

This report summarises the outcomes of a water quality review undertaken in response to an email sent to Melbourne Water.

The email outlines concern that the correlation between water renewal ('increased rainfall') and BGA biovolume have been dismissed during the preparation of the Quiet Lakes Water Quality Management Plan (Fig 1)

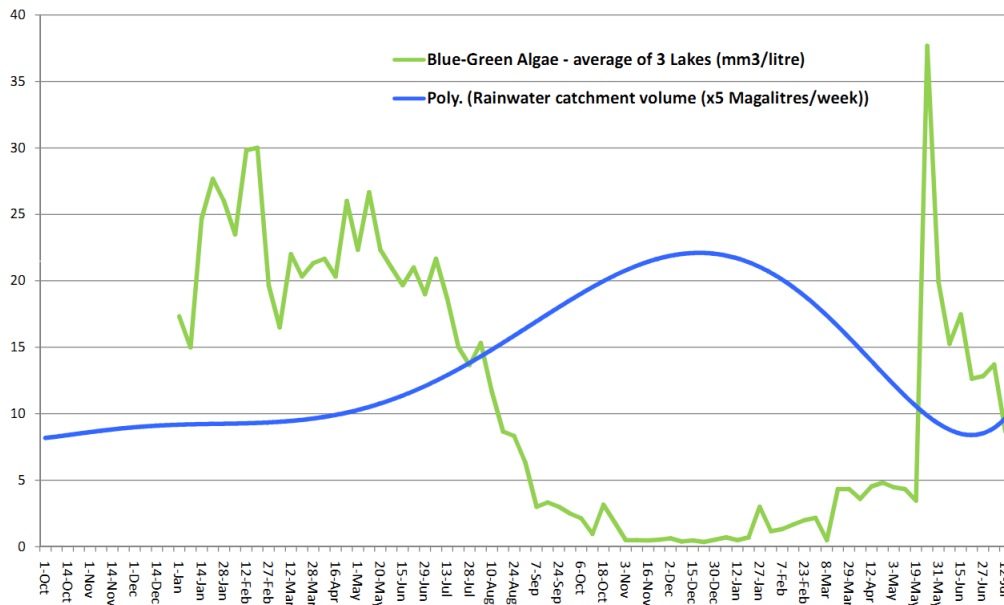


Figure 1 Plot of Blue-green algal biovolume and rainwater catchment volume provided to Melbourne Water.

Interpretation of blue-green algal biovolume and increased rainfall trends during 2010 to mid-2011

During the first 8 months of 2010 high cyanobacteria biovolumes were observed in both Lakes Illawong and Carramar whilst Lake Legana, for the same period, was comparatively low (Fig 2). A notable decline in cyanobacterial biovolumes occurred in all three lakes from May 2010, and biovolumes had fallen below the safety threshold of 10 mm³/L by September 2010. Low cyanobacterial biovolumes (< 10 mm³/L) persisted for 8 months in all three lakes until May 2011 (Fig 2).

The reduction in cyanobacterial biovolumes during the second half of 2010 corresponded to an increase in rainfall during this period (indicated as Phase 1) (Fig 3). The cumulative rainfall total from the start of the reduction in cyanobacterial biovolumes (18th May, 2010) to when cyanobacterial biovolumes fell below the safety threshold (10 mm³/L) (24th August, 2010) was 220 mm. The majority of the rainfall during this period occurred in June. (Rainfall data obtained from MW hydrographic stations at Riviera St Seaford and Skye Rd Frankston using only data with good quality codes)

The rainfall during this period of cyanobacterial reduction (Phase 1) would not have significantly influenced lake residence times in Lake Legana. For example, inflows to Lake Legana would have been approximately 10.9 ML, equating to approximately 13% of the Lake Legana volume (87 ML). The exchange of 13% (or even 20%) of the volume from Lake Legana would not have been enough to remove significant algal biomass from the lake, and is not sufficient enough to explain the reduction in cyanobacterial biovolumes observed during this time.

It is possible that some flushing of Lake Illawong may partly explain the reduction in cyanobacterial biovolume in Lake Illawong during Phase 1 (May-August, 2010). Inflows to Lake Illawong would have comprised of direct rainfall, surcharges from the drainage system, inflows from the adjoining properties and directly connected road surfaces; as well as water being flushed from Lake Legana and to a lesser extent, Lake Carramar. The

volume of Lake Illawong is approximately 37 ML, less than half the volume of Lake Legana. The estimated inflow to Lake Illawong during this period is 19 ML (8 ML from the lakes catchment and diversions, 10.9 ML from Lake Legana overflows), which equates to nearly 60% of the lake volume. It is important to note that the 10.9ML of water flushing into Illawong from Lakes Legana and Carramar during this time contained high levels of algae and therefore cannot really be considered as part of a flushing volume. During this time, even though Illawong had the maximum potential flow through of the three lakes, for most weeks it also recorded the highest cyanobacterial biovolumes compared with Legana and Carramar (Fig 2).

The comparatively small changes in salinity in the lake system during Phase 1 also indicates that little flushing of the lake system occurred. The average lake salinity of the Quiet Lakes on the 18th May, 2010 was 9200 uS/cm however this had reduced to only 7650 uS/cm by 24th August, 2010 following nearly 220 mm rainfall over the period (Fig 4)

Previous research undertaken for Melbourne Water (Stojkovic *et al.*, 2008, 'The effects of salinity on growth and germination of blue-green algae and its potential as a management tool', Monash University) indicated that growth rates of Planktolyngbya (the dominant blue-green algal species present within the Quiet Lakes) decreases at low salinities. It is possible that, whilst flushing was not adequate to displace a substantial algal biovolume, the small reduction in salinity brought about a reduction in the growth rate of Planktolyngbya.

The cumulative rainfall between 25th August 2010 and 11 May 2011, the period of low cyanobacterial biovolume known as Phase 2 was 716 mm (Fig 3). Rainfall during this period was relatively even, and included four high daily rainfall events. Three of these rainfall events occurred within a two week period in early November 2010. This combined event (during November, 2010) would have resulted in the displacement of approximately 10% of Lake Legana's volume and up to 15% of Lake Illawong's volume. Regular rainfall occurred to the end of December 2010, and was highly variable through to May 2011 (Fig 3).

Lake salinity at the start of Phase 2 (25th August) was 7650 uS/cm and continued to decrease through to 18th May, 2011) when salinity had fallen below 5000 uS/cm (Fig 5). It is likely that the reduction in lake salinity during this period would have disadvantaged the growth of Planktolyngbya, thereby maintaining low cyanobacterial biovolumes.

Stojkovic *et al.* (2008) observed that the average growth rate of Planktolyngbya (the dominant cyanobacteria in the Quiet Lakes) under optimal growth conditions at salinity 4.5 ppt (equivalent to 7,200 uS/cm) to be 0.0075 cells h⁻¹. This equates to a cell growth rate of one cell division per 5.5 days.

Assuming that the Planktolyngbya population within the Quiet Lakes are growing under optimal conditions at the maximum potential growth rate, the lake residence time required to remove Planktolyngbya cells at a rate equivalent or more than the maximum growth rate would be 5.5 days – equivalent to a flushing rate of 15 ML/day for Lake Legana. However it is unlikely that the maximum growth rates of Planktolyngbya would be achieved *in situ* within the Quiet Lakes system considering the variability of nutrient, light and temperature resources, and potential biotic interactions. Therefore, a less than optimal flushing rate may be adequate to control the Planktolyngbya population; however the specific flushing rate required will be a function of the *in situ* algal growth rates.

GHD (2008) modelled the flushing rates required to achieve a lake residence time of less than 15 days within the Quiet Lakes (considered to be the desirable flushing rate for controlling cyanobacterial growth). Assuming a total lake volume of 135 ML (including Lake Carramar), a theoretical flushing rate of approximately 8 ML/day would be required to achieve a lake residence time of 15 days; however three dimensional hydraulic modelling (undertaken by GHD) indicated that a lake residence time of 15 days would require at least 10 ML/day to ensure fully mixed conditions and exchange due to the irregular bathymetry of the lake system (GHD, 2008).

Based on this information and total rainfall over period 1 and 2 combined (936 mm) we estimate that Lake Legana would have displaced only 54% of its volume over a 12 month period. This equates to 0.13 ML/day; significantly less than either the desired or optimal turnover rates required to control algae.

Additionally, when examining the corresponding rainfall and cyanobacterial biovolume patterns for the period between July and November 2009 and 2010, (Figs 2 and 3) a similar cumulative rainfall pattern occurred in both years, but the cyanobacterial biovolume patterns observed in the lakes were distinctly different. The cumulative rainfall for July-Nov 2009 was 345mm (equating to a 20% turnover in Lake Legana), a period which corresponded to very high cyanobacterial biovolumes in all three lakes. In contrast, rainfall during the same period in 2010 was 416mm (equating to a 24% turnover in Lake Legana), yet cyanobacterial biovolumes steadily declined during this period. Some differences in the data between these two periods may have been due to the change in measurement methods that occurred at the beginning of 2010. 2009 data were determined using a biovolume calculator tool whereas the 2010 data were determined by direct measurement of biovolumes so we would expect that the absolute values between these times may differ. However, if water renewal across this period (created by rainfall) was consistently regulating cyanobacterial biovolumes we would expect the patterns to be similar between the two time periods.

Summary

The data shows a decrease in cyanobacterial biovolumes coincided with an increase in rainfall during the latter part of 2010, however this does not necessarily mean that the increase in rainfall was responsible for the observed decrease in cyanobacterial biovolume.

Analysis of the cyanobacterial biovolume and rainfall data does not clearly explain the reduction in cyanobacterial biovolumes within the Quiet Lakes system during 2010.

It is unlikely that the volume of rainfall and runoff that entered the lake system during the latter half of 2010 was sufficient to flush algal biomass from the lake system in order to permanently reduce cyanobacterial biovolumes.

It is likely that the reduction in lake salinity during Phases 1 and 2 reduced the growth rates of the dominant cyanobacterial species present within the Quiet Lakes.

It is also possible that the presence of zooplankton within the lake system may have also limited the cyanobacterial biovolumes observed, however this cannot be verified by the existing data available.

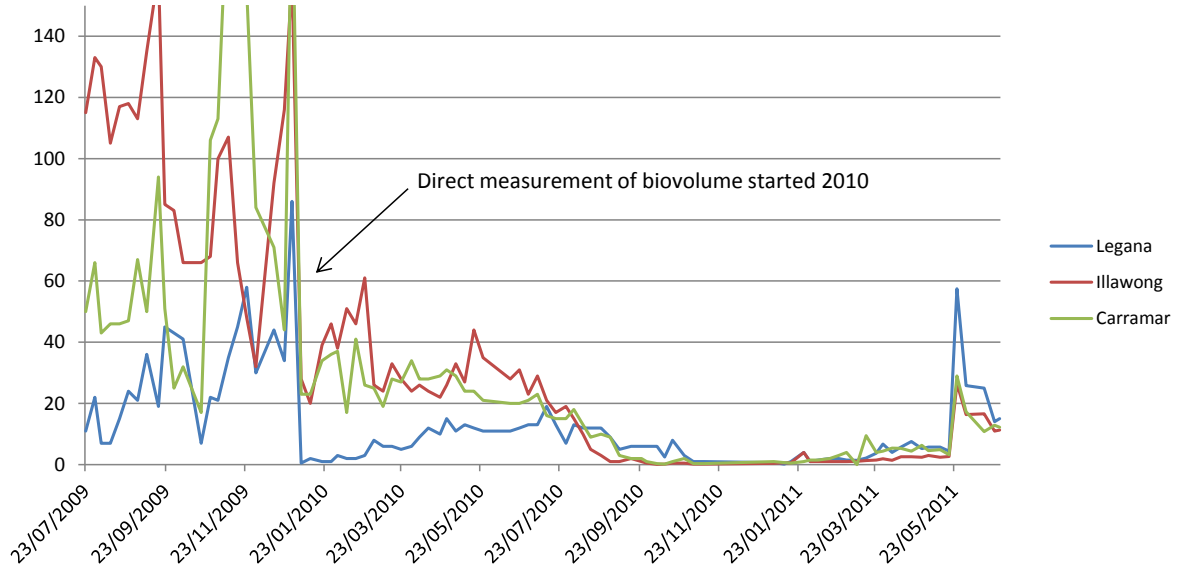


Figure 2 Cyanobacteria biovolumes measured between 2009 and 2011.

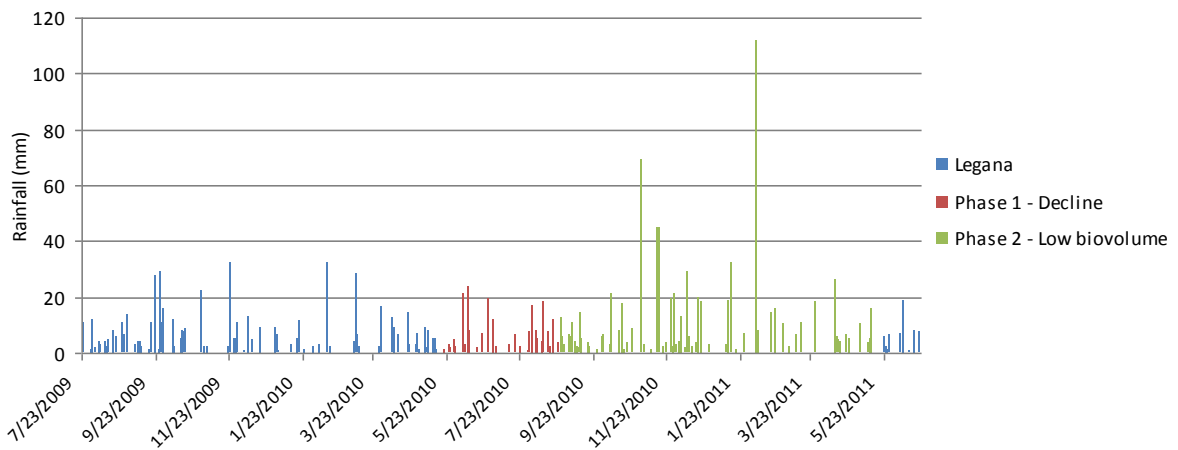


Figure 3 Rainfall (2009-11).

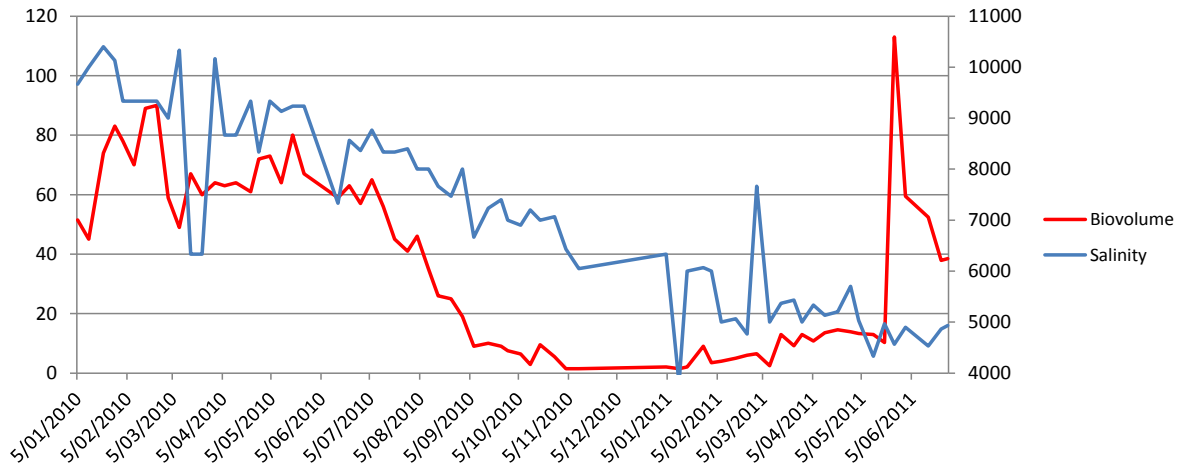


Figure 4 Cyanobacteria biovolumes and salinity (2010-11).