WALLBRIDGE GILBERT AZTEC

City of Charles Sturt

Freshwater Lake Options Assessment

OPTIONS ASSESSMENT

Project No. WGA212611
Doc No. WGA212611-RP-HY-0001
Rev. D

07 June 2022

Revision History

Rev	Date	Issue	Originator	Checker	Approver
A	23/05/2022	DRAFT ISSUE	EH & RD	JLS	EH
B	01/06/2022	FINAL	EH & RD	JLS	EH
C	01/06/2022	FINAL (MINOR AMENDMENT)	EH & RD	JLS	EH
D	07/06/2022	FINAL (CHANGES AS PER CCS REQUEST)	RD	EH	EH

CONTENTS

Appendices

1 EXECUTIVE SUMMARY

The City of Charles Sturt (Council) engaged WGA to undertake a review of the operation and management of the West Lakes Freshwater Lake (FwL), located on Delfin Island. Given the high level of ongoing maintenance and resources Council are seeking a review of the management and operational practices to see if there can be improvements made into the future.

The review considered two options for the lake:

- **Option 1:** Maintain the lake in its current form and continue with existing maintenance and management practices.
- **Option 2:** Maintain the lake in its current form with structural and management improvements to permanently enhance lake performance and quality, operations, and management.

The costs (both operational and capital), risks, constraints and opportunities associated with both these options have been investigated as part of the review process.

The key components and outcomes of the review are summarised within **Section 1**.

1.1 EXISTING LAKE OPERATIONS AND ISSUES

The existing lake was constructed in the 1970's and the management practices for the lake have change significantly over this time. These changes, along with changes in climatic conditions and amenity of the lake have impacted water quality.

The key changes in operation in the lake over time include:

- Reduce top-up water supply and flushing of the lake system to the downstream environment.
- Reduced frequency in weed management and routine water body inspections.
- Moving away from duck feeding activities, and reduction in duck numbers at the lake.
- Increasing algal blooms within the lake
- Increasing salinity in the lake.
- Changes to the edge treatment.
- Higher pest species populations such as carp and ibis.

Current operations and management of the lake is minimalistic and reactive with water quality management techniques often applied to address issues rather than to prevent to occurrence, a number of examples are:

- Coptrol application to control active algal blooms.
- Carp removal when turbidity increases and/or fish die off occurs due to lake deoxygenation in summer.
- Ongoing lake top-up to maintain water levels, due to high infiltration losses through the base and walls.
- Aerator turned on to manage water quality.
- Repair of waterbody assets (ie. pumps, aerators) as needed due to failure or issues.
- No defined or recorded waterbody operation and management plan.
- Draining and desludging of the lake to remove sludge deposits over time, undertaken ongoing every 5-10 years.

WGA have reviewed these practices and considered the future requirements to maintain the lake with these operational practices.

1.2 LAKE BASELINE REQUIREMENTS

There are two baseline improvements that need to be undertaken independent of the option selected due to the current status of the waterbody and associated infrastructure. These upgrades are desludging of the lake and upgrading the source water supply. These upgrades are upfront costs for all options outlined in this report which will reset the lake to a baseline prior to assessment of the options moving forward. The source water supply upgrade is considered as capital expenditure whereas the lake desludging is considered as an upfront operational cost.

Desludging Lake

A build-up of sludge and sediment over recent years due to the poor water quality, algal blooms, limited flushing and/or water treatment, has resulted in a build-up of sludge within the lake. To consider viable and comparable options moving forward desludging of the lake should be considered an upfront measure to provide a baseline to measure the future management options and allow for any implemented change to operate as designed. For this reason, desludging is assumed and costed as an upfront operational cost to all options assessed. The requirement for future dredging, however, is dependent on the selected option and improvements implemented, and is costed as additional as part of ongoing operational costs.

Dredging of the lake assumes the draining of the waterbodies (with disposal to sewer), scraping the base to remove the build-up of sludge, which is expected to be 300-500mm deep, removal of the sludge for offsite disposal and then reinstatement of the liner (as required) and refilling of the lake. It is assumed that this process would be staged to allow retention of water in select waterbodies to provide refuge for aquatic and bird life. Key risks and considerations from the desludging process are:

- Restrictions on discharge flow rates to sewer and timeline.
- The level of contamination classification of the sludge and disposal cost.
- An increase in the cost rate or volume of sludge disposal which would escalate the cost.
- Staging and disruption to the community and flora and fauna.

- Requirement to removal and dispose of significant numbers of carp during the draining down process.

- Managing the drawdown to protect aquatic life.

Source Water Upgrade

The lake top-up water supply is drawn from an existing groundwater bore on Corcoran Drive. This bore is nearing the end of its design life and will need to be upgraded soon to remain as a functional supply source. Therefore, to maintain the lake operation as existing this bore will need to be upgraded and this has been considered as a requirement to achieve a baseline scenario and has been costed as an upfront expenditure.

Further to this, Option 2 investigates opportunities to potentially source more sustainable or higher quality water supply, such as Council's regional recycled water supply. These options are subject to further investigation but should be considered and have been assumed as an alternative to the bore upgrade and covered within the cost allocation for water supply source.

1.3 OPTIONS ASSESSMENT

The options assessment considered two scenarios as defined by Council.

Two alternate options have been proposed and costed as part of Option 2, to outline the variables and broader considerations that may impact the final decision making.

For clarity the options are outlined below.

- **Option 1:** Maintain the lake in its current form and continue with existing maintenance and management practices.

- **Option 2:** Maintain the lake in its current form with structural and management improvements to permanently enhance lake performance and quality, operations, and management.

  - **Option 2A** (Offline Bioretention)
  - **Option 2B** (Inline Floating Wetland).

Given the preliminary nature of the assessment, and lack of site investigations. The options presented are all subject to further feasibility, site investigations and detailed design.

1.3.1 Option 1 – Maintain the Lake in Current Form

The review of Option 1 considers the future of the lake if it is maintained in its current form with existing maintenance and management practices.

The key risks and considerations from this option are that there will be ongoing management required that is reactive and potentially inefficient over time, and the lake will never be operating optimally or resolve the existing issues. In this scenario, water quality issues will continue to occur into the future and will need ongoing reactive treatment. As a summary the following will be ongoing risks:

- Ongoing water quality issues, that will be an amenity issues and possible health and safety risks.

- More frequent repair and/or upgrade of infrastructure that is not suitable maintained.

- Reactive management that does not resolve the issue.
- Unsustainable water management practices.
- Ongoing desludging which is expensive and disruptive.

In addition to the operational risks, social and environmental risks to be considered with Option 1 include:

- Ongoing maintenance cost, and the impact to ratepayers.
- The current form does not address indigenous cultural heritage value or connection.
- Potential risks to public health and safety with poor water quality.
- Risks to public enjoyment - Ibis management/ pest management.
- Limited educational opportunity to engage the community on environment and sustainability.
- Unsustainable water use, with high losses and top-up water supply required.
- Pest species and potential impacts to native and local environment.
- Water quality risk to the downstream receiving waters and local ecosystems.
- Environmental costs of maintenance activities, materials (and potential by-products) and energy demand.

The capital and operational costs for Option 1 are outlined in **Section 3.2 Financial Estimates – Option 1.** The costs consider the current budgets and records of works, as provided by Council, with the addition of WGA's assessment of the actual cost to continue these operations. The actual costs are typically above Council's budgeted costs and have been based on engineering judgement and allocation of staff costs to the reactive waterbody management, and what will be needed into the future to continue to maintain the lake with the same level of service. As outlined in **Section 3.2 Financial Estimates – Option 1** this option has also costed in the upfront capital cost for upgrading the water supply source. It addition, this option assumes that the desludging of the lake has been undertaken prior as this is an action that is required and for all options to reset the lake and allow a comparable baseline moving forward.

1.3.2 Option 2 – Maintain the Lake in Current Form with Improvements

The review of Option 2 considers retaining the Lake in its current form with structural and management improvements to permanently enhance lake performance and quality, operations, and management.

The key risks and considerations from this option are investigating solutions that will provide long-term benefit but without changing the lake form and/or fundamental values to the community (including the vegetation type, open water and views and local flora and fauna). The staging of implementation of any improvements is also a key risk and will need to consider the key objectives, inter-relationship of the recommended options and retention of the lake (or provision of refuge habitat) during the works.

The key risks the Option 2 improvements target are:

- Unsustainable water management
- Poor circulation within the water body
- Poor water quality

These have been determined as key issues that prevent the optimum benefit and value from the Lake, with respect to social, environmental and economic factors.

The improvement options available for the lake have been broken down into the following key areas:

- Structural Improvements
- Operational / Management Improvements
- Water Supply Source

Structural Improvements

Option 2 has investigated a long-list of structural changes that could be implemented at the lake, and then refined this down to a short-list of complementary improvements that will, when implemented together, optimise the lake function and value.

The short-listed structural solutions for the lake targeted the above three key risks as outlined:

- Relining the lake with an impermeable liner to prevent seepage losses and reduce top-up demand.
- Improved circulation within the waterbody, to reduce residence time and water quality issues.
- Improved water treatment systems, either within the lake waterbody or offline.

Two options have been investigated Option 2A (Offline Bioretention) and 2B (Inline Floating Wetland). These sub-options have been presented to provide Council will two options for further consideration that will both meet the key objectives, however, will present different cost and constructability constraints and benefits.

Table 1. Summary of Improvement Options 2A (Offline Bioretention) and 2B (Inline Floating Wetland)

Risk/Issue	Solution	Option 2A (Offline Bioretention)	Option 2B (Inline Floating Wetland)
Unsustainable water management	Line the lake with an impermeable liner, to prevent infiltration loss.	Drain the lake and construct a GCL liner to the base, and secure HDPE liner to the walls.	Drain the lake and construct a GCL liner to the base, and secure HDPE liner to the walls.

Poor circulation in the waterbodies	Improve circulation within the lake waterbody	Install additional sump/pumps to extract and reticulate lake water from each waterbody to the water treatment system, then supply treated water back through new inlet points. Retain existing inlets and bore supply to maintain the residual demand requirement.	Install additional inlet points to Lake 1 and 2 to increase the circulation of water through the lake. This will increase the flow rate through the in-lake water treatment system to optimise water quality treatment.
Poor water quality	Provide water quality treatment.	Install an offline water quality treatment system to treat and circulate freshwater back to the Lake. The proposed system is an Ocean Protect Filterra Bioretention system.	Install an in-line water quality treatment system. The proposed system is an SPEL Floating Wetland installed within the existing waterbodies.
Constructability Constraints and Benefits		Requires construction outside of the lake footprint (ie. trenching for the reticulation). Requires land outside of the lake footprint (ie. location for the Filterra treatment system. Requires the lake to be drained.*	Requires minor construction outside of the lake footprint (ie. trenching for the reticulation). Requires the lake to be drained.* Can be constructed in stages with less dependency on each stage. However, optimum outcome is only achieved with all stages complete.
Additional Benefits		Provides a closed system and retention of water within the network, therefore reducing water demand. Does not impact open water or view across the waterbody.	Reduced infiltration losses therefore retention of water within the lake. In-lake treatment therefore no loss of reserve open space.

** Note. It is assumed works will be undertaken as part of the dredging process which is to be undertaken upfront as part of all options (1, 2A (Offline Bioretention) and 2B (Inline Floating Wetland)).*

Details of the proposed improvement measure are provided within the main body of the report. Note, Options 2A (Offline Bioretention) and 2B (Inline Floating Wetland) have been proposed as complete upgrade packages and need to be implemented in full to provide optimum benefit to the lake. While some elements can be staged in the implementation, others are completely dependent on the implementation of all improvements. For the basis of this assessment the options presented should be considered based on implementation of the full package of structural improvements only.

Operational/ Management Improvements

Further to the above structural improvements, management improvements should be implemented. The management improvements should be applied to both Option 2A (Offline Bioretention) and 2B (Inline Floating Wetland), and include:

- Regular water quality monitoring
- O&M Plans and schedules for management of waterbody infrastructure (pumps, valves, aerators)
- Routine maintenance (such as removal over overgrown vegetation, or algae blooms)
- Maintain water supply, inflows, and circulation assets
- Undertaken inspections post heavy rain or storm events and remediate damage
- Maintenance plans for water treatment systems in-line with the supplier specification

Table 2 outlines the benefit of operational and management improvements in relation to the key risks

Table 2. Operational and Management Improvements (Option 2)

Risk/Issue	Outcome
Unsustainable water management	Improved efficiency of water supply and reticulation networks will mitigate against water losses.
Poor circulation in the waterbodies	O&M plan will maintain the functionality of all circulation and reticulation assets and reduce risk of failure which could result in water quality issues.
Poor water quality	Improvement management practices will create a proactive approach to water quality management and reduce the reactive water quality treatment requirements.

Source Water Supply

Source water supply is critical to the operation of the lake as top-up to meet evaporation losses and to allow periodic flushing of the lake to manage water quality is needed. The current supply source can be maintained, subject to upgrade works to reinstate the bore. However, investigating new and potentially more sustainable water supply may future proof the lake and enhance the water quality moving forward.

Alternate water sources considered include:

- City of Charles Sturt recycled water network supply.
- Stormwater harvesting.
- Treatment and reticulation of the lake water.

Further investigations into the available alternate water supplies to determine the most efficient sources from a risk, constructability, staging, economic and environmentally sustainable perspective. Given the external influences on these sources further monitoring and investigation is required.

For the purpose of this study both Option 2A and 2B consider,

- Reinstatement of the existing bore to meet the minimum supply requirements, including periodic flushing of the lake to manage salinity concentration as required; or
- Sourcing the recycled water supply from the West Lakes MAR scheme to supplement or meet the demand. This may be considered a more viable option than reinstating the existing bore.

These sources are considered sustainable and available to meet the minimum requirements and additional flushing to manage water quality as needed. The preferred source would be subject to a detailed assessment and comparison of options.

Table 3 outlines the benefit of operational and management improvements in relation to the key risks.

Table 3. Water Supply Source Improvements (Option 2)

Risk/Issue	Outcome
Unsustainable water management	There are multiple sustainable water sources that can be investigated for supply. These sources balanced with efficient water use will improve the overall sustainability of the FwL.
Poor circulation in the waterbodies	A reliable supply will allow increased circulation and flushing through the water body as required, which will improve water quality.
Poor water quality	A supply source that can meet the top-up demand and any periodic flushing requirement will maintain the desirable residence times and improve water quality. Sourcing a low-salinity supply will also reduce the risk of salinity escalation within the water body over time.

Social and Environmental Factors

The social and environmental benefits and risks to be considered with Option 2 include:

- Retention of community values and expectations for the lake and reserve.
- Retention of public open space.
- Residential value linked to the lake.
- Amenity value in the lake.

- Public health and safety improved through optimal operation of the lake.
- Education opportunities to engage the community of environment and sustainability.
- More sustainable water use, with high losses and top-up water supply required.
- Protection of local and downstream ecosystems, and improved biodiversity.
- Improvements do not provide indigenous cultural heritage value or connection.
- Costs of improvements and impact to rate payers.
- Implementation of new technology and risks in establishment.
- Potential loss of open water views.
- Disruptive construction period.
- Environmental costs of maintenance activities, materials (and potential by-products) and energy demand.

The capital and operational costs for Option 2 are outlined in **Section 4.5 Financial Estimates – Option 2.** The costs consider the ongoing costs that will be retained based on current budgets and records of works, as provided by Council, with the addition of WGA's assessment of the actual cost to continue these operations. Further to this, the new costs associated with capital construction of new improvements and ongoing operation of the improvements. The actual costs are typically above Council's budgeted costs and have been based on engineering judgement and allocation of staff costs to the reactive waterbody management, and what will be needed into the future to continue to maintain the lake with the same level of service. As outlined in **Section 4.5 Financial Estimates – Option 2**, this option has also costed in the upfront capital cost for upgrading the water supply source. It addition, this option assumes that the desludging of the lake has been undertaken prior as this is an action that is required and for all options to reset the lake and allow a comparable baseline moving forward.

1.4 COST COMPARISON

A summary of the cost break downs for the Options 1, 2A (Offline Bioretention) and 2B (Inline Floating Wetland) are outlined in **Table 4**.

Table 4. Summary of Costings

OPTION	UPFRONT OPERATIONAL COST	CAPITAL COST	OPERATIONAL COST
Option 1	$1,273,000	$195,000	$288,000
Option 2A (Offline Bioretention)	$1,273,000	$2,008,000	$257,000
Option 2B (Inline Floating Wetland)	$1,273,000	$1,801,000	$233,000

This is a high-level assessment based on desktop information only, and all options are subject to further site investigation, testing, detailed assessment, and detailed design. Cost estimates have been based on information provided by Council including budget records and maintenance activity report.

WGA have also applied rates based on our understanding of the lake management it is expected that costs will be incurred to maintain the lake in its current form. Rate assumptions by WGA are based on industry experience and similar project and are Opinion of Probable Cost (OPC). A 30% contingency has been applied to all costs due to the preliminary nature of the investigation. Costs exclude site investigation, design fees and project management costs. Refer to **Sections 3.2 Financial Estimates – Option 1 and Section 4.5 Financial Estimates – Option 2** for a detailed breakdown of the costs.

1.5 NEXT STEPS

This options assessment has been undertaken to investigate opportunities for upgrade to the lake and comparison of the options to allow Council to review the preferred solution for further investigation.

1.5.1 Staging and Implementation

Staging and implementations of improvements need to be well considered to minimise the impact on the community and reduce construction disruptions on site. In order to mitigate risk, initial investigations should be undertaken to understand the site conditions (ie. geotechnical) and which will assist to define the appropriate construction methodology.

Indicatively the construction timeframes for works on site (excluding permit approvals, tender, design or approvals) for the proposed works would be:

- Desludging: 6-8 weeks per lake, total 20 weeks. (Note: It is assumed that each of the 3 lakes are dredged separately to allow refuge for flora and fauna during the process and minimise the impact to the community).

- Lake Lining: 2-4 weeks per lake, total 10 weeks. (Note: It is assumed that each of the 3 lakes are lined separately to allow refuge for flora and fauna during the process and minimise the impact to the community). The lining will be undertaken directly after the desludging, as additional time.

- Circulation Improvements: 4-8 weeks. (Note. Electrical augmentation can have a longer lead time (up to 6 months) due to authority installations and approval periods).

- Water Treatment System Installations: 2-6 weeks (Note: establishment period can be up to 12 months, until the full treatment rate is achieved).

Some of the improvement options also rely on the installation of certain assets to be functional, ie. power supply for pumps, reticulation network to the water treatment system.

As Council review this report this staging and implementation should be considered. Both Option 2A (Offline Bioretention) and 2B (Inline Floating Wetland), have been selected as a suite of improvements to provide an optimum outcome, and if implemented in part may not achieve the required outcome.

As part of the preliminary and detailed design phase the designer will need to work closely with Council to manage this inter-relationship along with seasonal staging requirements and allow for required lead times for approvals and permits.

1.5.2 Limitations and Additional Investigation

Given the preliminary and broad nature of this option assessment all costs, design solutions and staging will be subject to further investigation and detailed design. The following key limitations and additional investigations should be undertaken prior to final budgets and detailed design.

- Confirm the sludge parameters in the existing lake:
  - Contamination testing of the sludge, sampling at multiple locations across the lake to confirm the expected contamination level of materials to be removed from site.
  - Assess the depth of sludge across the lakes, measure depth to base comparable to the design depth.
- Undertake geotechnical investigations to consider the groundwater level, and underlying earthworks to determine a suitable construction methodology for the lake liners.
- Initiate additional monitoring and/or testing of water supply and lake quality and seasonal variability.
- Undertake site investigations to confirm design solutions.
- Undertake preliminary design through to detailed design to firm the design solutions and costing.
- Electrical costs associated with the additional pumping and/or electrical augmentation have not been fully investigated based on the preliminary nature of the investigation. This would need to be investigated in detail as part of the detailed design and cost estimates.
- Council review and assessment of the options in the context of the wider social and environmental drivers, and with reflection on recent community consultation finding.
- Investigate the wider alternate water sources, where deemed potentially viable options.

1.5.3 Conclusion

The FwL is a key asset to the community and a unique Council operated passive and recreational asset. On review of both Option 1 and 2 it is noted there are significant financial investment associated with the maintenance of the lake in its current form and to improve the lake operations into the future. This will need to be considered along with the social and environmental benefits of the lake by Council when determining the future works associated with the lake.

2 INTRODUCTION

WGA understands that the City of Charles Sturt (Council) is investigating the current operation and functionality of the Freshwater Lake (FwL) that was constructed in the 1970's. We note that the lake is a key feature for the community, however, due to ongoing management issues associated with water quality and maintenance, Council seeks to investigate options for a sustainable solution to manage the lake into the future.

There have been minimal changes to the lake structure since its initial construction, however, there have been water quality improvement techniques to manage the lake, bank reinstatement, installation of aerators, changes to recreational use (such as duck feeding) and treatment dosing that have been implemented in recent years.

There are two options that Council is seeking investigation to understand the opportunities, constraints, pros and cons from a cost, functionality, and sustainability perspective. The lake holds significant value to the community as a place of recreation, relaxation and it provides a habitat for some flora and fauna, therefore changes to the lake will need to be well considered.

The two options for further investigation are:

- **Option 1:** Maintain the lake in its current form and continue with existing maintenance and management practices.

- **Option 2:** Maintain the lake in its current form with structural and management improvements to permanently enhance lake performance and quality, operations, and management.

Two other options were initially tabled by Council for investigation as part of the study, as outlined below. These options have however been removed from the scope based on the feedback obtained during preliminary community consultation.

- **Options Three:** Reduce or change the size, shape of the water body and increased the amount of terrestrial (land) open space as a result.

- **Option Four:** Have no lake and make the entire reserve terrestrial (land-based) open space.

No investigation of options three or four have been undertaken**.**

2.1 PROJECT UNDERSTANDING

WGA understand that shallow artificial lake systems are delicate environments and can be prone to water quality issues such as high turbidity, algae blooms resulting in sludge and sedimentation. The lake, however, provides an important amenity value to the community which needs to be acknowledged and valued as part of this review. The risks and opportunities WGA investigated are outlined below:

- Consider the water depth within the lake and how this could impact both public health and safety (deep water hazards, safe batter design), water quality and light penetration, and suitable planting for depth or seasonal fluctuations.
- The presence of fish such as carp that damage the natural ecosystems and stir up sediments, and how this can be managed.
- Water supply source from groundwater, treated stormwater or potable water, and the associated risks, management implications and benefits.
- Assess lake water residence time and options to improve circulation.
- Acknowledge and understand the community value of the lake and how this can be maintained by adopting a sustainable management systems approach.
- Recognition of the urban cooling benefits of the waterbody for the public and local fauna and fauna benefits.

This options assessment will provide Council with an understanding of the issues, constraints, and opportunities, along with preliminary cost estimated for comparison to guide the asset decision framework.

2.2 LOCALITY

FwL is located in West Lakes on Delfin Island. An aerial image of the FwL is provided in **Figure 1** below. The FwL is made up of three smaller lakes connected by a system of channels. The smaller lakes that make up FwL are referred to as Lake 1 (Front Lake), Lake 2 (Middle Lake) and Lake 3 (Back Lake).

Figure 1: Freshwater Lake Aerial Image

2.3 HISTORY OF THE LAKE

The lake was constructed in the 1970's as part of the West Lakes development. The lake was an amenity feature of the Delfin Island development.

The original design report for the lake (Proposed Freshwater Lake, Delfin Island, 1977) outlined the following key design parameters:

- 1.4 to 1.7 ha waterbody
- Depth approximately 1.5m
- Vertical edges where possible
- Large shade trees near the water edge

- Creek outflow with provision for flushing
- Salinity maximum 1500mg/L.
- Daily pumping at constant rate (7 hrs per day)
- Passive recreation only
- 10 small islands throughout the lake
- Stormwater to be excluded
- Avoid chemical treatments
- Permanent underground rising main for provision of inputs at each end of the lake

2.4 LAKE OVERVIEW

An overview of the lake and key infrastructure that supports the lake and reserve are detailed to provide context to the study. The focus of this investigation is to review the lake waterbody. The surrounding reserve has also been considered, however, with respect to water quality treatment and comparison of the proposed options under review, there are minimal changes to the reserve. The assessment focuses on the waterbody in its current form.

2.4.1 Freshwater Lake Reserve

The FwL Reserve is the open space surrounding FwL waterbody. The reserve is a high value community asset and provides a walking paths, BBQ and picnic facilities, shelter, public toilets, open lawn space, formal landscaping and is a preferred space for events and weddings.

The key areas and assets within the FwL Reserve are outlined in **Table 5**.

Table 5. Key Infrastructure and Areas for the Freshwater Lake Reserve

Key Features	Details
Irrigated lawn areas	Approx. 7700m^2 total
Pedestrian Accesses	Eight pedestrian access points.
Maintenance Accesses	Seven maintenance vehicle access points.
Bridges	Five footbridges
Shelters	Rotunda and gazebo
Walking paths	Approx. 1600m total. Typically 1.5m wide

2.4.2 Freshwater Lake Waterbody

The lake is the waterbody within the reserve, referred to in this report as the FwL. The FwL is a series of three lakes connected by channels and weirs to create what is known as the FwL. There is also an outlet canal at the downstream of the FwL for overflow. Key dimensions of the lake are outlined in **Table 6**.

Table 6. FwL Waterbody Dimensions

Description	Dimensions
Total Area	14,000 m^2
Lake 1 (Main Lake)	6,900 m^2
Lake 2 (Middle Lake)	3,300 m^2
Lake 3 (Back Lake)	3,800 m^2
Lake Typical Depth	1.2 - 1.5 m
Lake Volume	17- 20 ML

Key infrastructure supporting the waterbody has been summarised below and is shown on the Existing Infrastructure Plan provided in **Appendix A**.

- Lake 1, 2 and 3
- Bore pump and rising main
- Water supply inlets and stormwater outlets
- Weir structures
- Aerators
- Fountain
- Islands
- Overflow channel
- Overflow pond
- Edge treatment (hard edge and batter/landscape)

2.4.3 Water Supply and Balance

The FwL is an artificial lake and freshwater is supplied from a local groundwater bore supply. This supply maintains the water levels within the lake, and is float controlled to trigger top-up as needed.

The original lake design required daily supply to manage the draw-down of water in the lake. Draw-down will be a result of evaporation loss, seepage, overflow to the outfall channel and other system losses. Additional to the top-up supply the lake will have inflow from direct rainfall to the lake waterbody and stormwater runoff from the adjacent paving. A water balance assessment has been undertaken to review the losses and gains based on relative constants (such as evaporation, which will adjust climatically but not through management practices), and variables over time or due to management practices (ie. top-up supply, seepage). A summary of the original and current water balance is provided in **Table 7**. Note this is based on as the information provided in historical reports and records, and best engineering assessment, therefore are order of magnitude. No formal records such as detailed meter reading, flow monitors or infiltration testing has been undertaken to confirm the actual supply and losses.

Table 7. FwL – Water Balance

	Original Design			Current Operation	
INFLOW					
	1970-2000 (approx.)	**2004**	**Assumptions**	**2022**	**Assumptions**
Direct Rainfall (ML/a)	5.5ML/a	5.5ML/a	Based on BOM data (Seaton Gauge) median rainfall.	5.5ML/a	Based on BOM data (Seaton Gauge) median rainfall.
Stormwater Inflow (ML/a)	1ML/a	1ML/a	Based on carpark and footpath stormwater run-off to the lake.	1ML/a	Based on carpark and footpath stormwater run-off to the lake.
Top-up Supply (Bore) (ML/a)	174ML/a	88ML/a	Based on UniSA report 2004. Original supply 12hr/day @40kL/hr * Reduced to 6hrs/day @ 40kL/hr in 2004 *(to reduce water supply demand for the lake, during the drought).*	40ML/a	Based on meter data provided (April 2016 to July 2021 – 203,166kL)
TOTAL INFLOW	**180.5ML/a**	**94.5ML/a**		**46.5ML/a**	
OUTFLOW					
Evaporation	18ML/a	18ML/a	Based on UniSA report 2004.	18ML/a	Based on BOM recorded monthly evaporation.
Seepage	70ML/a	70ML/a	Based on UniSA report 2004.	28.5ML/a	Assumed the as the net loss.
Overflow channel (ML/a)	92.5ML/a*	6.5ML/a	Assumed as the net loss.	Minimal	No regular flushing.
TOTAL OUTFLOW	**180.5ML/a**	**94.5 ML/a**		**46.5ML/a**	
Assumed Residence Time (days)	*40 days*	*77 days*		*156 days*	

As shown in **Table 7** the inflows to the lake have been significantly reduced over time, and as a result flushing rarely occurs with current operations. It is understood that supply has changed overtime due to policy change and drivers, such as water restrictions during the drought, and water quality impacting discharges to the downstream saltwater lake also restricted operations. These changes have merit in the context of the wider environmental and sustainability impacts, however this has impacted the operations and management of the FwL.

Freshwater lakes should have a maximum residence time (or turn-over period for the volume of water) of 30 days. Based on the assumed inflows over time the residence time within the lake have been calculated in **Table 7** and as shown do not comply with the best practice for shallow freshwater lakes design.

2.5 CURRENT LAKE FUNCTIONALITY

The existing lake is presenting Council with a number of problems such as;

- Water quality issues – algae blooms, poor water quality and limits disposal methods (ie. EPA have restricted the discharge to the main West Lakes due to heavy metal contaminants, noting that at the time of construction (in the 1970's) the EPA water quality policy was not in effect.
- Duck feeding – the feeding of bird life results in excessive duck faeces around the lake resulting in on-going maintenance. The food waste also attracts pests such as rats, foxes and ibis. Water quality is also impacted from rotting waste and high bird numbers creating turbidity.
- Introduction of additional planting – the introduction of planting and macrophyte zones in the lake have in the past been met by resident objection due to loss of view.
- Carp – high numbers of carp within the waterbody result in increased sediment and turbidity.
- Dead fish – water quality and low oxygen have resulted in dead fish within the lake on multiple occasions.
- Ibis management – there is an increasing inhabitancy of ibis which are destructive to the reserve.

The key issue when discussed with the Council was water quality and how to improve this long-term, as currently this is managed with short-term solutions. The water quality issues are also generally linked to the above range of issues.

2.5.1 Comparison of Original Design to Current Lake

On review of the existing lake in comparison to the original design, it is noted that some of the proposed design features are not retained in the current day assets. These changes may present a risk to the water quality and have been ranked low-high to reflect the likely impact on water quality based on lake design principals and best practice, to understand potential triggers that maybe influencing the water quality issues. These are highlighted in **Table 8** and have been ranked based on:

- High Risk (H): Likely to impact overall water quality.
- Medium Risk (M): May increase risk and contribute to water quality issues.
- Low Risk (L): Unlikely to result in water quality issues.

Table 8. Comparison of Existing Lake Design to Current

	Original Lake Design (West Lakes Ltd, Design Report, 1977)	Current Lake (2022)	Risk Factor
Waterbody Size	1.4 to 1.7 ha waterbody.	1.4ha open water	L
Depth	Depth approximately 1.5m.	1.5m typical but sludge build-up limiting depth.	M
Edge Treatment	Vertical edges where possible.	Mixture of vertical edge (majority) and batter edge (in select locations) based on upgrades undertaken in 2007.	L
Vegetation (Terrestrial)	Large shade trees near the water edge.	Limited shade trees near the edge of the lake. Lake 1 in particularly has minimal shade trees around the perimeter.	M
Vegetation (Aquatic)	Not specified	Lake 1 (Main Lake) < 10% coverage Lake 2 < 20% coverage Lake 3 > 50% coverage	H H L
Water Supply & Flushing	Creek outflow with provision for flushing.	Provision of creek outflow provided, and functions based on overflows but there is currently limited flushing. There is not constant pumping to meet the daily 7hr pumping and turnover proposed in the original design. A reduction of approximately 50% of the water circulation has occurred due to the introduction of more sustainable water use/management practices (and water restrictions during the drought. This is however, impacting lake water residence time which are above best practice for an artificial water body.	H
Salinity	Salinity maximum 1500mg/L.	The current bore salinity is up to 2000mg/L.	M
Pumping and Circulation	Daily pumping at a rate of 18.7L/s for 7hrs/day. To a total of 172ML/a.	As above there is reduced pumping and circulation. The lake is currently topping up on average 12L/s for 3hrs/day. The annual supply is <50ML. Based on 50ML/a, the volume of the lake is only turned over 2.5 times a year.	H
Recreation	Passive recreation only.	Passive recreation, however, duck feeding has been an issue in recent years.	M

	Original Lake Design (West Lakes Ltd, Design Report, 1977)	Current Lake (2022)	Risk Factor
Islands	10 small islands throughout the lake.	There are 1 to 2 islands on each lake. A total of 7 islands across the whole lake.	M
Stormwater Discharge to the Lake	Stormwater to be excluded.	There is a small local catchment from a number of residential units and the dentist carpark that discharges to Lake 1. The footpaths around the perimeter of the lake are grading into the lake.	M
Water Quality Treatment	Avoid chemical treatments	There is chemical dosing with 'Coptrol' is undertaken a couple of times a year to manage algae blooms	M
Rising Main for Water Supply	Permanent underground rising main for provision of inputs at each end of the lake. (4 inlets proposed)	There are currently 3 inlet locations, 1 x main lake 2 x lake 3 (via two small bubblers)	H

2.6 IMPLEMENTED INITIATIVES AND OUTCOMES

In recent years Council has initiated management and maintenance techniques to improve the lake amenity, including mechanical, chemical, and educational campaigns as outlined below.

2.6.1 Carp Removal

Carp removal was undertaken in 2001 as a removal program that involved reduction of the lake water level to assist in the netting removal process. This was undertaken at an estimated budget of $50,000 (Council Report, 22 October 2001).

In 2015 there was significant fish death event (100+) which led to the removal of dead carp. This was likely due to the water quality and a significant spike in TSS and turbidity, and potential heavy metals or ammonia, fluctuating dissolved oxygen.

The was another carp removal including dead fish in April 2021, the aerators were switched to 24/7 to improve water quality and reduce risk of fish death.

Carp removal was undertaken in January 2002, the water level was lowered and netting undertaken. Water was pumped out and discharged to sewer at a cost of $1.50/kL (approx. $3,000-$4,000 total cost), to a maximum rate of 6 L/s.

It is noted by Council that the removal of carp is an ongoing issue. With the exception of draining the whole lake, it is not possible to removal all fish.

2.6.2 Dosing – Coptrol

The lake is currently dosed with algaecide ‘Coptrol’ a couple of times a year, to manage algae blooms within the water body. There is noticeable improvement in water quality, as outlined in the photograph provided by CoCS, **Figure 2**. However, the discolouration associated with the dead algae in following day often draws complaints from residents.

Figure 2. Water Quality Improvement with and without Coptrol (algaecide application)

The treatment is a short-term solution and will need reapplication. It is also important that the application is undertaken strictly in line with the supplier instructions. In particular, aeration of the lake is needed to prevent a rise in deoxygenation within the lake which can impact aquatic life as a co-effect of the treatment process. This is evident from recent experience where carp die-off following the treatment occurred due to low oxygen levels. The product also adds copper to the lake which can be a complicated by-product to remove. As a successful treatment a maintenance plan that outlines regularity of treatment and instruction is critical and will eliminate reactive action that is not always efficient or as effective.

2.6.3 Duck Feeding

Duck and bird feeding at the lake is an activity that has been engrained in the community since the construction of the lake. The lake was also known as the duck pond and old bread was sold to encourage bird feeding at the main lake.

In recent years this has led to excessive bird numbers, messy paths and landscape furniture, water quality issues and risk of pests, and poor health of the bird life. Therefore, Council undertook a campaign to educate the community around the issues of bird feeding to deter this activity at the lake.

This campaign was successful, and feeding has been significantly reduced. Educational signage is also present at the lake currently. In regard to water quality issues however, these are still present with the reduced feeding activities.

2.6.4 Ibis Management

Ibis have been present at FwL for a number of years, however these numbers have increased over time, particularly in breeding season. There are resident complaints when the ibis numbers are higher (ie. breeding season) due to noise and smell, the birds can also degrade the vegetation.

Current management of ibis at the FwL are focused on vegetation management and monitoring. There is significant pruning of the Date Palms within the vicinity of the lake to remover the nesting area and deter birds. Pruning occurs annually. Other options have been used nationally which can be investigated if the issue continues to be a problem, however, to date Council see the vegetation management as a suitable technique, and over the last 2 years the ibis population has reduced.

2.6.5 Water Supply and Circulation

Water supply in recent years (post-drought and water restrictions), has significantly reduced to less than half the originally proposed water supply and circulation. Initially the lake was flushing water daily with overflows directed to the West Lakes saltwater lake, however, in recent years drought and water quality issues have changes that strategy.

The reduction in water supply required due to a recognition that extracting freshwater from the aquifer to circulate the FwL and then discharge to the saltwater lake results in unsustainable use of water. Additionally, there were risks from the poor-quality water discharging from the FwL, discharging to the main saltwater lake, transferring contaminates to the downstream receiving water and effecting ecosystems.

Within the lake the circulation typically should follow the flow paths are indicated on **Figure 3** and further detailed on the Existing Infrastructure Plan provided in **Appendix A**. This is based on the location of water supply outlets in Lake 1 and Lake 3, and the outfall channel to Corcoran Drive. It should be noted the original design proposed four outlets which would provide increased circulation, particularly in the larger main lake. Given the shape of the lakes, low flushing / turn-over of water, and the islands circulation is an issue, with location of poor circulation forming at a number of locations.

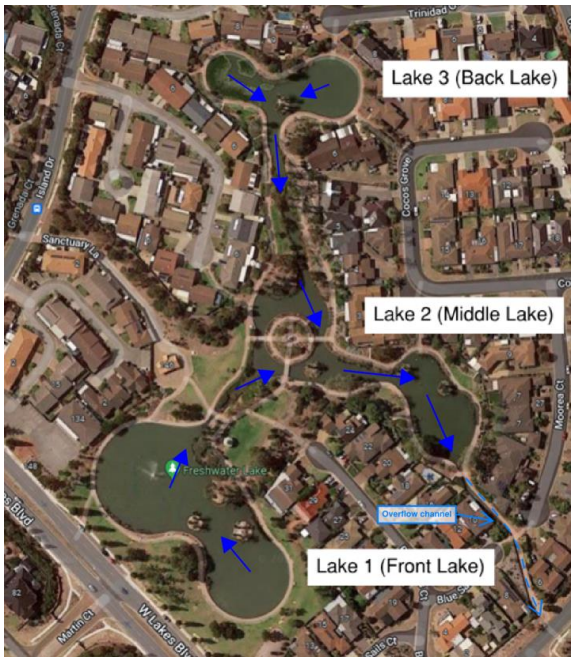


Figure 3. Lake Circulation

2.6.6 Aerators

Aerators have been installed in the lake in recent years There are three aerators for each lake as outlined in **Figure 4**. The aerators are running 14-16 hours a day.

Figure 4: Aerator Layout Plan (Solaris Group)

Feedback from lake maintenance staff is that the improvement in water quality appears limited, and the units have been presenting issues with blockage or malfunction. The operational issues that are occurring are likely to be influenced or increased due to the poor quality within in the water, including high sediment suspension resulting in blockage. When the aerators are operating as part of an improved water quality treatment method, there should provide improved efficiency and benefit.

2.6.7 Seepage and Losses

The lake has high-seepage losses, based on assessment of the inflow, outflow and a preliminary water balance with the provided information. Three are leakage points through the base of the lake and within its edge treatment. This seepage coupled with evaporation losses across the 1.4 ha surface area result in a high demand for top-up water supply and reduces the overflow/lake flushing. It is noted however, there are no available infiltration records, or detailed water level records to confirm the seasonal fluctuations, this is something that should be investigated to inform future improvement works.

Improving the lining of the lake will reduce seepage. To date, however, while repairs to the lake edge treatment have occurred (which will provide some reduction in seepage loss), no improvements to the lining have occurred.

2.7 REPORT STRUCTURE

The report has been structured as outlined below.

- **Section 3 – Option 1:** Investigation in the lake in its current form with existing maintenance and management practices. Reviewing the risks, constraints, benefits, and costs.

- **Section 4 – Option 2:** Investigation in the lake in its current form with improvements to maintenance and management practices. Reviewing the risks, constraints, benefits, improvement opportunities and costs estimates.

- **Section 5 – Environmental and Social Factors (All Options):** Considering the wider impacts of all options with a multicriteria framework.

- **Section 6 – Conclusions:** Outlining next steps, limitations, and cost comparison of all options.

3 OPTION 1 – MAINTAIN THE LAKE IN ITS CURRENT FORM AND CONTINUE WITH EXISTING MAINTENANCE AND MANAGEMENT PRACTICES

Option 1 is the base case assessment of the FwL in its current form, with no changes to the existing maintenance and management practices. The investigations undertaken by WGA include assessment of the existing functionality, site inspection, consultation with Council, review of recent maintenance activities (both proactive and reactive) and review of recent budgets and costs incurred by the FwL over the past 10 years.

Option 1's scope is defined as 'Maintain the lake in its current form and continue with existing maintenance and management practices'.

This option is a strictly 'as is' option, and should not address structural and operational issues including (but not limited to):

- Lake seepage (leaking),
- Water circulation issues,
- High evaporation,
- Treating the bottom of the lake to make future de-sludging easier and more effective,
- Or reviewing the source of water for filling the lake (note the source is currently drawn from groundwater).
- Regular cleaning of benches and public furniture to remove animal faeces.

3.1 LAKE OPERATIONS AND MANAGEMENT

3.1.1 Current Operations

The current operational status of the lake is outlined below:

Water supply sourced from groundwater. The lake is fed by a bore located in Corcoran Drive which extracts groundwater and pumps it to the lake at three inlet points, as outlined in

Figure 5.

- Water is pumped into the lake daily at a rate of 12 L/s for 3-4 hours per day, approximate 40-50 ML/a supply.
- There is a weekly overflow of approximately 25 kL based on the fill time of the downstream overflow pond. Noting, in rain events this is increased.
- 100% of the water supply is from the bore.
- Losses are through evaporation and seepage.
- There are aerators within in all the lakes (Lake 1, 2, 3) which are turned on routinely to improve aeration and dissolved oxygen content (DOC).
- There is reactive treatment to the lake to manage water quality issues and lake water infrastructure (including dosing with Coptrol anti-algal, carp removal, animal management).
- Desludging of the lake occurs every 5-10 years.

The lake asset is managed as part of the overall FwL Reserve maintenance and operation team from the CoCS. The reserve maintenance has broadly been assessed to provide a comprehensive understanding of the management of the public open space. The current operation of the reserve around the FwL includes:

- Irrigation & maintenance of the terrestrial planting and lawns
- Maintenance and repair of bridges, paths and landscape furniture
- Waste management and cleaning
- Electricity for lighting
- Management of the public toilet
- Animal management (birds, ducks, fish)

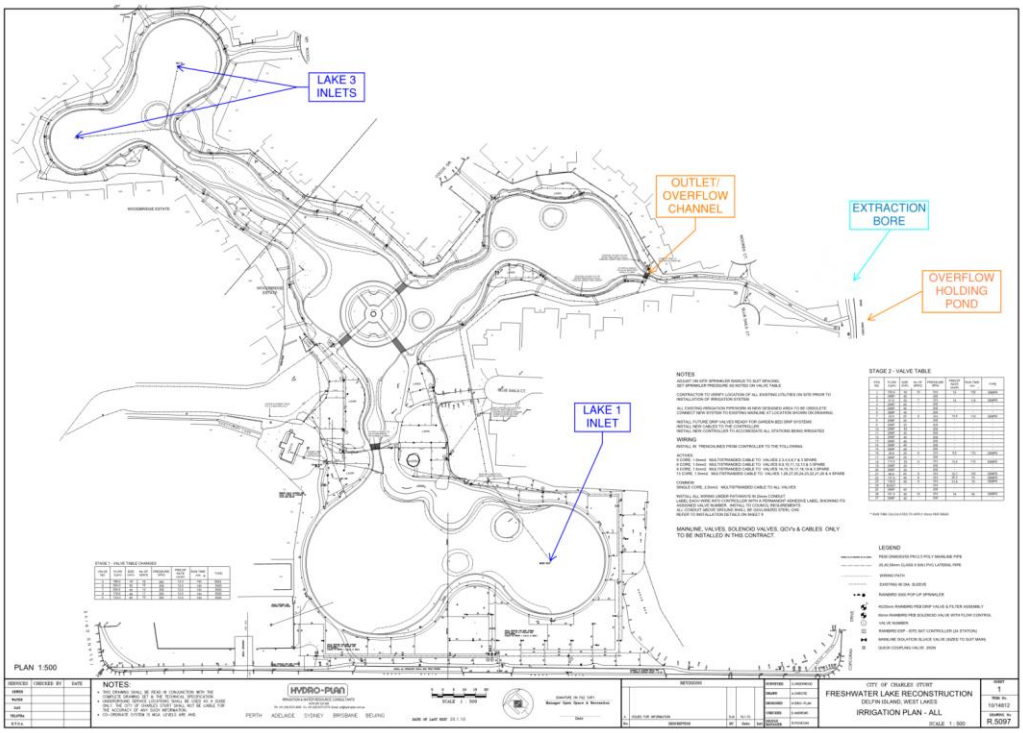


Figure 5. Existing Lake Inlets, Outlets, Overflows and Extraction

3.1.2 Ongoing Maintenance Activities – Retaining Existing

This option proposes to continue to operate FwL as it is operating currently, with no upgrade works.

The following ongoing waterbody maintenance activities are required:

- Ongoing top-up supply from the bore (maintenance and electrical costs).
- Reactive water quality treatment.
- Carp removal
- Dosing with Coptrol
- Animal management
- Aeration of the lake (maintenance and electrical costs).
- Repair and up-keep of assets.
- Draining, de-sludging and refill.

Further to this, the on-going reserve maintenance activities will be required:

- Irrigation of the terrestrial planting and lawns.
- Maintenance of the terrestrial planting and lawn mowing.
- Maintenance and repair of bridges, paths and landscape furniture.
- Waste management and cleaning.
- Electricity for lighting.
- Management of the public toilet.
- Animal management (birds, ducks, fish).

3.1.3 Risks and Issues

The key risk and issues that will result from retaining the waterbody in its current state are:

- Desludging alone will not provide a permanent improvement to water quality. It will provide a limited improvement for approximately 5-10 years. Removal of sludge material off-site is expensive and will continue to increase in cost over time.

- Water quality of the lake is not maintained at optimum. Water quality issues will continue to occur and increase over time, and seasonally.

- There is unsustainable water use. High seepage losses and draining of the groundwater storage. The existing bore is also near the end of its design life and may not be the most sustainable water source.

- There is insufficient circulation of water. Resulting in ongoing water quality issues.

- Reactive management is not an efficient management and can cause wider issues. Improved management plans may improve overall operation.

- Aging infrastructure will continue to be an issue. Particularly if dedicated management plans are not put in place.

3.1.4 Lake Baseline Requirements

There are two baseline lake improvements that need to be undertaken independent of the option selected due to the current status of the waterbody and associated infrastructure. These upgrades are desludging of the lake and upgrading the source water supply. These upgrades are upfront costs for all options outlined in this report that will reset the lake to a baseline prior to assessment of the options moving forward. The source water supply upgrade is considered as capital expenditure whereas the lake desludging is considered as an upfront operational cost.

Desludging Lake

A build-up of sludge and sediment over recent years due to the poor water quality, algal blooms, limited flushing and/or water treatment, has resulted in a build-up of sludge within the lake. To consider viable and comparable options moving forward desludging of the lake should be considered an upfront measure to provide a baseline to measure the future management options and allow for any implemented change to operate as designed. For this reason, desludging is assumed and costed as an upfront operational cost to all options assessed. The requirement for future dredging, however, is dependent on the selected option and improvements implemented, and is costed as additional as part of ongoing operational costs.

Dredging of the lake assumes the draining of the waterbodies (with disposal to sewer), scraping the base to remove the build-up of sludge, which is expected to be 300-500mm deep, removal of the sludge for offsite disposal and then reinstatement of the liner (as required) and refilling of the lake. It is assumed that this process would be staged to allow retention of water in select waterbodies to provide refuge for aquatic and bird life. It is assumed that desludging will occur prior to the implementation as part of Option 1, to allow the current operations to continue.

Source Water Supply

The lake top-up water supply is drawn from an existing groundwater bore on Corcoran Drive. This bore is nearing its design life based on a construction date 1974 and up to 50 year design life and will need to be upgraded soon to remain as a functional supply source. Therefore, to maintain the lake operation as existing this bore will need to be upgraded and this has been considered as a requirement to achieve a baseline scenario and has been costed as an upfront expenditure.

3.2 FINANCIAL ESTIMATES – OPTION 1

Financial estimates have been calculated for the FwL based on the Council provided historical data, review of existing budget and maintenance cost records and based comparable industry cost comparisons.

The above understanding of the operational and maintenance requirements informed the costing. The costing has been broken down into terrestrial landscape costs which include the wider management of the reserve, and the waterbody costs which will review the FwL management in more detail.

A summary table outlining assumptions for all costings is provide in **Appendix B**.

3.2.1 Capital Costs

Option 1 is to retain the FwL in the current state with no structural improvements. Therefore, the only capital cost allowance is for the baseline requirement, source water supply upgrade, as outlined in **Section 1.2 Lake Baseline Requirements**). An upfront operational cost to desludge the lake is also required which has been assumed to be undertaken prior as outlined in **Section 3.2.3 Upfront Costs**. These are considered necessary given the current state of the infrastructure. Given the age of the asset and the design life of key lake infrastructure there will still be costs associated with the lake to retain it in the current state over time.

Asset renewal over the next 50 years is expected to be based on the following design life:

- Water supply reticulation network & pump – 20 years
- Bore and pump – 20-30 years
- Fountain and aerators – 20 years
- Lake edge treatment – 30 years
- Footpath – 40 years
- Landscaping – 20 years
- Landscape Furniture – 20 years

These major asset upgrades will need to be budgeted on an as need basis and managed by Council's asset management team.

3.2.2 Operational Costs

Ongoing operation is required to maintain the FwL in its current form and to the level of service expected for safe operation, aesthetics, environmental management, and safety. The operational costs will be both regular annual maintenance and larger major upgrade works that will be undertaken periodically (such as dredging).

The operational costs have been broken-down into the following key areas:

- **Waterbody Management**
  - **Landscape – Aquatic:** These costs include management of assets within or associated with the waterbody. (ie. sediment removal/dredging, aquatic planting, outlets and lake infrastructure maintenance).
  - **Water Supply – Lake Top -up:** These costs relate to the supply of top-up water to service the FwL only. The supply costs include cost of water, permits, bore operation costs, pro-rata from the total based on the demand. The costs for irrigation of the terrestrial landscape are accommodated in Open Space Reserve (Terrestrial) Management.
  - **Electrical:** These costs relate to the supply of top-up water to service the FwL only. The cost has been assumed pro-rata based on the total electrical cost provided for both the waterbody and the terrestrial landscape. The costs for irrigation of the terrestrial landscape are accommodated in Open Space Reserve (Terrestrial) Management.
  - **Water Quality Treatment & Remediation:** These costs include the current techniques used to manage water quality issues (ie. aerators, carp management, algae removal and/or chemical dosing). Noting, these treatments have been reactive over the past decade, and will likely be required periodically (not annually), therefore the average annual equivalent cost has been assumed.
- **Open Space Reserve (Terrestrial) Management**
  - **Landscape – Terrestrial:** Cost includes management of the assets within the reserve surrounding the lake. (ie. lawn mowing, irrigation of garden beds/ lawn, waste management, cleaning, repair of landscape furniture.) This cost has been grouped as one separate category as the purpose of the options review is to assess upgrades to the waterbody (with no change in waterbody surface area), therefore these costs are expected to remain relatively constant across the options.
  - **Water supply – Irrigation:** These costs relate to the supply of top-up water to service the FwL only. The supply costs include cost of water, permits, bore operation costs, pro-rata from the total based on the demand. The costs for top-up of the waterbody are accommodated in Waterbody Management.
  - **Electrical:** Costs include irrigation pump costs and lighting. The cost has been assumed pro-rata based on the total electrical cost provided for both the waterbody and the terrestrial landscape.

The cost assumption includes both material and labour costs. Where costs are periodic or major upgrades these have been averaged back to an annual cost.

3.2.3 Upfront Costs

As outlined in Option 1, there are two baseline improvements that need to be undertaken independent of the option selected due to the current status of the waterbody and associated infrastructure. These upgrades are desludging of the lake and upgrading the source water supply. These upgrades are upfront costs for all options outlined in this report which will reset the lake to a baseline prior to assessment of the options moving forward. The source water supply upgrade is considered as capital

expenditure whereas the lake desludging is considered as an upfront operational cost. These major cost considerations are further outlined in **Section 3.2.6 Major Costs.**

3.2.4 Cost Estimate Summary – Option 1

Table 9. Option 1 – Upfront Operational Costs

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	SLUDGE REMOVAL	$ 979,000
	SUBTOTAL - A	**$ 979,000**
	CONTINGENCY (30%)	$ 293,700
	CONSTRUCTION TOTAL	**$ 1,273,000**

Table 10. Option 1 – Capital Costs

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	WATER SUPPLY SOURCE	$ 150,000
	SUBTOTAL - A	**$ 150,000**
	CONTINGENCY (30%)	$ 45,000
	CONSTRUCTION TOTAL	**$ 195,000**

Table 11. Option 1 – Operational Costs (Annual)

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	LANDSCAPE - AQUATIC	$ 110,000
2	WATER SUPPLY - LAKE TOP-UP	$ 20,000
3	ELECTRICITY	$ 5,000
4	WATER QUALITY TREATMENT & REMEDIATION	$ 16,000
	SUBTOTAL - A	**$ 151,000**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**	
6	LANDSCAPING - TERRESTRIAL	$ 56,000
7	WATER SUPPLY - IRRIGATION	$ 3,000
8	ELECTRICITY	$ 11,000
	SUBTOTAL - B	**$ 70,000**
	SUBTOTAL - A + B	**$ 221,000**
	CONTINGENCY (30%)	$ 66,300
	CONSTRUCTION TOTAL	**$ 288,000**

3.2.5 Assumptions

Cost estimates have been based on information provided by Council including budget records and maintenance activity report. WGA have also applied rates based on our understanding of the lake management it is expected that costs will be incurred to maintain the lake in its current form. Rate assumptions by WGA are based on industry experience and similar project and are Opinion of Probable Cost (OPC). A 30% contingency has been applied to all costs due to the preliminary nature of the investigation.

Costs exclude site investigation, design fees and project management costs.

A summary table of the rates assumptions for all cost estimates outlined in the report is provided in **Appendix B**.

3.2.6 Major Costs

There are two major costs specific to the water body management that need to be considered further.

Desludging of the Lake

As desludging is an ongoing operational cost that will be required routinely on an estimated 10-year basis this cost has been included in the above operational cost assumptions pro-rata to an annual cost in addition to the upfront operational cost for the works proposed in the immediate future. The desludging cost is a high-risk item, due to the high cost and the potential unknowns including the sludge volume, contamination classification and the waste disposal cost. The cost estimate undertaking as part of this report has assumed the parameters outlined in **Table 12**, however given the limit on information such as measure of sludge depth or contamination testing these are preliminary.

Table 12. Desludging Parameters

Parameter		Assumption
Sludge volume for removal (whole of lake)	2,800 Tonnes	Based on 300mm sludge across 1/3 of the lake area. 2.0 bulking factor to account for wet sludge
Sludge Disposal Costs	Low Level Contaminated Waste	$278.30 /Tonne
	Intermediate Waste	$38.50 /Tonne
Contamination classification	Low Level Contaminated Waste*	100% of total volume
	Intermediate Waste*	0% of total volume

*Based on Resource Co. Rates current May 2022.

This assessment has assumed the upper limit with all materials classified as low-level contaminated waste. There is potential for this to reduce and part of the sludge volume be classified as intermediate waste which would reduce the cost, however given the limited information and lack of testing the higher classification has been adopted.

The key risks are that:

- The volume of waste is significantly more than estimated. Currently the estimated sludge volume is based on 300mm across 1/3 of the waterbody. However, if this increased to 500mm across 1/3 of the waterbody the cost would increase from a total cost of $980,000 to $1.6 million.

- Disposal costs increase in the future increase. If the rates increase for disposal or the classification risk level of waste increase, this will increase the cost. As the volume of waste is significant this could be a significant cost increase, ie. 10% cost escalation in disposal results in additional cost of $980,000 to $1.16M.

- Contamination testing determines a high volume of contaminated material, or a higher risk classification.

To manage these risks Council should undertake site investigations and testing prior to committing to the works to refine the assumptions on volume and contamination level.

Replacement of the Extraction Bore

On review of the publicly available bore database, and the extraction bore construction, the bore is near the limit of its design life and is due for replacement. Steel casing within water wells typically last 25-50 years depending on water quality parameters and steel composition. Water quality parameters within the aquifer at Delfin Island have relatively low corrosive properties, however the bore is nearly 50 years old. Therefore, this bore will need to be replaced in the next few years to remain operational to the current standard of operation and water quality.

The estimated cost to replace the extraction bore is $150,000. This bore would then have a design life of approximately 30 years.

4 OPTION 2 – IMPROVE LAKE FUNCTIONALITY BUT RETAIN CURRENT FORM

Option 2 is the investigation and review of improvements that will permanently enhance the lake performance including through operational changes, engineering solutions and or updated management practices. The investigations undertaken by WGA are based on the findings of the Option 1 base-case assessment, and our understanding on the design and operation of artificial water bodies. Opportunities for improvement investigated include localised structural changes, operation and management practices, new technologies, and water supply source investigation.

The scope defined Option 2 as, 'Maintain the lake in its current form with improvements to permanently enhance lake performance and quality, operations and management.'

4.1 LAKE OPERATIONS AND MANAGEMENT

4.1.1 Current Operations

The outcomes of the Option 1 investigation highlight that there are a significant number of reactive maintenance and management measure that are required to preserve the lake in its current form while meeting the expected level of service for the community. This current operation is considered potentially unsustainable from a financial, social, and economic risk perspective.

There are a number of issues that need to be addressed to improve the functionality of the lake in its current form. Key issues include:

- Algal blooms and water quality issues
- Sludge build-up and costs for de-sludging
- Pest management – birds and fish
- Seepage and loss of water resulting in significant top-up requirements
- Poor circulation
- Water supply source sustainability and supply

Some of these issues can be addressed on a site scale such as structural and/or operational/management enhancement, however source water can be more complex and may require external supply sources to be investigated.

4.1.2 Risks and Issues – Targeted

The key risk and issues that will result from retaining the waterbody in its current state are:

- Desludging alone will not provide a permanent improvement to water quality. It will provide a limited improvement for approximately 5-10 years. Removal of sludge material off-site is expensive and will continue to increase in cost over time. *The improvement options will seek to reduce the desludging requirement (load or frequency).*

- Water quality of the lake is not maintained at optimum. Water quality issues will continue to occur and increase over time, and seasonally. *The improvement options will seek to retain suitable water quality all year round.*

- There is unsustainable water use with high seepage losses and draining of the groundwater storage. *The improvement options will seek to manage demand or source more sustainable supply.*

- There is insufficient circulation of water, resulting in ongoing water quality issues. *The improvements will include improved circulation.*

- Reactive management is not an efficient management and can cause wider issues. Improved management plans may improve overall operation. *Improved management plans will assist in managing the lake and extending the design life of assets*.

- Aging infrastructure will continue to be an issue, particularly if dedicated management plans are not put in place. *As above the improvements will include management plans.*

4.1.3 Lake Improvement Options

The improvement options available for the lake have been broken down into the following key areas:

- Structural Improvements

- Operational / Management Improvements

- Water Supply Source

Ultimately, Council needs to determine the agreed level of service for the water body and manage this against the financial costs and feasibility of the upgrades. WGA has investigated opportunities under each of the above key areas, initially a long-list of structural options have been assessed and short-listed. The operational and water supply improvements have then been considered based on the implementation of the structural solution.

4.1.4 Lake Baseline Requirement

There are two baseline lake improvements that need to be undertaken independent of the option selected due to the current status of the waterbody and associated infrastructure. These upgrades are desludging of the lake and upgrading the source water supply. These upgrades are upfront costs for all options outlined in this report that will reset the lake to a baseline prior to assessment of the options moving forward. The source water supply upgrade is considered as capital expenditure whereas the lake desludging is considered as an upfront operational cost.

Desludging Lake

As outlined in **Section 1.2 Lake Baseline Requirements,** Desludging of the lake is assumed as a baseline improvement required for the Option 2 assessment.

Source Water Supply

As outlined in **Section 1.2 Lake Baseline Requirements,** source water supply is assumed as a baseline improvement required for Option 2.

Option 1 has assumed the upgrade of the existing bore as the source water supply. As Option 2 is reviewed options to upgrade the lake functionality, sourcing an improved or more sustainable water source has been investigated. This is further detailed in **4.4 Water Supply Source Options And Improvements** and seeks to manage some of the risks associated with the current bore which include an increasing salinity in the supply water.

4.2 STRUCTURAL IMPROVEMENTS

It is understood the lake in its current form must be maintained as part of this option, therefore structural improvements have been considered within the existing waterbody footprint, or with offline treatment that will not impact the existing lake structure and functionality.

The structural improvement options have been considered by review of available options. These options include a range of opportunities including localised improvements, innovative products on the market, and whole of water body solutions. The long-list assessment is a high-level review to consider risks, constraints, benefits and costs for comparison purpose.

Following the workshop the short-listed options were determined and further investigated to develop Option 2. Regardless of the selected structural solution maintenance of the lake will be required to maintain optimum function and water quality.

4.2.1 Structural Improvement Options

The initial assessment and high-level comparison of a broad range of structural improvement options within the market has been undertaken to assess options for improvement. This long-list options assessment informed the short-listed solutions that have been proposed. The long-list assessment is provided in **Appendix D**.

4.2.1.1 Structural Improvement Shortlisted Options

The full list of structural improvement was reviewed to consider the risk, constraints, benefit, and cost and then short-listed to preferred solutions. Council was engaged as part of this assessment to ensure an understanding of the wider site constraints and opportunities are considered.

The key risks the Option 2 lake improvements target are:

- Unsustainable water management
- Poor circulation within the water body
- Poor water quality

The short-listed structural options that have been considered and further investigated, are summarised in **Table 13**.

Table 13. Shortlist of Improvement Options

Issue	Improvement
Unsustainable water management	Install impermeable liner to the lake base and walls.
Poor circulation within the water body	Improved Circulation, two options considered: – Retrofit the existing supply line to provide additional refill points (minimum two per Lake) – Retrofit the existing supply line to provide refill points, and upgrade to a new reticulation network including capture sumps to offline treatment and recirculate of lake water post-treatment
Poor water quality	Water Quality Treatment, two options considered: – Ocean Protect Filterra Bioretention Offline Treatment System – SPEL Floating Wetland installation

The key benefits of each improvement option are outlined in **Table 14**.

The objective was then to formulate two options for assessment that would optimise the outcomes and consider a broad range of benefits. These options have been packaged as a suit of improvements to target all the risks as outlined in **Table 13**. It should also be noted that many of the options will not provide optimum benefit, unless combined with other improvements, ie. the water quality treatment measures rely on upgraded circulation to reach the full improvement benefit. The options are:

- Option 2A (Offline Bioretention)
- Option 2B (Inline Floating Wetland)

There may be opportunities to deliver these packages in stages, however this needs to be carefully assessed due to the interdependency of many of the solutions to achieve optimal results. The assessment assumes the options are a package.

Table 14. Co-benefits of the Improvement Options 2A (Offline Bioretention) & 2B (Inline Floating Wetland)

	Install Impermeable Liner	Circulation improvements (within waterbody only)*	Circulation improvements (including reticulation external to the lake)**	SEPL Floating Wetland*	Ocean Protect Filterra Bioretention*	Engineered maintenance access
Cost Range	High	Low	Medium	Low	Medium	Low
Water quality improvement Ie. direct improvement to water quality		X	X	X	X	
Reduce water supply demand Ie. alternate source, loss reduction, reuse	X		X		X	
Improve the sustainability of operations Ie. Reduced water use, low energy, low material or recycled materials	X				X	
Increase biodiversity Ie. Improve environment to support increased biodiversity, urban cooling, green infrastructure				X	X	
Amenity Ie. Aesthetic improvement, increase public use.				X	X	
Co-benefit achieved within the selected options						
Option 2A (Offline Bioretention)						
Option 2B (Inline Floating Wetland)						

4.2.2 Improvement Option 2A (Offline Bioretention)

Option 2A (Offline Bioretention) considers a holistic improvement that integrates water supply reductions, improved sustainable water management, water quality treatment and improved reticulation and circulation of the lake. The objective will be to maintain suitable water quality year around, reduce the demand on the top-up supply (bore water) and create a more self-sustaining lake operation.

The proposed structural upgrades are:

a. Reduce Infiltration Losses: Install impermeable liner to the lake base and walls.

b. Improved Circulation: Retrofit the existing supply line and upgrade to a new reticulation network including capture sumps to offline treatment and recirculate of lake water post-treatment.

c. Water Quality Treatment: Ocean Protect Filterra Bioretention Offline Treatment System.

Note: Items b & c can be implemented without item a, however, this will require ongoing top-up supply to offset infiltration losses, therefore will not meet the sustainability objective.

Figure 6 provides a schematic diagram of Option 2A (Offline Biorientation)

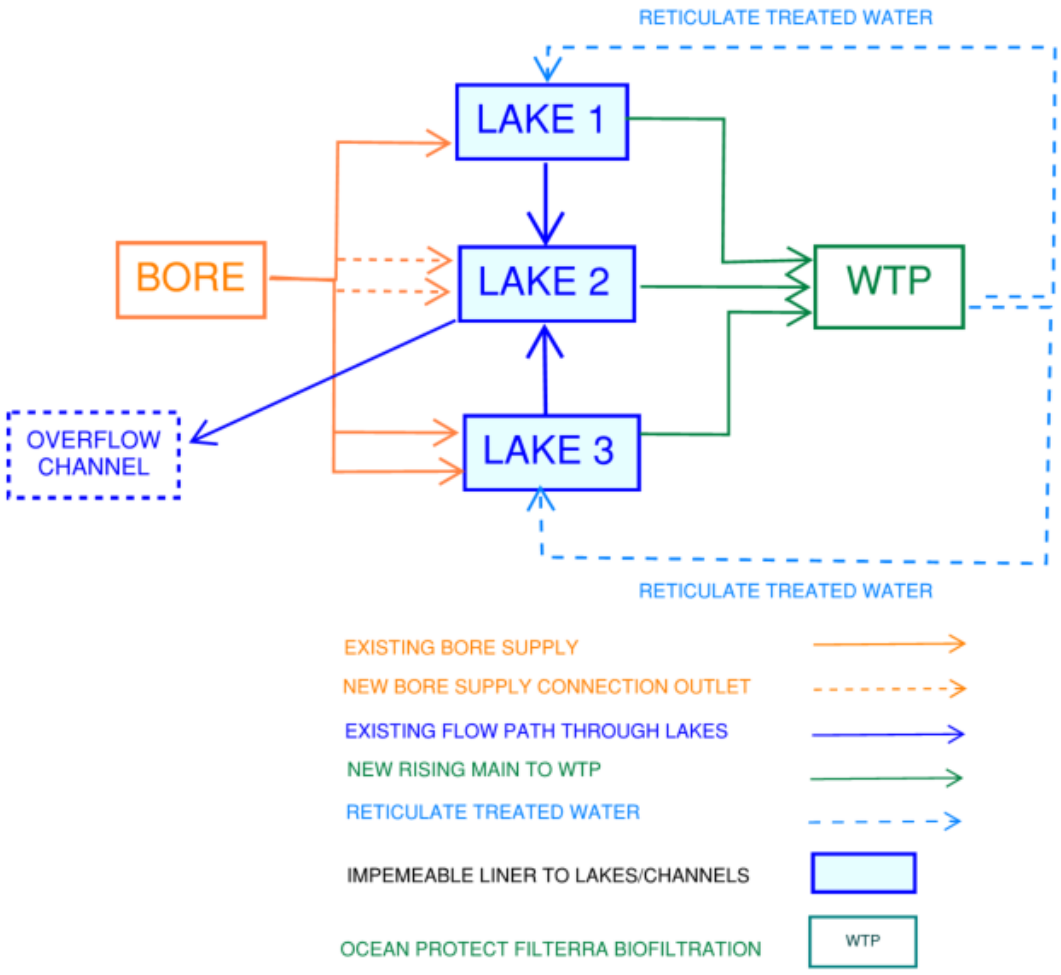


Figure 6. Option 2A (Offline Bioretention) Schematic Diagram

Further details on each option are provided below and a sketch of the proposed layout is provided in **Appendix A**.

a. Reduce Infiltration Losses – Impermeable Liner

It is understood that there is significant water loss from FwL through base and wall infiltration. This results in daily top-up supply to maintain the water level, this is increased in the warmer months when evaporation is high.

A preliminary water balance was undertaken for the current lake operations refer **Section 2.4.3 Water Supply and Balance**, which determined the infiltration losses to be of the order 28ML/a, or 70 %, of the top-up supply. If this can be reduced through lining the lake base and walls with an impermeable liner, there is the potential to reduce the demand on the groundwater bore, maintain appropriate water levels and improve the overall water quality and sustainability of the FwL.

The proposed lake liner solution is assumed to be a GCL liner to the base of the lake as this will allow planting. The GCL will be laid under 300mmm of site won material or crushed rock, this will secure the liner and activate the impermeably, and additionally provide protection for future desludging or lake maintenance. To line the walls of the lake it is proposed to install a 1.2m wide HDPE sheet fixed to the front facing of the C Loc piles. This is then folded inward 500mm onto the lake floor to provide a join to the Elcoseal GCL liner. The liner can then be pasted to the HDPE to form a water-tight seal before backfilling the GCL. The resultant voids behind the HPDE facing on the piled wall can be filled with concrete grout. This is a complex methodology but will be an alternate to reconstructing the lake walls, which has been unsuccessful in the past (due to asbestos in the original wall, and rock at shallow depth) which could be a more expensive and disruptive activity. To undertake these works the lake will need to be drained, this can be done in stages (ie. one lake at a time), to reduce the impact on amenity and habitat. Desludging of the lake has been assumed as an upfront expense, it is recommended that lake relining is undertaken as part of the desludging project, therefore dewatering costs and disruptions can be limited to one project. The cost estimate is provided in **Section 4.5 Financial Estimates – Option 2**.

b. Improve Lake Circulation and Reticulation Network

The current FwL freshwater supply and recirculation is limited to one freshwater inlets to lake 1, two freshwater inlets to lake 3, overflow to the outlet channel and aerators in each lake. This system is limited and does not promote significant water circulation, particular given the size and shape of the lake bodies which are typically wide and short. For optimal circulation design dimensions, a target 3L:1W length to width, is recommended to promote hydraulic movement.

This option proposes to retrofit the existing supply line and upgrade to a new reticulation network to provide a minimum of two fresh/treated water inlets to each lake waterbody and integrate capture sumps within each lake to pump flows to an offline treatment system, prior to recirculation of lake water post-treatment.

The key components of this design are:

- 4 new bore or treated water inlets.
- Retrofit connections to the existing bore supply rising main.
- 3 new inlet sump pumps (extraction).
- Rising main/ reticulation network and pavement reinstatements.
- Valve, fixtures and controls.

- Electrical supply and augmentation.

The cost estimate is provided in **Section 4.5 Financial Estimates – Option 2**.

c. Water Quality Treatment (WQT) – Offline (Filterra)

An offline water quality treatment system will filter water and remove nutrients and sediments that contribute to algae blooms and poor water quality outcomes. The system must be installed with an improve reticulation and circulation network that allows the water within each lake to be turned-over more frequently. The result is that there is a reduced residence time which is critical in managing water quality and prevent stagnant water or allowing algae blooms to develop, and treatment of the water through the filtration system.

The proposed offline WQT is the Ocean Protect Filterra, a high-flow biofiltration / bioretention system. The key benefit in this system are:

- The specific media used allows a high treatment rate therefore a reduce treatment area footprint

- The unit can be installed above or in-ground which allows flexibility in design application and the implementation of bioretention in location where traditional bioretention would not be practical due to space constraints or existing assets and infrastructure.

Given the high-amenity value of the FwL reserve the Filterra is considered a good fit as the treatment system can be located with reduced impact to the existing amenity, and it can be integrated into the landscape design.

Ocean Protect have reviewed the FwL parameters, including lake size, volume, depth, locality, and water quality data. Based on this they proposed a treatment unit size of 150 m^2, pumping twice a week at 36L/s for 9 hrs per event (assumed overnight for off-peak power supply). The system could also operate additional hours if required to manage isolated periods of poor water quality. This system would reduce the residence time in the lakes to 30-60 days which is in-line with the original lake design. It is proposed to operate the scheme as a single centralised treatment system with inflows fed from each of the three lakes. This would allow for a managed turn-over of each lake and individual offtake sump pumps can be sized relative to the individual lake area. This option requires the installation of the upgraded circulation and reticulation network to be operational.

It is proposed to construct and install the system above-ground to avoid clashes with existing services, for ease of maintenance and as an aesthetic feature, however, this and the location can be altered to suit Council preference. The proposed location is central to all three lakes and located near the maintenance access point and power supply. The proposed location of the treatment system is shown in **Figure 7** along with an example of an installed above-ground system (20 m^2).

Figure 7. Potential Location Ocean Protect Filterra & Example photo of above-ground system (Gold Coast, Aust)

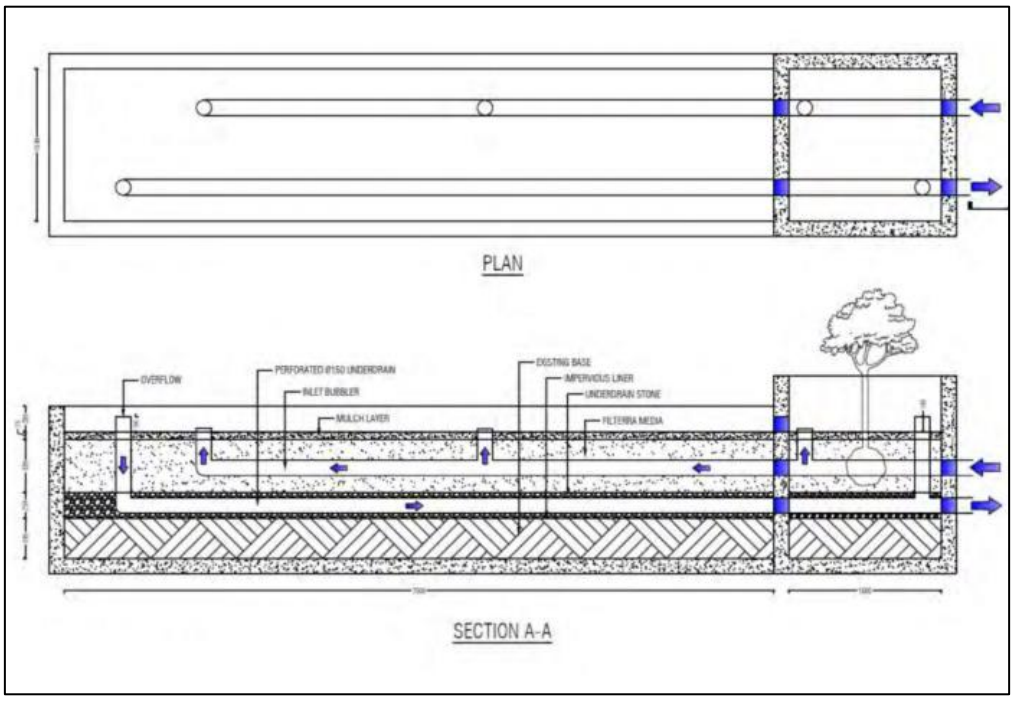


Figure 8. Example Cross-section of Ocean Protect Filterra

The proposal is to extract flows from each of the lake waterbodies and pump through the Filterra system for water quality treatment, then reticulate the water back to the water body. When this proposal is coupled with the lining of the lake, there should be a much more closed water management system, with reduced top-up supply required from the bore supply. There will be some losses through the biofiltration process along with evaporation, however, this is much less than the infiltration losses currently experienced across the lake.

The Filterra system will require maintenance including:

- Overall system inspection, pruning of vegetation (as required) and removal of litter.
- The mulch layer for Filterra biofiltration systems replaced approximately every 12 months.

- Removal of litter and sediment accumulate on the top of the mulch (easily removed and typically disposed to landfill).

- Fresh double-shredded hardwood mulch placed on top of the filter media (to an approximate depth of 75mm) and not removed until the next maintenance visit.

Estimated costs for maintenance are $\$70/m^2$/annum as provided by the supplier for the above maintenance. A copy of the maintenance manual recommended by Ocean Protect is provided in **Appendix C**.

A full product specification and proposal is provided in **Appendix C** and has been used as the basis for the review in this report.

The cost estimate is provided in **Section 4.5 Financial Estimates – Option 2**.

4.2.3 Improvement Option 2B (Inline Floating Wetland)

Option 2B (Inline Floating Wetland) considers a holistic improvement that integrate water supply reductions, improved sustainable water management, water quality treatment and improved circulation of the lake. The objective will be to primarily improve water quality in the lake and maintain suitable water quality year around, and secondly, reduce the demand on the top-up supply (bore water) and create a more self-sustaining lake operation. If the primary objective is to improve water quality, then this option can be implemented without the lake impermeable liner which would reduce the capital cost investment (reduction of approximately $1M), however, this would reduce the benefit in water saving and sustainable water management outcomes.

The proposed structural upgrades are:

a. Water Quality Treatment: SPEL Floating Wetland (FW) Installation.

b. Improved Circulation: retrofit the existing supply line to increase the number of water supply inlets to a minimum of two inlets to each lake and increase the circulatory flow through the lake system.

c. Reduce Infiltration Losses: Install impermeable liner to the lake base and walls.

Note: items a, b & c can be implemented in a staged delivery noting that the optimised outcome will be achieved when all three stages are implemented.

Figure 9 provides a schematic diagram of Option 2B (Inline Floating Wetland).

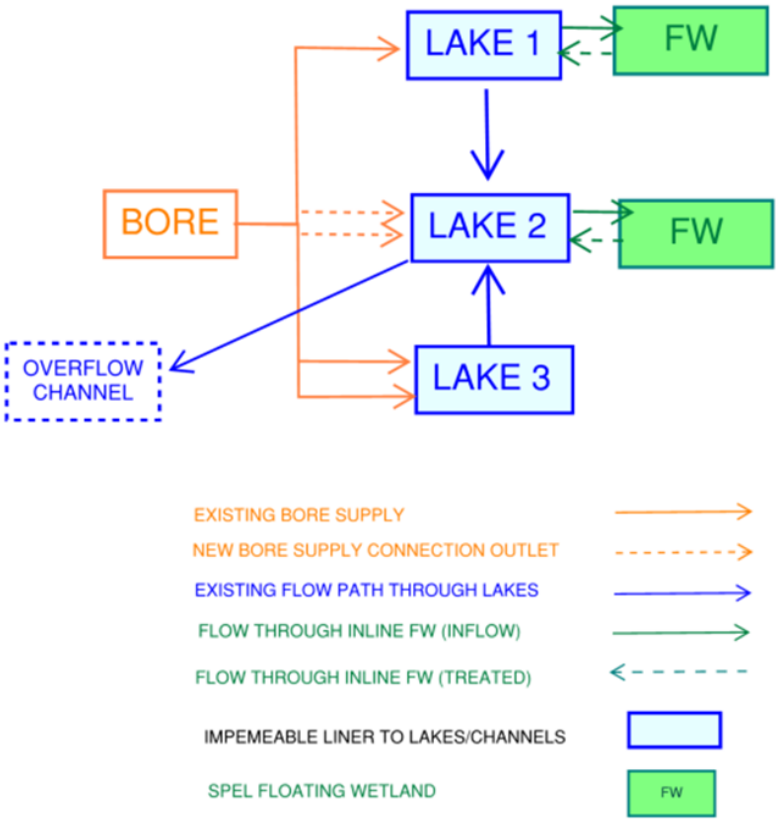


Figure 9. Option 2B (Inline Floating Wetland) Schematic Diagram

Further details on each option are provided below and a sketch of the proposed layout is provided in **Appendix A**.

a. Water Quality Treatment (WQT) – Inline SPEL Floating Wetland

The SPEL Floating Wetland system will filter water and remove nutrients and sediments that contribute to algae blooms and poor water quality outcomes. The Floating Wetland system is a biological treatment that consists of anaerobic and aerobic treatment process on biomass fixed to the plant root and artificial media. The system is a floating matrix that is planted such that the plant roots submerge into the lake below, the planted finish provides an aesthetic outcome. The system can be retrofitted to the existing water body and floats on the surface which allows fluctuation with the lake water levels. For optimum preformation the system requires, suitable circulation in the waterbody to allow flows past the biological system. Improvements to the lake circulation are recommended (as outlined in **Section 4.2.3b**) to support the wetland installation and to allow the lake water to be turn over more frequently, therefore reducing residence time which is critical in managing water quality and to maximise the benefit of the wetland.

It is proposed to install the FW system on Lake 1 and 2, this is based on the understanding that Lake 3 has minimal water quality issues (likely due to the water lily coverage and two freshwater inlets). The proposed location and size of the FW system have been provided by SPEL as are shown schematically in **Figure 10**, **Figure 11** and **Figure 12**. The total area of FwL is 200m^2.

Figure 10. Example photos of SPEL Floating Wetland (https://spel.com.au/floating-wetlands-stormwater/)

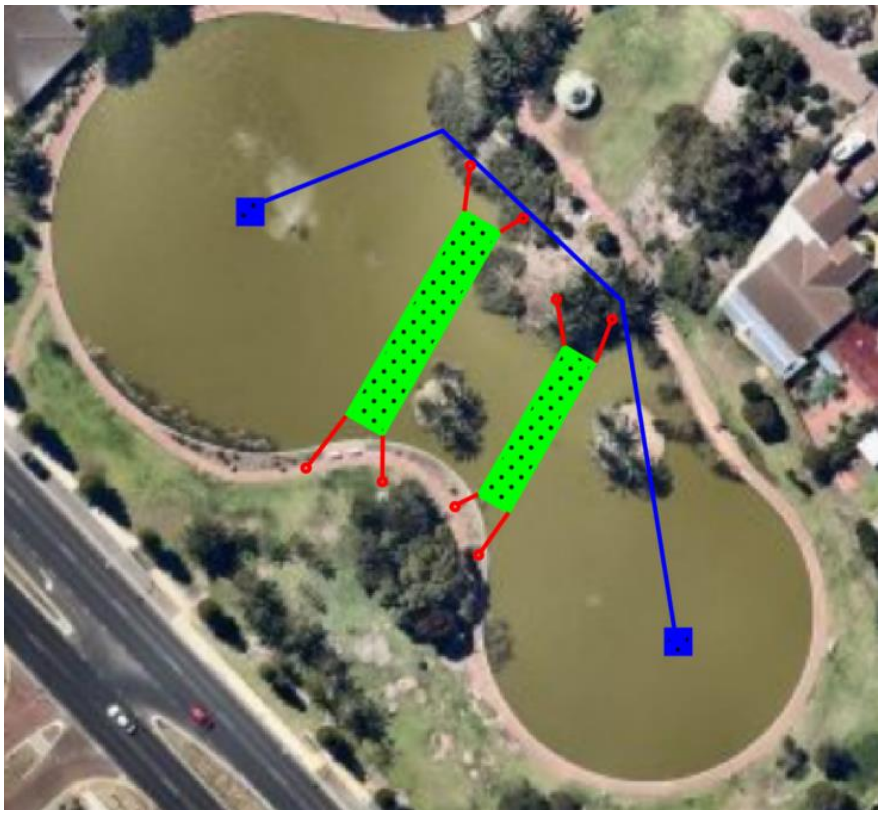


Figure 11. Example of Floating Wetland Installation to Lake 1

Figure 12. Example of Floating Wetland (FW) Installation to Lake 2

The SPEL FW system will be maintained through the establishment period of 1 year by SPEL. During this period there is typically 5-10% die-off and replanting while the scheme establishes. Once the scheme has established there is typically minimal maintenance with the key tasks:

- Check anchor points, stainless steel cables and fixings and replace as necessary (approx. 10+ years).
- Plant coverage and establishment – quarterly to check on physical appearance and health.
- Buoyancy – monitored annually.
- Weed control – twice annually remove any unwanted plants and weeds. (Noting, the FW system is secured to the banks which will allow easy access for maintenance).
- Dredge to capture the sediments that fall out below the FW system – (approx. every 10 years). Note. Unlike the current dredging of the whole of lake, this option will be isolated the area under the FW, and directly adjacent (as the system will capture and remove sediment but with sludge by-product. Therefore, a more manageable and affordable maintenance undertaking than dredging the whole of lake.

The cost estimate is provided in **Section 4.5 Financial Estimates – Option 2.**

A full product specification and proposal is provided in **Appendix C** and has been used as the basis for the review in this report.

b. Improve Lake Circulation and Reticulation Network

The current FwL freshwater supply and recirculation is limited to one freshwater inlets to lake 1, two freshwater inlets to lake 3, overflow to the outlet channel and aerators in each lake. This system is limited and does not promote significant water circulation, particular given the size and shape of the lake bodies which are typically wide and short (ie. not a 3L:1W length to width to promote hydraulic movement).

This Option 2B (Inline Floating Wetland) proposes to retrofit the existing supply line to provide a minimum of two bore water supply inlets to each lake waterbody. These inlets are proposed to provide fresh top-up supply to each of the lake water bodies and improve circulation. The proposal does not provide top-up supply but instead reduce the other inlet flows to all balance the existing top-up supply across all three lakes (pre-rata to the size of the lake waterbody). The location of these inlets is typically close to the existing rising main to minimise cost.

The key components of this design are:

- 3 new bore water supply inlets
- Retrofit connections to the existing bore supply rising main
- Localised pavement reinstatements
- Valve, fixtures and controls
- Electrical supply and augmentation

The cost estimate is provided in **Section 4.5 Financial Estimates – Option 2.**

c. Reduce Infiltration Losses – Impermeable Liner

As outlined for Option 2A, it is understood that there is significant water loss from FwL through the base and wall infiltration. This results in daily top-up supply to maintain the water level, constructing an impermeable liner will reduce this loss. Refer to **Section 4.2.2 Improvement Option 2A (Offline Bioretention) (a)** for details on the proposed liner installation. The cost estimate is provided in **Section 4.5 Financial Estimates – Option 2.**

4.2.4 Structural Improvement – Enhancement Options

A number of options were not shortlisted. These are improvements that when implemented as stand-alone solution will have only minimal or localised benefit. However, when these solutions are implemented in addition to a broader water management strategy, they may provide additional benefit or simplify management practices. Therefore, these opportunities could be considered as enhancements. These improvements are:

Redirection of stormwater away from the waterbody.

Provide a hard-engineered base at select locations to provide maintenance access.

Council can consider the implementation of these solutions as future projects or when opportunities may arise to integrate them into other works.

The other options outlined in the long-list have not been priorities, however are subject to Council's review.

4.3 OPERATIONAL/ MANAGEMENT IMPROVEMENTS

From discussion with Council, and review of the provided data, it appears that waterbody management is part of the overall reserve management. However, as a waterbody there are requirements that differ and can require specialist skills. There are no specific operational and management plans for the waterbody and given this is a natural system with site specific controls,

management will be different to a typical reserve. Further to this, management appears to often be reactive maintenance rather than proactive management, such a remediation of algal blooms rather than prevention of the cause. This is a key operational issue that can be improved and will provide a beneficial outcome to the FwL, in ongoing operational requirements, cost, impacts to the community and long-term maintenance requirements.

4.3.1 Operation and Management Plan

Waterbody management should be clearly defined in an asset management plan with actions to maintain and operate the waterbody outlined in an Operation and Maintenance Plan (O&M Plan). The original design report for the lake had a vision for this O&M and over time due to changing industry practices and external environmental drivers (such as the drought), the practices for the lake have changes. It is noted that some of these changes are valid as best practice management changes and social and environmental responsibly evolves over several decades. However, some of these changes have resulted in impacts to the lake functionality.

Some key operational and management issues that should be required and documented are:

- Regular water quality monitoring
- O&M Plans and schedules for management of waterbody infrastructure (pumps, valves, aerators)
- Routine maintenance (such as removal over overgrown vegetation, or algae blooms)
- Maintain water supply, inflows, and circulation assets
- Undertaken inspections post heavy rain or storm events and remediate damage
- Maintenance plans for water treatment systems in-line with the supplier specification

4.3.2 Reactive Management

The existing lake relies on reactive management to target key issues, such as carp numbers, algal blooms. It is assumed that with suitably designed structural improvements that reactive treatment will no longer be required or will be significantly reduced. Operational costs for Option 2A (Offline Bioretention) and 2B (Inline Floating Wetland) have excluded treatment dosing for algal blooms and have reduced the frequency of carp removal.

4.3.3 Specific Product Review – PURUS Water Treatment

As requested by Council the PURUS Water treatment system was specifically investigated, as outlined in the structural solutions long-list. It is noted however, it is actually a management practice, as it is not a permanent treatment system, instead the injection of ozone is routinely undertaken by PURUS staff under a water quality management agreement. PURUS is a new technology that injects ozone into the lake within nano-bubbles to create O2 radicals that attack and remove algae and pathogens and increase dissolved oxygen. This provides improved water quality, clarity and oxygenation. PURUS have had success in the USA in improving water quality issues in lakes and waterbodies, along with industrial applications, however the technology is still in the development stage.

In reviewing the PURUS system for application in the FwL there are a couple of key risks and consideration that need further review and clarification, as outlined below:

- The PURUS water treatment management plan is charged monthly for a minimum of a 4 year contract. Within this time PURUS are responsible for water monitoring and management of the

treatment. This treatment is therefore an ongoing management obligation and that there are no structural changes to permanently manage water quality.

- This treatment is being developed in the USA, and to date any field testing and reporting is based in the USA. The treatment has not been applied in Australia and it is recommended that prior to implementation the treatment should be subject to field testing and peer review within Australia.

- PURUS are still establishing in Australia therefore the treatment is not likely to be available until 2024 at the earlier, possibly longer subject to local field testing.

- There are no comparable applications of the product within a similar ecosystem, therefore the outcomes or risks are largely unknown.

With the implementation of Option 2A (Offline Bioretention) or 2B (Inline Floating Wetland), management with PURUS treatment is considered unnecessary as the water quality issues should be resolved. However, this option could be considered as an interim management technique during the establishment of the new treatment systems. Alternatively, it could be considered as a management strategy to be paired with Option 1. It is advisable however, that further investigation be undertaken on the product prior to any implementation, due to the limited research or testing within the Australian market.

4.4 WATER SUPPLY SOURCE OPTIONS AND IMPROVEMENTS

Water supply to the lake to allow effective circulation is a key factor in maintaining the water body. It is understood that water supply to the FwL was reduced in the drought from 180ML/a to less than 50ML/a. The original operation of the lake saw a continual flushing of the lake water in-line with water body management standards of < 30 days residence time, in recent years the turnover of water would be of the order > 90days. Residence time in the lake and insufficient turn-over is a critical factor in lake water quality management.

Historically water was flushed through the FwL and into West Lakes the downstream saltwater lake. The water supply for the FwL is from groundwater (bore supply) so the flushing practice results in a net loss in fresh water source, on top of infiltration and seepage loss. This activity of flushing the freshwater was significantly reduced during the drought when restriction on freshwater supply were put in place and this activity was considered unsustainable. It is understood that an artificial lake is a significant water use, and given the losses due to seepage, flushing, evaporation and windblown loss through fountains that the benefits (such as habitat, urban cooling and amenity) need to be carefully considered and balanced.

In the years following the reduction in freshwater supply to the lake, the water quality of the lake suffered due to the reduction in circulation. This in turn resulted in poor water quality in the lake, which in turn led to a decision to cease discharging to the saltwater lake. The EPA restricted untreated discharge to the saltwater lake to prevent the distribution of water quality issue to the downstream environment. The practice remains unviable and restricted by EPA guidelines.

Increasing inflow into the FwL to allow flushing and/or improved circulation, would benefit water quality. A number of alternate water supply options that could be considered for the lake are outlined below. These options could be considered if more sustainable, or if accessibility to the existing bore is restricted in future due to groundwater licensing issues. It is also noted that the salinity if the existing supply bore is relatively high at 1400mg/L, with the lining of the lake this may lead to an increase in lake salinity over time. Sourcing of an alternate lower salinity water source will reduce the risk of increased salinity and will reduce the need to flush the lake routinely to manage the salinity level.

4.4.1 Water Supply Sources Options

The below options can be considered either now, or into the future. As a whole, the options are provided for Council review and consider water supply redundancy which may future proof the design and to avoid water supply issues or risks in the future. At this stage no detailed costing of these options has been undertaken, given the preliminary nature of the assessment and external influences that need further investigation. There has however been the upfront allowance for the reinstatement of the existing bore (or indicative allowance for connection to the recycled water supply source) to maintain the baseline water supply requirement.

4.4.1.1 Existing Bore Supply (Current Source)

The current bore is operational but will need upgrade in the next few years. Increasing the bore extraction rate back to the pre-drought demand would be an increase of over a 100ML/a of additional demand. This historical demand was drawn from the groundwater resource prior to groundwater permits, monitoring, and allocation. It is understood that under the current groundwater licence that this is in-excess of the allowable allocation.

With the implementation of Option 2A (Offline Bioretention) or 2B (Inline Floating Wetland) increasing the supply from the bore is not necessary, and the demand on the bore supply could be reduced by up to 50% with implementation of Option 2A (Offline Bioretention). A couple of risks with the existing bore are the increased salinity, which over time will increase the salinity concentration within the lake, this will need to be managed through periodic flushing or supplementing the source with lower salinity sources (subject to further monitoring and management investigations). The age of the bore means that it will also need reinstatement.

As outlined below, there are alternate sources of supply in the region that may be considered more sustainable and should be further investigated. Given the cost associated with the bore reinstatement sourcing a new supply could be offset by this future capital cost saving. The benefits of this source are however minimal supply costs, with the ongoing costs based on maintenance and pumping only.

4.4.1.2 Mains Water Supply

The site is currently serviced by mains potable water supply. Potable water is a clean source of water that is readily available, at a cost. To source potable water as a top-up supply and/or a flushing supply source would improve the water quality in the lake, but it is an unstainable water use practice. Mains potable water is heavily treated to meet drinking water standards which is an energy intensive practice so from a whole-of-life perspective this is not efficient use. Additionally, the lake does not require this level of treatment and when mixed in the lake the water would no longer be suitable for drinking and would be lost to the downstream system. Sourcing fit-for-purpose water supply is of key importance from a sustainable water management perspective; therefore, this option is considered non-viable.

4.4.1.3 City of Charles Sturt Recycled Water Network

There are options to consider the transfer of treated stormwater from the Waterproofing the West stormwater harvesting and Managed Aquifer Recharge (MAR) scheme to supplement or provide the top-up supply for the FwL. This additional supply could provide either increased inflow to improve lake residence time or periodic flushing.

This option needs to be considered in the context of sustainable water management and the best use of water. This water supply is fit-for-purpose, but is the use of the water in this application the best use within the context of the wider Council demands (ie. could the water be used to irrigate a site currently

sourcing potable water). The knowledge that the water is currently lost in the system, through flushing process (to the saltwater lake), or infiltration and evaporation need to also be considered.

Two options have been considered as outlined below:

- Option 1 is to source supply from the West Lakes Golf course MAR scheme. This supply could meet the entire lake supply demand (currently sourced from the existing Corcoran Drive bore) or supplement this supply. It is understood that there is an existing recycled water network adjacent the FwL that could be augmented as a connection, there would then be internal supply costs allocated by Council to cover the pumping/reticulation network. Alternatively, a new supply line to be constructed from the MAR scheme across to the lake. An initial estimate of cost is that this option is expected to be of the similar order to replacing the existing ASR bore either as a capital expense or over a 25-year design life. Given the risk of salinity levels building-up in the water body with the proposed liner installation and existing supply bore salinity, sourcing the treated stormwater water may provide a better supply source with reduced salinity.

- Option 2 is to further investigate is to consider a 'closed loop' which pumps more water through the lake (sourced from the recycled water network) but with the overflow from the lake to be captured, treated, and then injected into a local injection bore (located at the West Lakes MAR scheme) retaining the water for future recovery and supply. The existing groundwater licence held by Council allows for the groundwater extraction to share the supply allocation across the regional schemes. Therefore, water can continue to be drawn from the existing bore (and at a higher rate to allow lake water quality improvement) on the understanding that the recharge is occurring at the West Lakes Golf Course MAR, with a reduced net loss in water within the recycled water scheme.

  This option would require water quality treatment to the lake water to manage water quality outflows and prevent overloading the West Lakes MAR scheme. It is understood there is a water treatment system at the MAR scheme, however pre-treatment as a minimum should occur at-source ie. Option 2A (Offline Bioretention) and 2B (Inline Floating Wetland).

4.4.1.4 Local Catchment Stormwater Harvesting

A new stormwater harvesting scheme could be investigated which captures the local stormwater drainage, treats, stores and then recycles the water through the FwL. This outcome would reduce the discharge of stormwater and contaminants to the saltwater lake from stormwater and the FwL, and capture the water for more sustainable water use. This scheme would have multiple benefits, however it may not be the most cost effective solution (particularly given the access to the bore water currently at low cost). As an indication the development of a stormwater harvesting scheme sourcing the local catchment would conceptually require and yield:

- **Stormwater Diversion:** Assuming (A) diversion of two x 750mm diameter stormwater drains in Corcoran Drive, adjacent directed back to the reserve and to the south. (B) diversion of the larger catchment picking up Island Drive diverted to the Corcoran Drive reserve.

- **Urban Catchment Area (ha):** 6ha / 15ha

- **Treatment system footprint (if designed into the reserve as a wetland):** 1,800m^2/ 4,500m^2

- **Yield Potentia**l: 8ML/a/ 20ML/a

The smaller stormwater harvesting scheme (when treated) could be used as a supplementary source to reduce the demand on the existing bore, and/or provide periodic flushing through the lake. Further investigation of this option is required to assess the feasibility in more detail.

4.4.1.5 Closed Loop System - Option 2A (Offline Bioretention)

Option 2A (Offline Bioretention) is to develop a closed system with reticulation of the lake water through an off-line treatment process. This option when coupled with a new impermeable liner to the lake will provide a significant reduction in demand from external water sources (ie. the bore). The bore water top-up supply would reduce as an estimate to 15ML/a (to offset evaporation, minor seepage and losses in the system), this is a 50% reduction in demand. Subject to the quality of the supply water however, there is a risk that salinity levels in the lake will increase, therefore this will need to be balanced within either periodic flushing to lower the salt concentrations or sourcing low salinity supply.

4.4.2 Water Supply Source Recommendations

The recommendation for water supply source improvements is to undertake further investigations into the available alternate water supplies to determine the most efficient sources from a risk, constructability, staging, economic and environmentally sustainable perspective. Given the external influences on these sources further monitoring and investigation is required.

For the purpose of Option 2 and with the understanding that the source water supply is critical to the operation of the FwL the following assumptions have been made on source water supply in Option 2, with further investigations to refine and/or improve this based on future works.

- Reinstatement of the existing bore to meet the minimum supply requirements, including periodic flushing of the lake to manage salinity concentration as required; or

- Sourcing the recycled water supply from the West Lakes MAR scheme to supplement or meet the demand. This may be considered a more viable option than reinstating the existing bore.

These sources are considered sustainable and available to meet the minimum requirements and additional flushing to manage water quality as needed. The preferred source would be subject to a detailed assessment and comparison of options.

4.5 FINANCIAL ESTIMATES – OPTION 2

4.5.1 Capital Costs

Capital costs have been based on the cost to implement structural changes to the FwL based on the Option 2A (Offline Bioretention) and Option 2B (Inline Floating Wetland) as outlined above. As outlined in **Section 3.2.1 Capital Cost (Option 1)** assets will need to be reinstated over time based on the design life. These costs have been excluded as they are constant across the options and are assumed to be budgeted on an as need basis and managed by Council's asset management team.

4.5.2 Operational Costs

Ongoing operation is required to maintain the upgraded FwL, this will include some of the existing activities and additional activities as required for the upgraded design. The operational costs maintain the level of service expected for safe operation, aesthetics, environmental management, and safety. The operational costs will be both regular annual maintenance and larger major upgrade works that will be undertaken periodically (such as dredging or structural repair).

The operational costs have been broken-down into the following key areas:

- **Waterbody Management**
  - **Landscape - Aquatic**: These costs include management of assets within or part of the waterbody. (ie. sediment removal/dredging, aquatic planting, outlets and lake infrastructure maintenance).
  - **Water Supply – Lake Top -up**: These costs relate to the supply of top-up water to service the FwL only. The supply costs include cost of water, permits, bore operation costs, pro-rata from the total based on the demand. The costs for irrigation of the terrestrial landscape are accommodated in Open Space Reserve (Terrestrial) Management.
  - **Electrical:** These costs relate to the supply of top-up water to service the FwL only. The cost has been assumed pro-rata based on the total electrical cost provided for both the waterbody and the terrestrial landscape. The costs for irrigation of the terrestrial landscape are accommodated in Open Space Reserve (Terrestrial) Management.
  - **Water Quality Treatment & Remediation**: These costs include the current techniques used to manage water quality issues (ie. aerators, carp management, algae removal and/or chemical dosing). Noting these treatments have been reactive over the past decade, and will likely be required periodically (note annually), therefore the average annual cost has been assumed.
- **Open Space Reserve (Terrestrial) Management**
  - **Landscape – Terrestrial**: Cost includes management of the assets within the reserve surrounding the lake. (ie. lawn mowing, irrigation of garden beds/ lawn, waste management, cleaning, repair of landscape furniture.) This cost has been grouped as one separate category as the purpose of the options review is to assess upgrades to the waterbody (with no change in waterbody surface area), therefore these costs are expected to remain relatively constant across the options.
  - **Water supply- Irrigation:** These costs relate to the supply of top-up water to service the FwL only. The supply costs include cost of water, permits, bore operation costs, pro-rata from the total based on the demand. The costs for top-up of the waterbody are accommodated in Waterbody Management.
  - **Electrical –** Costs include irrigation pump costs and lighting. The cost has been assumed pro-rata based on the total electrical cost provided for both the waterbody and the terrestrial landscape.
  - Note: the operational costs for the Open Space Reserve (Terrestrial Management) are unchanged between Option 1 and 2A (Offline Bioretention) & 2B (Inline Floating Wetland).

4.5.3 Upfront Costs

As outlined in Option 1, there are two baseline improvements that need to be undertaken independent of the option selected due to the current status of the waterbody and associated infrastructure. These upgrades are desludging of the lake and upgrading the source water supply. These upgrades are upfront costs for all options outlined in this report which will reset the lake to a baseline prior to assessment of the options moving forward. The source water supply upgrade is considered as capital expenditure whereas the lake desludging is considered as an upfront operational cost. These major cost considerations are further outlined in **Section 4.5.6 Major Costs.**

4.5.4 Cost Estimate Summary – Option 2

Table 15. Option 2 – Upfront Operational Costs

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	SLUDGE REMOVAL	$ 979,000
	SUBTOTAL - A	**$ 979,000**
	CONTINGENCY (30%)	$ 293,700
	CONSTRUCTION TOTAL	**$ 1,273,000**

Table 16. Option 2A (Offline Bioretention) – Capital Costs

Item	DESCRIPTION	AMOUNT ($)
B	**FRESHWATER LAKE - OPTION 2A**	
1	WATER SUPPLY SOURCE	$ 150,000
2	LAKE LINER	$ 998,000
3	CIRCULATION - LEVEL 2 - FULL RETICULATION	$ 131,000
4	WATER TREATMENT	$ 255,000
5	MANAGEMENT	$ 10,000
	SUBTOTAL	**$ 1,544,000**
	CONTINGENCY (30%)	$ 463,200
	CONSTRUCTION TOTAL	**$ 2,008,000**

Table 17. Option 2A (Offline Bioretention) – Operational Costs (Annual)

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	LANDSCAPE - AQUATIC	$ 39,000
2	WATER SUPPLY - LAKE TOP-UP	$ 6,000
3	ELECTRICITY	$ 3,000
4	WATER QUALITY TREATMENT & REMEDIATION	$ 8,000
	SUBTOTAL - A	**$ 56,000**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**	
5	LANDSCAPING - TERRESTRIAL	$ 56,000
6	WATER SUPPLY - IRRIGATION	$ 2,000
7	ELECTRICITY	$ 11,000
	SUBTOTAL - B	**$ 69,000**
C	**OPTION 2A - TREATMENT UPGRADES**	
8	LAKE LINER	$ 7,000
9	CIRCULATION - LEVEL 2 - FULL RETICULATION	$ 8,000
10	WATER TREATMENT	$ 23,000
11	MANAGEMENT	$ 34,000
	SUBTOTAL - C	**$ 72,000**
	SUBTOTAL - A + B + C	**$ 197,000**
	CONTINGENCY (30%)	$ 59,100
	CONSTRUCTION TOTAL	**$ 257,000**

Table 18. Option 2B (Inline Floating Wetland) – Capital Costs

B	**FRESHWATER LAKE - OPTION 2B**	
1	WATER SUPPLY SOURCE	$ 150,000
2	LAKE LINER	$ 998,000
3	CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY	$ 32,000
4	WATER TREATMENT	$ 200,000
5	MANAGEMENT	$ 5,000
	SUBTOTAL	**$ 1,385,000**
	CONTINGENCY (30%)	$ 415,500
	CONSTRUCTION TOTAL	**$ 1,801,000**

Table 19. Operational Costs (Annual) – Option 2B (Inline Floating Wetland)

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	LANDSCAPE - AQUATIC	$ 39,000
2	WATER SUPPLY - LAKE TOP-UP	$ 7,000
3	ELECTRICITY	$ 4,000
4	WATER QUALITY TREATMENT & REMEDIATION	$ 8,000
	SUBTOTAL - A	**$ 58,000**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**	
5	LANDSCAPING - TERRESTRIAL	$ 57,000
6	WATER SUPPLY - IRRIGATION	$ 2,000
7	ELECTRICITY	$ 11,000
	SUBTOTAL - B	**$ 70,000**
C	**OPTION 2B - TREATMENT UPGRADES**	
8	LAKE LINER	$ 7,000
9	CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY	$ 1,000
10	WATER TREATMENT	$ 9,000
11	MANAGEMENT	$ 34,000
	SUBTOTAL - C	**$ 51,000**
	SUBTOTAL - A + B + C	**$ 179,000**
	CONTINGENCY (30%)	$ 53,700
	CONSTRUCTION TOTAL	**$ 233,000**

4.5.5 Assumptions

Cost estimates have been based on information provided by Council including budget records and maintenance activity report. WGA have also applied rates based on our understanding of the lake management it is expected that costs will be incurred to maintain the lake in its current form. Rate assumptions by WGA are based on industry experience and similar project and are Opinion of Probable Cost (OPC). A 30% contingency has been applied to all costs due to the preliminary nature of the investigation.

Costs exclude site investigation, design fees and project management costs.

Electrical costs associated with the additional pumping and/or electrical augmentation have not been fully investigated based on the preliminary nature of the investigation. This would need to be investigated in detail as part of the detailed design and cost estimates.

It should also be noted that the Option 2 capital cost estimates assume that the lake liner upgrade is undertaken in parallel with desludging. If not, additional costs for desludging and dewatering may apply.

A summary table of the rates assumptions for all cost estimates outlined in the report is provided in **Appendix B**.

4.5.6 Major Costs

There are two major costs specific to the water body management that need to be considered further.

Desludging of the Lake

Desludging requirements are significantly reduced for Option 2A (Offline Bioretention) and 2B (Inline Floating Wetland). It is assumed that desludging will be reduced to every 20-30 years if Option 2A (Offline Bioretention) is implemented (but based on the whole of lake as outlined in **Table 19**. Desludging for Option 2B (Inline Floating Wetland) will be reduced in scope as outlined below.

Desludging will be required under the Floating Wetland System only, every 10 years. This is an ongoing operational cost that will be required routinely and has been included in the above operational cost assumptions pro-rata to an annual cost. The desludging cost remains a high-risk item, due to the high cost and the potential unknowns including the sludge volume, contamination classification and the waste disposal cost. The cost estimate undertaking as part of this report (for Option 2) has assumed the parameters outlined below, however given the limit on information such as measure of sludge depth or contamination testing these are preliminary.

Table 20. Desludging Parameters – Floating Wetland

Parameter		Assumption
Sludge volume for removal (whole of lake)	300 Tonnes	Based on 300mm sludge across 1/3 of the lake area. 2.0 bulking factor to account for wet sludge.
Sludge Disposal Costs	Low Level Contaminated Waste	$278.30/ tonne
	Intermediate Waste	$38.50 / tonne
Contamination classification	Low Level Contaminated Waste*	100% of total volume.
	Intermediate Waste*	0% of total volume.

*Based on Resource Co. Rates current May 2022.

This assessment has assumed the upper limit with all materials classified as low-level contaminated waste. There is potential for this to reduce and part of the sludge volume be classified as intermediate waste which would reduce the cost, however, given the limited information and lack of testing the higher classification has been adopted. The reduction in volume therefore reduces the cost risk, however, should the contamination, volume, or cost of disposal increase then the cost will also increase proportionately. To manage these risks Council should undertake site investigations and testing prior to committing to the works to refine the assumptions on volume and contamination level.

Replacement of the Extraction Bore

On review of the publicly available bore database, and the extraction bore construction, the bore is near the limit of its design life and is due for replacement. Steel casing within water wells typically last 25-50 years depending on water quality parameters and steel composition. Water quality parameters within the aquifer at Delfin Island have relatively low corrosive properties, however the bore is nearly 50 years old. Therefore, this bore will need to be replaced in the next few years to remain operational to the current standard of operation and water quality. As outlined in **4.4.2 Water Supply Source Recommendations,** Council recycled water supply may be implemented in place of the replacement bore, the cost of augmenting a new source are likely to be of the order of the replacement bore cost and as such the cost allowance is unchanged.

5 SOCIAL AND ENVIRONMENTAL FACTORS

Social and environmental factors are important in undertaking a holistic assessment of the FwL and required management. In addition to assessment of the financial costs, to address the budget and financial impacts of the asset under each option. The social and environmental factors must also be understood and further considered by Council as part of the overall options assessment and ranking. The below outlines the social and environmental factors including benefits and considerations for the options reviewed.

As the scope of the assessment excludes a recommendation of the preferred solution (ie. Option 1 or Option 2) this qualitative assessment is considered suitable, and an important step to provide a comprehensive review. It is recommended that Council consider the below factors in assessing and understanding the FwL management. Council should also, as part of the formal review process and selection of best solution, should assign value based to the social and environmental factors as part of a multi-criteria assessment and options selection process. These values can be based on the drivers and expected level.

5.1.1 Social

Social factors, and social sustainability is about providing a place that promotes wellbeing and considers the community on all levels. The benefits and considerations can include impacts to the local residents, workforce and broader community, physical and mental health, cultural heritage, legacy, engagement with the community.

Social benefits and considerations relevant to each options are outlined in **Table 21**.

Table 21. Social - Benefits and Considerations

SOCIAL BENEFITS			
	Option 1	**Option 2A**	**Option 2B**
Community Value	X	X	X
Placemaking	X	X	X
Increase residential valuation	X	X	X
Public open space	X	X	X
High amenity value	X	X	X
Connection to community	X	X	X
Public health and safety improved with better water quality		X	X
Sustainable water management and education showcase opportunities		X	X
SOCIAL CONSIDERATIONS			
Capital and operational cost to ratepayers		X	X
Limited or no indigenous cultural value	X	X	X
Ibis management/ pest management (public health)	X		
New technology is proposed and there is a risk that the outcomes don't match public opinion		X	
Loss of open water views or reduction in open water			X
Operation noise and/or loss of open space for plant		X	

5.1.2 Environmental

Environmental factors include the natural environment, impacts on the surrounding environment (such as waste, noise, pollution, temperature, noise), ecology, biodiversity, short-term and long-term impacts, energy and carbon, sustainable use of natural resources.

Environmental benefits and consideration relevant to each option are outlined in **Table 22**.

Table 22. Environmental - Benefits and Considerations

ENVIRONMENTAL BENEFITS			
	Option 1	**Option 2A**	**Option 2B**
Increased biodiversity and freshwater ecosystem		X	X
Improved water quality and habitat		X	X
Sustainable water management and reduction in top-up demand		X	X
Retention of an open water body	X	X	
Urban cooling	X	X	X
Canopy cover	X	X	X
Public open space, with open water	X		
ENVIRONMENTAL CONSIDERATIONS			
Unsustainable water use, high losses and top-up supply required.	X		
Pest species and issue to native and local environment.	X		
Water quality risk to the downstream receiving waters and local ecosystems	X		
Environmental costs of maintenance materials, by-products and energy	X	X	X
Energy use		X	X
Materials used in operation, supply and/or construction.		X	X

6 CONCLUSIONS

The objective of the study is to review the management and operations of the FwL and see if there can be improvements made in the future. This report provides Council with:

- Clarity on the current operations, management, risks and costing to retain the FwL in its current form with existing maintenance and management practices.
- Estimated operational, management and costs relating to the lake in its current form with structural and management improvements to permanently enhance lake performance and quality, operations, and management. To allow comparison to the existing and determine the value future works.
- Provide a number of short-listed improvement options that can be considered to improve the FwL operations and management into the future.
- A comparison of costs and estimate of likely costs to improve the FwL.
- Assessment of key social and environmental factors to be considered as part of a multi-criteria assessment.

This is a high-level assessment based on desktop information only, and all options are subject to further site investigation, testing, detailed assessment and detailed design.

6.1 COST COMPARISON

The FwL is a key asset to the community and a unique Council operated passive and recreational asset. On review of both Option 1 and 2 it is noted there are significant financial investment associated with the maintenance of the lake in its current form and to improve the lake operations into the future. This will need to be considered along with the social and environmental benefits of the lake by Council when determining the future works associated with the lake.

A summary of the cost break downs for the Options 1, 2A (Offline Bioretention) and 2B (Inline Floating Wetland) are outlined in **Table 23**.

Table 23. Summary of Costings

OPTION	UPFRONT OPERATIONAL COST	CAPITAL COST	OPERATIONAL COST
Option 1	$1,273,000	$195,000	$288,000
Option 2A (Offline Bioretention)	$1,273,000	$2,008,000	$257,000
Option 2B (Inline Floating Wetland)	$1,273,000	$1,801,000	$233,000

Detailed breakdown and assumptions are provided in the body of the report.

6.2 STAGING AND IMPLEMENTATON

Staging and implementations of improvements need to be well considered to minimise the impact on the community and reduce construction disruptions on site. In order to mitigate construction risk, initial investigations should be undertaken to understand the site conditions (ie. geotechnical) and which will assist to define the appropriate construction methodology.

Indicatively the construction timeframes for works on site (excluding permit approvals, tender, design or approvals) for the proposed works would be:

- Desludging: 6-8 weeks per lake, total 20 weeks. (Note: It is assumed that each of the 3 lakes are dredged separately to allow refuge for flora and fauna during the process and minimise the impact to the community).

- Lake Lining: 2-4 weeks per lake, total 10 weeks. (Note: It is assumed that each of the 3 lakes are lined separately to allow refuge for flora and fauna during the process and minimise the impact to the community). The lining will be undertaken directly after the desludging, as additional time.

- Circulation Improvements: 4-8 weeks. (Note. Electrical augmentation can have a longer lead time (up to 6 months) due to authority installations and approval periods).

- Water Treatment System Installations: 2-6 weeks (Note: establishment period can be up to 12 months, until the full treatment rate is achieved).

Some of the improvement options also rely on the installation of certain assets to be functional, ie. power supply for pumps, reticulation network to the water treatment system.

As Council review this report this staging and implementation should be considered. Both Option 2A (Offline Bioretention) and 2B (Inline Floating Wetland) have been selected as a suite of improvement to provide an optimum outcome, and if implemented in part may not achieve the required outcome.

As part of the preliminary and detailed design phase the designer will need to work closely with Council to manage this inter-relationship along with seasonal staging requirements and allow for required lead times for approvals and permits.

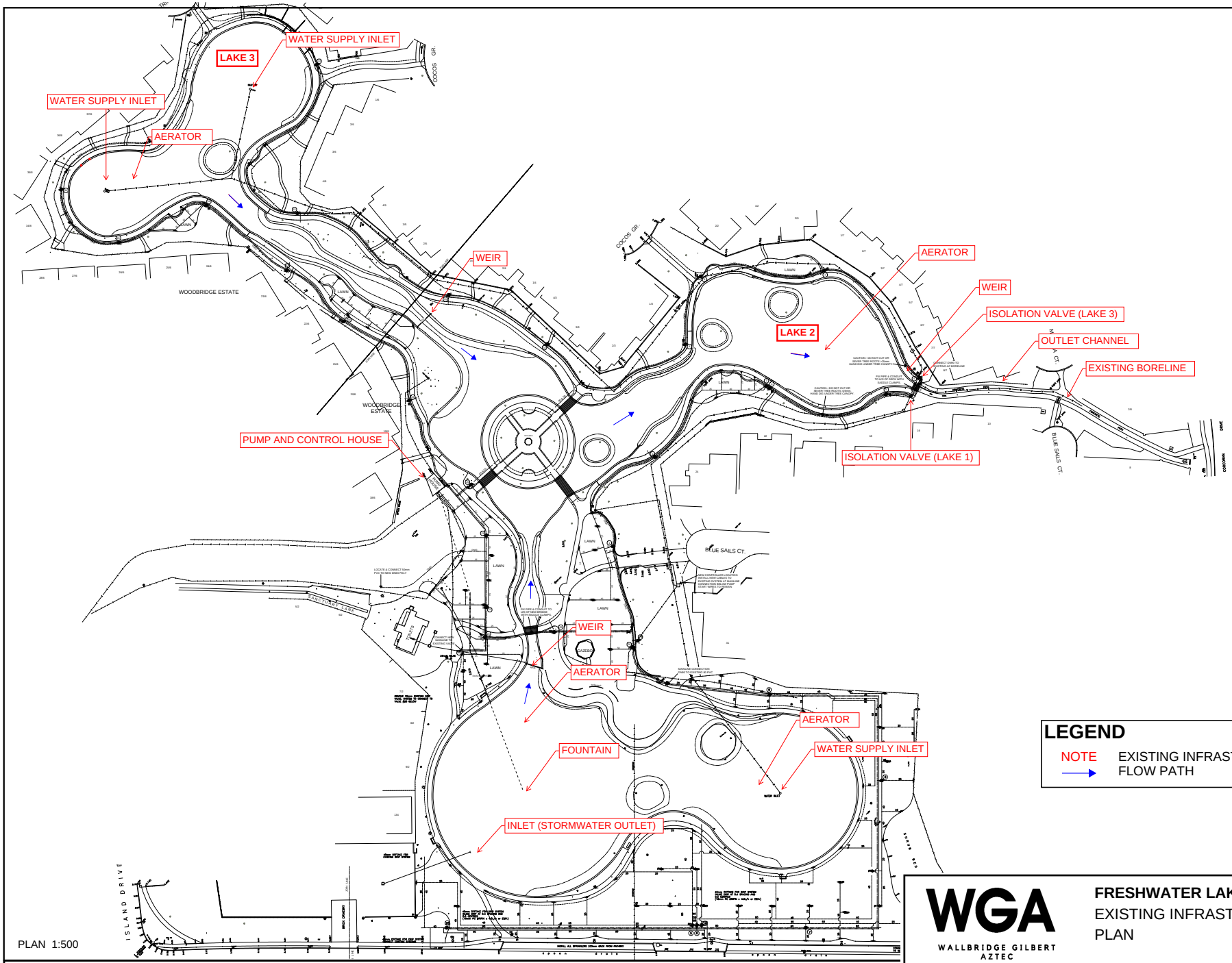
6.3 LIMITATIONS AND ADDITIONAL INVESTIGATIONS

The following key limitations and additional investigations should be undertaken prior to final budgets and detailed design.

- Confirm the sludge parameters in the existing lake:
  - Contamination testing of the sludge, sampling at multiple locations across the lake to confirm the expected contamination level of materials to be removed from site.
  - Assess the depth of sludge across the lakes, measure depth to base comparable to the design depth.
- Undertake geotechnical investigations to consider the groundwater level, and underlying earthworks to determine a suitable construction methodology for the lake liners and existing infiltration rates to inform a detailed water balance.
- Review the water supply options, salinity levels and opportunities to diversify the supply and/or source more sustainable solution.
- Undertake site investigations to confirm design solutions.
- Undertake preliminary design, feasibility through to detailed design to produce the design solutions and costing.
- Electrical costs associated with the additional pumping and/or electrical augmentation have not been fully investigated based on the preliminary nature of the investigation. This would need to be investigated in detail as part of the detailed design and cost estimates.

APPENDIX A

SITE PLANS (INFRASTRUCTURE, OPTION 2A - OFFLINE BIORETENTION & 2B - ONLINE FLOATING WETLAND)



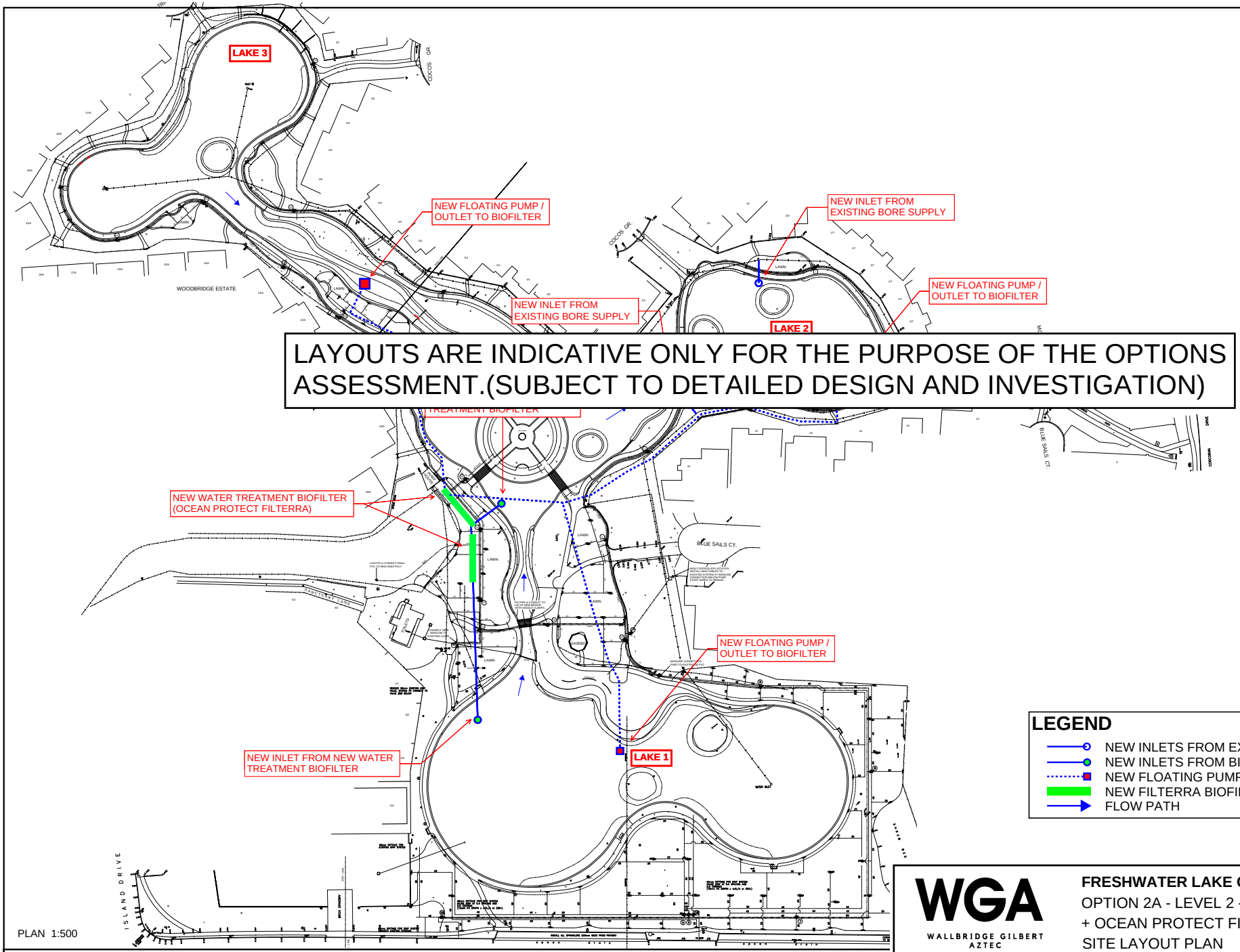
PLAN 1:500

WGA
WALLBRIDGE GILBERT AZTEC
60 Wyatt Street, Adelaide
South Australia 5000
Telephone 08 8223 7433
Email adelaide@wga.com.au

FRESHWATER LAKE OPTIONS ASSESSMENT

EXISTING INFRASTRUCTURE - SITE LAYOUT PLAN

A1	DRAWING NUMBER		
	Job Number	Sheet No.	Rev.
Design EH	Drawn RD	WGA181900-DR- SK-0001	A



LAYOUTS ARE INDICATIVE ONLY FOR THE PURPOSE OF THE OPTIONS ASSESSMENT.(SUBJECT TO DETAILED DESIGN AND INVESTIGATION)

PLAN 1:500

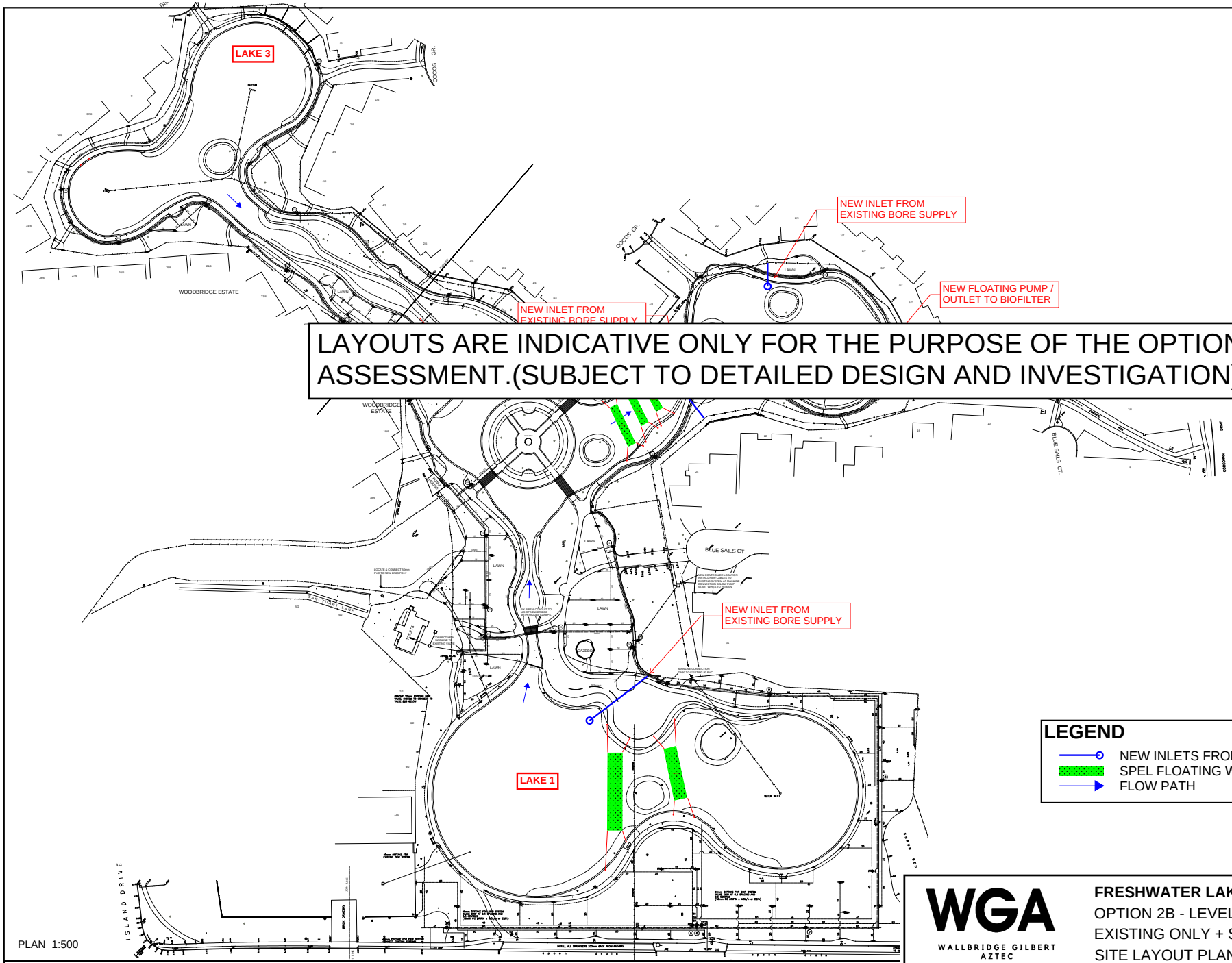
LEGEND

- NEW INLETS FROM EXISTING BORE SUPPLY
- NEW INLETS FROM BIOFILTER
- NEW FLOATING PUMP AND PRESSURE PIPE
- NEW FILTERRA BIOFILTER
- FLOW PATH

WGA
WALLBRIDGE GILBERT AZTEC
60 Wyatt Street, Adelaide
South Australia 5000
Telephone 08 8223 7433
Email adelaide@wga.com.au

FRESHWATER LAKE OPTIONS ASSESSMENT
OPTION 2A - LEVEL 2 - FULL RETICULATION + OCEAN PROTECT FILTERRA BIOFILTER
SITE LAYOUT PLAN

A1	DRAWING NUMBER Job Number	Sheet No.	Rev.
Design EH	Drawn RD	WGA181900-DR- SK-0001	A



LAYOUTS ARE INDICATIVE ONLY FOR THE PURPOSE OF THE OPTIONS ASSESSMENT.(SUBJECT TO DETAILED DESIGN AND INVESTIGATION)

LEGEND

- NEW INLETS FROM EXISTING BORE SUPPLY
- SPEL FLOATING WETLAND
- FLOW PATH

PLAN 1:500

WGA
WALLBRIDGE GILBERT AZTEC
60 Wyatt Street, Adelaide
South Australia 5000
Telephone 08 8223 7433
Email adelaide@wga.com.au

FRESHWATER LAKE OPTIONS ASSESSMENT
OPTION 2B - LEVEL 1 - NEW INLETS OFF EXISTING ONLY + SPEL FLOATING WETLAND
SITE LAYOUT PLAN

A1	DRAWING NUMBER Job Number	Sheet No.	Rev.
Design EH	Drawn RD	WGA181900-DR- SK-0001	A

APPENDIX B

COST BREAKDOWN AND ASSUMPTIONS

CITY OF CHARLES STURT - FRESHWATER LAKE
UPFRONT OPERATIONAL COSTS

Consultant: WGA
Revision: A

Date 7/06/2022
Job No. WGA212611
Eng RD

SUMMARY

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	SLUDGE REMOVAL	$ 979,000
	SUBTOTAL - A	**$ 979,000**
	CONTINGENCY (30%)	$ 293,700
	CONSTRUCTION TOTAL	**$ 1,273,000**

BREAKDOWN

Item	DESCRIPTION	UNIT	QUANTITY	RATE ($)	AMOUNT ($)
A	**WATERBODY MANAGEMENT**				
1	**SLUDGE REMOVAL**				
	Sludge Removal	Item	1	$ 978,700.00	$ 978,700.00
				Subtotal	**$ 978,700.00**
				SUBTOTAL - LAKE LINER	**$ 979,000.00**
				A - WATERBODY MANAGEMENT - SUBTOTAL	**$ 979,000.00**

Subtotal	$ 979,000.00
Contingency (30%)	$ 293,700.00
TOTAL	**$ 1,273,000.00**

This estimate is based on estimated prices from recent projects and on the information available to Wallbridge Gilbert Aztec (WGA) at the time of preparing the estimate.
WGA does not accept any liability for actual costs varying from those estimated.

Notes, Exclusions & Assumptions:

- GST excluded
- CITB Levy excluded
- Site investigations, Design and Project Management Fees

CITY OF CHARLES STURT - FRESHWATER LAKE
OPTION 1 - CAPITAL COST ESTIMATE

Consultant: WGA
Revision: A

Date 7/06/2022
Job No. WGA212611
Eng RD

SUMMARY

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	WATER SUPPLY SOURCE	$ 150,000
	SUBTOTAL - A	**$ 150,000**
	CONTINGENCY (30%)	$ 45,000
	CONSTRUCTION TOTAL	**$ 195,000**

BREAKDOWN

Item	DESCRIPTION	UNIT	QUANTITY	RATE ($)	AMOUNT ($)
A	**WATERBODY MANAGEMENT**				
1	**WATER SUPPLY SOURCE**				
	ASR Bore Upgrade	Item	1	$ 150,000.00	$ 150,000.00
				Subtotal	**$ 150,000.00**
				SUBTOTAL - LAKE LINER	**$ 150,000.00**
				A - WATERBODY MANAGEMENT - SUBTOTAL	**$ 150,000.00**

Subtotal	$ 150,000.00
Contingency (30%)	$ 45,000.00
TOTAL	**$ 195,000.00**

This estimate is based on estimated prices from recent projects and on the information available to Wallbridge Gilbert Aztec (WGA) at the time of preparing the estimate.
WGA does not accept any liability for actual costs varying from those estimated.

Notes, Exclusions & Assumptions:

- *GST excluded*
- *CITB Levy excluded*
- *Site investigations, Design and Project Management Fees*
- *Assumes Upfront Operational Cost for Desludging has been undertaken prior*

CITY OF CHARLES STURT - FRESHWATER LAKE
OPTION 1 - OPERATIONS COST ESTIMATE (ANNUAL)

Consultant: WGA
Revision: A

Date 7/06/2022
Job No. WGA212611
Eng RD

SUMMARY

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	LANDSCAPE - AQUATIC	$ 110,000
2	WATER SUPPLY - LAKE TOP-UP	$ 20,000
3	ELECTRICITY	$ 5,000
4	WATER QUALITY TREATMENT & REMEDIATION	$ 16,000
	SUBTOTAL - A	**$ 151,000**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**	
6	LANDSCAPING - TERRESTRIAL	$ 56,000
7	WATER SUPPLY - IRRIGATION	$ 3,000
8	ELECTRICITY	$ 11,000
	SUBTOTAL - B	**$ 70,000**
	SUBTOTAL - A + B	**$ 221,000**
	CONTINGENCY (30%)	$ 66,300
	CONSTRUCTION TOTAL	**$ 288,000**

BREAKDOWN

Item	DESCRIPTION	UNIT	QUANTITY	RATE ($)	AMOUNT ($)
A	**WATERBODY MANAGEMENT**				
1	**LANDSCAPE - AQUATIC**				
	Sludge Removal	Item	1	$ 97,870.00	$ 97,900.00
				Subtotal	**$ 97,900.00**
	Soft edge plantings				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
				Subtotal	**$ 3,600.00**
	Clear Stormwater Pits, Outlets, Screens etc				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
				Subtotal	**$ 3,600.00**
	Monitor and removal overgrown vegetation around lake				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
	Disposal fee	Item	1	$ 500.00	$ 500.00
				Subtotal	**$ 4,100.00**
				SUBTOTAL - LANDSCAPING - AQUATIC	**$ 110,000.00**
2	**WATER SUPPLY - LAKE TOP-UP**				
	Water Supply (Bore)	ML	40	$ -	$ -
				Subtotal	**$ -**
	Manual pumping at Corcoran Dr Reserve				
	Staff x 1	Day	13	$ 880.60	$ 11,500.00
	Tools	Item	10%	$ 11,500.00	$ 1,200.00
				Subtotal	**$ 12,700.00**
	Maintain Bore	Day	2	$ 880.60	$ 1,800.00
				Subtotal	**$ 1,800.00**
	Bore Lift Pump	Item	1	$ 2,400.00	$ 2,400.00
				Subtotal	**$ 2,400.00**
	Groundwater Quality Testing	Item	1	$ 1,600.00	$ 1,600.00
				Subtotal	**$ 1,600.00**
	Maintain bore rising main	Item	1	$ 800.00	$ 800.00
				Subtotal	**$ 800.00**
				SUBTOTAL - WATER SUPPLY - LAKE TOP-UP	**$ 20,000.00**
3	**ELECTRICITY**				
	Bore pump, aerators, etc.	Item	1	$ 4,500.00	$ 4,500.00
				Subtotal	**$ 4,500.00**
				SUBTOTAL - ELECTRICITY	**$ 5,000.00**
4	**WATER QUALITY TREATMENT & REMEDIATION**				
	Algae Control (Coptrol)				
	Dosing (high-dose)	No	1	$ 2,824.56	$ 2,900.00
	Staff x 1	Day	2	$ 880.60	$ 1,400.00
				Subtotal	**$ 4,300.00**
	Carp removal	No	1	$ 2,097.12	$ 2,100.00
				Subtotal	**$ 2,100.00**
	Aerators	Item	1	$ 4,500.00	$ 4,500.00
				Subtotal	**$ 4,500.00**
	Water quality testing	Item	1	$ 1,800.00	$ 1,800.00
				Subtotal	**$ 1,800.00**
	Misc.	Item	1	$ 2,861.95	$ 2,900.00
				Subtotal	**$ 2,900.00**
				SUBTOTAL - WATER QUALITY TREATMENT & REMEDIATION	**$ 16,000.00**
				A - WATERBODY MANAGEMENT - SUBTOTAL	**$ 151,000.00**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**				
5	**LANDSCAPING - TERRESTRIAL**				
	Bridges	Item	1	$ 2,636.41	$ 2,700.00
				Subtotal	**$ 2,700.00**
	Art Work	Item	1	$ 19.76	$ 100.00
				Subtotal	**$ 100.00**
	Shelter	Item	1	$ 656.26	$ 700.00
				Subtotal	**$ 700.00**
	BBQ	Item	1	$ 2,300.00	$ 2,300.00
				Subtotal	**$ 2,300.00**
	Irrigation System	Item	1	$ 2,800.00	$ 2,800.00
				Subtotal	**$ 2,800.00**
	Monitor and trim Ibis palms				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
	Boat	Day	2	$ 1,000.00	$ 2,000.00
	Tools	Item	10%	$ 5,600.00	$ 600.00
	Disposal fee	No	1	$ 500.00	$ 500.00
				Subtotal	**$ 6,700.00**

	Footpaths	Item	1	$ 18,200.00	$ 18,200.00
				Subtotal	**$ 18,200.00**
	Fences	Item	1	$ 4,500.00	$ 4,500.00
				Subtotal	**$ 4,500.00**
	Toilet Block				
	Asbestos Inspection	Item	1	$ 100.00	$ 100.00
	Cleaning	Hr	208	$ 85.00	$ 17,700.00
				Subtotal	**$ 17,800.00**
				SUBTOTAL - LANDSCAPING - TERRESTRIAL	**$ 56,000.00**
6	**WATER SUPPLY - IRRIGATION**				
	Water Supply (Bore)	ML	10	$ -	$ -
				Subtotal	**$ -**
	Water Supply (Recycled)	ML	10	$ -	$ -
				Subtotal	**$ -**
	Maintain Bore	Day	2	$ 880.60	$ 1,800.00
				Subtotal	**$ 1,800.00**
	Bore Lift Pump	Item	1	$ 600.00	$ 600.00
				Subtotal	**$ 600.00**
	Groundwater Quality Testing	Item	1	$ 400.00	$ 400.00
				Subtotal	**$ 400.00**
	Maintain bore rising main	Item	1	$ 200.00	$ 200.00
				Subtotal	**$ 200.00**
				SUBTOTAL - WATER SUPPLY - IRRIGATION	**$ 3,000.00**
7	**ELECTRICITY**				
	Bore pump	Item	1	$ 10,500.00	$ 10,500.00
				Subtotal	**$ 10,500.00**
				SUBTOTAL - ELECTRICITY	**$ 11,000.00**
				A - OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT - SUBTOTAL	**$ 70,000.00**

Subtotal	$	221,000.00
Contingency (30%)	$	66,300.00
TOTAL	**$**	**288,000.00**

This estimate is based on estimated prices from recent projects and on the information available to Wallbridge Gilbert Aztec (WGA) at the time of preparing the estimate.
WGA does not accept any liability for actual costs varying from those estimated.

Notes, Exclusions & Assumptions:

- GST excluded
- CITB Levy excluded
- Site investigations, Design and Project Management Fees

CITY OF CHARLES STURT - FRESHWATER LAKE
OPTION 2A - CAPITAL COST ESTIMATE

Consultant: WGA
Revision: A

Date 7/06/2022
Job No. WGA212611
Eng RD

SUMMARY

Item	DESCRIPTION	AMOUNT ($)
B	**FRESHWATER LAKE - OPTION 2A**	
1	WATER SUPPLY SOURCE	$ 150,000
2	LAKE LINER	$ 998,000
3	CIRCULATION - LEVEL 2 - FULL RETICULATION	$ 131,000
4	WATER TREATMENT	$ 255,000
5	MANAGEMENT	$ 10,000
	SUBTOTAL	**$ 1,544,000**
	CONTINGENCY (30%)	$ 463,200
	CONSTRUCTION TOTAL	**$ 2,008,000**

BREAKDOWN

Item	DESCRIPTION	UNIT	QUANTITY	RATE ($)	AMOUNT ($)
B	**FRESHWATER LAKE - OPTION 2A**				
1	**WATER SUPPLY SOURCE**				
	ASR Bore Upgrade or MAR Scheme Connection	Item	1	$ 150,000.00	$ 150,000.00
				Subtotal	**$ 150,000.00**
				SUBTOTAL - LAKE LINER	**$ 150,000.00**
2	**LAKE LINER**				
	Preliminaries	Item	10%	$ 906,600.00	$ 90,700.00
				Subtotal	**$ 90,700.00**
	GCL X1000 liner	m2	15071	$ 50.00	$ 753,600.00
				Subtotal	**$ 753,600.00**
	Wall treatment	m	1530	$ 100.00	$ 153,000.00
				Subtotal	**$ 153,000.00**
				SUBTOTAL - LAKE LINER	**$ 998,000.00**
3	**CIRCULATION - LEVEL 2 - FULL RETICULATION**				
	Preliminaries	Item	10%	$ 118,900.00	$ 11,900.00
				Subtotal	**$ 11,900.00**
	Floating Pumps	No	3	$ 7,843.69	$ 23,600.00
				Subtotal	**$ 23,600.00**
	Pressure Pipe	m	317	$ 75.33	$ 23,900.00
				Subtotal	**$ 23,900.00**
	PVC Drain	m	88	$ 243.46	$ 21,500.00
				Subtotal	**$ 21,500.00**
	Surface reinstatement	m	405	$ 50.00	$ 20,300.00
				Subtotal	**$ 20,300.00**
	Valve and fixtures	Item	1	$ 4,540.00	$ 4,600.00
				Subtotal	**$ 4,600.00**
	Wiring of pumps	Item	1	$ 3,921.85	$ 4,000.00
				Subtotal	**$ 4,000.00**
	Controls	No	3	$ 5,000.00	$ 15,000.00
				Subtotal	**$ 15,000.00**
	Power Connection	No	3	$ 2,000.00	$ 6,000.00
				Subtotal	**$ 6,000.00**
				SUBTOTAL - CIRCULATION - LEVEL 2 FULL RETICULATION	**$ 131,000.00**
4	**WATER TREATMENT**				
	Ocean Protect Filterra	m2	146	$ 1,400.00	$ 204,400.00
				Subtotal	**$ 204,400.00**
	Planter box	Item	1	$ 40,000.00	$ 40,000.00
				Subtotal	**$ 40,000.00**
	Reinstate landscape	Item	1	$ 10,000.00	$ 10,000.00
				Subtotal	**$ 10,000.00**
				SUBTOTAL - WATER TREATMENT	**$ 255,000.00**
5	**MANAGEMENT**				
	O&M Manual	Item	1	$ 10,000.00	$ 10,000.00
				Subtotal	**$ 10,000.00**
				SUBTOTAL - MANAGEMENT	**$ 10,000.00**
				B - FRESHWATER LAKE - OPTION 2A - SUBTOTAL	**$ 1,544,000.00**

Subtotal	$ 1,544,000.00
Contingency (30%)	$ 463,200.00
TOTAL	**$ 2,008,000.00**

This estimate is based on estimated prices from recent projects and on the information available to Wallbridge Gilbert Aztec (WGA) at the time of preparing the estimate.
WGA does not accept any liability for actual costs varying from those estimated.

Notes, Exclusions & Assumptions:

- GST excluded
- CITB Levy excluded
- Site investigations, Design and Project Management Fees
- Assumes Upfront Operational Cost for Desludging has been undertaken prior
- Assumes Lake Liner undertaken in parallel with Desludging. If not, additional costs for desluding and dewatering may apply

WGA WALLBRIDGE GILBERT AZTEC

CITY OF CHARLES STURT - FRESHWATER LAKE
OPTION 2A - OPERATIONS COST ESTIMATE (ANNUAL)

Consultant: WGA
Revision: A

Date 7/06/2022
Job No. WGA212611
Eng RD

SUMMARY

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	LANDSCAPE - AQUATIC	$ 39,000
2	WATER SUPPLY - LAKE TOP-UP	$ 6,000
3	ELECTRICITY	$ 3,000
4	WATER QUALITY TREATMENT & REMEDIATION	$ 8,000
	SUBTOTAL - A	**$ 56,000**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**	
5	LANDSCAPING - TERRESTRIAL	$ 56,000
6	WATER SUPPLY - IRRIGATION	$ 2,000
7	ELECTRICITY	$ 11,000
	SUBTOTAL - B	**$ 69,000**
C	**OPTION 2A - TREATMENT UPGRADES**	
8	LAKE LINER	$ 7,000
9	CIRCULATION - LEVEL 2 - FULL RETICULATION	$ 8,000
10	WATER TREATMENT	$ 23,000
11	MANAGEMENT	$ 34,000
	SUBTOTAL - C	**$ 72,000**
	SUBTOTAL - A + B + C	**$ 197,000**
	CONTINGENCY (30%)	$ 59,100
	CONSTRUCTION TOTAL	**$ 257,000**

BREAKDOWN

Item	DESCRIPTION	UNIT	QUANTITY	RATE ($)	AMOUNT ($)
A	**WATERBODY MANAGEMENT**				
1	**LANDSCAPE - AQUATIC**				
	Sludge Removal	Item	1	$ 26,743.56	$ 26,800.00
				Subtotal	**$ 26,800.00**
	Soft edge plantings				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
				Subtotal	**$ 3,600.00**
	Clear Stormwater Pits, Outlets, Screens etc				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
				Subtotal	**$ 3,600.00**
	Monitor and removal overgrown vegetation around lake				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
	Disposal fee	Item	1	$ 500.00	$ 500.00
				Subtotal	**$ 4,100.00**
				SUBTOTAL - LANDSCAPING - AQUATIC	**$ 39,000.00**
2	**WATER SUPPLY - LAKE TOP-UP**				
	Lake filling (bore water)	ML	20	$ -	$ -
				Subtotal	**$ -**
	Manual pumping at Corcoran Dr Reserve				
	Staff x 1	Day	0	$ 880.60	$ -
	Tools	Item	10%	$ -	$ -
				Subtotal	**$ -**
	Maintain Bore	Item	1	$ 1,056.72	$ 1,100.00
				Subtotal	**$ 1,100.00**
	Bore Lift Pump	Item	1	$ 1,500.00	$ 1,500.00
				Subtotal	**$ 1,500.00**
	Groundwater Quality Testing	Item	1	$ 2,000.00	$ 2,000.00
				Subtotal	**$ 2,000.00**
	Maintain bore rising main	Item	1	$ 1,000.00	$ 1,000.00
				Subtotal	**$ 1,000.00**
				SUBTOTAL - WATER SUPPLY - LAKE TOP-UP	**$ 6,000.00**
3	**ELECTRICITY**				
	Bore pump, aerators, etc.	Item	1	$ 2,250.00	$ 2,300.00
				Subtotal	**$ 2,300.00**
				SUBTOTAL - ELECTRICITY	**$ 3,000.00**
4	**WATER QUALITY TREATMENT & REMEDIATION**				
	Algae Control (Coptrol)				
	Dosing (high-dose)	No	0	$ 2,824.56	$ -
	Staff x 1	Day	0	$ 1,761.20	$ -
				Subtotal	**$ -**
	Carp removal	No	1	$ 524.28	$ 600.00
				Subtotal	**$ 600.00**
	Aerators	Item	1	$ 2,250.00	$ 2,300.00
				Subtotal	**$ 2,300.00**
	Water quality testing	Item	1	$ 1,800.00	$ 1,800.00
				Subtotal	**$ 1,800.00**
	Misc.	Item	1	$ 2,861.95	$ 2,900.00
				Subtotal	**$ 2,900.00**
				SUBTOTAL - WATER QUALITY TREATMENT & REMEDIATION	**$ 8,000.00**
				A - WATERBODY MANAGEMENT - SUBTOTAL	**$ 56,000.00**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**				
5	**LANDSCAPING - TERRESTRIAL**				
	Bridges	Item	1	$ 2,636.41	$ 2,700.00
				Subtotal	**$ 2,700.00**
	Art Work	Item	1	$ 19.76	$ 100.00
				Subtotal	**$ 100.00**
	Shelter	Item	1	$ 656.26	$ 700.00
				Subtotal	**$ 700.00**
	BBQ	Item	1	$ 2,300.00	$ 2,300.00
				Subtotal	**$ 2,300.00**
	Irrigation System	Item	1	$ 2,800.00	$ 2,800.00
				Subtotal	**$ 2,800.00**

	Monitor and trim Ibis palms				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
	Boat	Day	2	$ 1,000.00	$ 2,000.00
	Tools	Item	10%	$ 5,600.00	$ 600.00
	Disposal fee	No	1	$ 500.00	$ 500.00
				Subtotal	**$ 6,700.00**
	Footpaths	Item	1	$ 18,200.00	$ 18,200.00
				Subtotal	**$ 18,200.00**
	Fences	Item	1	$ 4,500.00	$ 4,500.00
				Subtotal	**$ 4,500.00**
	Toilet Block				
	Asbestos Inspection	Item	1	$ 100.00	$ 100.00
	Cleaning	Item	1	$ 17,680.00	$ 17,700.00
				Subtotal	**$ 17,800.00**
				SUBTOTAL - LANDSCAPING - TERRESTRIAL	**$ 56,000.00**
6	**WATER SUPPLY - IRRIGATION**				
	Water Supply (Bore)	ML	10	$ -	$ -
				Subtotal	**$ -**
	Water Supply (Recycled)	ML	10	$ -	$ -
				Subtotal	**$ -**
	Maintain Bore	Item	1	$ 422.69	$ 500.00
				Subtotal	**$ 500.00**
	Bore Lift Pump	Item	1	$ 600.00	$ 600.00
				Subtotal	**$ 600.00**
	Groundwater Quality Testing	Item	1	$ 400.00	$ 400.00
				Subtotal	**$ 400.00**
	Maintain bore rising main	Item	1	$ 200.00	$ 200.00
				Subtotal	**$ 200.00**
				SUBTOTAL - WATER SUPPLY - IRRIGATION	**$ 2,000.00**
7	**ELECTRICITY**				
	Bore pump	Item	1	$ 10,500.00	$ 10,500.00
				Subtotal	**$ 10,500.00**
				SUBTOTAL - ELECTRICITY	**$ 11,000.00**
				A - OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT - SUBTOTAL	**$ 69,000.00**
C	**OPTION 2A - TREATMENT UPGRADES**				
8	**LAKE LINER**				
	Monitor liner for damage				
	Staff x 1	Day	6	$ 880.60	$ 5,300.00
				Subtotal	**$ -**
	Repairs to liner	Day	1	$ 968.60	$ 1,000.00
				Subtotal	**$ 1,000.00**
				SUBTOTAL - LAKE LINER	**$ 7,000.00**
9	**CIRCULATION - LEVEL 2 - FULL RETICULATION**				
	Floating Pumps	No	3	$ 1,000.00	$ 3,000.00
				Subtotal	**$ 3,000.00**
	Pressure Pipework	Item	1	$ 1,000.00	$ 1,000.00
				Subtotal	**$ 1,000.00**
	PVC Drain	Item	1	$ 1,000.00	$ 1,000.00
				Subtotal	**$ 1,000.00**
	Electricity	Item	1	$ 2,200.00	$ 2,200.00
				Subtotal	**$ 2,200.00**
				SUBTOTAL - CIRCULATION - LEVEL 2 FULL RETICULATION	**$ 8,000.00**
10	**WATER TREATMENT**				
	Ocean Protect Filterra				
	Management of landscape	Day	13	$ 880.60	$ 11,500.00
	Management of reticulation network and controls	Day	13	$ 880.60	$ 11,500.00
				Subtotal	**$ 23,000.00**
				SUBTOTAL - WATER TREATMENT	**$ 23,000.00**
11	**MANAGEMENT**				
	Management Plan Implementation & Reporting	Day	12	$ 880.60	$ 10,600.00
				Subtotal	**$ 10,600.00**
	Staff resource to monitor and maintain the water body	Day	26	$ 880.60	$ 22,900.00
				Subtotal	**$ 22,900.00**
				SUBTOTAL - MANAGEMENT	**$ 34,000.00**
				A - OPTION 2A - TREATMENT UPGRADES - SUBTOTAL	**$ 72,000.00**

Subtotal	$	197,000.00
Contingency (30%)	$	59,100.00
TOTAL	**$**	**257,000.00**

This estimate is based on estimated prices from recent projects and on the information available to Wallbridge Gilbert Aztec (WGA) at the time of preparing the estimate.
WGA does not accept any liability for actual costs varying from those estimated.

Notes, Exclusions & Assumptions:

- GST excluded
- CITB Levy excluded
- Site investigations, Design and Project Management Fees

CITY OF CHARLES STURT - FRESHWATER LAKE
OPTION 2B - CAPITAL COST ESTIMATE

Consultant: WGA
Revision: A

Date 7/06/2022
Job No. WGA212611
Eng RD

SUMMARY

Item	DESCRIPTION	AMOUNT ($)
B	**FRESHWATER LAKE - OPTION 2B**	
1	WATER SUPPLY SOURCE	$ 150,000
2	LAKE LINER	$ 998,000
3	CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY	$ 32,000
4	WATER TREATMENT	$ 200,000
5	MANAGEMENT	$ 5,000
	SUBTOTAL	**$ 1,385,000**
	CONTINGENCY (30%)	$ 415,500
	CONSTRUCTION TOTAL	**$ 1,801,000**

BREAKDOWN

Item	DESCRIPTION	UNIT	QUANTITY	RATE ($)	AMOUNT ($)
B	**FRESHWATER LAKE - OPTION 2B**				
2	**WATER SUPPLY SOURCE**				
	ASR Bore Upgrade or MAR Scheme Connection	Item	1	$ 150,000.00	$ 150,000.00
				Subtotal	**$ 150,000.00**
				SUBTOTAL - LAKE LINER	**$ 150,000.00**
3	**LAKE LINER**				
	Preliminaries	Item	10%	$ 906,600.00	$ 90,700.00
				Subtotal	**$ 90,700.00**
	GCL X1000 liner	m2	15071	$ 50.00	$ 753,600.00
				Subtotal	**$ 753,600.00**
	Wall treatment	m	1530	$ 100.00	$ 153,000.00
				Subtotal	**$ 153,000.00**
				SUBTOTAL - LAKE LINER	**$ 998,000.00**
4	**CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY**				
	Preliminaries	Item	10%	$ 28,200.00	$ 2,900.00
				Subtotal	**$ 2,900.00**
	PVC Drain	m	88	$ 243.46	$ 21,500.00
				Subtotal	**$ 21,500.00**
	Surface reinstatement	m	88	$ 50.00	$ 4,500.00
				Subtotal	**$ 4,500.00**
	Valve and fixtures	Item	1	$ 2,150.00	$ 2,200.00
				Subtotal	**$ 2,200.00**
				SUBTOTAL - CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY	**$ 32,000.00**
5	**WATER TREATMENT**				
	Floating Wetland	Item	1	$ 200,000.00	$ 200,000.00
				Subtotal	**$ 200,000.00**
				SUBTOTAL - WATER TREATMENT	**$ 200,000.00**
6	**MANAGEMENT**				
	O&M Manual	Item	1	$ 5,000.00	$ 5,000.00
				Subtotal	**$ 5,000.00**
				SUBTOTAL - MANAGEMENT	**$ 5,000.00**
				B - FRESHWATER LAKE - OPTION 2B - SUBTOTAL	**$ 1,385,000.00**

Subtotal	$	1,385,000.00
Contingency (30%)	$	415,500.00
TOTAL	**$**	**1,801,000.00**

This estimate is based on estimated prices from recent projects and on the information available to Wallbridge Gilbert Aztec (WGA) at the time of preparing the estimate.
WGA does not accept any liability for actual costs varying from those estimated.

Notes, Exclusions & Assumptions:

- GST excluded
- CITB Levy excluded
- Site investigations, Design and Project Management Fees
- Assumes Upfront Operational Cost for Desludging has been undertaken prior
- Assumes Lake Liner undertaken in parallel with Desludging. If not, additional costs for desluding and dewatering may apply

WGA WALLBRIDGE GILBERT AZTEC

CITY OF CHARLES STURT - FRESHWATER LAKE
OPTION 2B - OPERATIONS COST ESTIMATE (ANNUAL)

Consultant: WGA
Revision: A

Date 7/06/2022
Job No. WGA212611
Eng RD

SUMMARY

Item	DESCRIPTION	AMOUNT ($)
A	**WATERBODY MANAGEMENT**	
1	LANDSCAPE - AQUATIC	$ 39,000
2	WATER SUPPLY - LAKE TOP-UP	$ 7,000
3	ELECTRICITY	$ 4,000
4	WATER QUALITY TREATMENT & REMEDIATION	$ 8,000
	SUBTOTAL - A	**$ 58,000**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**	
5	LANDSCAPING - TERRESTRIAL	$ 57,000
6	WATER SUPPLY - IRRIGATION	$ 2,000
7	ELECTRICITY	$ 11,000
	SUBTOTAL - B	**$ 70,000**
C	**OPTION 2B - TREATMENT UPGRADES**	
8	LAKE LINER	$ 7,000
9	CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY	$ 1,000
10	WATER TREATMENT	$ 9,000
11	MANAGEMENT	$ 34,000
	SUBTOTAL - C	**$ 51,000**
	SUBTOTAL - A + B + C	**$ 179,000**
	CONTINGENCY (30%)	$ 53,700
	CONSTRUCTION TOTAL	**$ 233,000**

BREAKDOWN

Item	DESCRIPTION	UNIT	QUANTITY	RATE ($)	AMOUNT ($)
A	**WATERBODY MANAGEMENT**				
1	**LANDSCAPE - AQUATIC**				
	Sludge Removal	Item	1	$ 26,743.56	$ 26,800.00
				Subtotal	**$ 26,800.00**
	Soft edge plantings				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
				Subtotal	**$ 3,600.00**
	Clear Stormwater Pits, Outlets, Screens etc				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
				Subtotal	**$ 3,600.00**
	Monitor and removal overgrown vegetation around lake				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
	Disposal fee	Item	1	$ 500.00	$ 500.00
				Subtotal	**$ 4,100.00**
				SUBTOTAL - LANDSCAPING - AQUATIC	**$ 39,000.00**
2	**WATER SUPPLY - LAKE TOP-UP**				
	Lake filling (bore water)	ML	30	$ -	$ -
				Subtotal	**$ -**
	Manual pumping at Corcoran Dr Reserve				
	Staff x 1	Day	0	$ 880.60	$ -
	Tools	Item	10%	$ -	$ -
				Subtotal	**$ -**
	Maintain Bore	Item	1	$ 1,585.08	$ 1,600.00
				Subtotal	**$ 1,600.00**
	Bore Lift Pump	Item	1	$ 2,250.00	$ 2,300.00
				Subtotal	**$ 2,300.00**
	Groundwater Quality Testing	Item	1	$ 2,000.00	$ 2,000.00
				Subtotal	**$ 2,000.00**
	Maintain bore rising main	Item	1	$ 1,000.00	$ 1,000.00
				Subtotal	**$ 1,000.00**
				SUBTOTAL - WATER SUPPLY - LAKE TOP-UP	**$ 7,000.00**
3	**ELECTRICITY**				
	Bore pump, aerators, etc.	Item	1	$ 3,375.00	$ 3,400.00
				Subtotal	**$ 3,400.00**
				SUBTOTAL - ELECTRICITY	**$ 4,000.00**
4	**WATER QUALITY TREATMENT & REMEDIATION**				
	Algae Control (Coptrol)				
	Dosing (high-dose)	No	0	$ 2,824.56	$ -
	Staff x 1	Day	0	$ 1,761.20	$ -
				Subtotal	**$ -**
	Carp removal	No	1	$ 524.28	$ 600.00
				Subtotal	**$ 600.00**
	Aerators	Item	1	$ 1,800.00	$ 1,800.00
				Subtotal	**$ 1,800.00**
	Water quality testing	Item	1	$ 1,800.00	$ 1,800.00
				Subtotal	**$ 1,800.00**
	Misc.	Item	1	$ 2,861.95	$ 2,900.00
				Subtotal	**$ 3,000.00**
				SUBTOTAL - WATER QUALITY TREATMENT & REMEDIATION	**$ 8,000.00**
				A - WATERBODY MANAGEMENT - SUBTOTAL	**$ 58,000.00**
B	**OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT**				
5	**LANDSCAPING - TERRESTRIAL**				
	Bridges	Item	1	$ 2,636.41	$ 2,700.00
				Subtotal	**$ 2,700.00**
	Art Work	Item	1	$ 19.76	$ 100.00
				Subtotal	**$ 100.00**
	Shelter	Item	1	$ 656.26	$ 700.00
				Subtotal	**$ 700.00**
	BBQ	Item	1	$ 2,300.00	$ 2,300.00
				Subtotal	**$ 2,300.00**
	Irrigation System	Item	1	$ 2,800.00	$ 2,800.00

				Subtotal	**$ 2,800.00**
	Monitor and trim Ibis palms				
	Staff x 2	Day	2	$ 1,761.20	$ 3,600.00
	Boat	Day	2	$ 1,000.00	$ 2,000.00
	Tools	Item	10%	$ 5,600.00	$ 600.00
	Disposal fee	No	1	$ 500.00	$ 500.00
				Subtotal	**$ 6,700.00**
	Footpaths	Item	1	$ 18,200.00	$ 18,200.00
				Subtotal	**$ 18,200.00**
	Fences	Item	1	$ 4,500.00	$ 4,500.00
				Subtotal	**$ 5,000.00**
	Toilet Block				
	Asbestos Inspection	Item	1	$ 100.00	$ 100.00
	Cleaning	Item	1	$ 17,680.00	$ 17,700.00
				Subtotal	**$ 17,800.00**
				SUBTOTAL - LANDSCAPING - TERRESTRIAL	**$ 57,000.00**
6	**WATER SUPPLY - IRRIGATION**				
	Water Supply (Bore)	ML	10	$ -	$ -
				Subtotal	**$ -**
	Water Supply (Recycled)	ML	10	$ -	$ -
				Subtotal	**$ -**
	Maintain Bore	Item	1	$ 422.69	$ 500.00
				Subtotal	**$ 500.00**
	Bore Lift Pump	Item	1	$ 600.00	$ 600.00
				Subtotal	**$ 600.00**
	Groundwater Quality Testing	Item	1	$ 400.00	$ 400.00
				Subtotal	**$ 400.00**
	Maintain bore rising main	Item	1	$ 200.00	$ 200.00
				Subtotal	**$ 200.00**
				SUBTOTAL - WATER SUPPLY - IRRIGATION	**$ 2,000.00**
7	**ELECTRICITY**				
	Bore pump	Item	1	$ 10,500.00	$ 10,500.00
				Subtotal	**$ 10,500.00**
				SUBTOTAL - ELECTRICITY	**$ 11,000.00**
				A - OPEN SPACE RESERVE (TERRESTRIAL) MANAGEMENT - SUBTOTAL	**$ 70,000.00**

C	**OPTION 2B - TREATMENT UPGRADES**				
8	**LAKE LINER**				
	Monitor liner for damage				
	Staff x 1	Day	6	$ 880.60	$ 5,300.00
				Subtotal	**$ 5,300.00**
	Repairs to liner	Day	1	$ 968.60	$ 1,000.00
				Subtotal	**$ 1,000.00**
				SUBTOTAL - LAKE LINER	**$ 7,000.00**
9	**CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY**				
	PVC Drain maintenance - repairs or investigate	Item	1	$ 1,000.00	$ 1,000.00
				Subtotal	**$ 1,000.00**
				SUBTOTAL - CIRCULATION - LEVEL 1 - NEW INLETS OFF EXISTING ONLY	**$ 1,000.00**
10	**WATER TREATMENT**				
	Floating Wetland				
	Dredging/Sludge removal	Item	1	$ 3,207.62	$ 3,300.00
	Check anchor points and cables	Day	0.1	$ 880.60	$ 100.00
	Plant coverage and establishment	Day	4	$ 880.60	$ 3,600.00
	Weed control	Day	2	$ 880.60	$ 1,800.00
				Subtotal	**$ 8,800.00**
				SUBTOTAL - WATER TREATMENT	**$ 9,000.00**
11	**MANAGEMENT**				
	Management Plan Implementation & Reporting - 1 day month	Day	12	$ 880.60	$ 10,600.00
				Subtotal	**$ 10,600.00**
	Staff resource to monitor and maintain the water body (1/2 day per week)	Day	26	$ 880.60	$ 22,900.00
				Subtotal	**$ 22,900.00**
				SUBTOTAL - MANAGEMENT	**$ 34,000.00**
				A - OPTION 2A - TREATMENT UPGRADES - SUBTOTAL	**$ 51,000.00**

Subtotal	$ 179,000.00
Contingency (30%)	$ 53,700.00
TOTAL	**$ 233,000.00**

This estimate is based on estimated prices from recent projects and on the information available to Wallbridge Gilbert Aztec (WGA) at the time of preparing the estimate.
WGA does not accept any liability for actual costs varying from those estimated.

Notes, Exclusions & Assumptions:

- GST excluded
- CITB Levy excluded
- Site investigations, Design and Project Management Fees

APPENDIX C

PRODUCT DETAILS – SHORTLISTED PRODUCTS

Filterra®

Stormwater Bio-retention Filtration System

The Filterra® System is a high-flow bio-filtration/retention technology. It has been optimised for high volume/flow treatment and high pollutant removal. Its small footprint allows it to be used on highly developed sites such as landscaped areas, parking lots and streetscapes.

How does it work?

Stormwater runoff enters the Filterra system through a kerb-inlet opening or pipe and flows through a specially designed filter media mixture contained in a landscaped concrete container. The filter media captures and immobilises pollutants; those pollutants are then decomposed, volatilised and incorporated into the biomass of the Filterra system's micro/macro flora and fauna. Stormwater runoff flows through the media and into an underdrain system at the bottom of the container, where the treated water is discharged.

filterra
Bioretention Systems

Features

- High media flow rate (up to 3550mm/hr)
- Filterra offers the most cost-effective stormwater treatment system featuring low cost, easy installation and simple maintenance
- Landscaping enhances the appearance of your site, making it more attractive while removing pollutants
- Available in multiple configurations and sizes
- No confined space access and the first year of maintenance is included with the purchase of every system

Benefits

- Reduced footprint compared with traditional bioretention
- Value
- Adds aesthetic appeal to your site
- Flexibility to meet site-specific needs
- Simple and easy maintenance

Configurations and Applications

- Inline
- Offline
- Filterra Bioscape
- Custom Configurations
- WSUD, Green Infrastructure and Environmental Site Design
- High pollutant removal requirements
- New construction and urban retrofits
- Pretreatment for above-ground or shallow below-ground storage
- Shallow, decentralised treatment

Maintenance

- Vegetation selection guidance based on your climate zone
- On-site planting and activation included with every system
- The first year of maintenance is included with the purchase of every system
- Ongoing maintenance is simple (clean biofiltration bay with simple landscape tools (rake and shovel))
- No confined space entry required (everything can be accessed from the surface)

Floating Wetlands

Floating Treatment Wetlands - Stormwater

spelstormwater
joy in water

spel.com.au

APPLICATIONS

- Stormwater Treatment
- Beautification and Landscaping
- Lake and Pond Restoration
- Lagoon Augmentation
- Fine Collodial and Particulate Heavy Metal Removal
- Algal Bloom Prevention

OVERVIEW

In wastewater applications, floating wetlands have proven efficient and low-cost enhancements to municipal wastewater treatment plants — either retrofitted to existing facilities or encompassed into the design of new constructions. Truly environmentally sound and sustainable, the SPEL Waterclean floating wetlands have a dramatic effect on:

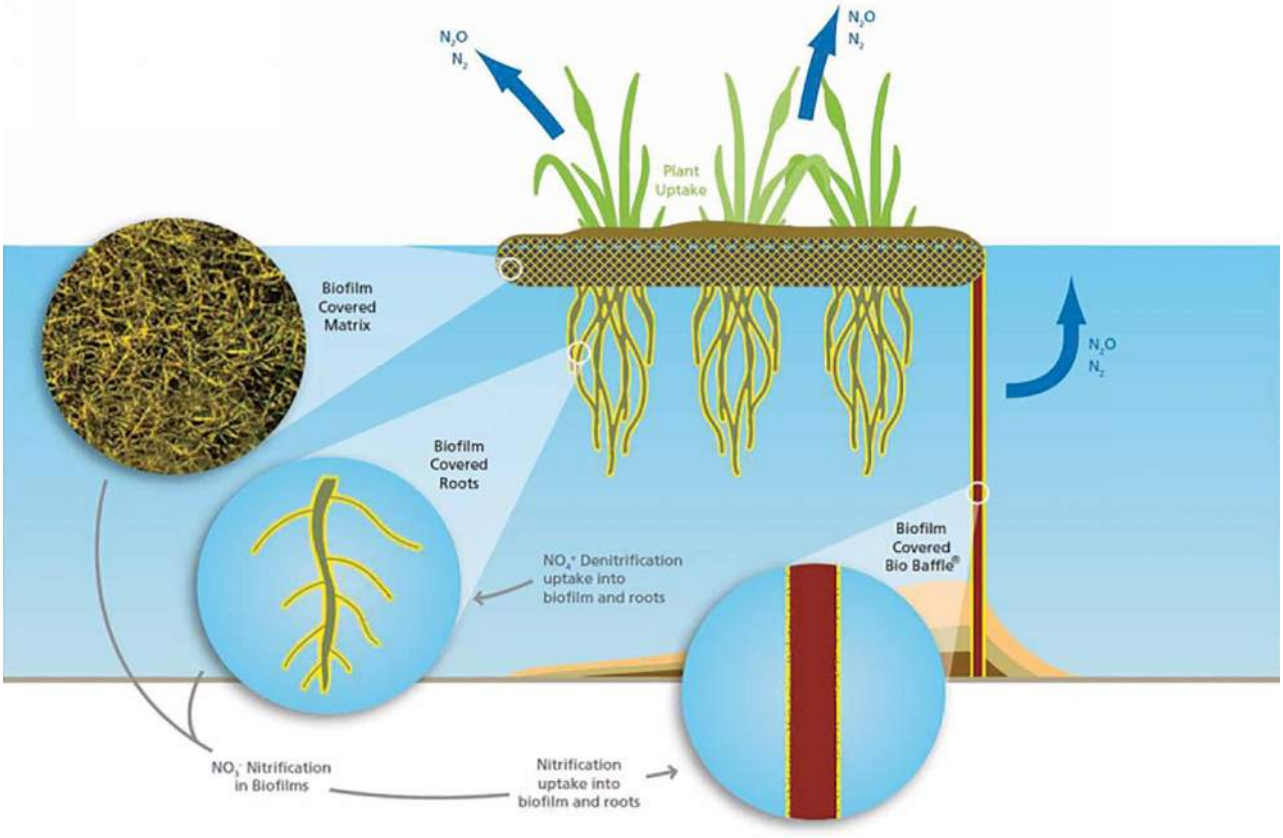
- Anaerobic digestion
- Odour mitigation
- Nitrification processes
- De-nitrification and polishing
- Bio-chemical oxygen demand
- Removal of TSS
- Reduction in faecal coliforms
- Reduction in phosphorus

In stormwater applications, the installation of floating wetlands into inlet zones or detention lagoons greatly enhances the stormwater cleaning process by removing:

- Total suspended solids
- Nutrients
- Gross pollutants
- Heavy metals
- Fine colloidal and particulates

Independently tested and validated, these systems provide high-rate performance in both average flow and storm events.

HOW IT WORKS



The floating wetlands, which can be used in any water environment requiring treatment, provide a lush and fertile base for plants and vegetation to grow. As the roots spread down through the fibrous structure of the wetlands, an extraordinarily vast activated surface area is created for microbes and bacteria to take on their role of bio-remediation - the use of micro-organisms to remove pollutants.

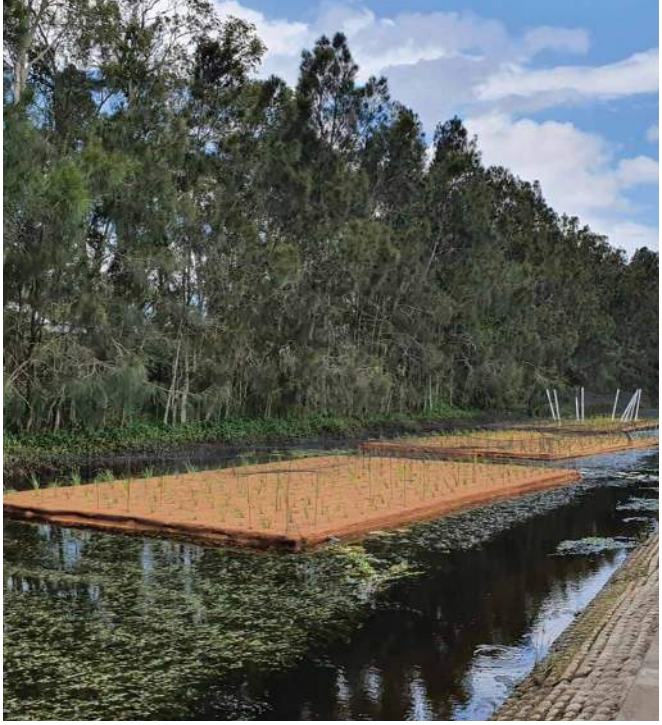
The microbes and bacteria, are UV sensitive and adhere to the roots and microscopic root hairs of the plants, and within the fibrous structure of the wetlands themselves, secreting sticky extracellular proteins and exist in the environs of biofilms.

It is within these biofilms which microbes and bacteria trap and digest organic matter and nutrients in stormwater, including total suspended solids, biochemical oxygen demand, nitrogen and phosphorus.

What makes SPEL Stormwater's floating treatment wetlands a unique scientific innovation, that has created a revolution within the water treatment industry, is the massive activated surface area they provide for microbes and bacteria to survive.

BENEFITS

SPEL Stormwater's Floating Treatment Wetlands are floating modules that support the establishment of wetland vegetation, and thereby allows the creation of a floating wetland environment on top of a permanent waterbody. It mimics a wetland's ability to absorb nutrient loads with only around a 1/3 of the land space required by a natural or constructed wetland. Furthermore, by having a wetland float over a water body means that land space does not have to be taken up to construct a man made wetland. And finally, the Floating Treatment Wetland becomes a virtually self sustaining system with minimal maintenance required.



MINIMAL ENVIRONMENTAL IMPACT

- Using a waste product to bio-remediate waste, our floating treatment wetlands have strong environmental credentials including:
- Satisfying stringent water quality consent requirements
- Eliminating the need for chemical dosing
- Eliminating the need for further high-impact ‘concrete and steel’ construction
- No energy used in the operation process; low energy in the manufacture process
- Zero-land use requirement
- Manufacture from recycled PET
- Using plants from eco-sourced seeds to harmonise with the natural vegetation

FLEXIBLE

Floating treatment wetlands are completely flexible and can:

- Fit any existing space or water body shape
- Operate effectively in all climate and environmental conditions
- Operate in fluctuating water levels
- Maximise retention times for treatment optimisation
- Concentrate on removal of particular pollutants through design adjustments

What this flexibility will mean for you is that, whatever your water treatment issue, the wetlands can be adapted to provide a benefit-loaded solution.

BEAUTIFICATION

Although the floating treatment wetlands are primarily a water treatment tool, they have the added bonus of being visually appealing as a floating wetland. As a water-based feature in community facilities, they can enhance the natural environment and provide a habitat for land-based and marine wildlife. They also can be used as a landscaping feature on private residential projects.

PLANTING

The plant species suitable for floating wetlands are selected according to the reserve buoyancy required for the application. Generally, terrestrial species such as wetland sedges, rushes and grasses are the best option as they develop superior root structures within the water to provide for an increased surface area. However, many other planting types are also used. Recommended planting density is three to five plants per square metre.

EFFECTIVE

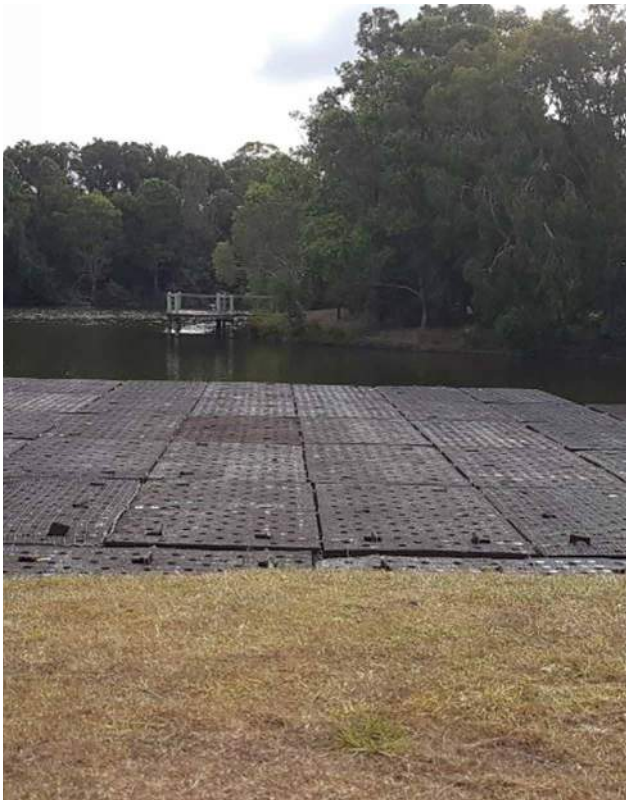
The process is simple, completely natural - and highly effective. You have the assurance of an installation that has been developed to exploit the unsurpassed water cleaning properties of naturally-occurring microbes.

ZERO LAND USE

In situations where water treatment demands have outgrown existing assets, the wetlands can be retrofitted as a low-cost, zero land use alternative to building additional ponds or constructed wetlands. This eliminates the need for costly land purchase and contributes to the minimal environmental impact of the wetlands – saving you money and time-consuming confrontations over land use.

For example, local authority saved $500,000.00 when we retro-fitted floating treatment wetlands on an existing pond instead of purchasing land and constructing an alternative constructed wetland system.

In areas where irrigation schemes are used to dispose of treated water, the efficiency of our wetlands in reducing the nutrients in treated water means less land is required for the disposal fields. Again, money is saved and environmental needs met.



MODULAR BIOLOGICAL SYSTEM

The Floating treatment wetlands is a modular system therefore can be installed in stages. This proves beneficial where monetary budget constraints restrict the ability to install full systems in one financial year.

Each floating module measures approximately 4m x 2.3m each, and are joined together with nylon bolts, to create virtually any size of area.

Staging also proves beneficial where discharge consents may change in the future while a smaller system meets current demands. A simple additional modular upgrade can be retrofitted at a later stage to future proof the wastewater plant.

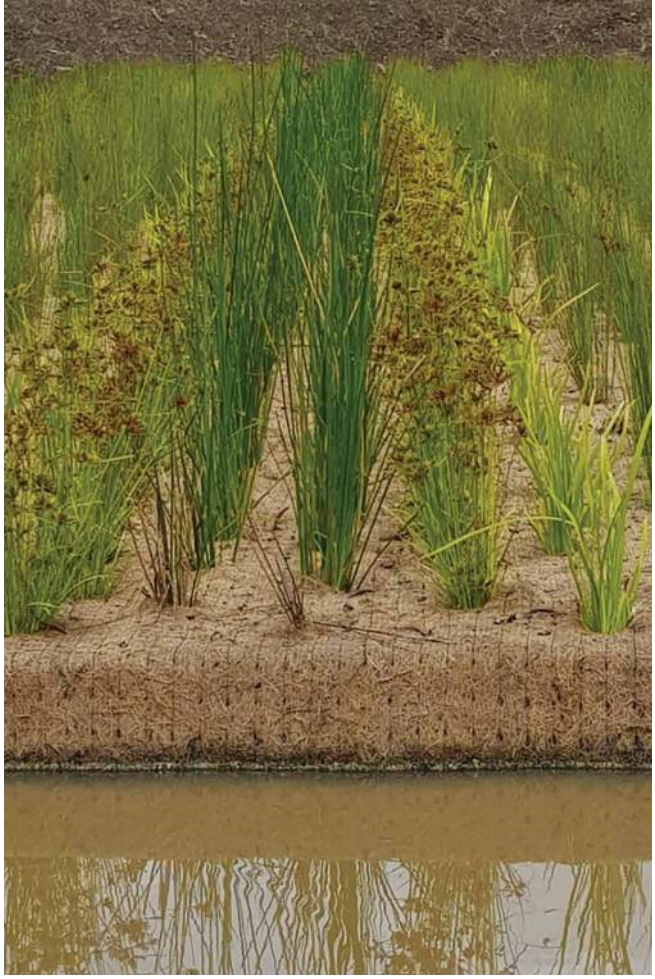
ANCHORING AND TETHERING

The floating treatment wetlands can be secured into position by anchoring or tethering, depending on local climate and water conditions.

The technique we use is to secure to the embankment above the maximum water level. The floating treatment covers are partially submerged which provides a “suction” effect to occur that creates a powerful anchoring mechanism, imparting the greater part of the forces needed for anchoring these systems in place.

COST SAVINGS

Floating treatment wetlands require low capital investment with minimal operating and maintenance costs, and, there are no operational energy costs. (1) NH4N requires an input of O2 to nitrify. This is often via mechanical aeration



STORMWATER

SPEL STORMWATER'S FLOATING TREATMENT MEDIA - COMPLETE POND COVER

The floating wetlands, which can be used in any water environment requiring treatment, provide a lush and fertile base for plants and vegetation to grow. As the roots spread down through the fibrous structure of the media, an extraordinarily vast activated surface area is created for microbes and bacteria to take on their role of bio-remediation - the use of micro-organisms to remove pollutants.

The microbes and bacteria, which do not swim, and are UV sensitive, adhere to the roots and microscopic root hairs of the plants, and within the fibrous structure of the media themselves, secreting sticky extracellular proteins and exist in the environs of biofilms. It is within these biofilms which microbes and bacteria trap and digest odours and nutrients in wastewater.

What makes SPEL Stormwater's floating treatment media a unique scientific innovation, with the potential to create a revolution within the water treatment industry, is the massive activated surface area they provide for microbes and bacteria to survive.

CONSTRUCTION

SPEL Stormwater floating treatment wetlands are made from 100 per cent recycled polyethylene terephthalate, commonly known as PET and used in plastic drink bottles. The recycled plastic is made into a non-woven, non-toxic durable matrix of fibres. Dense and porous, it is extremely inert and has been coated in a UV resistant resin to US Environmental Protection Agency irradiation accelerated degradation standards.

Sheets of fibre matrix are bonded together with foam which provides the buoyancy needed for each specific application. Plants are inserted into the material and grow down into the water hydroponically.

Cleaning water of pollutants is an on-going challenge for communities across the globe as the demand for environmental improvements grows in line with the need to find cost-effective and sustainable methods to remove ever-increasing amounts of contaminants from diverse bodies of water.

SPEL Stormwater's revolutionary low cost, highly flexible system of floating treatment media is meeting this need. This innovative system has strong scientific credentials based on the outcomes of independent trials, is an environmentally-sound process, and meets business requirements for sustainable solutions.

Developed alongside leading international scientists, Waterclean Technologies™ floating treatment media represent a highly technical development that uses, and improves on, a naturally occurring phenomenon. In short, SPEL Stormwater's, modular biological technology, being active suspended media provide a colossal environment of active surface area for pollutant-digesting microbes and bacteria to bioremediate water laden with nutrients, heavy metals or suspended solids. They represent an industry breakthrough with scores of benefits that include:

- Cost savings
- Proven effective performance
- Self-cleaning
- Minimal environmental impact
- Flexibility
- Zero land use
- Fluctuating water levels

SCAN FOR MORE DETAILS ONLINE

Floating Wetlands

Floating Treatment Wetlands - Stormwater

NSW HEAD OFFICE 100 Silverwater Rd, Silverwater NSW 2128 PO Box 7138, Silverwater NSW 1811 P: +61 2 8705 0255 P: 1300 773 500 E: nsw.sales@spel.com.au	**QLD MAIN OFFICE** 130 Sandstone Pl, Parkinson QLD 4115 P: +61 7 3271 6960 P: 1300 773 500 I E: qld.sales@spel.com.au **QLD SUNSHINE COAST BRANCH** 19-27 Fred Chaplin Circuit, Bells Creek, QLD 4551 P: 1300 773 500 I E: qld.sales@spel.com.au	**VIC & TAS OFFICE** 897 Wellington Rd Rowville VIC 3178 P: +61 3 5274 1336 P: 1800 810 139 I E: sales@spel.com.au **VIC GEELONG BRANCH** 70 Technology Close, Corio, P: +61 3 5274 1336 P: 1800 810 139 I E: sales@spel.com.au
SA OFFICE 9 Hampden Road, Mount Barker SA 5251 P: 1300 773 500 E: sales@spel.com.au	**WA OFFICE** 2 Modal Crescent Canning Vale WA 6155 P: +61 8 9350 1000 P: 1800 335 550 E: sales@spel.com.au	**NZ OFFICE AUCKLAND** 100 Montgomerie Road Airport Oaks P: +64 9 276 9045 E: sales@spel.com.au
NZ OFFICE WANGANUI 43 Heads Road Wanganu New Zealand P: +64 6 349 0088 I E: sales@spel.com.au	**NZ OFFICE WELLINGTON** 41 Raiha St Porirua Wellington New Zealand P: +64 4 239 6006 I E: sales@spel.com.au	**PHILIPPINES OFFICE METRO MANILA** Unit 2210 Lumiere Residences Pasig Boulevard, Pasig City P: +61 2 8705 0255 P: 1300 773 500 E: sales@spel.com.au
SINGAPORE OFFICE 512 Chai Chee Lane, #06-04 Bedok Industrial Estate, Singapore 469028 P: +61 2 8705 0255 P: 1300 773 500 I E: sales@spel.com.au	**UK OFFICE UNITED KINGDOM** Lancaster Rd Shrewsbury SY1 3NQ UK P: +44 (0)1743 445200 I E: sales@spel.com.au	**USA OFFICE CLEVELAND** 4548 Industrial Parkway Cleveland, Ohio 44135 P: +61 2 8705 0255 P: 1300 773 500 E: sales@spel.com.au

We believe clean water is a right not a privilege and we work to ensure a joy in water experience for you with your children and grandchildren.

spelstormwater
joy in water

100 Silverwater Rd, Silverwater NSW 2128 Australia
Phone: (02) 8705 0255
Email: sales@spel.com.au
spel.com.au

APPENDIX D

LONG-LIST REVIEW STRUCTURAL SOLUTIONS

Table 1: Structural Improvement Options - Long-list Assessment

COST		BENEFIT	
High	>$500,000	High	Significant Improvement (Holistic)
Medium	151,000-499,000	Medium	Improvement (WQ only)
Low	<$150,000	Low	Select Improvement

Improvement Option	Description	Constraints	Benefits	Cost Estimate (Prelim).		Benefit	Improvement
Dredging the lake	Dredging the lake will remove the sediment and sludge that has built-up over recent years. *It is understood that dredging is required in order to reset the lake in its current form, prior to implementing new improvements.*	Dredging is a disruptive and expensive activity that will: - Disrupt the community. - Disrupt existing flora and fauna. - Is expensive and cost is subject to further pre-work investigation (ie. contamination testing).	Dredging is considered necessary to allow the lake to be reset, and for improvements to establish and operated effectively. The key benefits are: - An opportunity to undertake improvements that require lake draw down. - A clean and operational lake at commencement of new lake management.	Preliminary cost estimates for dredging the lake, as outlined in the Option 1 (Section 2.2.4). Dredging and sludge removal costs are estimated $1.3 M. **$1.3M**	**HIGH**	**HIGH**	• Biodiversity • Water Quality
Reline the lake (impermeable liner)	Relining the lake to reduce seepage. Lining the lake with HDPE or a Geosynthetic Clay Liner (GCL) liner to reduce infiltration to the base and fixing HDPE sheeting to the walls to prevent lateral leakage. A supplier has provided an option to secure HDPE sheeting up the wall (in lieu of new wall construction).	Reduction in seepage: - Won't directly treat the water quality issues, however, it will assist in maintaining normal water level and allow for improved circulation without sourcing new water supply. - Installation on the walls of the lake will be more technically complex. - Assumes dewatering to allow installation.	Reduction in seepage loss will: - Assist to maintain the normal water level in the lake. - Reduce losses. - Allow for improved recirculation of water. - Reduce the water supply demand. - Result in more sustainable water management.	Estimated costs for relining the waterbody have been based on: $50/m^2 HPDE or GCL liner, and an additional $100/lm for the fixing of HDPE sheets to the wall with concrete backfill. Estimated Total Cost = $1M (installation). **$1M**	**HIGH**	**HIGH**	• Sustainable Water Use • Efficiency • Low waste • Low energy operation
Modify bed levels	Modifying the bed levels to provide improved hydraulic movement and water body zones. Create different depths to support different planting and water treatment zones.	Modifying bed levels may: - High cost. - Requires additional geotechnical assessment. - Groundwater may be an issue where excavation has increased. - This would be a disruptive construction with significant structural change. - Requires dewatering	Reshaping the bed levels will: - Provide different water zones and align the design more closely to a wetland design. - Improve hydraulic circulation. - Reduce stagnation and water quality issues.	To reduce cost and risk assume that earthworks shaping assumes no cut, to avoid geotechnical or groundwater issues. Assumed rate for earthworks design, shaping, groundwater management, testing and select fill. $50/m^2. **$750k**	**HIGH**	**MEDIUM**	• Biodiversity • Water Quality • Low waste • Minimal maintenance • Low energy operation

Improvement Option	Description	Constraints	Benefits	Cost Estimate (Prelim).		Benefit	Improvement
Increase aquatic planting	Increasing aquatic planting for improved water quality treatment.	Constraints on additional vegetation are: - There has been previous feedback provided to Council that local residents don't like increased vegetation in the lake as it restricts their view to the open water and across the waterbody. - Plant selections need to consider maintenance and local species, biodiversity and existing habitat.	Increased vegetation: - Improves sediment and nutrient removal and water quality. - Provides habitat and protection for fauna (fish, birds, frogs). - Increases the biodiversity in the lake.	Additional vegetation costs are typically $50/m^2 aquatic planting. To achieve a minimum 50% coverage in line with shallow lake design guideline this would be of the order 25% more planting. Allowance needed for additional annual maintenance costs for vegetation maintenance. **$150k**	**LOW**	**LOW**	• Biodiversity • Water Quality • Low waste • Low energy operation
Install Floating Wetland	Install 'floating wetlands' for water quality improvement.	Floating wetlands: - Will reduce open water area. - Are more expensive than increased planting only. - May be more expensive to maintain. - Will still require periodic desludging (but this may be localised).	Floating wetlands: - are a proprietary system that provide a high rate of water quality treatment, within a floating wetland system. - The system can be retrofitted to an existing water body, with minimal structural impact. - Increased biodiversity. - Select location and should not impact direct view for residents.	$200,000 (Capital inclusive of 1 year maintenance. Based on the supplier recommendation this installation is a 200m^2 total area. (This will be split between two locations sized proportionate to the lake size in Lake 1 and Lake 3). *Additional costs will be required to improve circulation in the lake to get the full benefit of the system* Allowance for maintenance costs - Maintenance of planting / root trim. - Sediment dredging every 10 years. **$250k**	**MEDIUM**	**MEDIUM**	• Biodiversity • Water Quality • Low waste • Low energy operation
Improve the lake water circulation	Improve circulation through upgrade to aerators or installation of circulation pumps. *This option will be of most value when coupled with additional water quality treatment measures*	Improved circulation requires: - Additional pumps, inlets or outlet sumps and additional civil works for installation. - Power supply and capacity of the existing main and pumps need to be investigated.	Improved circulation will: - Reduce the residence time in the lakes. - Optimise water treatment systems and/or be a requirement in the effective operation of the treatment option. - Retention of water within the system (reduced losses).	Improved circulation requires a minimum two water supply inlets per lake, aeration or circulation pumps and may need outlet sump pumps. Retrofit and upgrade to the distribution network is also required. *For maximum benefit this should be installed with a water quality treatment solution*	**LOW**	**LOW***	• Water Quality • Sustainable water use
						***** Medium – *If paired with WQ Treatment option*	

Improvement Option	Description	Constraints	Benefits	Cost Estimate (Prelim).		Benefit	Improvement
				Ongoing maintenance and power supply will be additional operational costs. **$100k**			
Redirection of stormwater away from the water body.	Redirection of stormwater away from the water body: ie. stormwater inlets to the lake, and/pr paths grading into the lake.	This option is limited by: - The available options for redirection of existing stormwater, and the associated civil costs. - Diverting the landscape and path surrounding the lake will require a new footpath grading, stormwater drainage and this may result in high cost.	Reducing stormwater inflows to the water body will: - Reduce the risk of contamination. - Reduce the nutrient loads into the lake (particularly where fertilised landscapes discharge to the lake). - Reduce sediment transport into the lake. - Improve overall water quality.	The costs are likely high due to the significant additional civil works required. An investigation into stormwater diversion options could be undertaken and potentially integrated into future civil works projects opportunistically to offset the costs. **$350k**	**MEDIUM**	**LOW**	• Water Quality
Offline Water Treatment System	Ocean Protect – Bioretention System (Filterra) Above or in-ground bioretention system within a packaged supply with high-rate treatment media and planting.	Filterra (Bioretention): - Requires available space for the construction of the unit. - Will take up recreational space. - Will require maintenance, flushing and media replacement over time. - Will need an upgraded circulation/reticulation network.	Filterra (Bioretention): - Provide high water quality treatment. - Reduce the residence time in the lake. - Allow recirculation of water, reducing the demand for flushing/top-up. - Is a smaller footprint than a typical bioretention system.	The costs based on a recommended treatment area (unit) of 150m2 (minimum). For the installation of the biofiltration is $250,000. Additionally upgraded circulation and pit and pumps will be needed at approx. $100,000 (as outlined above). Additional maintenance, power and periodic filter media and plant replacement will also be required. **$350k**	**MEDIUM**	**HIGH**	• Sustainable water use • Water Quality • Biodiversity • Low waste
	Ocean Protect – Treatment Pit System Similar to the above however, the water treatment is through a series of water treatment cartridges installed in a pit chamber.	Stormfilter (Treatment cartridges): - Requires upgrade to the filter cartridges periodically. - Increased cost for construction in excavation and pit construction. - Will need an upgraded circulation/reticulation network.	Stormfilter (Treatment cartridges): - Provide high water quality treatment. - Reduce the residence time in the lake. - Allow recirculation of water, reducing the demand for flushing/top-up. - Are located underground so will not impact useable open space.	The costs based on a recommended treatment area (unit) of 150m2 (minimum). For the installation of the biofiltration is $600,000. Additionally upgraded circulation and pit and pumps will be needed at approx. $100,000 (as outlined above). Additional maintenance, power and periodic filter media and	**HIGH**	**HIGH**	• Sustainable water use • Water Quality

Improvement Option	Description	Constraints	Benefits	Cost Estimate (Prelim).		Benefit	Improvement
				plant replacement will also be required. **$700k**			
	Bioretention (in-ground traditional). Construct an offline bioretention bed at the reserve or at the adjacent Corcoran Drive Reserve.	The constraints on this option are: - The space and size of bioretention required. - Loss of public open space. - Reticulation requirement to feed to and from the treatment unit.	The benefits on this option are: - Provide high water quality treatment. - Reduce the residence time in the lake. - Allow recirculation of water, reducing the demand for flushing/top-up.	The cost of the bioretention bed, (approx. 400m^2) would be of the order $150,000. However, additional costs for the reticulation network and circulation would be $150k (allowing an off-site construction). Additionally, there would be a cost associated with the loss of public open space. Maintenance costs would also need to be accounted in this option. **$300k (min)**	**MEDIUM*** ***HIGH** *When accounting for land costs.*	**MEDIUM**	• Sustainable water use • Water Quality
	Wetland (in-ground traditional). Construct an offline Wetland at the adjacent Corcoran Drive Reserve.	The constraints on this option are: - The space and size of wetland. It will not fit within the reserve and would need to be offsite at Corcoran Drive. - Significant loss of public open space. - Reticulation requirement to feed to and from the treatment unit.	The benefits on this option are: - Provide high water quality treatment. - Reduce the residence time in the lake. - Allow recirculation of water, reducing the demand for flushing/top-up. - Public amenity if wetland landscaped well. - Increased biodiversity.	The cost of the wetland (approx. 3500m^2) would be of the order $750,000. However, additional costs for the reticulation network and circulation would be $150k (allowing an off-site construction). Additionally, there would be a cost associated with the loss of public open space. Maintenance costs would also need to be accounted in this option. **$900k (min)**	**HIGH**	**HIGH**	• Sustainable water use • Water Quality • Biodiversity • Low waste • Amenity
	Offline media filtration (treatment plant). An offline system that pumps flow through a media filter. With the treatment unit/pumps/controls housed in a treatment shed.	The constraints on this option are: - Power supply requirements. - Loss of space within the reserve and possibly views. - Will need an upgraded circulation/reticulation network. - This system will not remove nutrients. - Ongoing power and operational maintenance costs. - Specialist maintenance.	The benefits on this option are: - Provide high water quality treatment. - Reduce the residence time in the lake. - Allow recirculation of water, reducing the demand for flushing/top-up.	Estimated costs would include: Media Filters $150-200k Housing $50 -150k Power augmentation $70k Reticulation and circulation. $100k Ongoing maintenance and power costs.	**HIGH**	**MEDIUM**	• Sustainable water use • Water Quality

Improvement Option	Description	Constraints	Benefits	Cost Estimate (Prelim).		Benefit	Improvement
		- Sludge removal.		**$370-570k**			
Provide hard engineered base at select locations for improved maintenance access.	Provision of a hard/engineered base at select locations to provide for improved maintenance and sediment removal, and outlet sumps for draw-down or sediment/sludge removal.	The constraint on this option are: - Limited locations for access from road. - This option provides improved operations and maintenance only. - No water quality improvement. - Will require removal of grass and planted areas	The benefit of this option are: - Ease of maintenance reducing the cost of maintenance. - Allow more frequent maintenance.	An estimate for one maintenance access point per lake, allowing an access from the road to the lake and then a hard-base (concrete) lake base (to a localise low-point in the lake). **$150k**	**LOW**	**LOW**	• Low energy • Operational improvement
PURUS Water Treatment	PURUS is a new technology that injects ozone into the lake within nano-bubbles to create O2 radicals that attack and remove algae and pathogens and increase dissolved oxygen. This provides improved water quality, clarity and oxygenation.	The constraints on this option are: - This is not technically a structural solution as it is not a permanent feature, it is operated by a maintenance plan with the supplier who will routinely attend and inject the lake (typically quarterly). - It is a new technology - in Australia and there is no field testing in a similar application. - Impact to ecosystem not tested. - The system relies on a 4 year contract with the supplier. - This is a reactive measure and will not stop the issue occurring. - Unlikely to be available (tested in Australia) until 2024.	The benefits are: - No capital upfront costs. - Maintained and operated by specialist contractors. - Could be a trial prior to capital investment and improvements.	The cost estimates for a 4- year contract for PURUS to manage water quality and treatment is: $3,000-6,000 per month. Average annual cost: $36,000 – 72,000. 4-year term: $140-$288k Note: after this time the water quality issues will still remain. **$70k / per annum**	**UNTESTED OPERATIONALLY FOR THIS APPLICATION IN AUSTRALIA**	**HIGH**	• Water Quality • Water Quality

Emma Hendy
SENIOR CIVIL ENGINEER
Telephone: 08 8223 7433
Email: ehendy@wga.com.au

ADELAIDE
60 Wyatt St
Adelaide SA 5000
Telephone: 08 8223 7433
Facsimile: 08 8232 0967

MELBOURNE
Level 6, 312 St. Kilda Rd
Southbank VIC 3006
Telephone: 03 9696 9522

PERTH
Level 1, 66 Kings Park Rd
West Perth WA 6005
Telephone: 08 9336 6528

BRISBANE
Ground Floor, 154 Melbourne St
South Brisbane QLD 4101
Telephone: 07 3519 5555

DARWIN
Suite 7/9 Keith Ln
Fannie Bay NT 0820
Telephone: 08 8941 1678
Facsimile: 08 8941 5060

WHYALLA
1/15 Darling Tce
Whyalla SA 5600
Phone: 08 8644 0432

WALLBRIDGE GILBERT AZTEC
www.wga.com.au
adelaide@wga.com.au