Government of **Western Australia**
Department of **Water and Environmental Regulation**

Oxygenating the Canning

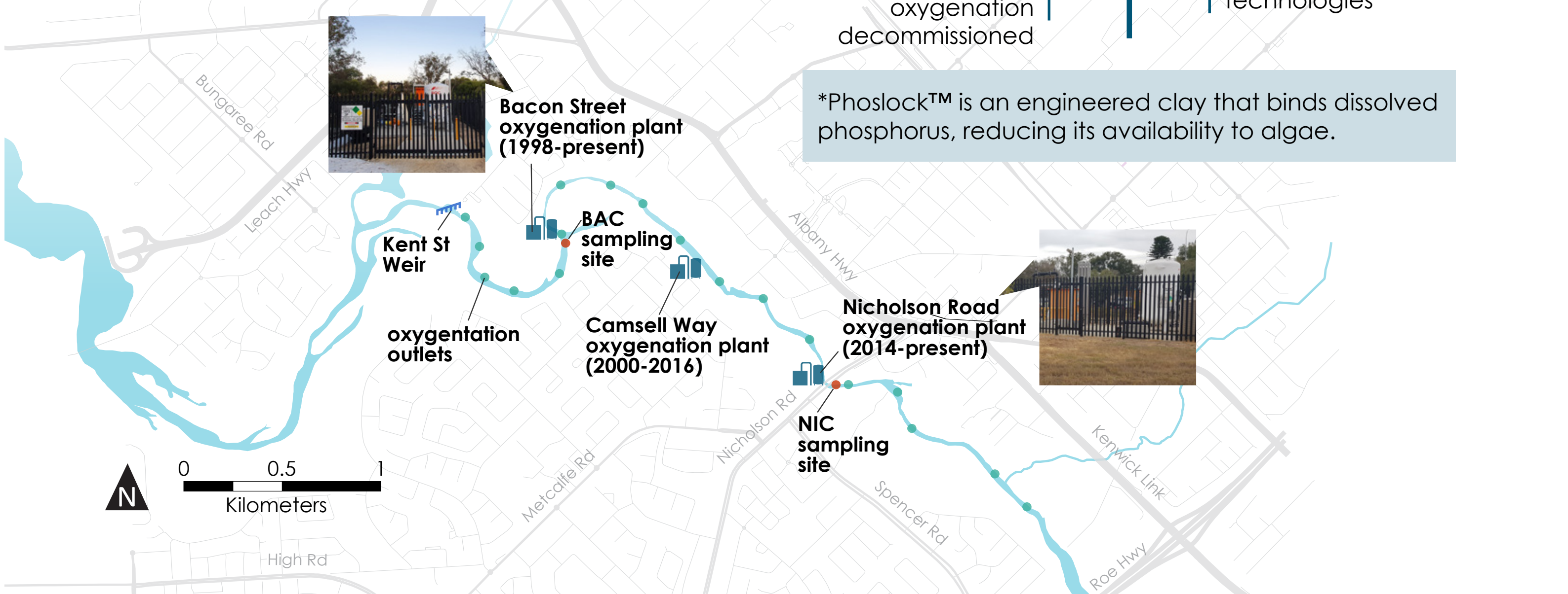
The first oxygenation plant in Western Australia was constructed on the Canning River in the summer of 1998. It was part of a trial to investigate the feasibility of artificial oxygenation to improve water quality in the river and reduce phytoplankton blooms. Over 20 years later, the oxygenation plants have become important tools for maintaining the health of the Canning River.

The plants work by increasing oxygen concentrations and reducing nutrient concentrations in the Canning, thereby reducing harmful cyanobacteria (blue-green algae) blooms.

The plants are located upstream of the Kent Street Weir. The weir holds back saline water, making the Canning River an impounded freshwater system for most of the year. Development and other human activities in the catchment (e.g. agriculture and housing) have increased the input of nutrients such as nitrogen and phosphorus into the river. Enrichment of nutrients may lead to eutrophication and excessive phytoplankton (e.g. algae) growth. Nuisance and toxic phytoplankton blooms in the 1990s were signs that this stretch of the Canning River was stressed, prompting a search for a solution to the problem.

- **1994** – Swan-Canning monitoring program starts
- **1998** – First oxygenation plant at Bacon Street treats 300 m of Canning River
- **1999** – Improved Bacon Street oxygenation plant treats 1.3 km of river
- **2000** – Camsell Way oxygenation plant is constructed, extending treatment area to 2 km
- **2000** – 40 tonnes of Phoslock* applied over an 800 m stretch of the river
- **2007** – Two monitoring stations installed in the river
- **2008** – New technology enables remote access and plant operation to be triggered by real-time oxygen concentrations
- **2010** – 50 tonnes of Phoslock* applied over a 2.5 km stretch of the river
- **2014** – Nicholson Road oxygenation plant constructed, extending treatment area to 4.5 km
- **2016** – Bacon Street oxygenation plant decommissioned for rebuild
- **2017** – Bacon Street oxygenation plant rebuilt with improved technologies
- **2017** – Camsell Way oxygenation decommissioned

*Phoslock™ is an engineered clay that binds dissolved phosphorus, reducing its availability to algae.



Oxygenation plants

While the technology of the oxygenation plants has evolved over the years, the underlying principles remain the same. A fenced compound houses an oxygen vessel that stores liquid oxygen, a vaporiser to convert liquid oxygen to gas, a dissolution device to dissolve the oxygen into water, a pump, and a control panel. Water is pumped from the bottom of the river to the plant, where oxygen is added under pressure. A network of distribution pipes returns the highly oxygenated water to the deeper sections along the river, where it is rapidly diluted. This improves oxygen concentrations from the Kent Street Weir to upstream of Nicholson Road Bridge (~4.5 km).

Water quality monitoring

The water quality of the Canning River has been monitored since 1994, with regular measurements of dissolved oxygen, salinity, temperature, pH, nutrients and phytoplankton density and composition. This long-running data set shows changes in water quality associated with the construction of the oxygenation plants, and the evolution of technology and management practices. Monitoring data is used to optimise plant operation and assess plant performance. The first monitoring stations were installed in 2007, with water quality data collected continuously and available via telemetry. In 2008, the plants were upgraded to enable operation to be triggered by in-river oxygen concentrations.

Phytoplankton

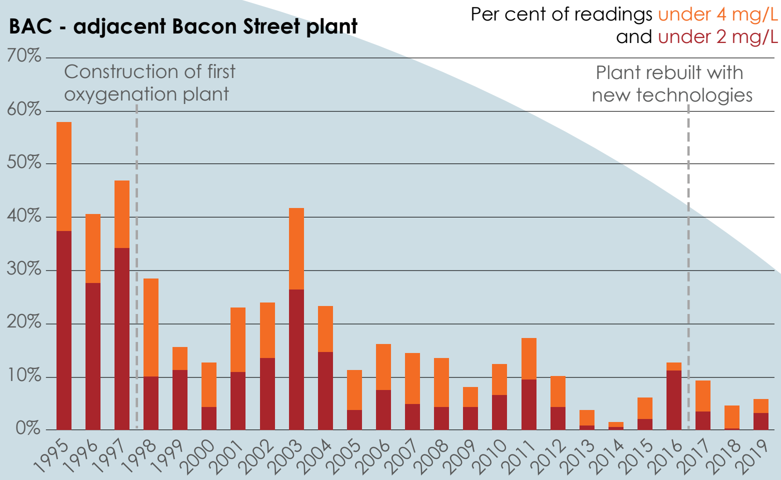
Phytoplankton are microscopic aquatic plants. They are essential to the food chain and support life by releasing oxygen (via photosynthesis) to the water and atmosphere. However, when conditions are favourable (e.g. excessive nutrients; calm, warm water; abundant sunlight) they can multiply rapidly – known as a phytoplankton bloom. Most phytoplankton blooms are harmless. However, some species, such as cyanobacteria or blue-green algae, can produce toxins which can harm humans and animals. When a large phytoplankton bloom inevitably dies off and decomposes, oxygen concentrations can decline rapidly, which is damaging and possibly fatal to aquatic life.

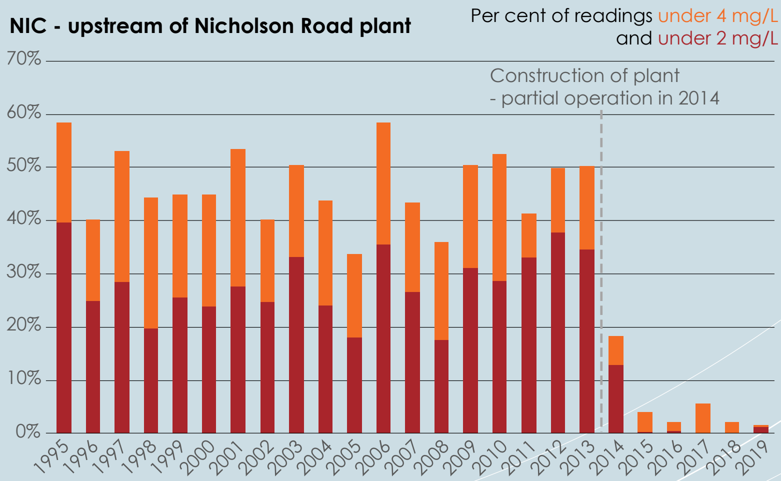
Improving dissolved oxygen concentrations

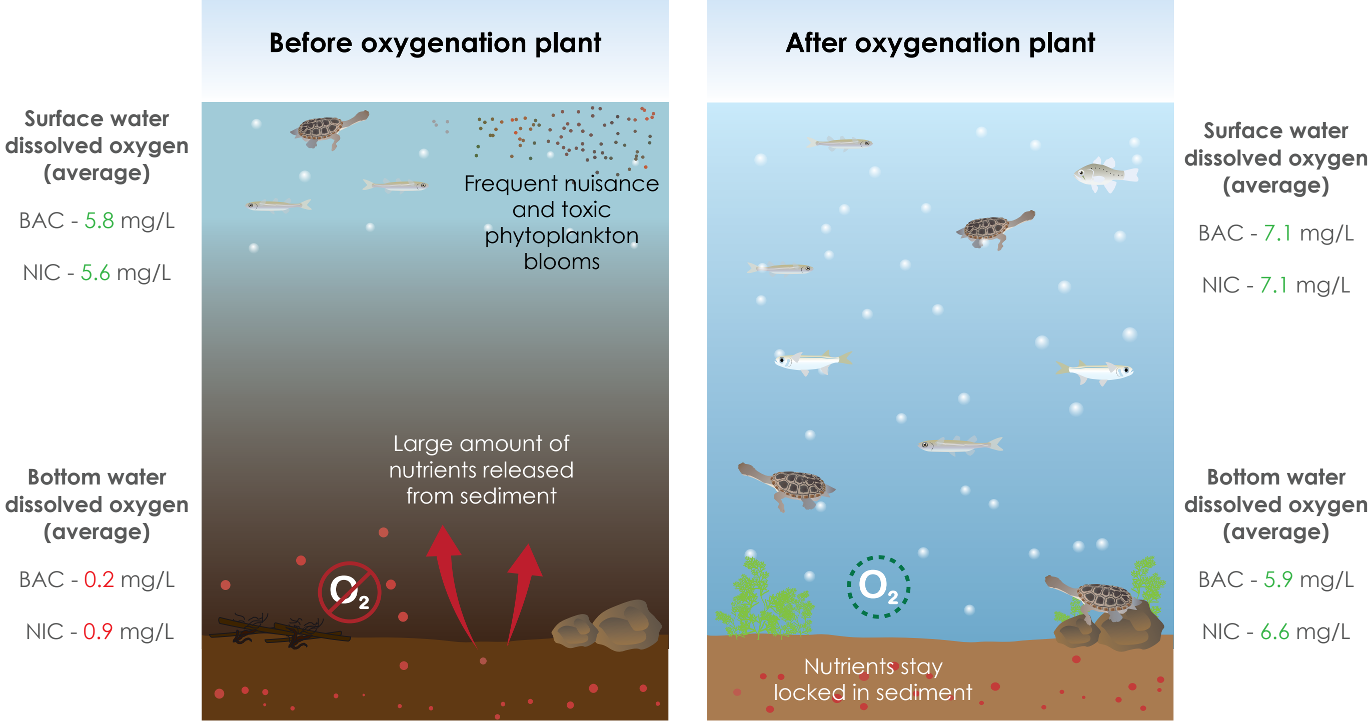
Dissolved oxygen concentrations below 4 mg/L may limit the growth, feeding and breeding of fish, and concentrations below 2 mg/L may cause fish deaths.

The construction and upgrades of the oxygenation plants immediately and distinctly reduced the occurrence of low oxygen (under 4 mg/L) and hypoxic (under 2 mg/L) conditions at two sampling sites.

The Bacon Street oxygenation plant reduced low oxygen readings from an average of 46 per cent (1995–97) to 15 per cent (1998–2019) at the BAC site (adjacent to the plant). The Nicholson Road oxygenation plant's influence was even more apparent, reducing low oxygen readings at the NIC site (upstream of the plant) from 45 per cent on average before the plant's construction (1995–2014) to 3 per cent after construction (2015–19).







Reducing nutrient concentrations

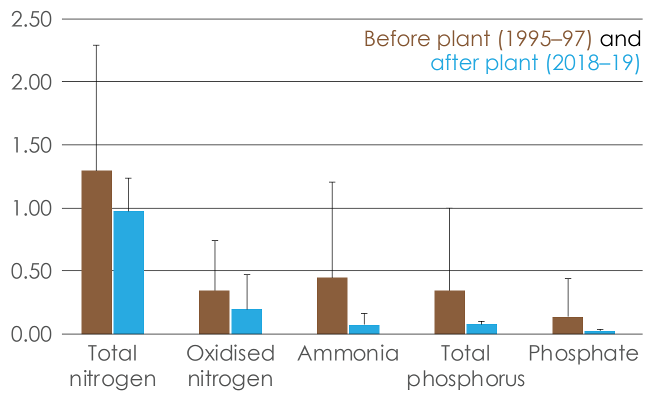
The availability of nutrients largely controls phytoplankton abundance. Oxidised nitrogen (nitrite and nitrate), ammonia and inorganic phosphorus in the form of phosphate are essential nutrients for phytoplankton growth. The oxygenation plants reduce the availability of these nutrients by facilitating aerobic biological and chemical reactions. Under oxygenated conditions, aerobic bacteria convert ammonia into nitrite and nitrate through a process called nitrification. Nitrite and nitrate can then be converted to nitrogen gas and lost to the atmosphere through denitrification. Additionally, phosphate tends to bind with minerals in the sediment in well-oxygenated conditions, making them unavailable for phytoplankton. In low-oxygen conditions, more phosphate is generally released from sediments, which can fuel phytoplankton growth.

Nutrient concentrations were notably lower after several years with healthy dissolved oxygen. When comparing dissolved nutrient concentrations from before and after plant operation, we saw the following changes at BAC (1995–97 compared with 2018–19) and NIC (2009–13 compared with 2015–19):

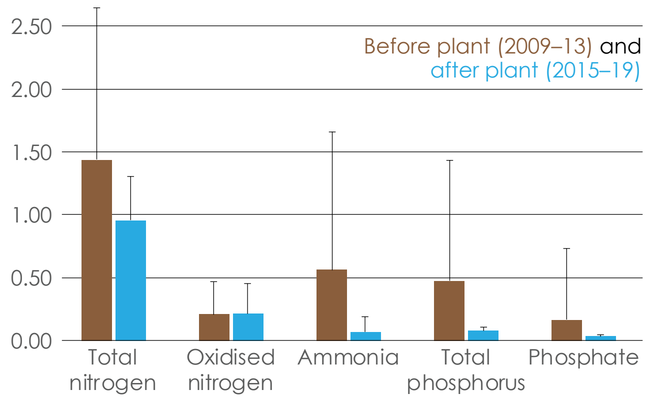
	BAC (% reduction)	NIC (% reduction)
Ammonia	84%	88%
Phosphate	83%	79%
Oxidised nitrogen	43%	-5% (increase)

Reducing nutrient concentrations lowers the frequency and intensity of phytoplankton blooms. In addition, as some types of cyanobacteria can absorb the nitrogen they need from air, reducing phosphorus concentrations can result in a decrease of these harmful species.

BAC - adjacent Bacon Street plant



NIC - upstream of Nicholson Road plant

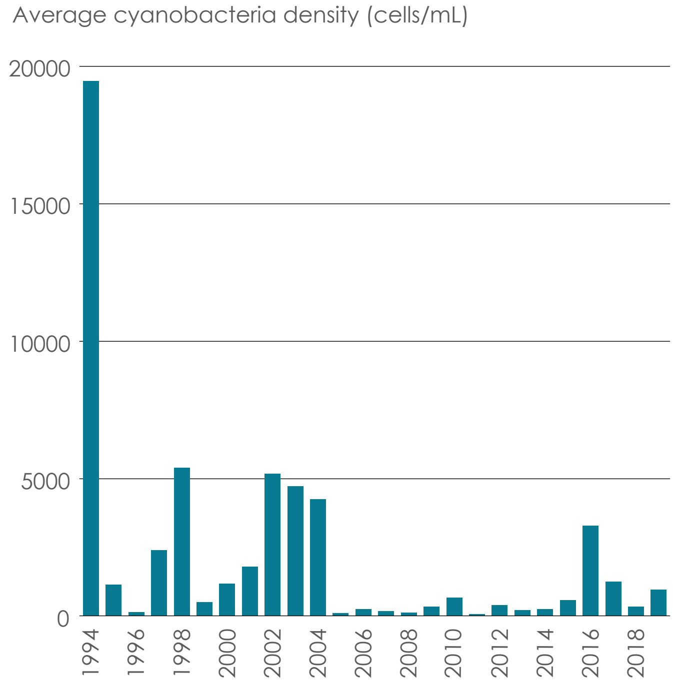


Average concentration (mg/L), with error bars indicating one standard deviation

Reducing cyanobacteria

Blue-green algae blooms occurred frequently in the Canning River between 1994–2004, with average cyanobacteria densities of up to 19,500 cells/mL. Since then, cyanobacteria densities have distinctly reduced, coinciding with the construction of the oxygenation plants and the application of Phoslock.

A cyanobacteria bloom in 2016 was the exception. At this time, the Bacon Street and Camsell Way oxygenation plants had been decommissioned and in-river works were occurring as part of the rebuild of the Bacon St plant. As a result, a large section of the river was not supplemented with oxygen for most of the year, and the works disturbed the sediment, which likely increased the availability of nutrients in the water column. Once the rebuilt oxygenation plant was operating again in 2017, the cyanobacteria densities reduced to their previously low levels.



The Canning oxygenation plants have dramatically improved dissolved oxygen concentrations and supported aerobic processes. Harmful phytoplankton blooms are now a rare occurrence. Sustained healthy oxygen conditions increase the resilience of the river and allow populations of aquatic animals to flourish.

Although the oxygenation plants play a key role in reducing nutrients available to phytoplankton, we must continue to reduce the amount of nutrients entering the river from activities in the catchment. Our long-term vision should be to return the Canning River to a point of balance, where artificial oxygenation is no longer required. Until then, the oxygenation plants will continue to be vital in keeping the river healthy.

Acknowledgements

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The Canning River Oxygenation project was a partnership between the department and the Department of Biodiversity, Conservation and Attractions (DBCA) until June 2020. Since July 2020, the Canning River oxygenation project is managed by DBCA. BOC Gas Australia were responsible for plant design, maintenance, and operation, and we acknowledge their academic and technical support.

If you have any questions or feedback about this fact sheet, email oxygenation@dwer.wa.gov.au.