Quiet Lakes Water Quality Management Plan

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DesignFlow

Please note:

These slides are provided as a reference for PLAC members who attended the presentation at Melbourne Water on 9-3-2011. They should not be read or interpreted as a stand alone document. Please refer to ‘The Quiet Lakes Water Quality Management Plan’ for a full explanation of the water quality improvement strategies presented herein.

Context

Objective:

- Independently review strategies for improving water quality within the Quiet Lakes
- Focus upon the sustainable management of blue green algae

Document for each option:

- Actions required
- Ecological impact on the lake system
- Capital and ongoing costs

Overview

- Lake health issues
- Previous initiatives
- Strategies to improve lake health
- Implementation plan
- Potential costs

Summary: Lake health issues

Algal biomass:

- Regular algal blooms
- Occur throughout year
- Toxic blue-green algal species

Water plants:

- Low water plant cover
- Ruppia, Potamogeton and Charophytes abundant prior 1990
- Lack of substantial water plant cover since late 1990's

Lake health issues:

Lake water quality:

- Brackish (9,000 uS/cm, up to 12,000 uS/cm)
- Dissolved oxygen - good
- Low phosphorus
- Overall quality - reasonably good

Previous initiatives

Macrophyte planting (2000)

- Planting observed to initially grow well.
- Plantings removed from areas of the lake system.

Sediment sampling (2000)

- Elevated nitrogen levels, phosphorus comparatively low.
- Organic carbon levels - moderate.
- Composition of the sediments considered to be within the expected ‘normal’ range for urban lakes.

Previous initiatives

Lake water profiling (2000-01)

- Water column in all lakes relatively well mixed - January 2000.
- Weak stratification observed in isolated areas of each lake - February 2001.

Research - Zooplankton herbivory (2000)

- Planktolyngbya cell concentrations decreased when placed in tanks with Daphnia.
- Results indicated that zooplankton may influence the development of algal blooms.

Previous initiatives

Daphnia released into Lake Legana (2001)

- Monitoring of Daphnia in Lake Legana indicated that most of the population had disappeared within two months

Groundwater sampling (2000-01)

- Slightly brackish (7,500 uS/cm)
- High ammonia (0.55 mg/L) – high in nitrogen
- February 2001 samples also apparently indicated high TP concentrations (data from this sampling event is not available, cited from Condina et al., 2001)

Previous initiatives

Continuous pumping of groundwater (2000)

- Low maximum pumping rate unlikely to substantially decrease lake detention times and result in significant water quality improvement.
- Increased pumping of groundwater may have increased the overall nutrient load within the lake system.

Estuary perch introduced to Lake Legana (2001)

- No noticeable decline or control of the carp population.
- Re-capture rates for Estuary perch low
- Uncertain how many individuals remain in the lake system.

Previous initiatives

Active barriers trialled (2002)

- Two precipitated calcite materials proved to be effective at reducing the release of phosphorus from the sediments under anaerobic conditions.
- Under anaerobic conditions - release of soluble phosphorus is highly dependent upon the sediment type
- Lake Carramar sediments did not release phosphorus until after 10-12 days incubations under anaerobic conditions.

Previous initiatives

Aeration and pumping system installed in Lake Legana (2006-07)

- The trials were deemed to be unsuccessful as they did not result in a reduction of algal levels to levels required for primary contact and recreational use.

Impact of salinity on dominant blue-green algal species (2009)

- Increasing salinity levels - not significantly reduce the risk of cyanobacterial growth.
- Increasing salinity may benefit some blue-green species and disadvantage other species.
- Increased salinity decreased the overall diversity of blue-green algal species, transition to diatoms

Initiatives previously considered

- Draining of the lake system
- Altering lake salinity
- Use of algicides within lake system
- Stormwater event sampling
- Pump water from the Patterson River into the Quiet Lakes
- Introduce more groundwater, plus water from Eummemering Creek
- Water from Patterson River (US of weir) plus more groundwater
- More groundwater plus filter lake water through constructed wetlands.

Strategies being considered

- Vegetation restoration
- Mixing
- Lake salinity
- Nutrient reduction
- Lake detention time
- Carp removal and fish stocking

- Floating macrophyte beds
- Hypolimnetic withdrawl
- Ultrasonication

Vegetation restoration

- Re-establishment of submerged waterplants will restore the lake system to a macrophyte dominated state.

- Presence of waterplants provides a stabilising mechanism that helps to maintain low turbidity and competition for nutrient resources thereby reducing algal growth.

Vegetation restoration

- Prioritory = HIGH
- Minimum 50% waterplant cover within each lake

- ➢ Direct seeding
- ➢ Propagules
- ➢ Selected planting zones

- Chara spp.
- Lepilaena australis
- Ruppia megacarpa
- Ruppia polycarpa

[Potamogeton pectinatus]

Vegetation restoration

Key assumptions:

- Restoration of submerged vegetation will restore the lake system to waterplant dominated state
- Suitable conditions for waterplant growth are present:
  - Well mixed water column
  - Stable lake salinity
  - Adequate light availability
  - Suitable sediment conditions
  - Minimal grazing pressure

Vegetation restoration

Pros:

- Sustainable long term solution - naturally stabilise
- Reduction in lake turbidity and algal growth.
- Cost effective

Vegetation restoration

Cons:

- Water levels may need to be lowered to facilitate successful establishment of the vegetation.
- Vegetation may compromise beneficial uses of the lake system such as swimming and boating, and potential public safety risks.
- Harvesting may be required.

Vegetation restoration

Recommendations:

- At least 50% of each lake bottom area is ultimately colonised by submerged macrophytes, and preferably up to 75%.
- Re-establishment of Potamogeton pectinalis - low priority
- The conditions for harvesting macrophytes should be clearly established.
- Retrieval of sand minimised.
- Alternative methods for stabilising the beaches from ‘sand creep’ investigated.

Vegetation restoration

Tasks:

Item	Task	Start	Finish
V1	Sediment removal trial	15-Jun-2011	15-Aug-2011
V2	Planting trials	15-Aug-2011	01-Nov-2011
V3	Monitoring (bimonthly)	01-Nov-2011	15-Jun-2012
V4	Evaluation of macrophyte restoration trial	15-Jun-2012	16-Jun-2012
V5	Extensive planting trials	15-Aug-2012	01-Nov-2012
V6	Monitoring (quarterly)	15-Aug-2012	15-Jun-2014
V7	Evaluation of macrophyte restoration	15-Jun-2014	16-Jun-2014

Mixing - SolarBee

- Prioritory = HIGH
- Increased mixing of the water column within the lake system

- Trial using SolarBee unit in Lake Illawong
- Installation in Lakes Legana and Carramar if trial sucessful

- Improve lake circulation
- Reduce stratification
- Maintain aerobic conditions

Mixing - SolarBee

Key assumptions:

- Use of the SolarBee units will facilitate fully mixed conditons and prevent stratification from occuring.
- Aeration of the sediments - prevent the release of nutrients from the sediments and reduce the concentration of bioavailable nutrients in the water column

Mixing - SolarBee

Pros:

- Long term sustainable option for ensuring that water bodies are fully mixed.
- Increased mixing of the lake aerates the sediments, reducing potential nutrient release.
- Aeration of the upper sediments encourages increased denitrification, the development of algal biofilms and the growth of macrophytes.
- The SolarBee units will not obstruct beneficial lake uses such as swimming and boating.
- Initial trial cost effective.

Mixing - SolarBee

Recommendations:

- Presence of stratification within the Quiet Lakes is further investigated.
  - spatial and temporal extents
- Effectiveness of SolarBee units to promote mixing evaluated, and the potential impacts on lake stratification and algal biomass assessed for a minimum of 12 months.

Mixing - SolarBee

Tasks:

Item	Task	Start	Finish
M1	Install SolarBee in Lake Illawong	01-Apr-2011	30-May-2011
M2	Monitoring of water column stability in all lakes (monthly)	01-Apr-2011	16-Apr-2016
M3	Evaluation of mixing in Lake Illawong	15-Jun-2012	16-Jun-2012
M4	Install Solarbee units in Lakes Legana and Carramar	01-Aug-2012	30-Sep-2012
M5	Evaluation (April 2014)	15-Apr-2014	16-Apr-2014
M6	Evaluation (April 2016)	15-Apr-2016	16-Apr-2016

Lake salinity

- Prioritory = LOW
- Variations in lake salinity may profoundly impact waterplant and algal community composition
- Salinity > 6,000 uS/cm detrimental to long term health of most freshwater submerged waterplants
- Desirable to maintain lake salinity below 6,000 uS/cm via dilution of lake water

Potential sources of water:

- Groundwater
- Stormwater diversion

Lake salinity

Groundwater:

- Salinity = 7,000 uS/cm
- High ammonia nitrogen

Introduction of a high nitrogen load to the lake system is likely to have a profound impact upon the stability of the lake ecosystem, and result in increased algal growth.

- Option not deemed suitable

Lake salinity

Stormwater diversion:

- Diverting low flows from the Gladesville Boulevard pump station.
- Potential volume available from the Gladesville Boulevard pump station is approximately 50 ML per year.
- Additional source of stormwater is available from catchment to the south-east of Lake Carramar.

- The pollutant load associated with the stormwater runoff would necessitate that all stormwater is treated prior to entering the lake system.

Lake salinity

Pros:

- The maintenance of lake salinity below 6,000 uS/cm would promote the development of a healthy and diverse self sustaining macrophyte population.
- Growth of macrophytes would provide increased habitat for zooplankton - increased predation of phytoplankton.

Lake salinity

Conclusion:

Not possible maintained below 6,000 uS/cm based upon the current lake operation and available water sources.

Little information available on the salinity balance within the Quiet Lakes:

- Brackish conditions within lakes are maintained by evaporation and the use of groundwater to maintain water levels
- Interactions with the local groundwater may also be influencing salinity within the lake system.
- Develop salinity balance model

Lake salinity

Tasks:

Item	Task	Start	Finish
S1	Feasibility study - stormwater diversion to manage lake salinity	01-Jul-2014	31-May-2015

Future options:

Installation of shallow groundwater bores around the lake system would enable the nature of the potential local groundwater interaction with the lake system to be established.

Nutrient reduction

Potential sources of nutrient inputs into the Quiet Lakes:

- Stormwater inflows – garden runoff and stormwater surcharges
- Groundwater pumped - Gladesville Boulevard bore
- Nutrients released from lake sediments.

Diversion of stormwater runoff and reduction in groundwater not considered due to the negative impacts on lake water levels and lake detention times.

Sediment removal

- Potential nutrient store present in the sediments that is available for release to the overlying waters.
- Average depth of the accumulated sediments in the lake system is approximately 0.1-0.3 m

Sediment removal

- Priority = LOW

- Water level within each lake be drawn down in order to expose the accumulated sediments.
- Dry out sediments for an extended period of time (e.g. 4-6 weeks)
- Mechanical removal using earthmoving machinery.

Sediment removal

Key assumption:

- Lake water columns of each of the Quiet Lakes regularly stratify during the year, resulting in the release of nutrients into the overlying water column and thereby stimulating cyanobacterial blooms.

Sediment removal

Pros:

- Remove the majority of the nutrient store present
- Reduce the release of nutrients into the overlying water column.
- Drawing down and drying down of the lake system would enable carp to be removed from the lake system.
- Opportunity to modify or fill in the deeper sections of the lakes which are likely to be more prone to stratification.

Sediment removal

Cons:

- Expensive - dewatering and disposal
- Exposure of the lake sediments - decomposition of organic matter present within the sediments - odours.
- Public health risks.
- Impacts upon benthic organisms, including the removal of macrophytes and fauna from the lake.
- Limited potential for managing cyanobacteria where stormwater inputs also contribute nutrient loads.

Sediment removal

Conclusion:

- Removal of accumulated sediments considered ‘last resort’ option for reducing the risk of cyanobacterial growth.
- Contingent upon confirmation of persistent stratification and nutrient release.
- Presence of stratification to be further investigated.

Tasks:

Item	Task	Start	Finish
SR1	Feasibility study - sediment removal	01-May-2016	31-Jul-2016

Lake detention time

- Prioritory = NOT FEASIBLE

- Current lake detention time approximately 3.5 years

- Possible to decrease lake detention times by providing a constant flushing flow using groundwater from the Gladesville Boulevard bore.
- Lake detention times may also be potentially reduced using local or imported stormwater – not considered a feasible option due to treatment requirements prior to discharging stormwater into lake system.

Lake detention time

- Lake detention time of less than 15 days required for flushing to be effective at controlling cyanobacterial growth.
- Based upon previous modelling, required flow rate ranges between 9-18 ML/day (minimum vol. required 3000 ML/year).

- Preliminary pumping tests - daily yield of 2-4 ML/day.
- Current daily yield - 2 ML/day (approx. 730 ML/year).
- Minimum lake detention time that can be achieved is 60-120 days.

Lake detention time

Cons:

- Increased use of groundwater - maintain lake salinity levels and introduce unacceptably high nitrogen load to the lake system.
- Impacts upon the stability of the ecosystem - may increase algal growth if the flushing rate is insufficient.
- Permanent pumping of groundwater - expensive.
- Potential impacts upon downstream aquatic ecosystems - discharge of high nitrogen loads into Port Phillip Bay.

Lake detention time

Conclusion:

Use of groundwater to provide not deemed acceptable due to:

- Insufficient groundwater capacity to achieve the desired lake detention time of 15 days.
- High nitrogen concentrations associated with the groundwater - stability of the lake system and potential impacts on Port Phillip Bay.

Carp removal and fish stocking

- Prioritory = HIGH
- Trial carp removal using specialised electro-fishing boat developed to work in brackish-estuarine conditions.
- Expected to be more efficient and quicker than conventional siene nets - all size classes of the carp to be removed.
- Permanent fish traps - designed and installed.
- Flows manipulated by shutting and opening the lake connections or pumping water between the lakes.
- Fish stocking - species adapted to brackish conditions e.g. Estuary perch and Black bream

Carp removal and fish stocking

Key assumptions:

- Presence of carp - reduce macrophyte cover and remobilise nutrients - greater prevalence of cyanobacterial biomass.
- Constant disturbance by carp (grazing and physical disturbance)
- Removal of carp pressure - encourage expansion of the waterplant root systems and provide more favourable conditions for propagule germination and growth.

Carp removal and fish stocking

Pros:

- Reduction in turbidity (less disturbed sediments) and nutrients released from sediments.
- Increased macrophyte growth including germination and growth of seedlings.
- Use of electro-fishing unit will not disturb the lake sediments or macrophyte communities
- Removal of smaller size classes of carp.

Carp removal and fish stocking

Tasks:

Item	Task	Start	Finish
F1	Trial carp removal using electrofishing boat (one day per lake)	01-May-2011	31-May-2011
F2	Followup netting and assessment	01-Jun-2011	30-Jun-2011
F3	Evaluation of capture techniques	15-Jul-2011	16-Jul-2011
F4	Design and installation of fish trap between Lakes Legana and Illawong	01-Jul-2011	31-Dec-2011
F5	Trial fish stocking	15-Jul-2011	30-Sep-2011
F6	Monitoring, carp removal and evaluation	01-Feb-2012	31-Mar-2012
F7	Annual fish stocking	01-May-2012	31-Jul-2013
F8	Monitoring, carp removal and evaluation	01-Feb-2014	31-Mar-2014
F9	Annual fish stocking	01-May-2014	31-Jul-2015
F10	Monitoring, carp removal and evaluation	01-Feb-2016	31-Mar-2016

Floating macrophyte beds

- Prioritory = MED-LOW
- Floating macrophyte beds placed within each of the lakes – minimum overall cover of 30-40%.
- Individual racks containing a range of emergent macrophyte species.
- Permanently tethered within the lake using fixed anchor points or movable anchors.
- Distributed throughout each lake - two or three macrophyte 'islands' are present within each lake.
- Regularly maintained to replace dead plants and to remove plant biomass.

Floating macrophyte beds

Key assumption:

- Emergent macrophytes able remove sufficient nutrients from the water column to reduce algal growth.

Floating macrophyte beds

Pros:

- Reduction to internal nutrient loadings within the lake system and decrease algal growth.
- Shading also likely to diminish algal growth.
- ‘Natural’ solution
- Unlikely to be impacted by carp.
- Flexibility in terms of locating the beds within the lake system.
- Could be integrated with other lake features such as floating pontoons.

Floating macrophyte beds

Cons:

- Lake cover required to control algal growth may be substantially greater than 40%.
- No guarantee of algal control
- Detract from the aesthetic amenity of the lake system.
- Require regular ongoing maintenance
- Potential safety issue in terms of swimming
- May increase the overall number of waterbirds utilising the lake system.
- Potnentially reduce wind forced mixing and increase the risk of stratification occurring within the lake system.

Floating macrophyte beds

Recommended - floating macrophyte beds be considered as an alternative option if macrophytes cannot be established within the lake system.

Tasks:

Item	Task	Start	Finish
FM1	Trial floating macrophyte beds	01-Jul-2014	01-Apr-2016
FM2	Evaluation of floating macrophyte beds	15-Apr-2016	16-Apr-2016

Hypolimnetic withdrawal

- Prioritory = LOW
- Submerged outlet pipe placed at the base of each lake in order to enable withdrawal of hypolimnetic water.
- Outlet pipe in Lake Legana would be connected to the Gladesville Boulevard pump station
- Outlet pipes in Lakes Illawong and Legana to the McLeod Road pump station.
- Hypolimnetic water withdrawn from the base of each lake and discharged to either the Patterson River or Wadsley Drain.
- Volume of water withdrawn from the lake replaced by groundwater from the Gladesville Boulevard bore.

Hypolimnetic - lower water column in a stratified lake that is often characterised by cooler and more dense, and sometimes de-oxygenated water.

Hypolimnetic withdrawal

Key assumptions:

- Stratification occurs for extended periods of time and results in release of nutrients from sediments into the hypolimnion.
- Hypolimnetic layer deep enough to pump from
- Groundwater used to replace the volume withdrawn from the lake is of equal or higher quality than the lake water.
- Groundwater pumping rate able to match the hypolimnetic withdrawal rate.

Hypolimnetic withdrawal

Pros:

- Cost effective strategy for removing nutrient rich water from a lake system.

Cons:

- Short term solution - does not address the underlying causes of sediment nutrient release.
- Release of nutrient rich water to the downstream waterways and the discharge of nitrogen to Port Phillip Bay.
- Frequent water quality monitoring required
- Increased use of groundwater - nitrogen input to lake system.
- Expensive to retrofit lake infrastructure – outlets and connections to pump stations.

Hypolimnetic withdrawal

- Unlikely technique could be used to effectively manage water quality within the Quiet Lakes.
- Addition of groundwater – unacceptable risk due to the additional nutrient load introduced to lake system.
- Is not a long term sustainable solution for managing nutrient loads within the Quiet Lakes.
- Release of anoxic water with high nutrient concentrations is considered too risky in terms of potential impacts upon downstream ecosystems.

Ultrasonication

- Prioritory = NOT FEASIBLE

- Ultrasonic irradiation of cyanobacterial cells
- Deemed to be inappropriate method for removing algal biomass from the Quiet Lake system.
- Effectiveness of ultrasonic systems to control algal biomass in shallow lake systems is currently unknown
- Potential impacts on other beneficial lake biota are yet to be fully determined.

Proposed implementation plan

Item	Task	Start	Finish
V1	Sediment removal trial	15-Jun-2011	15-Aug-2011
V2	Planting trials	15-Aug-2011	01-Nov-2011
V3	Monitoring (bimonthly)	01-Nov-2011	15-Jun-2012
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FM1	Trial floating macrophyte beds	01-Jul-2014	01-Apr-2016
FM2	Evaluation of floating macrophyte beds	15-Apr-2016	16-Apr-2016
S1	Feasibility study - stormwater diversion to manage lake salinity	01-Jul-2014	31-May-2015
M1	Install SolarBee in Lake Illawong	01-Apr-2011	30-May-2011
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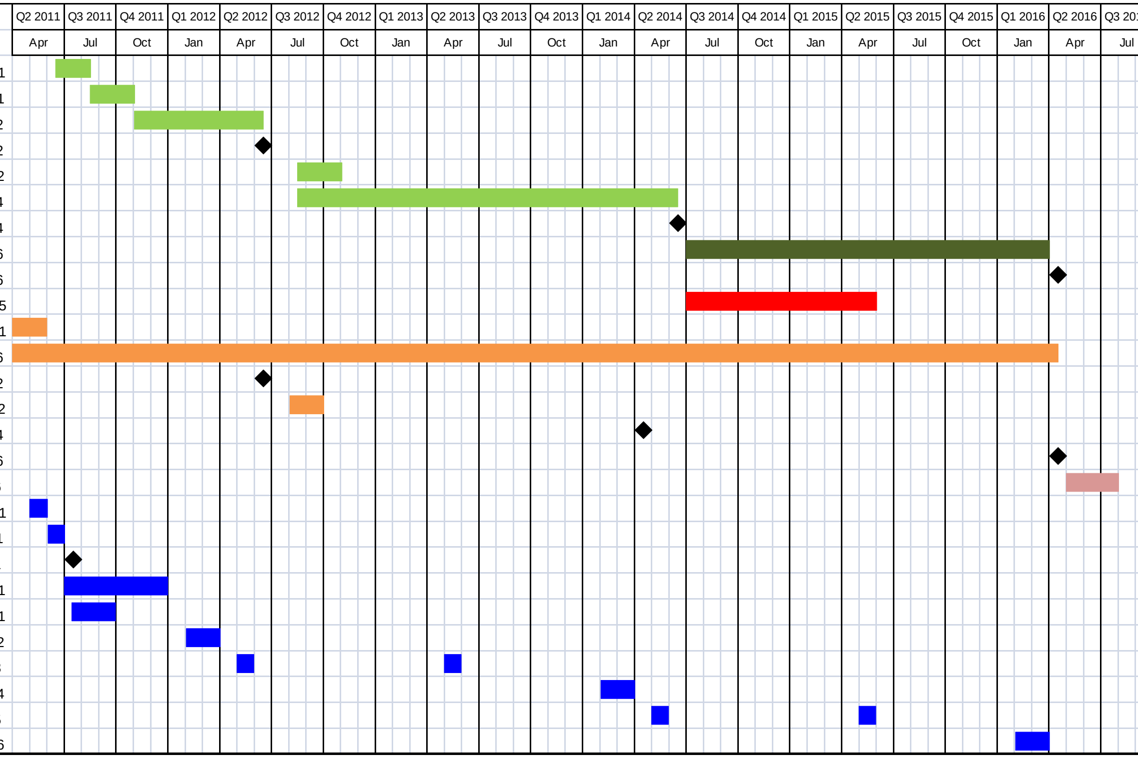

Estimated costs

Strategy	Estimated cost
Vegetation – trial	$65,000-85,000
Vegetation – full implementation	TBD according to trial
SolarBee – trial	$12,000-20,000
SolarBee – full implementation	$400,000-450,000
Carp removal – trial	$20,000-25,000
Fish program	$50,000-80,000