Responses to poor raw water quality: Destratification and PAC use in the ACT

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ABSTRACT

Googong reservoir is Canberra's largest water storage dam, however regular blue green algae blooms make water treatment more difficult in summer. In summer 06/07 low dam levels in Canberra's alternative catchment meant that Googong water was required for town supply. This paper discusses the strategies which were used to allow extraction from the reservoir.

Dosing with powdered activated carbon was critical for final water quality. A variety of operation and maintenance issues were associated with the high PAC consumption rates of around 50kg/hour. Destratifying mixers were installed in the reservoir during summer 06/07 as a long term algal management technique. They had an immediate effect on reservoir stratification, helping to resolve problems with anoxic water and dissolved manganese.

KEY WORDS

Powdered activated carbon (PAC), destratification, mixers, algae, manganese.

INTRODUCTION

ActewAGL uses three sources of water to supply Canberra and Queanbeyan - the Cotter, Googong and Murrumbidgee catchments. Historically, the Cotter catchment has been the primary source of water for Canberra with the Googong catchment used in periods of high demand. The Murrumbidgee is a new source of water, brought online in May 2007 in response to the ongoing drought.

The Googong Water Treatment Plant is located in NSW just over the border from the ACT. The plant treats water from the Googong Dam situated on the Queanbeyan River. At 124 GL Googong Dam is the largest of the four dams in the ACT water supply system.

The quality of the water available from the two long-term catchments is quite different. The Cotter catchment is protected, resulting in excellent raw water quality. The Googong catchment includes rural residential and grazing land-uses; nutrient levels in the runoff are higher and each summer a significant algal bloom occurs in the reservoir. The reservoir develops a strong temperature stratification in summer with very low dissolved oxygen levels at depth. These factors were all present in late 2006 when the Googong catchment had to be used due to very low dam levels in the Cotter catchment.

Two water quality issues came to the fore in summer 06/07. The first was geosmin produced by the break-down of blue-green algae in the reservoir, the second was dissolved manganese present in the deeper levels of the stratified reservoir. Broadly, two strategies were used to deal with these problems: powdered activated carbon (PAC) dosing and mechanical mixing to destratify the reservoir.

PAC dosing was installed as part of a plant upgrade in 2004, however prior to summer 06/07 Googong reservoir had not been used during significant algae blooms and thus the system had not been proven in operation. Issues with the operation of the PAC system are discussed below, together with information on ActewAGL's responses and solutions.

Installation of destratifying mixers was scheduled for March 2007 as part of a longer term strategy to manage the blue-green algae in the reservoir. Installing the mixers in late summer was not expected to have an impact on the algae in the 06/07 season, however the mixers proved effective at resolving the dissolved manganese problem which was experienced in late summer.

DISCUSSION

Googong WTP operations in summer 06/07

Googong WTP was commissioned in 1979 with conventional clarification and filtration processes capable of treating 180ML/d. The plant capacity was augmented in 2004 with the addition of six Dissolved Air Flotation (DAF) filters capable of treating 90 ML/d. Also added at this time were a PAC dosing system and expanded sludge thickening and dewatering facilities.

In December 2006 geosmin was detected in the treated water from the plant, although algae levels in the reservoir remained low. PAC dosing was commenced at the plant for the first time. The PAC facility had only had a short commissioning period and a variety of maintenance and operational issues became apparent. Careful sludge management was required as algal matter broke down and geosmin concentrated in the sludge handling facilities.

By late January the geosmin levels in the shallower waters of Googong Dam became untreatable. The PAC dose required to reduce geosmin below detectable levels was beyond the capacity of the dosing facility. The offtake depth was changed to allow water to be drawn from below the thermocline where the geosmin levels were lower.

At this depth the water was anoxic and problems were encountered with dissolved manganese leading to customer complaints of 'yellow' water. Careful water monitoring throughout the plant and a change in operational philosophy were required to manage both the geosmin and the manganese problems. Dissolved manganese levels in the raw water were reduced in late summer due to the impact of the destratifying mixers.

PAC dosing for geosmin removal at Googong WTP

In early January 2007 geosmin levels at the Googong dam intake tower were 22ng/L, well above the human taste threshold of 5 – 10ng/L. The other major taste and odour compound, MIB, is not typically detected in Googong reservoir.

Analysis by the Australian Water Quality Centre determined that 20ng/L of geosmin could be reduced below 10ng/L with a PAC dose of 10mg/L (AWQC, 2007). This was based on using an alum dose of 35mg/L with raw water DOC of 7mg/L.

To achieve a dose of 10mg/L at plant flow of 120ML/d, 50kg/hr of PAC was required, as shown in Table 1. Daily PAC usage was thus projected to be about 1200kg.

Table 1: *PAC feed rates (kg/hr) for given plant flows*

PAC feed rates (kg/hour)		Plant Flow Rate (ML/day)						
		60	**75**	**90**	**105**	**120**	**135**	**150**
PAC Dose Rate (mg/L)	**10**	25	31	38	44	50	56	63
	20	50	63	75	88	100	113	125
	30	75	94	113	131	150	169	188
	40	100	125	150	175	200	225	250

PAC maintenance issues

Prior to summer 06/07 the PAC facility had not had an extended run. Several problems were found with the system. Loading of each 400kg bag was taking up to two hours. Given the substantial consumption rate, this made the loading of bags a full-time job for maintenance personnel. During loading, there was also a lot of dust being created. To overcome these issues an air lance was made up which reduced loading time to 30 minutes per bag. Dust suppression was achieved by increasing the vacuum on the exhaust system located under the bag loader.

Problems also occurred with dosing, which is via a water-driven venturi system. Because PAC is hydrophobic one of the biggest challenges is getting adequate wetting of the powder. A wetting column with level controlling probes was part of the original system, however, the powder was constantly contaminating the head of the probes. This would result in an electrical short between the probes, tripping the system on ‘high column level’. The wetting column and probes were removed and a simple wetting assembly consisting of a stainless steel cone with mixing water was installed. This requires occasional cleaning to remove powder build up on the cone wall but is otherwise effective. ‘Ratholing’ was also occurring in the 4000kg hopper leading to fluidisation through the feeder and considerable mess. This problem was effectively overcome by installing an air puffer system in the hopper.

Operational issues and sludge management

The dosing of PAC resulted in up to 2000kg of additional sludge being produced each day. Coagulation, flocculation and clarifier settling were all impeded by the PAC in the inlet water. The alum dose was increased from 35 to 40mg/L in response with no adverse affect on geosmin removal. Due to the difficulty of doing drop tests with PAC, the hopper weight was used to calculate doses.

Throughout this period operators conducted four hourly checks of taste and odour of the final water. With geosmin test turnaround times at a minimum of seven days, this provided the best warning of arising issues.

Careful operation of the washwater reclamation basins and sludge thickener was required. It was found that high concentrations of geosmin were occurring in these tanks due to algal cells lyseing in the sludge. At times the geosmin level in the plant inflow exceeded the levels in the dam water due to the return of supernatant from the sludge system. A number of operational changes were made to resolve this issue:

- Washwater reclamation basin sludge levels were measured daily to ensure they were well below the level from which supernatant return to the head of the plant is drawn.

- After backwashes washwater was allowed to settle in the reclaim basins for at least 30 mins before returning any water to the plant inlet.
- The reclaim basins were rotated out of service more frequently and cleaned of sludge.
- In the event of a PAC system failure supernatant was diverted to the sludge drying beds instead of the head of the plant.
- The sludge thickener was also monitored and sludge levels kept to a minimum, rather than running it with a blanket as is standard operation.
- Clarifiers were also run with a minimal blanket to safeguard against the possibility of algae breaking down in older sludge and releasing geosmin.

Change in raw water characteristics and effects on operation

In January 2007, the geosmin levels at the shallow depths were above a level that could be treated with any confidence. To avoid the high levels of geosmin, water was drawn from lower offtakes at a depth of about 9 metres. At the lower intake level geosmin was treatable, however dissolved oxygen levels were low (see Figure 1). Manganese testing was conducted, revealing levels above normal but still well within guidelines (0.025mg/L in the treated water compared to normal levels <0.010mg/L).

Over the following weeks, colour in the treated water began to increase. The level of dissolved manganese in the plant inlet reached 0.046 mg/L on February 22, well above the aesthetic level of concern of 0.02 mg/L. Dissolved manganese was passing through the clarification and filtration processes then being oxidised by chlorine before it left the plant. This led to ‘yellow’ water in the network. At the time no chemical dosing facilities for removal of manganese were in place; therefore the treatment plant had to be shut down until raw water improved. This was achieved through destratification of the dam.

Destratification of Googong reservoir

ActewAGL has successfully managed an iron and manganese problem using a mechanical mixer in Cotter reservoir (post 2003 bushfires). Similar mixers were installed in Googong reservoir in March 2007 in an effort to reduce the blue-green algae blooms experienced each summer. Two sets of close coupled mixers were installed in the main basin at a distance of about 600 metres from the offtake tower. The units consist of two 5m diameter counter-rotating impellers with draft tubes (WEARS Australia, 2007). The mixer speed and draft tube length are adjustable to allow for changes in reservoir depth and water quality.

The theory behind these mixers is that they push warmer, oxygen rich surface water down through the reservoir profile, preventing the typical temperature stratification from developing as summer progresses (Steve Elliot, *pers comm.*). This can diminish the competitive advantage blue green algae species enjoy. Blue green algae can regulate their buoyancy, allowing them to move between light surface waters and the nutrient rich deeper waters. The water shearing of the currents set up by the mixers may also destroy the buoyancy vessels in blue green algae. The ability of the mixers to manage algae will not become apparent until summer 07/08, however they have proven effective at destratifying the reservoir.

The mixers commenced operation on March 14, after Googong WTP had been shut down due to high dissolved manganese levels in the raw water. The water at the offtake depths was anoxic (Figure 1). Within a week of the mixers commencing operation a noticeable change was apparent in the temperature and DO profiles at the offtake tower as shown in Figures 1 and 2 below. The reservoir was effectively destratified at the offtake tower by the third week of April. Based on experience with the mixer in Cotter reservoir, it is anticipated that Googong reservoir will remain mixed throughout future summer seasons.

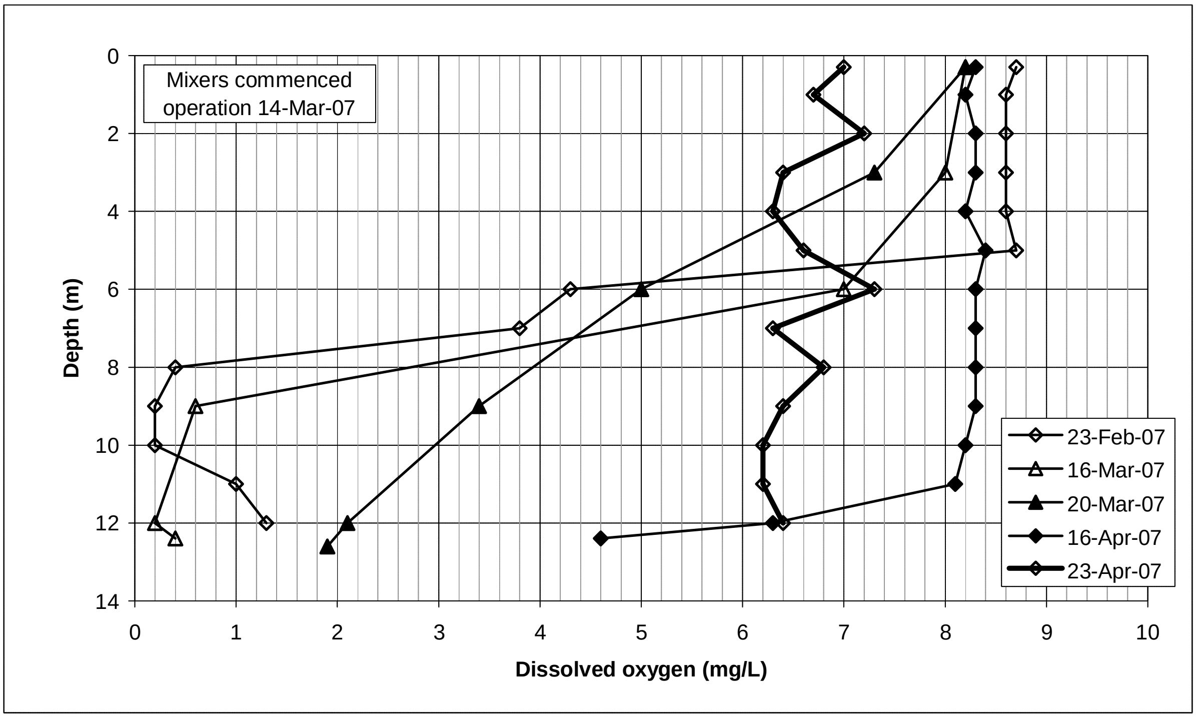

Figure 1: ***Dissolved oxygen profiles at the Googong Dam offtake tower***

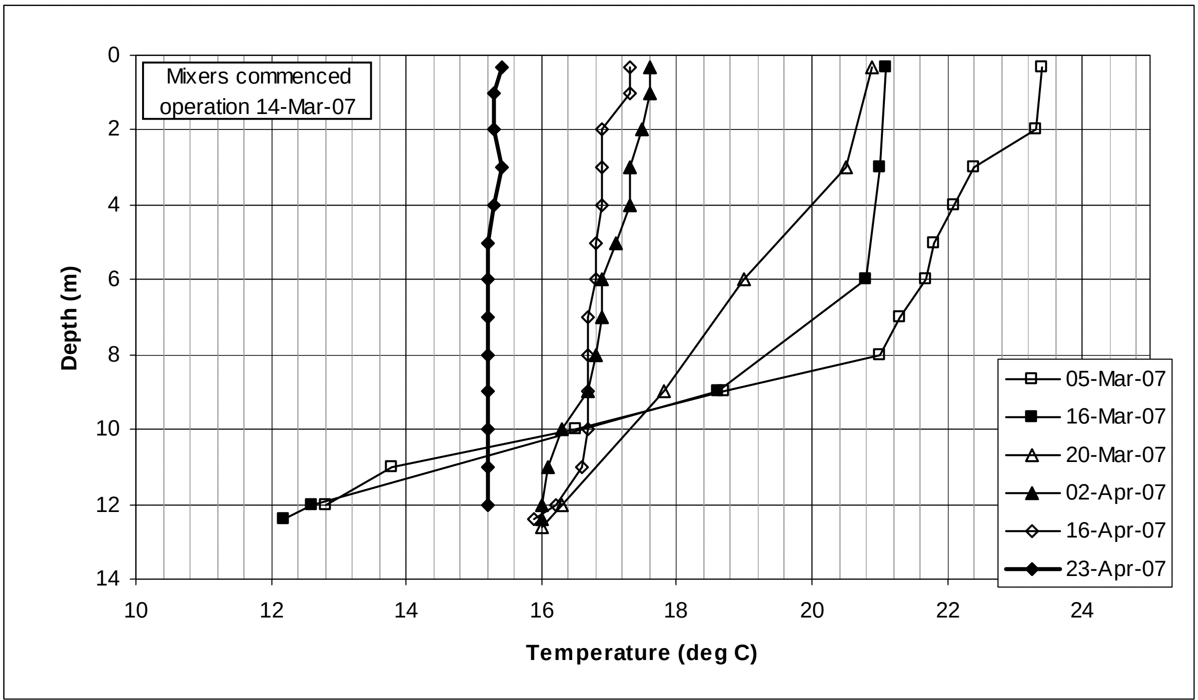

Figure 2: ***Temperature profiles at the Googong Dam offtake tower***

The reservoir destratification initially mixed dissolved manganese throughout the reservoir profile, similar to the results of natural reservoir turnover. Changes in dissolved manganese with time are shown in Figure 3. Reservoir mixing occurred more quickly under the influence of the destratifiers. By the time the reservoir was fully mixed in late April, the dissolved manganese had stabilised to levels that could be managed by the WTP.

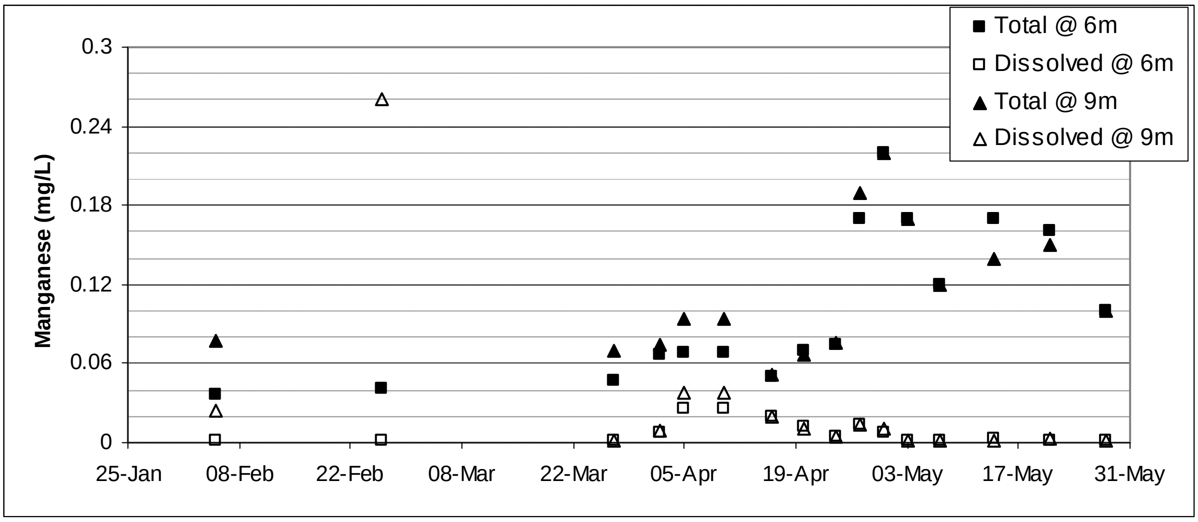

Figure 3: ***Manganese levels at Googong Dam offtake depths***

CONCLUSIONS

Operation of the Googong dam in summer requires careful attention to taste and odour compounds, particularly geosmin. When operating the PAC system at high dose rates a number of operational issues become significant. Chief among these are the manual intervention required to load PAC into the dosing system, handling and mixing problems associated with the nature of the PAC and the requirement to control return of geosmin contaminated washwater to the plant.

Hypolimnetic water may contain lower levels of geosmin, but elevated levels of dissolved manganese in this anoxic water are not effectively removed by the Googong WTP without a pre-oxidation step. Mechanical destratification mixers had a rapid effect, destratifying the reservoir and increasing the dissolved oxygen content throughout the profile thus reducing the concentration of dissolved manganese.

Achieving a reduction in the algal blooms in Googong reservoir will have major operational benefits. Destratification mixers installed in March 2007 have the potential to reduce the severity of blooms in summer and the impact of the mixers on algae counts will start to become apparent in the summer of 07/08.

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