This guideline (500 *E.coli*/100 mL) is the level that would have triggered a public health warning for the Yarra River in Melbourne to advise people not to swim [8,14].

In comparison, the Yarra River more frequently had results above the 500 *E.coli*/100 mL guideline were detected in Hawkesbury-Nepean data. Over the period 2013-2018 four sites on the Yarra River failed the guideline over the 16-week (December to March) swimming season on between four and 15 occasions (Table 2). As weekly samples are collected, over the swimming season, for the Yarra River this would translate to failing the guideline on between 4.2% and 15.6% of samples.

Table 1. *E. coli* summary results for samples collected by WaterNSW from seven freshwater sites on the Nepean River (2013-2018). The statistics include number of samples, the mean value, the maximum value, the 95th percentile (%ile). The proportion of samples higher than the 100 org/100 mL [9] and the 500org/100 mL [8,14] are both indicated.

Site/Location	WHO cat. [6]	Samples taken	Mean	Max.	95th %ile	% of Samples >100 <i>E.coli</i> /100ml	% of Samples >500 <i>E.coli</i> /100 ml
N44 Nepean (Yarramundi)	E	90	306.9	8800	1920	15.50%	6.66%
N57 Nepean (Penrith Weir)	D	89	146.6	2400	630	32.58%	7.86%
N67 Nepean (Wallacia Bridge)	C	86	55.0	920	238	9.30%	1.16%
N75 Nepean (Sharpes Weir)	C	87	81.1	2000	238	18.39%	1.14%
N85 Nepean (Menangle Bridge)	B	89	45.3	2000	80.5	1.12%	1.12%
N86 Nepean (Pheasants Nest)	C	104	68.9	1700	180	8.65%	2.88%
N92 Nepean (Maldon Weir)	B	95	20.5	370	89	3.15%	0%

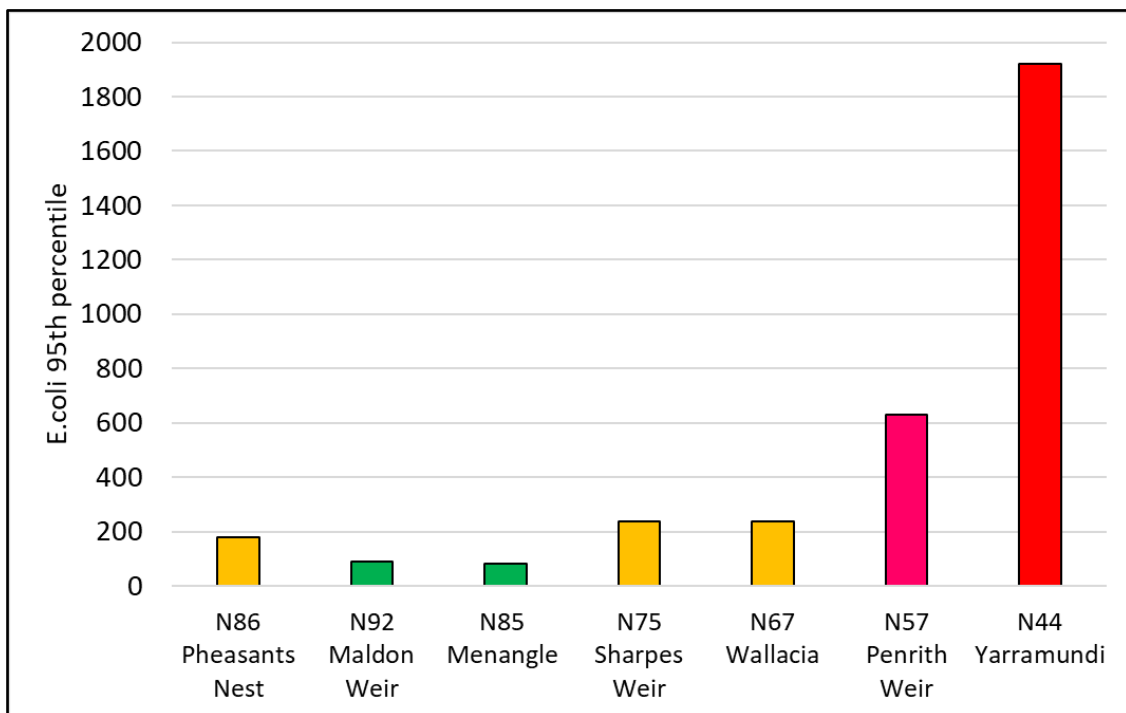


Figure 1. Results for Nepean River sampling sites compared to the WHO Annapolis Protocol [15d] microbial assessment categories. Based on the 95th percentile *E.coli* statistic for each site. Category E is >1000 (shaded red); Category D is 501-1000 (shaded purple); Category C is 131-500 (shaded ochre); Category is B 36 – 130 (shaded green); Category A is <35.

Table 2. Yarra River *E.coli* results published by ABC News on the 25th of May 2018, based on data provided to them by Melbourne Water. Statistics shown in this table include how many samples taken at a given site during 2013-2018 exceeded Melbourne Water / Victorian EPA guideline of 500 or less CFU/100 ml.

Location	Samples that exceeded 500 <i>E.coli</i> /100ml during 2013-2018
Launching Place	15
Healesville	10
Warrandyte	4
Kew	11

If the *E.coli* guideline for primary contact recreation in Ontario was used for the Nepean River results, each site would have failed this at various sites for between 1.12% and 32.58% of samples (Table 1).

The *E.coli* results in the Nepean River at Penrith Weir increased steeply after light rainfall. In dry weather conditions (<3.0 mm in previous 7 days) *E.coli* results at this site were acceptable for swimming with a mean of 64.8 and a median of 73.9. After light rain (>3mm in 7 days) the *E.coli* levels at this site were generally much higher and were unsafe for swimming, increasing by almost a factor of 10, with a mean of 620.2 and a median of 781.2. The difference was statistically significant ($p=0.01$).

The *E.coli* 95th percentile results for sampling sites on the Nepean River, based on many years of data were compared (Figure 1). None of the sites would be categorised as ‘A’, using the WHO ‘Microbial Assessment Categories’ with no Nepean River sites achieving an *E.coli* 95th percentile of less than 35 organisms per 100 mL [6] (Figure 1). Of most concern was that the very popular swimming site ‘Yarramundi’ is categorised ‘E’ with a 95th percentile *E.coli* value of 1920 organisms per 100 mL. A cursory sanitary site investigation [4,6] reveals that the Yarramundi site is exposed to many sources of potential faecal contamination. The river receives treated sewage effluent from four treatment plants upstream [11]. The closest two were the Winmalee STP (10.6 km upstream) and Penrith STP (18 km upstream). The surrounding landuses are dominated by agricultural lands with domestic livestock (cattle and horses) and vegetable farms, many of which use chicken manure as fertilizer (personal observation). In addition, approximately 18 to 20km upstream, many stormwater drains from urban settlements direct urban runoff into the Nepean River. Consequently, we consider that the likely susceptibility of this site to faecal contamination would probably be ‘moderate’ or ‘high’ [6]. Under the WHO ‘Annapolis’ protocol this would classify this river swimming site as ‘poor’ or ‘very poor’ [6].

Continuing community use of the ‘Yarramundi’ site on the Nepean River for swimming requires action to provide a safe and healthy location for swimming, particularly for microbial water quality [4, 6]. The *E.coli* results show that all locations examined on the Nepean River indicate that there are substantial public health risks, based on microbial quality, for people that swim the river. All sites had one or more very high *E.coli* results recorded, with maximum *E.coli* levels exceeding 1000 org/100 mL for five of the seven sites (Table 1). The failure to alert health authorities and advise the community of health risks when highly elevated *E.coli* results were detected in the Nepean River at or near sites of primary-contact recreation, is exposing people to the river at times of potentially hazardous water quality.

4. Conclusion

The Hawkesbury-Nepean River in western Sydney is a popular venue for many water-based recreational activities. It is important for public health that ‘swimmability’ of the river is recognised

and is often occurring at times when historical data suggests that the river is contaminated by faecal wastes at levels unsafe for swimming. The swimming sites need to be carefully managed according to the WHO and Australian guidelines for managing risks associated with recreation [4,6]. The long-term microbial data suggests that the river is susceptible to periods of elevated faecal contamination, particularly after rainfall. The source(s) of the faecal contamination need to be investigated and managed.

One of the limitations using *E.coli* testing is the long time before results are received after sample collection, and consideration should be given to using rapid-and effective pathogen assessment techniques such as PCR molecular analysis [15].

The community also need to be alerted when water quality is hazardous and when human contact with water should be avoided. It is unacceptable that microbial data is regularly collected, and at times hazardous levels of faecal bacteria are detected the results are not shared with potentially vulnerable river users. This is a failure of the ‘duty of care’ of the agencies that collect water quality data, but remain silent when bacterial water quality results indicate a potential risk to human health and safety.

We encourage the regular testing and reporting of river water quality for swimming, using social media and on-line reporting. For example, this is effectively done using the Victorian approach for swimming in the Yarra River under the ‘Yarra-watch’ program [14], or for the coastal and estuarine beaches of eastern Sydney under the ‘Beachwatch program’ [10]. A third approach is used in Canberra for swimming in ‘Lakes, Ponds and Rivers’ [16]. As important as regular testing is that public communication of the testing results is effective and timely, and that it reaches the target audience of river users. Currently the people swimming in the Hawkesbury-Nepean River are potentially doing so when water quality may be harmful for their health’.

5. Recommendations

To improve the ‘swimmability’ of the Hawkesbury-Nepean River we recommend that the following actions are implemented by relevant agencies within Government and the wider community:

- The WHO Annapolis protocol [6] and Australian guidelines [4] need to be applied as the guiding risk-based methodology for managing recreation in the popular swimming locations on the Hawkesbury-Nepean River.
- Microbial water quality of the Hawkesbury-Nepean River urgently needs to be more regularly monitored during the swimming season for its ‘swimmability’ based on bacterial water quality and careful assessment of sources of faecal contamination.
- Water sampling of key recreational sites on the Hawkesbury-Nepean River needs to be carried out more regularly. We suggest that sampling be increased to a minimum of one sample per week over the swimming season, with additional sampling after wet weather.
- The rapid and effective communication of microbial results for ‘swimmability’ of the Nepean River should follow a similar methodology used for the Yarra River [14] in Melbourne, Beachwatch [10] for Sydney’s ocean and estuarine beaches or in Canberra ‘Lakes, Ponds and Rivers’ [16].

Microbial water quality is not the only factor influencing safe recreational conditions in the Hawkesbury-Nepean River that needs to be carefully managed. The Australian recreational guidelines include assessment and management of physical hazards, blue-green algae, hazardous organisms, chemical water quality and aesthetic attributes [4].

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