Integrating QMRA-based assessment with the good practice guidance on supernatant return

Yulia Shutova[1,2], Chris Owens[3], Hannah Norris[3], Jordan Mayne[3], Connor Peters[1], Kaye Power[1]

1. Sydney Water, Sydney, NSW, Australia
2. Aquayukla, Sydney, NSW, Australia
3. Veolia Australia and New Zealand, Sydney, NSW, Australia

Water RA Research project 1129

Context - Supernatant Return

WSAA Good Practice Guide

Note	Measure	Frequency and Measure of Assessment	Required Result
1	Any water returned to the head of the WTP must occur upstream of all processes designed to remove solids from the raw water, in particular coagulant dosing. Any return must be well mixed with the raw water entering the WTP (AWWA 2001). The coagulant dose should be adjusted for the additional flow and load to ensure coagulation is optimised.	***One off*** Should be reassessed after any major refurbishment or capital works.	Complies
2	The flow rate of return streams to the head of the plant should be continuous with a target <5% of inflow and a critical limit <10% of inflow (AWWA 2001).	***Monthly*** (No. of recycle flow periods Qr <5% x 100) / (No. of recycle flow periods) (Total time recycle flow operates)/ (Total time plant operates)	% <5% = 100% As close to 1 as possible.
3	The turbidity of any wastewater recycle is monitored (AWWA 2001) and the recycle shut down if >20NTU or set operational target.	***One off*** Should be reassessed after any major refurbishment or capital works.	Complies
4	In high risk catchments, for example, Category 4 catchments as defined in WSAA's HBT Manual (WSAA 2014), sludge from the clarification step is directed to sewer or otherwise removed, or the supernatant is treated prior to any recycling.	***One off*** Should be reassessed after any major refurbishment or capital works.	Complies

Factsheet Project 1129

Filter backwash recycling practices in drinking water treatment systems

Water Research AUSTRALIA

Introduction

The Filter Backwash Recycling Rule (FBRR) has been implemented around the world as best practice, recommending that water treatment systems can adopt continuous recycling to the head of the plant at a target of below 5% of inflow volume with a maximum critical limit of below 10%. However, based on the review of relevant studies and legislative documents to date, there is no specific scientific evidence for setting the recycle percentage at 5%. The rule appears to be largely based on high pathogen concentrations and large volumes of backwash water generated, potentially resulting in exceedance in treatment capacity when recycled.

In Australia, this rule has subsequently reduced opportunities for water treatment plants to recycle higher proportions of backwash water for increased water recovery. As such, the aim of this project was to determine the maximum recycle rates and the appropriate level of treatment that media filters backwash water required for safe operation and compliance with the Water Services Association of Australia's (WSAA) Health-based Targets (HBT).

Health-Based Targets for Backwash Recycling

The objective of the HBT for drinking water safety was to supplement the Australian Drinking Water Guidelines (ADWG) to help in decision-making on drinking water treatment requirements. Using the HBT recommended Log Removal Value (LRV) credited to various water treatment processes, the critical maximum and minimum LRV limits at which media filters could operate at, before non-compliance were determined for Category 2, 3, and 4 source waters. Note that this study is based on the LRV originally provided in the HBT manual, rather than in the recently implemented ADWG document (November 2022).

Category 2 Source Waters

Category 2 water sources can be treated via direct filtration followed by chlorination (Figure 1). In a direct filtration process, the protozoan removal is achieved solely from media filtration with no protozoan LRV credited to either the coagulation and flocculation or the chlorination processes, hence, it was clear that the filter has be operated at a maximum and minimum protozoan LRV limits of 3.5 and 2.5 respectively (Table 1).

Table 1 Maximum and Minimum Filter LRV for Category 2 Source Waters

Treatment Processes	Protozoa LRV
Coagulation and Flocculation	0
Media Filter	2.5 - 3.5
Chlorination	0
Total LRV Achieved	2.5 - 3.5
HBT LRV	2.5
Maximum Filter LRV Credits	3.5
Minimum Filter LRV Credits	2.5

"It is also recognised that the assumed targeted LRV as a basis of the mass balance model is an over-conservative approach for risk assessment and the use of a [QMRA] has the potential to result in more practical outcomes."

Aquayukla

Sydney WATER

VEOLIA

Context - Woronora Case Study

Woronora WFP treatment processes include:

- pH correction, coagulation, filtration, chlorination, fluoridation.
- Supernatant returned to head of works after thickner.

Plant has constraints impacting backwash cycles, resulting in temporary higher supernatant return rates:

- Low network demand (35-40 ML/day) compared with the WFP design capacity (160 ML/day)
- Low relative raw water yield available for treatment (approximately 90 ML/day)
- Stand by backup supply for part of the Prospect system up to 160 ML/day
- Raw water quality historically affected by high inflow events following the recent drought, particularly higher NOM impacting filter runtime and increasing volumes of backwash water.

Despite these challenges, Woronora WFP continues to produce high quality and safe drinking water that meets the Australian Drinking Water Guidelines.

Aquayukla

Sydney WATER

VEOLIA

Desktop assessment - Woronora Case Study

- WFP raw water generally has low levels of protozoa detected.
- WFP treatment processes are suitable for the source water risk level.
- Supernatant is returned upstream of all processes designed to remove pathogens.
- The rapid mixers provide an appropriate level of mixing with the raw water.
- Supernatant turbidity met the recommended target.
- Historic proportion of supernatant returned, however, varied between around 3 to 30% of total plant inflow.

Further investigation of protozoal risk posed by supernatant return, in context of the quantitative HBT analysis, was considered appropriate to increase certainty of control effectiveness.

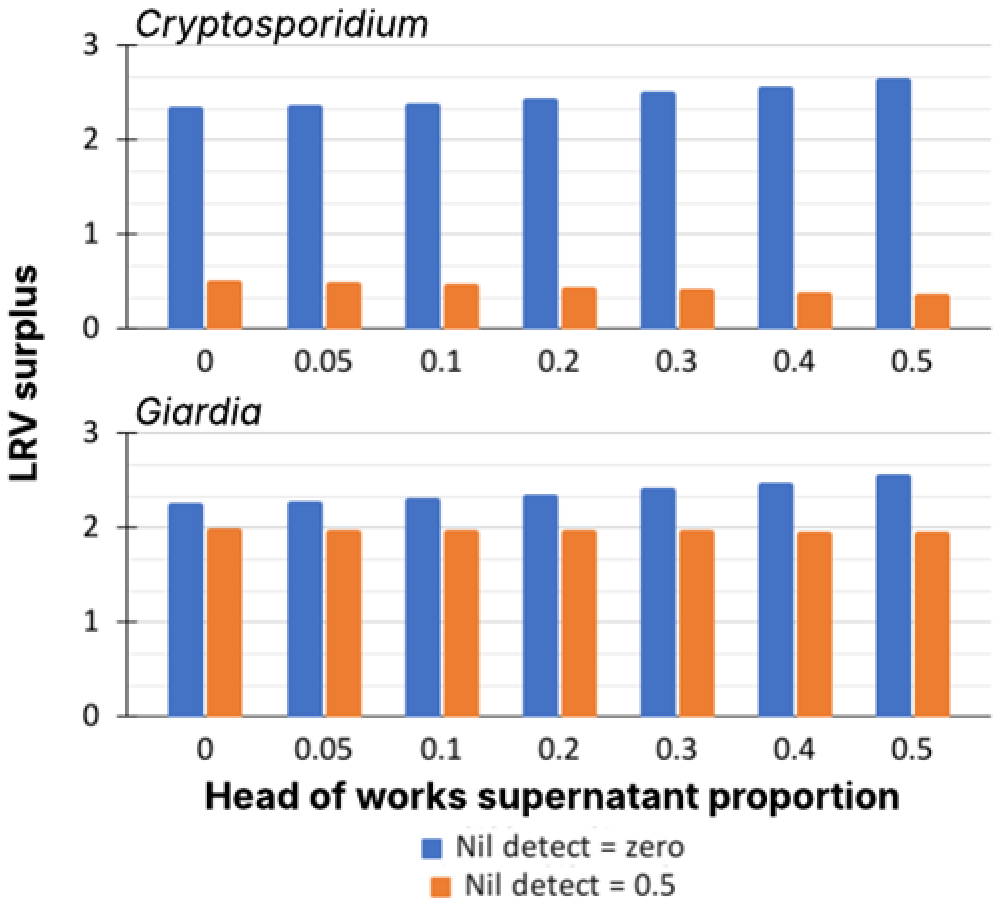
Parameter	Giardia	*Cryptosporidium*
No. samples (2/week)	437	436
No. positive detections	32	6
Percentile of positive detections (%)	7.3	1.4
Maximum result	4.0 cysts/10L	0.7 oocysts/10L

Aquayukla Sydney WATER VEOLIA

Monitoring

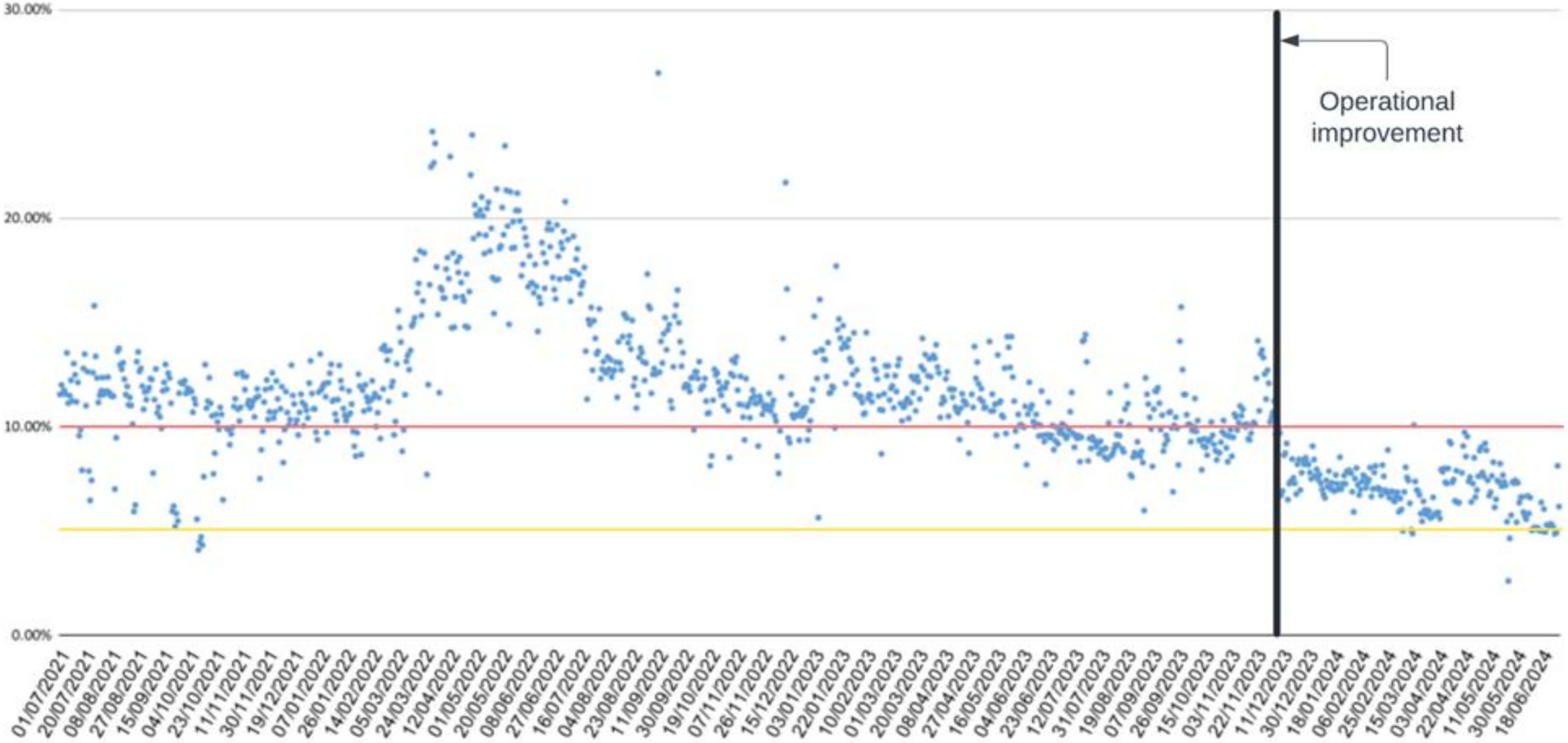
- A unique continuous supernatant monitoring dataset had been collected over one year and analysed.
- *Cryptosporidium* and *Giardia* were not detected in any supernatant sample (N=48).
- Of the raw water samples (N=114), *Cryptosporidium* was detected in 1% (n=1) and *Giardia* in 26% (n=30).
- For QMRA, the *Cryptosporidium* and *Giardia* testing needed to account for viability, infectivity, and adjusted for volume and recovery.

QMRA scenario analysis



- WFP produced safe drinking water under all examined scenarios
- Data treatment for nil detects was of greater influence than supernatant return proportion

Operational improvements



Aquayukla

Outcomes

- This study has provided a much-needed example of the industry adoption of the Good Practice Guide on supernatant return in the context of the microbial HBT.
- QMRA did not identify unacceptable risk of historic supernatant return rates.
- Operational improvements were implemented in line with preventive risk management and continuous improvement principles.
- Reuse of any water treatment residuals should be thoroughly understood and cautiously managed.
- The outcomes align with the conclusions of the WaterRA Project 1129