DISINFECTION RESIDUALS STRATEGY

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ABSTRACT

One of Shoalhaven Water's water quality management barriers is the maintenance of a consistent free chlorine residual throughout the entire water distribution network to provide a final barrier against pathogens. In 2011, Shoalhaven Water embarked on the development of a Disinfection Residuals Strategy (DRS) to identify the most technically appropriate and cost effective approach for providing a disinfection residual throughout the entire distribution network.

The DRS has culminated in the creation of a model that accurately estimates water age and chlorine residual throughout the water supply network, enabling Shoalhaven Water to consider the specific water supply zones and how they are effected by flows, demands, valving configurations and storage sizes. The combination of water age modelling and chlorine decay testing contributed to a chlorine residual model that correlates well with field data. Model output suggets that water age is the predominant factor in low chlorine residuals at the extremities of the system. The model can now be used to focus on the characteristics of specific problem zones and components. Inputting potential solutions into the model such as alternative reservoir operating levels, valving configurations, and potential additional satellite chlorinators provides an indication of the effectiveness and implications for these approaches. The model will continue to evolve with the collection of further data, particularly from the zones considered most problematic.

1.0 INTRODUCTION

Shoalhaven Water is a Local Water Utility (LWU) operating as a business group under Shoalhaven City Council (SCC) supplying safe drinking water to approximately 100,000 people on the south coast of New South Wales (NSW). The 1500 km distribution network extends from Berry in the north to Lake Tabourie in the south. During holiday periods water supply demands regularly triple in size. Shoalhaven Water manages its water supply systems in line with the Australian Drinking Water Guidelines (ADWG), which outline a risk based management approach to managing drinking water quality. This risk based approach includes the "multiple barrier framework". One of the barriers is the maintenance of a consistent chlorine residual throughout the entire water distribution network to provide a final barrier against pathogens.

Regular water distribution monitoring results indicate areas of low to nil levels of chlorine residual. Low chlorine residuals pose a risk to biologically safe drinking water quality and may lead to water quality incidents. Initial operational investigations indicate that this is likely to be a greater problem in areas furthest away from water treatment plant reservoirs and satellite chlorinators. It should be noted that there is presently no direct regulatory requirement for a minimal disinfectant residual in the distribution systems and Shoalhaven Water consistently meets biological regulatory requirements for the distribution network. However, from both a quality and regulatory perspective, it is preferable that consistent chlorine residuals are maintained for the distribution systems.

Shoalhaven Water embarked on the development of a Disinfection Residuals Strategy (DRS) to identify the most technically appropriate and cost effective approach for providing a disinfection residual throughout the entire distribution network.
Specifically the objectives of the DRS included gaining a clear understanding of the extent

of disinfection residuals within the existing distribution systems, a thorough review of monitoring data, identifying and filling knowledge gaps, quantifying chlorine decay rates of all source waters, development of a water age and chlorine residuals network model, and identifying potential options to increase the persistence and extent of disinfection residuals. This paper details the achievements and outcomes from the DRS investigations to date.

2.0 DISCUSSION

2.1 Methodology

Shoalhaven Water and Hunter Water Australia (HWA) first examined the distribution disinfection residuals in 2003 with more detailed investigations undertaken in 2011/2012. Shoalhaven Water applies chlorine as a primary disinfectant at its water treatment plants and other strategic locations throughout the water supply network to provide disinfection.

In 2012 Shoalhaven Water commissioned HWA to assist in the development of a DRS which first consisted of creating a water age model of the water supply network using *Infoworks WS* software by inputting distribution trunk main lengths, pipe junctions (nodes), open and closed valves, dead ends, reservoir hydraulic levels, flow monitoring data and historical water supply demands.

Chlorine decay testing of filtered waters from each water treatment plant was then conducted at both 12ºC and 25ºC (Figure 1) to derive decay coefficients (Table 1).

Figure 1: ***Free chlorine decay curves of Bamarang WTP filtered water at 25ºC***

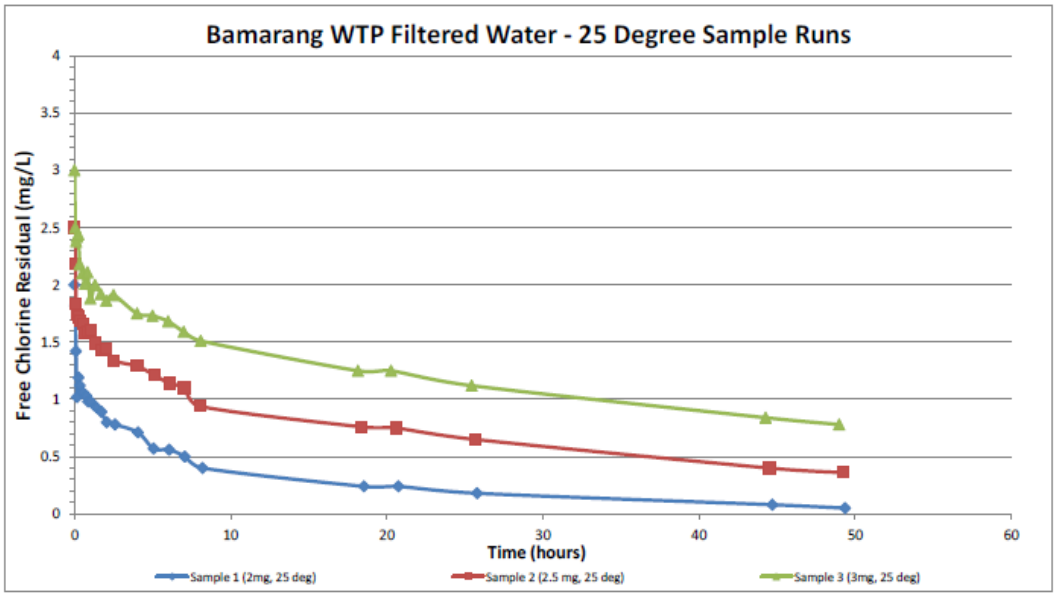

Table 1: ***Free chlorine decay coefficients***

Location	Decay Coefficient	
	Measured	Modelled
Bamarang	-0.01 to -0.03	-0.01, -0.03, -0.06
Kangaroo Valley	-0.01	-0.01
Milton	-0.02 to -0.03	-0.01, -0.03, -0.06

The chlorine decay testing results were then used as inputs into the water age model

(Figure 2) to predict chlorine residuals throughout the network and to eventually calibrate the chlorine residuals model with available system chlorine monitoring data. This calibrated model can be used to identify potential solutions to enable adequate chlorine residuals to be maintained in the identified problem zones.

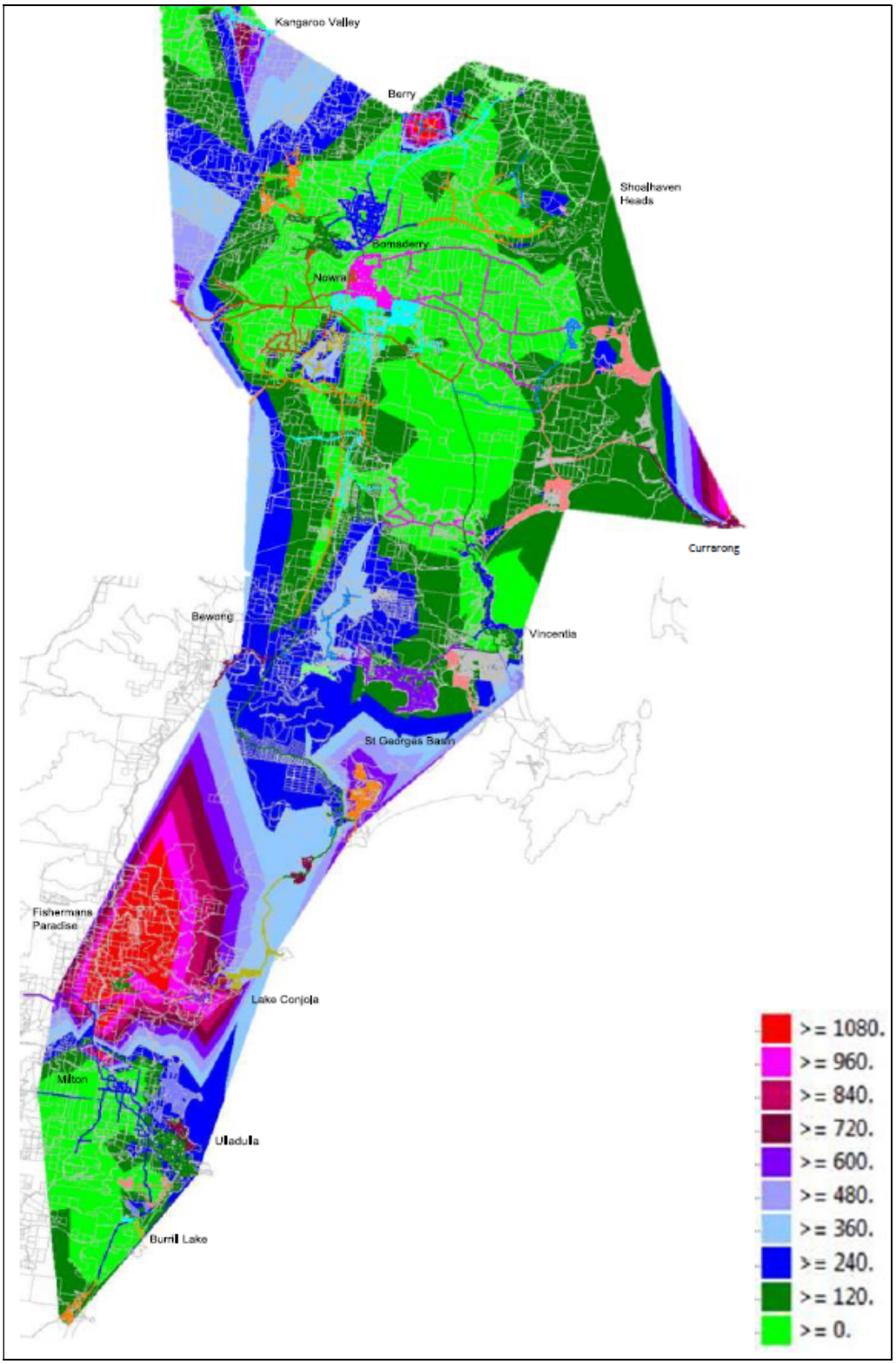

Figure 2: ***Water age model of the water supply network (in hours)***

3.0 CONCLUSION

3.1 Outcomes of strategy

The work undertaken to date in development of the DRS has produced a chlorine residuals model correlated with actual data taken from the field (Figure 3). The identified chlorine deficient areas in the model are consistent with those thought anecdotally to be problematic. Water age modelling identified two main areas that experience high water age, namely Cambewarra (northwest of Nowra) and Conjola/Fishermans Paradise. Lake Tabourie and Currarong were also shown as chlorine deficient areas.

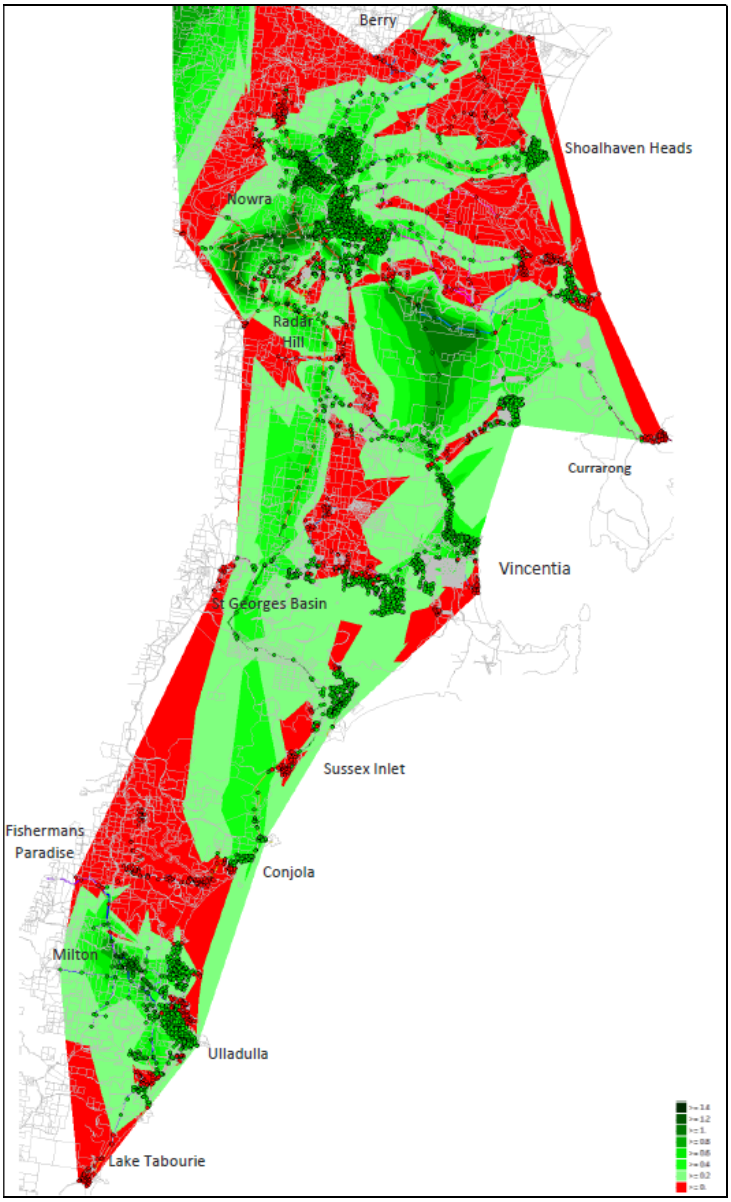

Figure 3: ***Modelled free chlorine residuals (mg/L) of the water supply network***

Cambewarra's high water age of >1080 hrs and chlorine residuals of between 0 and 0.18 mg/L is due to the small amount of turnover in the reservoir caused by low demand and relatively large storage. Chlorine residuals are adequate whilst the reservoir is filling, however, the residuals drop when the reservoir pays out (Figure 4).

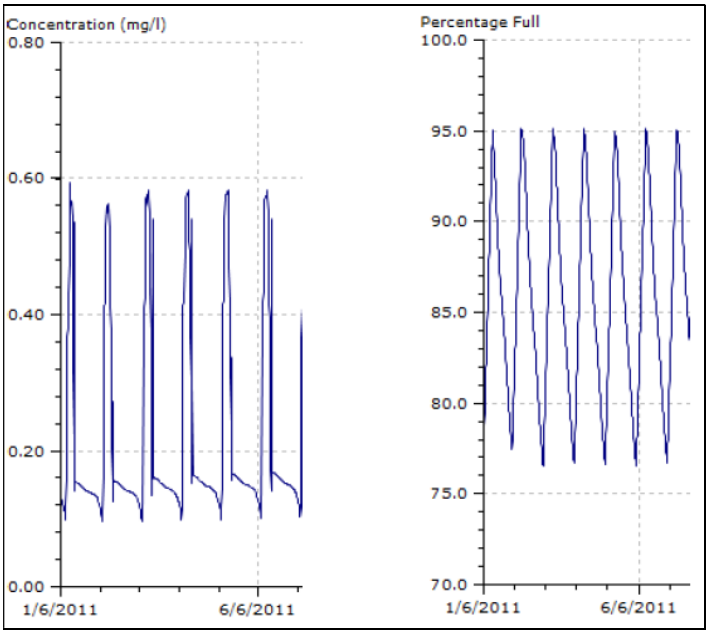

Figure 4: ***Free chlorine residual and capacity levels for Cambewarra reservoir***

Conjola/Fishermans Paradise also experiences high water age (>1080 hrs) due to a combination of the long travel times to reach this extremity of the northern system, as well as from low turnover of relatively large storages. This high water age results in consistently low or non-existent chlorine residuals (Figure 3).

The model has enabled the effects of different operating modes such as different water delivery paths, and diurnal demand patterns to be observed. One-off grab sampling does not show these effects. The model will enable solutions to be tailored around inflow and outflow characteristics from reservoirs and water age in reservoirs. This will lead to the development of engineering solutions around these zones to be considered and eventually implemented.

The DRS has culminated in the creation of a model that accurately estimates water age and chlorine residual throughout the water supply network, enabling Shoalhaven Water to consider the specific water supply zones and how they are effected by flows, demands, valving configurations and storage sizes. The combination of water age modelling and chlorine decay testing contributed to a chlorine residual model that correlates well with field data.

Model output suggets that water age is the predominant factor in low chlorine residuals at the extremities of the system. The model can now be used to focus on the characteristics of specific problem zones and components. Inputting potential solutions into the model such as alternative reservoir operating levels, valving configurations, and potential additional satellite chlorinators provides an indication of the effectiveness and implications for these approaches. The model will continue to evolve with the collection of further data, particularly from the zones considered most problematic.

3.2 Supply system innovations and improvements

Since the initial outcomes of the DRS were produced several water quality improvement initiatives have been implemented by Shoalhaven Water.

Based on the modelling output and routine monitoring data an additional satellite chlorinator is being trialled in the southern water supply system at Ulladulla to improve free chlorine residuals in the southern extermities. Chlorine (calcium hypochlorite) tablets are also being trialled at a number of reservoirs in the network including North Ulladulla, Currarong, Greenwell Point, Fishermans Paradise, as well as some of the small reservoirs. Increased routine monitoring of free chlorine residuals in the network is also now undertaken with the intention that this data will enable a recalibration of the chlorine residuals model in the near future which will provide an even greater understanding of the water supply systems.

A possible future initiative for Shoalhaven Water is the use of live data modelling using the existing *Infoworks WS* model integrated with the existing SCADA systems.

It is percieved that the DRS has been successful in helping to resolve the issue of nil to very low free chlorine residuals for each of Shoalhaven Water's supply systems. In addtion the DRS methodology has been a successful innovation for Shoalhaven Water's operations divison and may also have postive implications to other water utilities.

4.0 ACKNOWLEDGEMENTS

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