Water Engineering Partners Pty Ltd

Updated Lake Concept Design

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Water Engineering Partners Pty Ltd
ABN: 47 664 596 105
Level 1, 21 Quay Street, Brisbane QLD 4000
PO Box 5106, West End, QLD 4101
P: 0455866107
E: info@wep.com.au

www.wep.com.au

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1 Introduction and Purpose of the Report

Over the last two years, the conceptual design of the proposed Riverlea lake system has been progressively refined with two main strategies progressed being external salt water exchange water pumping for lake turnover and flushing (BMT with Martin Giles as author); and, more recently, in-lake treatment with dedicated water treatment devices and plant (Simmonds & Bristow June 2024).

In addition, considerable water quality monitoring and assessment of the receiving environment and on the proposed exchange water source has now been carried out, to better inform the lake design (Water Engineering Plus (November 2023) with Martin Giles as author).

The aim of the lake management system design is to ensure that suitable water quality is maintained in the lakes. For lake 1, secondary contact standards are proposed, enabling some water based recreational activity such as sailboarding and canoeing.

There are many examples of successful saline lake systems that rely solely on volumetric turnover for water quality control, including Emerald Lakes on the Gold Coast, Twin Waters on the Sunshine Coast, Pelican Waters Lamerough Creek and Cornmeal Creek town centre. For the Riverlea project, a range of in-lake water treatment systems and a dedicated water treatment plant has also been considered.

Arising out of the work to date is a refined, updated hybrid lake water management strategy and concept design, which combines key elements of both pumped salt water exchange and in-lake treatment strategies, using a progressive adaptive strategy to provide an extremely robust and flexible management system, which will ensure that the desired lake water quality objectives will be met. Water quality monitoring is on-going, with full seasonality testing the aim, across a range of tidal conditions.

Most importantly, the updated lake concept design proposes the incorporation of a full scale optimization strategy for turnover and treatment measures for lake 1, to allow further refinement of the lake water quality management and to better inform the final detailed design for the total lake system proposed. The optimization strategy will specifically inform the final design requirements for lakes 2 and 3.

The purpose of this report is to provide details of a review of the system concept design to date, and to provide details of the updated lake management strategy arising from a recent design team workshop, the range of treatment and turnover contingency measures proposed, and to detail the proposed lake water management trial.

Refined lake water treatment concept design details for this refined, updated strategy are provided by Simmonds & Bristow in their June 2024 report, which is included as Appendix A to this report.

Figure 1-1 shows the current master plan for the development, and shows lakes 1, 2 and 3.

Since completion of version 1 of this report in July 2024, the lake turnover system proposed has been refined, as shown on our updated figures 3-1 and 4-1. In addition, refinements to cost estimates have been carried out, and the revised cost estimates are included in Appendix C. Appendix A (the Simmonds and Bristow report) remains unchanged from our version 1 reporting. Burchill has updated two key drawings (BE170039-SK113G and SK138G) showing the refined circulation and treatment system now proposed, and these are included in Appendix B.

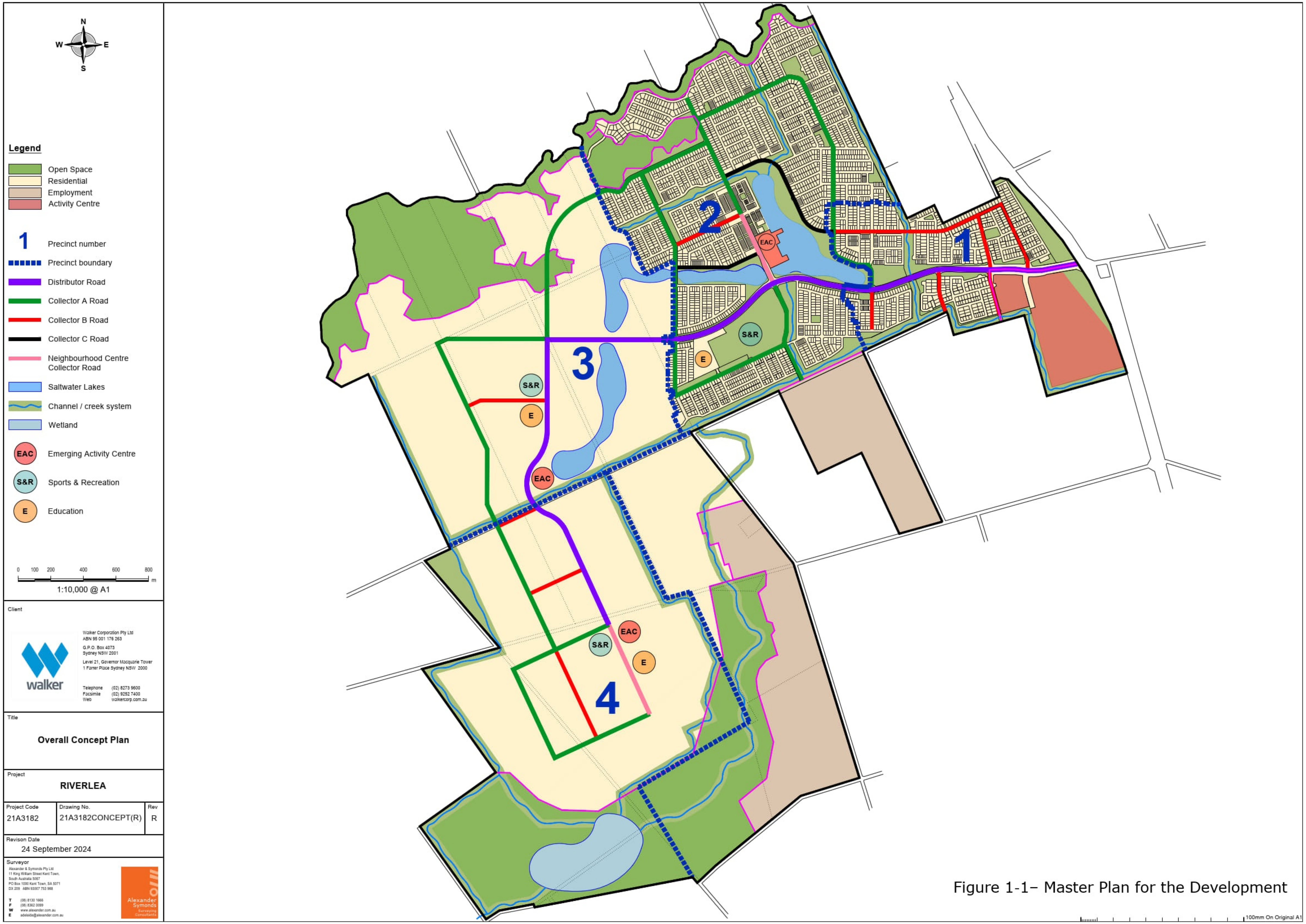


Figure 1-1– Master Plan for the Development

2 Previous relevant Reports and Refinement of the Lake Concept Design

On 15 February 2022, BMT produced a report entitled 'Riverlea Lake Concept Design Report.'

This report proposed a lake management system comprising:

- 40 day volumetric turnover of the 1,110 ML system, which is made up of three lakes, through pumping from Chapman Creek;
- One way flow through system with outfall to Thompson Creek outfall channel;
- In lake mixing as required;
- Clay lining of the lake to prevent seepage losses and to protect groundwater;
- Addition of additional lake water quality treatment devices and plant if required; and
- Extensive monitoring.

On 13 November 2023, Water Engineering Plus produced a report entitled 'Water Quality Monitoring Program Results to 13 September 2023' in relation to the Riverlea project.

This report summarized the findings of water quality monitoring based on the initial sampling from 10 March 2022 to 13 September 2023 as follows for Chapman Creek at the proposed intake site:

- *Consistent and acceptable pH values;*
- *Typically, highly saline water except for short periods following local rainfall events;*
- *Very low suspended solids and turbidity levels;*
- *Relatively high Total Nitrogen concentrations, predominantly associated with organic Nitrogen;*
- *Relatively high Total Phosphorus concentrations;*
- *Very low chlorophyll 'a' values;*
- *Variable but typically high dissolved oxygen levels; and*
- *Low heavy metal concentrations (well below guideline limits for recreational waters);*

In contrast, the sampling points in Thompson Creek and the Outfall Channel have indicated very high Total Nitrogen, Total Phosphorus and chlorophyll 'a' concentrations. These concentrations were found to fall progressively to the Inshore Bolivar Outlet and Offshore monitoring points due to ocean mixing.

The low chlorophyll results at the proposed intake site appear to indicate low potential for significant algal growth, despite the high nutrient levels. Full seasonality and tide range testing is recommended to confirm this preliminary finding.

Additional field data is now also available for the period September 2023 to March 2024 and this data will further inform the optimisation strategy.

These previous reports remain valid and should be read in conjunction with this report. For detailed information on in lake treatment and dedicated treatment plants, reference should be made to Simmonds & Bristow's June 2024 report, which is included as Appendix A to this report.

3 Summary of lake water quality, top-up and turnover strategies

The BMT and the Simmonds and Bristow reports described above propose two lake water quality management measures. The BMT report relies on a high rate of lake water volumetric turnover, with inflow waters to be pumped from Chapman Creek, with in-lake mixing required, and additional lake water quality treatment if required.

The BMT report also details a large number of existing saline lake systems that have historically managed lake water quality to an acceptable level through high volumetric turnover rates alone, without extensive additional in-lake treatment.

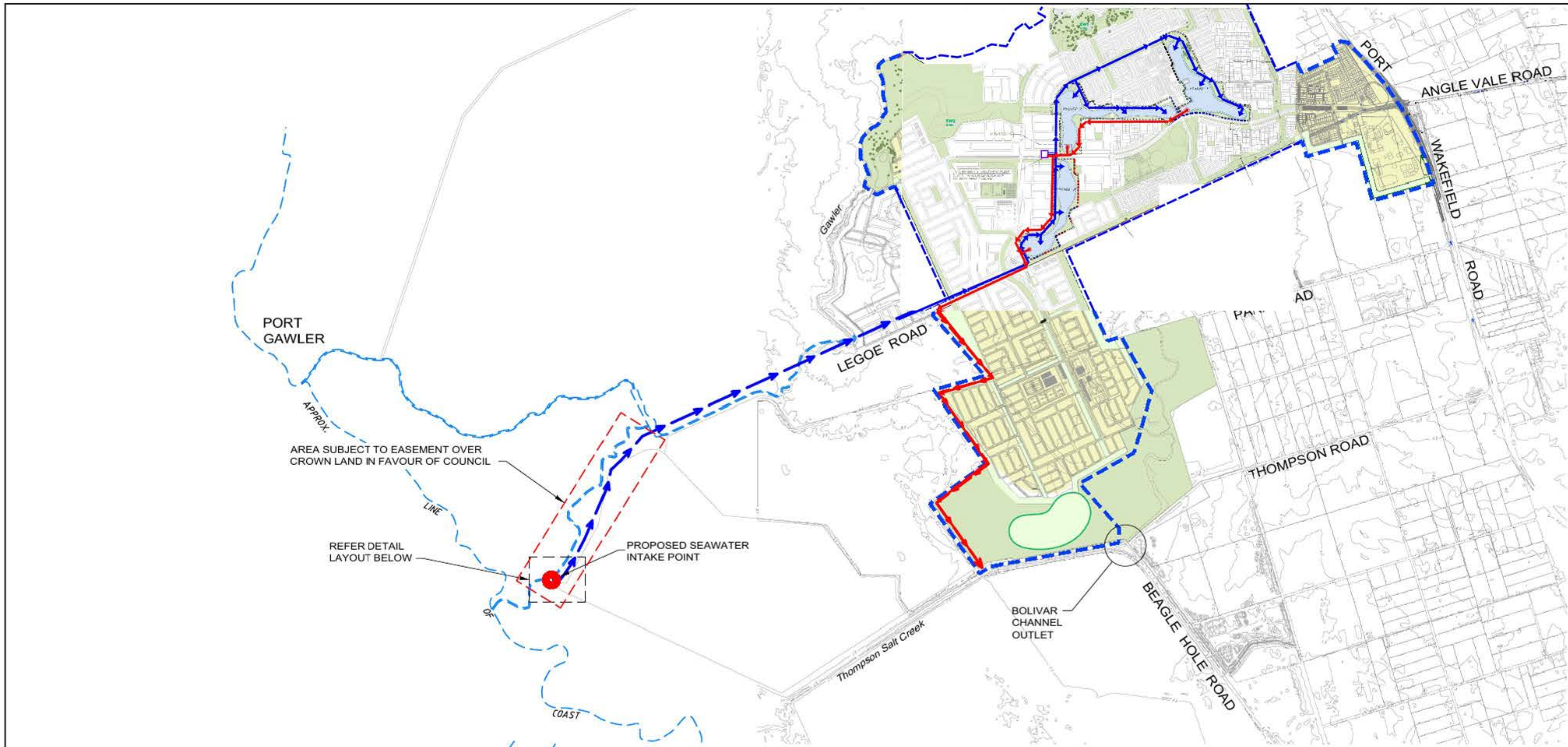
The Simmonds and Bristow report considers reduced turnover flow rates with in-lake treatment and pre-treatment for effective nutrient and algal management. The solution proposed is robust in managing lake water quality, and to control algal growth to an acceptable level if excessive algal growth were to occur, and in removing the high level of nutrients in turnover waters.

The Water Engineering Plus Water Quality Monitoring Report indicates that, on testing results to date, that there is little evidence of significant algal growth in the waters of Chapman Creek adjacent to the intake site, despite the high nutrient levels. This may be related to the high salinity levels; however more seasonal and full tide ranging testing is needed to validate this.

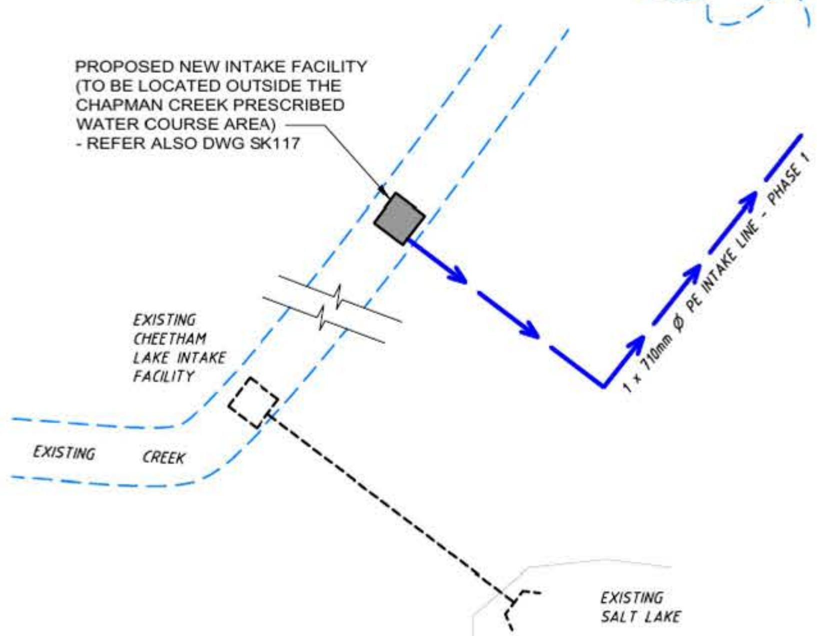
The proposed outlet receiving waters of Thompson Creek currently has poor water quality with high nutrient and chlorophyl a levels, and is likely to experience significant algal growth and blooms at times. Significant discharge flow rates from the lake system using Chapman Creek waters has the potential to improve the water quality in Thompson Creek, through a reduction in nutrients and potential for algal growth.

As a minimum, a pumping system from Chapman Creek is required to provide top-up water to the lakes to replenish losses from evaporation.

Figure 3-1 shows the location of Chapman and Thompson Creeks relative to the site.



SEAWATER INTAKE AND OUTLET LINES GENERAL ARRANGEMENT



SEAWATER INTAKE LINE
SCHEMATIC ARRANGEMENT
NOT TO SCALE

NOTE:

- REFER ALSO DWG SK113 FOR DETAILED INTERNAL CIRCULATION STRATEGY

LEGEND

DEVELOPMENT EXTENTS
PROPOSED SEAWATER INTAKE LINES
OUTLET LINES (PHASE 1 & 2)

THIS DRAWING IS FOR PRELIMINARY DISCUSSION PURPOSES ONLY AND IS SUBJECT TO DETAILED ANALYSIS, DETAIL SURVEY, HYDRAULICS, SOILS INVESTIGATIONS, DETAILED DESIGN AND RELEVANT AUTHORITY APPROVALS. ALLOTMENT BOUNDARIES SHOWN ARE APPROXIMATE ONLY AND ARE SUBJECT TO DETAILED SURVEY CALCULATIONS.

PRELIM CONCEPT PURPOSES ONLY

Data Source:
Burchills Engineering Solutions - Riverlea Development
Adapted from Drawing: BE170039-SK138-H and BE170039-SK106-N

Coordinate System: GDA94 / MGA zone 54

N

PROJECT: Riverlea Lake Concept Design	TITLE: Proposed Development at Buckland Park
CLIENT: Walker Corporation	WATER ENGINEERING plus — WWW.WEP.COM.AU
SCALE: 0 — 500 — 1,000 m	FIGURE NUMBER: 3-1
REVISION:	DATE: 01-October-2024

Filepath: C:\Users\glong\OneDrive - SLR Consulting\Documents\30073\6_GIS\QGIS\30073.GIS.001_Riverlea_BurchillsDrawings.qgz

4 Refined Lake Management Concept Design& Optimisation / Progressive Adaptive Strategy

4.1 Refined Concept Design

Taking account of the above previous reporting, a workshop was held between Walker Corporation, Water Engineering Plus (including Martin Giles the author of the 2022 BMT and the November 2023 Water Engineering Plus reports) and Simmonds and Bristow (David Bristow) on 21 May 2024. The end result of this workshop was an agreement on a 'hybrid' approach to lake water management (Option 4 Progressive Adaptive Water Quality Management Approach), with the provision of a system that is capable of high lake turnover volumes if required, as well as the ability to progressively add in-lake and on-line water quality treatment measures as the staging of the development progresses, and as required. In addition, it was agreed that the best way forward is to carry out a full scale optimization / progressive adaptive strategy for the lake management system, using lake 1, whilst continuing with background water quality monitoring.

The proposed initial lake turnover pumping rates will achieve an 80 day volumetric turnover rate (with the ability to half this if required to 40 days), which results in approximately 380 L/s daily discharge rate over a 10 hour per day pumping period. This will require the installation of a single 710 mm diameter supply pipeline from the Chapman Creek intake site to Lake 1, as shown in figure 3-1 and 4-1. This pipe size is larger than required for the initial proposed turnover rate, but allows flexibility for increased rates if required, and can cater for the 40 day turnover rate.

In lake mixers will be incorporated in the initial design to ensure a well mixed lake with no dead spots.

Extensive monitoring of Lake 1 performance will be carried out commencing immediately following filling of the lake. Circulation rates and in-lake treatment devices required will be considered in light of sensitivity pumping rates and water quality results over the Maintenance period for the lake.

A staged, single wastewater treatment plant to treat lake waters will be incorporated as necessary following conclusion of the trial. Figure 4-1 shows the nominal location of the dedicated treatment plant. This plant will need to be designed to allow for possible expansion in stages to align with the development staging of the lake system.

A summary of key Features of the Option 4 Progressive Adaptive Water Quality Management Approach (Wastewater Treatment Plant (WTP) Contingency inclusion) as follows: -

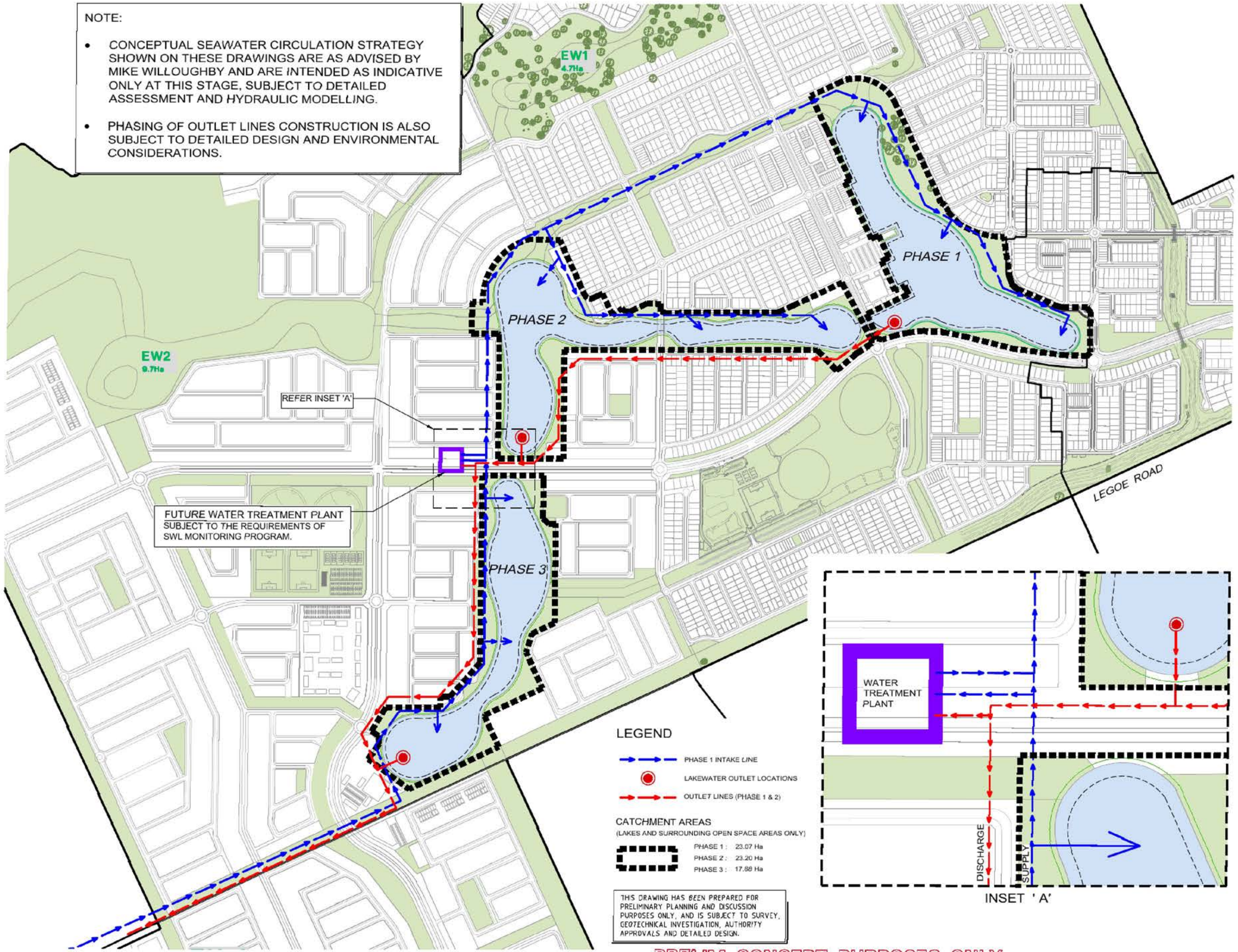
1. A primary intake and lake piped circulation system is to be promoted to deliver an 80-day lake volumetric turnover.

2. The primary circulation system is to be designed to provide stand-alone circulation to all three lake systems.

3. A WTP Contingency is to be included to provide de-nitrification alone for lake 1 (with a contingency allowance for lake 2).

   Note that lake 3 can be managed by new water turnover alone, which allows for the intake line to be run at higher discharges for pipeline cleansing reasons, whilst maintaining additional environmental water for the Thompson Creek outfall channel.

4. The primary circulation system is to be designed to be used for individual lake recirculation lines (with suitable valving controls to suit). Primary circulation is only running for 10 hrs/day. The WTP treatment can be running in parallel, and for extended periods to that of the main lake reticulation system.



PRELIM CONCEPT PURPOSES ONLY

Data Source: Burchills Engineering Solutions - Riverlea Development Drawing: BE170039-SK138-H	
Coordinate System: GDA94 / MGA zone 54	
Water Engineering Plus endeavours to ensure that the information provided in this map is correct at the time of publication. Water Engineering Plus does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map	

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PROJECT: Riverlea Lake Concept Design	TITLE: Conceptual Seawater Circulation Strategy Layout Plan (Phases 1 & 2)
CLIENT: Walker Corporation	WATER ENGINEERING plus — WWW.WEP.COM.AU
SCALE: 0 — 160 — 320 m	FIGURE NUMBER: 4-1
REVISION:	DATE: 01-October-2024

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5. A combination of new water and treated lake water (recirculated with new water) is a preferred targeted solution for the progressive adaptive water quality management.

    a) New water turnover alone.

    b) Nutrient removal and filtration first to be installed in the WTP.

    c) Further treatment progression as required.

6. The proposed progressive adaptive water quality management proposal allows for the best water quality for the lakes to delivered using live data.

4.2 Lake Water Sources

Initial lake filling will be supplied by pumped seawater sourced from Chapman Creek. Top-up water is needed because of lake evaporation, and will be sourced primarily from pumped seawater from Chapman Creek. In addition, local site runoff will be directed to the lakes after treatment to manage nutrients and sediment.

As noted in Chapter 2 above, the testing to date indicates high total nitrogen levels associated with organic nitrogen and high total phosphorus levels at the intake point in Chapman Creek; however, the chlorophyll 'a' values are low, meaning that algal growth is low despite the higher nutrient levels. De-nitrification treatment is proposed for the water supply from Chapman Creek. The internal site runoff volumes are limited due to the relatively small local catchment area and the low rainfalls. Extensive treatment of runoff is proposed prior to discharge to the lakes via bio-basins and gross pollutant traps, to limit nutrient and sediment loads entering the lake from the development runoff.

4.3 Treatment Contingencies

Treatment contingencies to be incorporated as necessary, based on Simmonds & Bristow April 2024 include:

- Nutrient removal, through a dedicated treatment plant
- Algaecide dosing
- Algal disruption, including mixing and ultrasonic systems
- Suspended solids removal

A further option arising from the workshop for treating algae is the injection of a high salt dose to the lake as an emergency measure, with locally sourced raw salt likely suitable for the task.

Details of these additional treatment contingencies are provided by Simmonds and Bristow in their June 2024 report, which is included as Appendix A to this report.

4.4 Lake 1 Optimisation / Progressive Adaptive Strategy

The intent is to carry out an optimization assessment for lake 1 over a 12-month period, with progressive adaptation of water treatment as required, to ensure full seasonality is considered. A range of lake turnover rates will be tested, and detailed lake monitoring carried out on a maximum monthly basis, with daily observations for algal growth.

If algal growth indicates the potential for an algal bloom, contingency measures such as chemical dosing may need to be applied, and if necessary, other in-lake treatment measures and stage 1of the dedicated treatment plant incorporated.

A detailed Lake 1 Management Plan will need to be prepared in advance of the trial. Additional details are provided by Simmonds and Bristow in Appendix A.

4.5 Indicative Costings

Appendix C provides detailed budget cost estimates for the proposed water circulation and treatment system.

A summary of costings is as follows:

Revised Circulation + Single WTP Train (de-nitrification only) Cost Estimate:

Primary Circulation (Lakes SWL 1, 2 and 3):	
CAPEX Estimate	$10,689,240
OPEX	$217,850
Adding the WTP Costs (SWL 1):	
CAPEX Estimate	$7,389,000
OPEX	$233,000
Revised Budget Cost Estimates:	
CAPEX Estimate	$18,399,240
OPEX	$868,850

5 Potential improvements to Thompson Creek and downstream waterways due to lake outfall waters

With the updated lake concept design now proposed, lake turnover waters are to be discharged to Thompson Creek outfall channel. The initial trial proposes a lake turnover rate of approximately 150 L/s over a 12 hour per day pumping period. Discharge waters initially, without additional lake treatment, are expected to be of similar quality to that of the intake waters in Chapman Creek, with high salinity levels and low chlorophyl a counts. This will result in an improvement in the quality of water in Thompson Creek outfall channel and downstream waterways. As additional dedicated treatment plant and in lake treatment measures are brought on line, nutrient levels will also reduce leading to further improvements in the water quality in Thompson Creek outfall channel.

6 Conclusions

As our knowledge of the existing water quality in Chapman Creek, Thompson Creek and further downstream receiving waters has improved, the conceptual design for the proposed lake system has been able to be progressively refined.

The refined lake management concept design outlined in this report (Progressive Adaptive Water Quality Management Approach (Wastewater Treatment Plant (WTP) Contingency inclusion)) proposes a hybrid system combining key elements of both the external salt water exchange water pumping for lake turnover and flushing and, more recently, in-lake treatment with dedicated water treatment devices and plant , the details for which are provided in Simmonds and Bristow's June 2024 report which is included in Appendix A of this report.

A full scale optimization / progressive adaptive strategy using the proposed lake 1 over a 12 month period with sensitivity testing of varying lake turnover rates, and water quality treatment arrangement is also now proposed. This optimization exercise, along with additional water quality monitoring results of supply waters from Chapman Creek and lake 1 over a full year to capture seasonality,

and of the receiving waters including Thompson Creek outfall channel, will enable the final lake management design to be determined to achieve the water quality objectives set for the proposed lakes.

The refined lake management concept design has the flexibility to deliver a large range of lake turnover rates and times, the staging contingency of a dedicated water treatment plant and of in lake treatment measures, thus ensuring that a robust system is in place that can respond to the optimization strategy and monitoring feedback as the development progresses over time.

Appendix A Simmonds & Bristow June 2024 Report

Walker Corporation Adelaide

Riverlea Development
Lake Water Treatment Concept
Progressive Adaptive Water Quality Management

October 2024

Head Office: 6/62 Curzon Street, Tennyson, QLD 4105
Postal Address: PO Box 849, Archerfield, QLD 4108
1800 620 690 | +61 7 3434 3800 | Fax: +61 7 3434 3899
info@simmondsbristow.com.au | www.simmondsbristow.com.au

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Simmonds & Bristow Established 1965 ACN 010 252 418 Pty Ltd		
Originating Office: 6/62 Curzon Street, Tennyson, QLD, 4105	PO Box 849 Archerfield QLD 4108	Ph: 07 3434 3800 Fax: 07 3434 3899
Document Number:	C2311-013	
Client:	Walker Corporation Adelade	
Client Contact:	Brent Eddy & Patrick Mitchell	

	Name	Signed	Date
Written by:	Terrence Allen *BE(Chem)* Process Engineer		16/10//2024
Reviewed & Authorised by:	David Bristow *B.E(Chem), CPEng, RPEQ* Managing Director		16/10//2024

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1.0	26/06/24	TA	Final Draft	Superseded
1.1	27/06/24	TA	Update from client Feedback	Superseded
1.2	27/06/24	DB/TA	Final Draft	Superseded
1.3	09/07/24	DB/TA	Final Draft	Superseded
1.4	11/07/24	DB/TA	Final Draft	Superseded
1.5	10/10/24	DB/RK	Final	

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Whilst Simmonds & Bristow has made every effort to ensure the accuracy of the information contained within this document it may include typographical errors and may be changed or updated without notice.

EXECUTIVE SUMMARY

The Riverlea development is a large residential development being constructed to the northwest of Adelaide. The site includes a series of 3 salt-water lakes, intended to provide stormwater attenuation and detention, as well as aesthetic and secondary contact recreation opportunities. The lakes are to be installed in three phases, consisting of one lake per phase.

Simmonds & Bristow have been engaged to provide advice on the need for active treatment measures for the management of lake water quality.

A range of treatment strategies and technology options have been reviewed, developed and considered.

An adaptive management strategy is consequentially proposed for the management of lake water quality.

The adaptive strategy consists of the initial installation of the lake filling and recirculation systems. Water quality will be monitored in Lake 1 (SWL1) for 12 months, with the provision of further treatment equipment based on the outcome of this quality monitoring program.

Additional water quality treatment systems could consist of the provision of a nutrient removal treatment system for nutrient control, filtration for turbidity removal, and algal disruption technologies, such as ultrasonic or lake mixing for algae reduction. The strategy also includes the provision of algaecide dosing if necessary.

Proactive management of water quality are likely to require treatment systems to be installed, to maintain consistent lake water quality, particularly if secondary contact recreational use of the lakes is to be supported.

Reactive management of water quality may avoid significant capital investment in treatment infrastructure and the adaptive management strategy allow this to be tested and evaluated for evidenced based decisions to be made for the makeup of sustainable, practical treatment technology mix.

The treatment systems could be located centrally, allowing for a sequential installation of equipment; initially a single train will be installed to support SWL1. The installation of further trains would be based on the performance of SWL1, and whether Lakes 2 & 3 (SWL2 and 3) require additional treatment, either due to water quality concerns or changes in intended lake use. The system would be configured to allow water to be fed from any of the lakes to the treatment system for polishing, and from the raw lift system.

Walker Corporation Adelade
Riverlea Lake Water Treatment Concept
Adaptive Water Quality Management

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1. INTRODUCTION

Simmonds & Bristow have been engaged by Walker Corporation to provide advice for potential treatment options for a saltwater lake system within a new development currently being constructed at Riverlea, northwest of Adelaide.

Following a detailed review of treatment options, an adaptive water quality management solution has been developed. This report provides details for the water quality management provisions within this proposed solution.

1.1 Development Description

The Riverlea Development is located north-west of Adelaide and is currently under construction by Walker Corporation.

Figure 1: Site locality plan.

The development once fully realised will comprise approximately 12,000 residential allotments, a number of commercial areas, three permanent neighbourhood centres, one retail centre and both primary and secondary school sites.

Figure 2: Development Masterplan (Walker Corporation)

1.2 Lake Description

The system is proposed to include a series of constructed saltwater lakes (SWL). These lakes are intended to provide stormwater attenuation and will also provide aesthetic and community benefits via secondary contact recreational activities.

The lakes are proposed to be implemented in three stages or phases, as the site is developed over an approximately 25-year period, subject to the rate of sales and development progress.

The stages/phases of development (from Burchills Engineering Drawings) are shown with indicative timing for implementation in Figures 3 & 4 following.

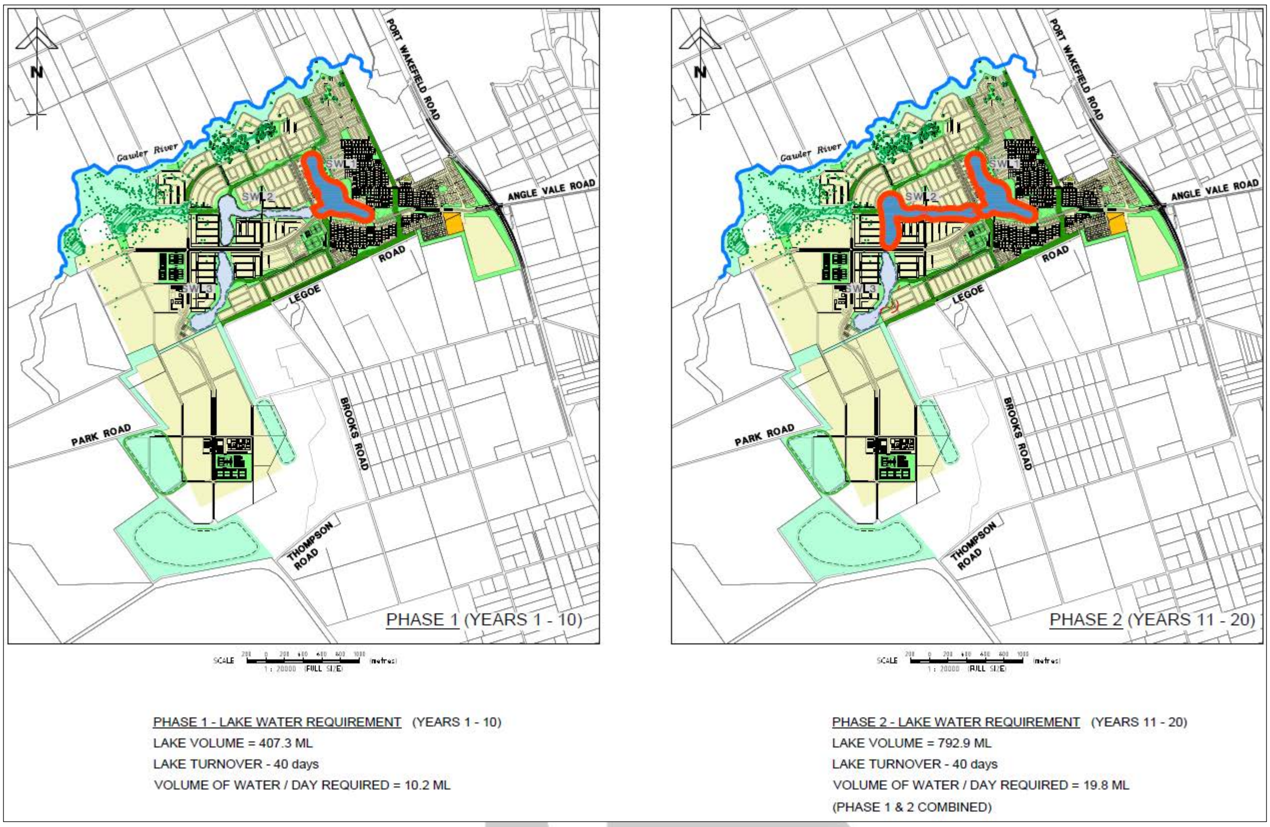


Figure 3: Phases 1 & 2 (lake outlined in red) (Burchills Engineering Solutions)

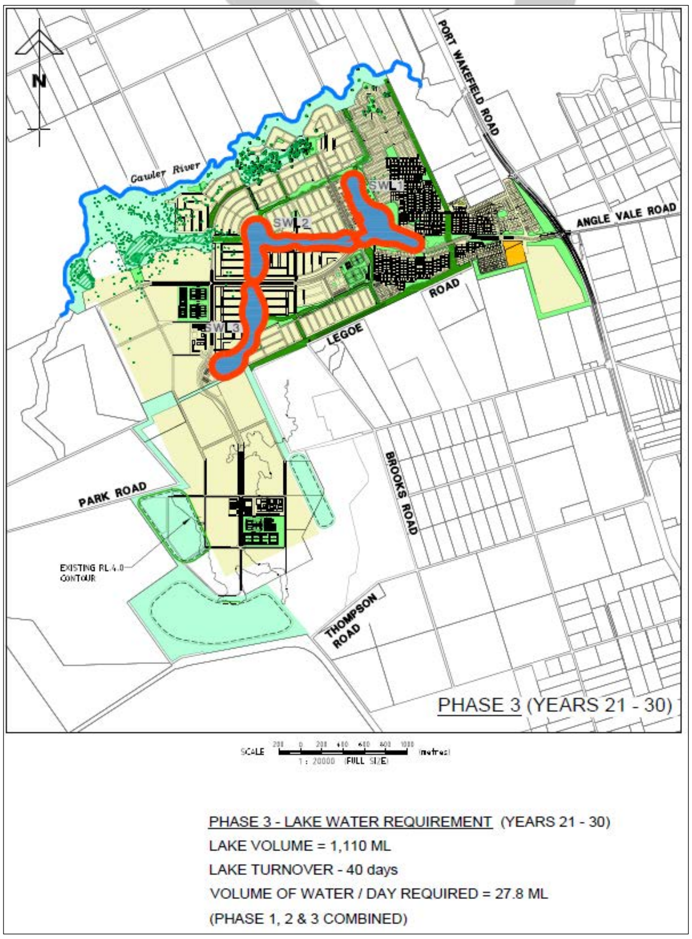


Figure 4: Phases 3 (lake outlined in red) (Burchills Engineering Solutions)

Phase 1 consists of a single lake of approximately 407 ML volume.

Phase 2 adds an additional lake of approximately 385 ML, increasing total lake volume to approximately 792 ML.

Phase 3 adds the final lake, at a volume of approximately 318 ML, for a total volume of 1,110 ML.

1.3 Lake Water Source

Saltwater is sourced from within the tidal zone of Chapman Creek, which is subject to the ebb and flow of the ocean, close to an existing offtake for the local salt lakes.

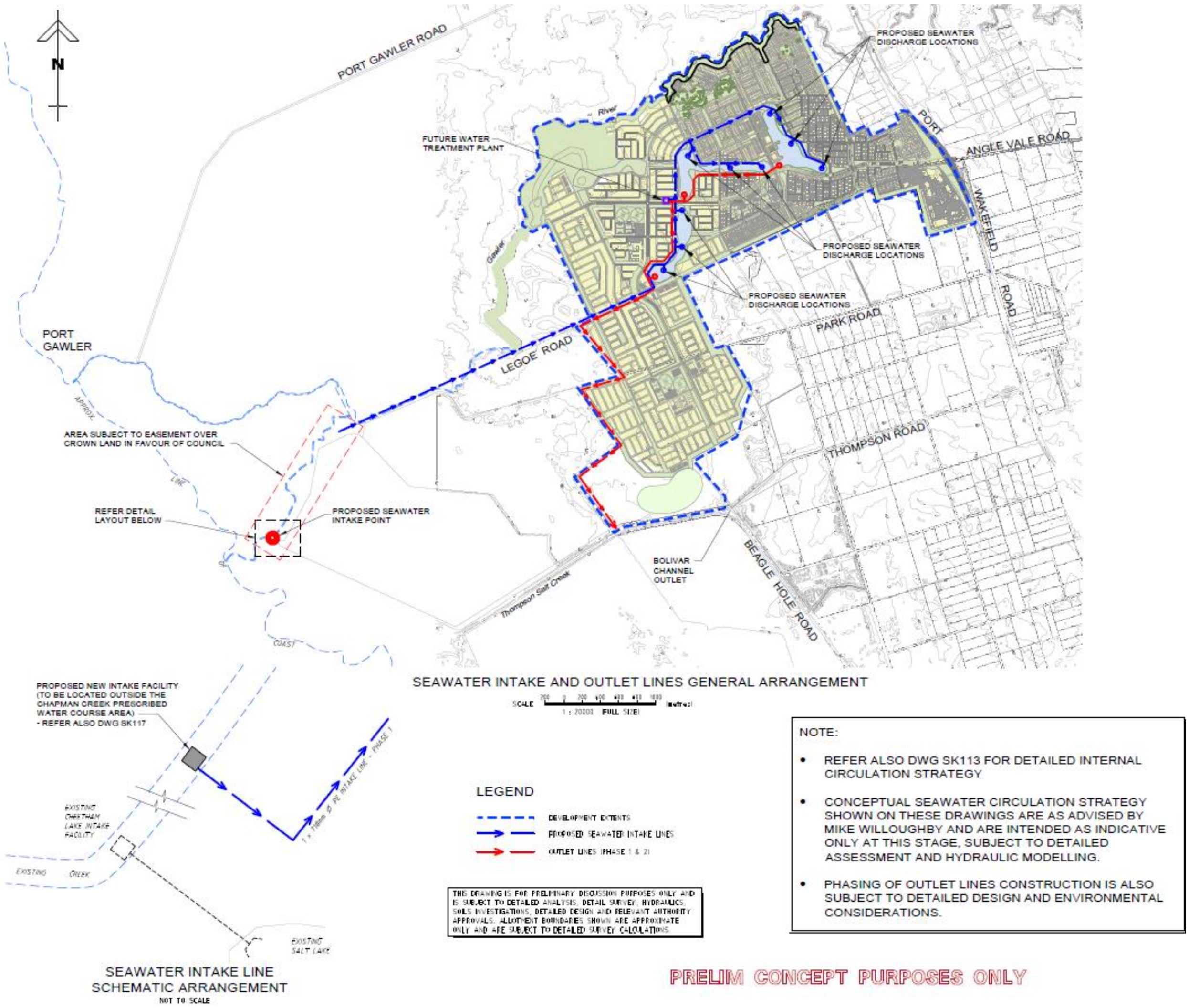


Figure 5: Saltwater Intake Line (Burchills Engineering Solutions)

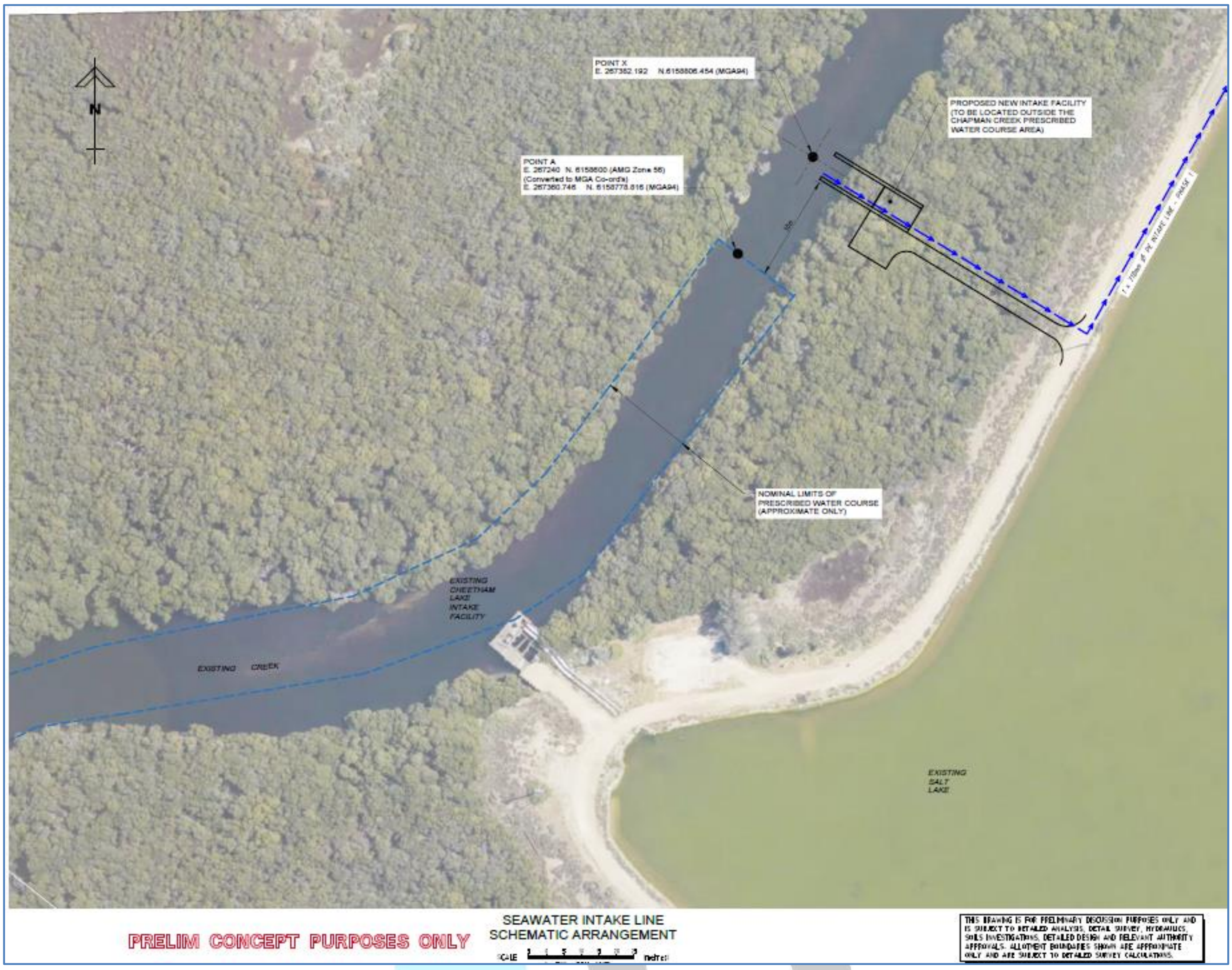


Figure 6: Intake Schematic (Burchills Engineering Solutions)

The offtake would pump water several kilometres to the development's lakes.

A raw water quality sampling program has been conducted, with results indicating relatively variable water quality, especially in respect of Nitrogen and Phosphorus.

Raw water quality is variable with physical chemistry and nutrient concentrations ranging s detailed as follows:

Table 1 - Raw Water Quality Range

Parameter	Range
Conductivity uS/cm	12700-70500
Suspended Solids mg/L	1-64
Total Nitrogen mgN/L	0.1-4.4
Ammonia mgN/L	0.01-0.18
Total Phosphorus mgP/L	0.02-1.45

Water Quality ranges considerably as shown in Figures 8-12 below.

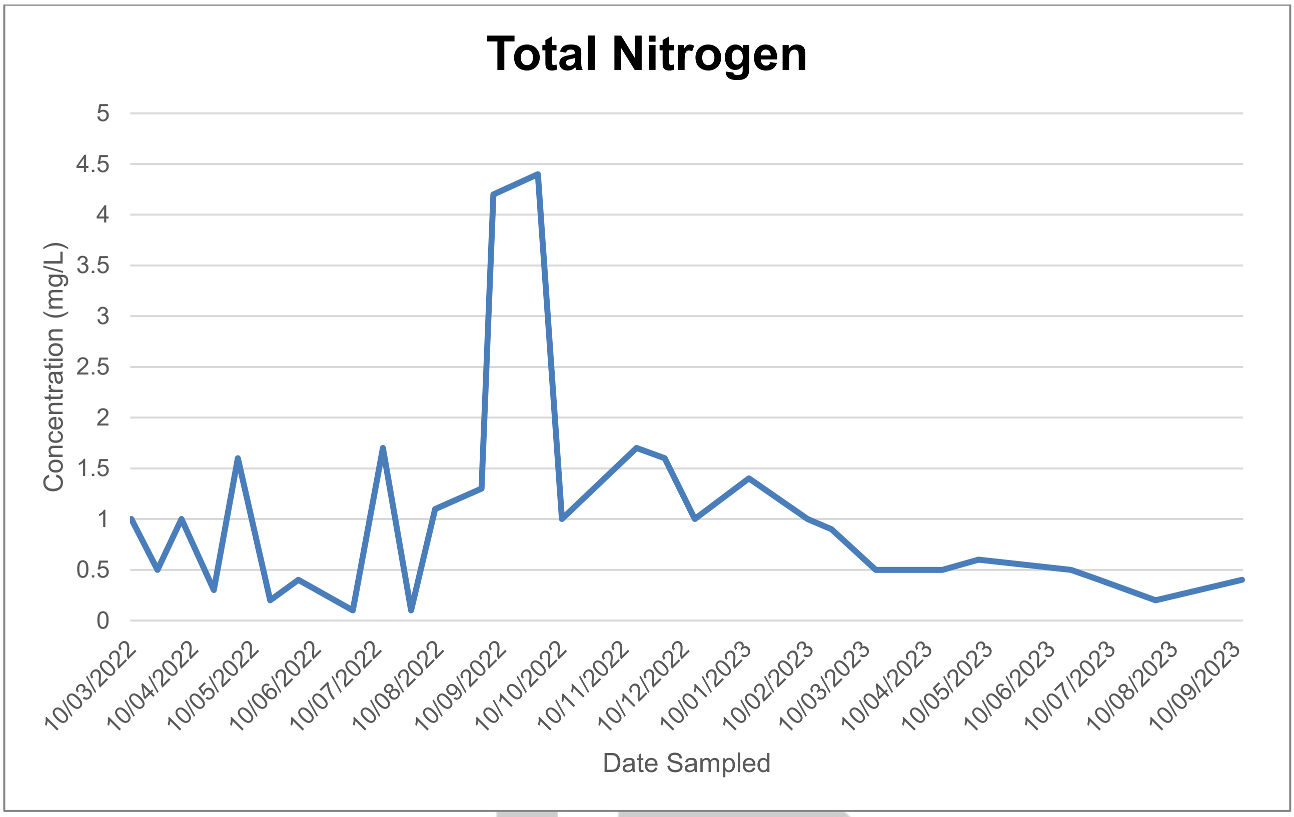


Figure 7: Chapman Creek Inlet Total Nitrogen Results

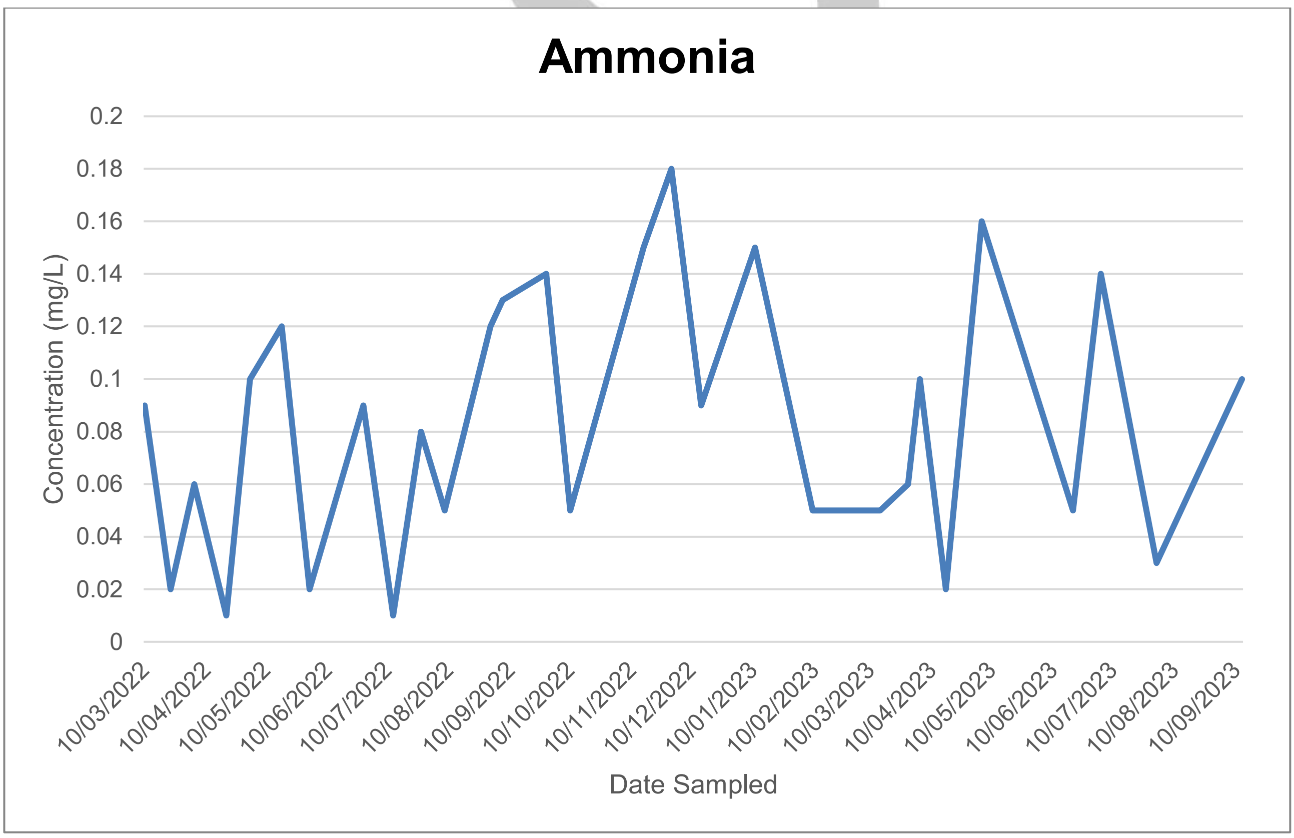


Figure 8: Chapman Creek Inlet Ammonia Results

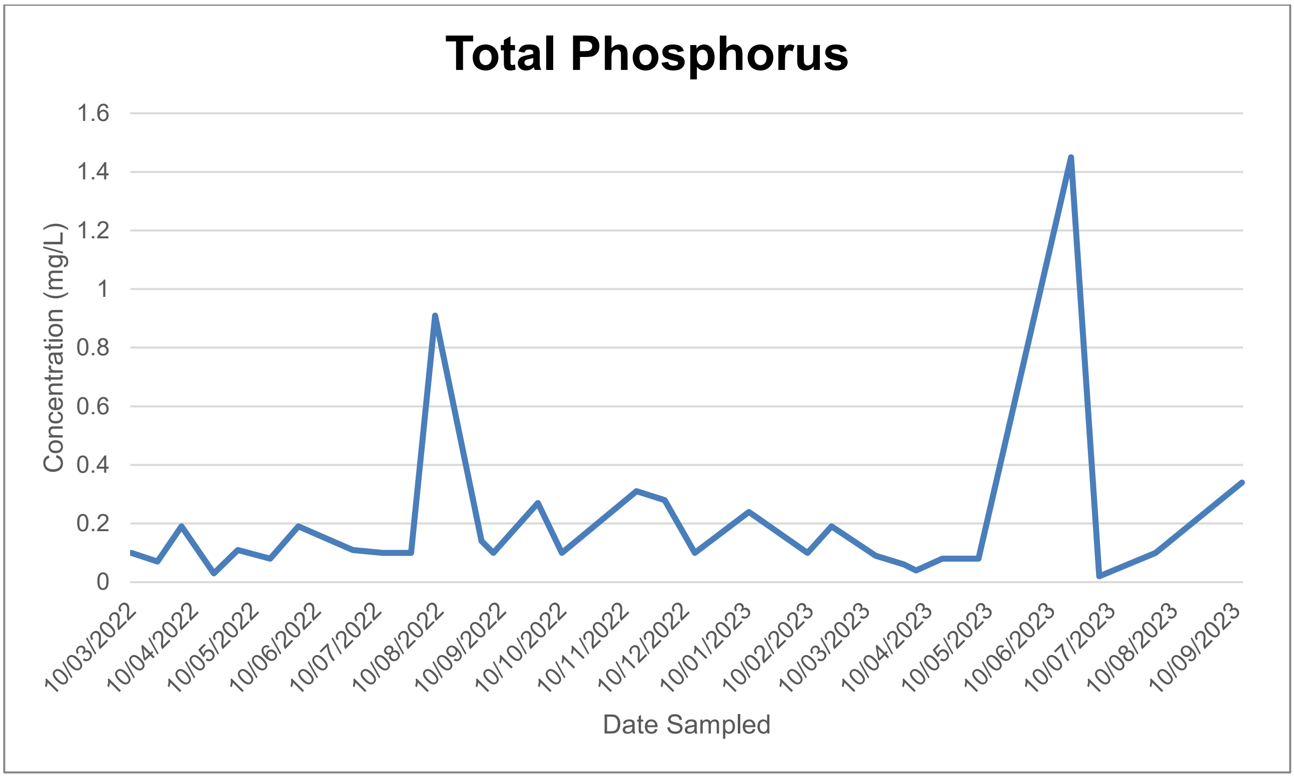


Figure 9: Chapman Creek Inlet Total Phosphorus Results

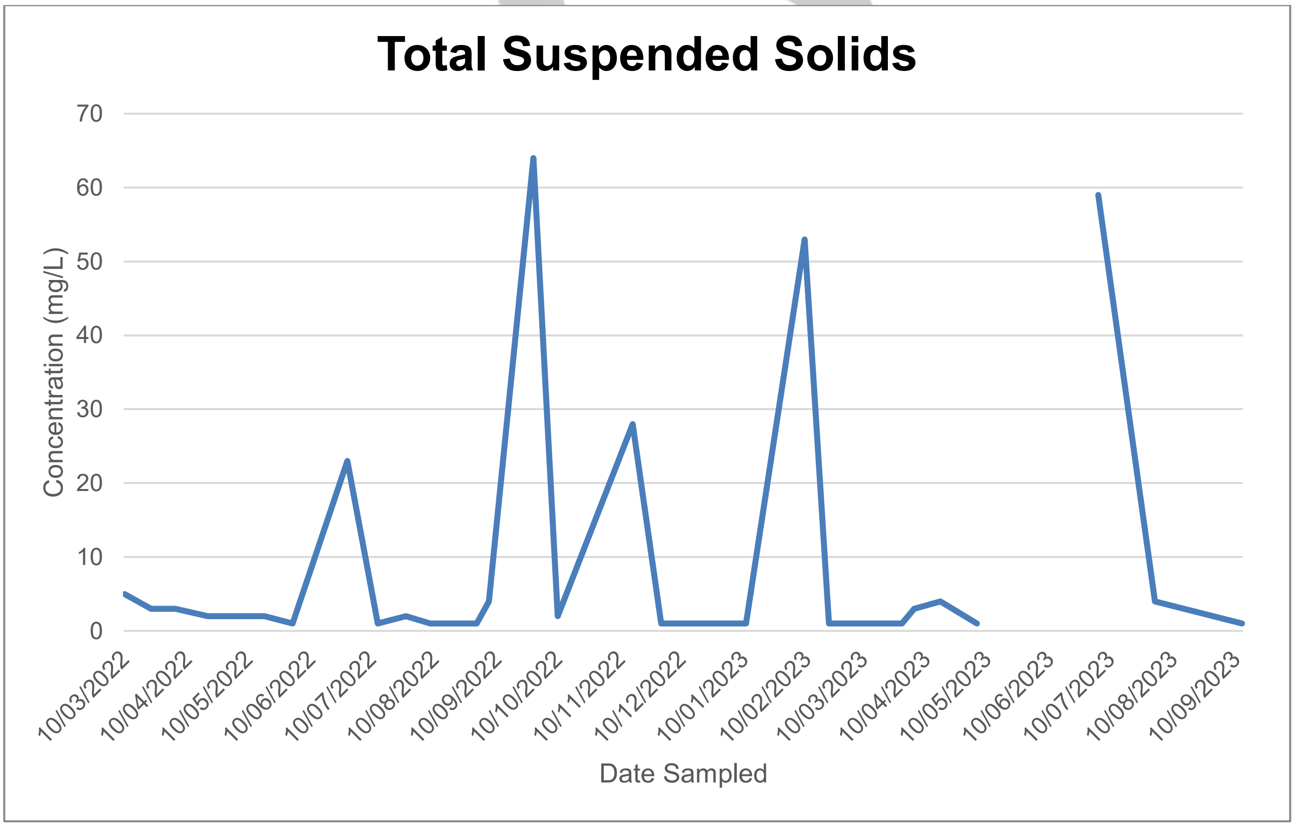


Figure 10: Chapman Creek Inlet Total Suspended Solids Results

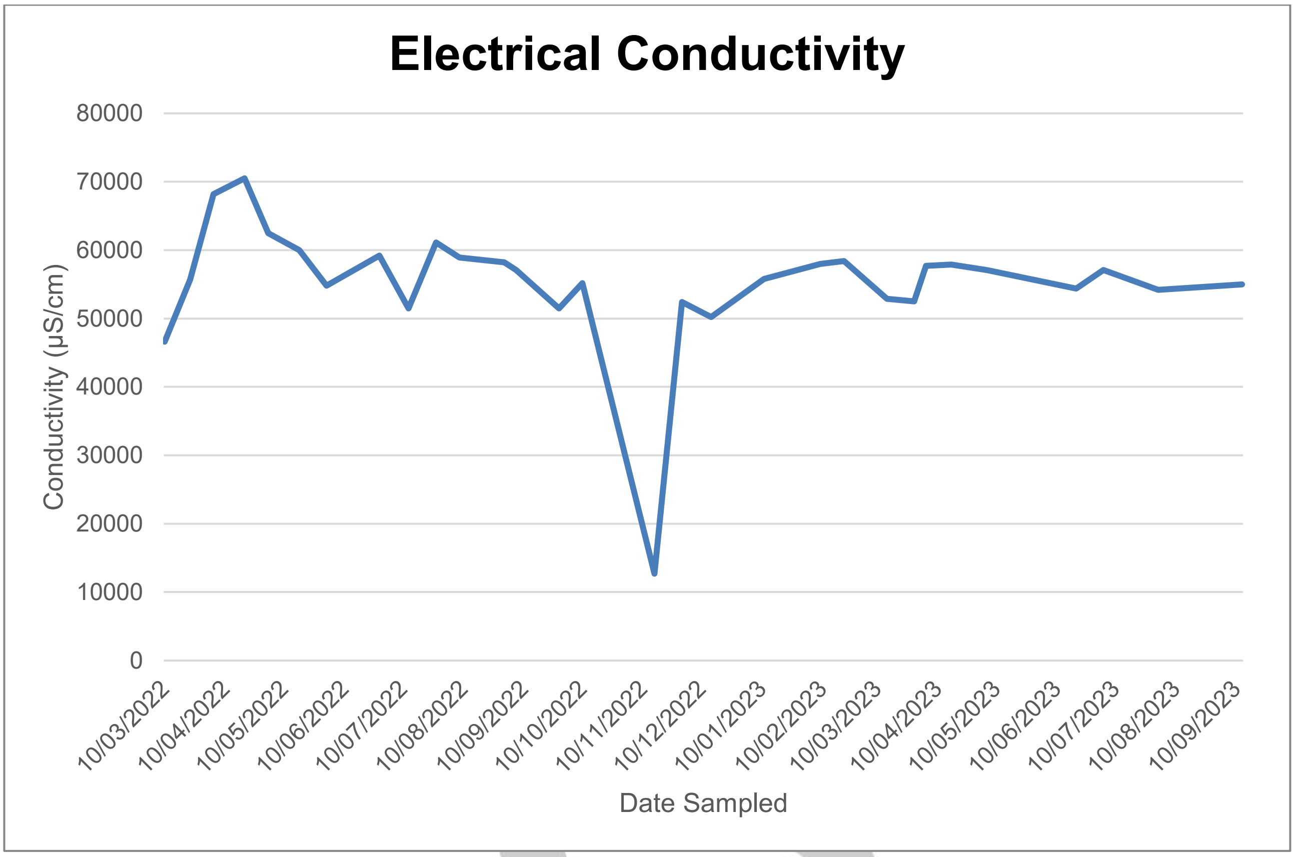


Figure 11: Chapman Creek Inlet Electrical Conductivity

1.4 Lake Discharge

The lakes discharge to Thompson Salt Creek Outfall via gravity.

Figure 12 - Thompson Salt Creek Outfall

Thompson Salt Creek outfall is a highly modified environment comprising a constructed open channel running parallel and between the local salt lake operations and the Bolivar HSP (High Salinity Wastewater Treatment Plant) outfall.

The Thompson Creek outfall receives stormwater flows from three main sources, including flows from:

a) rural and agricultural land surrounding Thompson Creek,

b) an unnamed channel traversing more intensive horticultural and industrial land uses, extending from Buckland Park through Virgina and beyond and

c) drainage channels abutting the eastern aspects of the local salt lake operations in Buckland Park,

and discharges to the Gulf St Vincent, where it mixes with seawater and the Bolivar outfall water within the near shore environment.

2. WATER QUALITY OBJECTIVES

SWL1 is intended to maintain a water quality suitable for *Secondary Contact Human Recreation*. Requirements for this are detailed in the *National Health & Medical Research Council's* (NH&MRC) *Guidelines for Managing Risks in Recreational Waters*, and *ANZECC & ARMCANZ's Water Quality Guidelines*.

The objectives are primarily focused on maintaining microbiological and algal quality.

Objectives included in NHMRC (2008) guidelines, include:

- intestinal enterococci: 95th percentile ≤ 40 organisms per 100mL (for healthy adults) (NHMRC, 2008; Table 5.7)
- cyanobacteria/algae—refer objectives for primary recreation, NHMRC (2008)

Green level surveillance mode[1]	Amber level alert mode[1]	Red level action mode[1]
Fresh waters		
≥ 500 to <5000 cells/mL *M. aeruginosa* or biovolume equivalent of >0.04 to <0.4 mm^3/L for the combined total of all cyanobacteria.	≥ 5000 to <50 000 cells/mL *M. aeruginosa* or biovolume equivalent of ≥ 0.4 to <4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume[2]. or[3] ≥ 0.4 to <10 mm^3/L for the combined total of all cyanobacteria where known toxin producers are not present.	Level 1 guideline[4]: ≥ 10 µg/L total microcystins or ≥ 50 000 cells/mL toxic *M. aeruginosa* or biovolume equivalent of ≥ 4 mm^3/L for the combined total of all cyanobacteria where a known toxin producer is dominant in the total biovolume. or[3] Level 2 guideline[4]: ≥ 10 mm^3/L for total biovolume of all cyanobacterial material where known toxins are not present. or cyanobacterial scums are consistently present[5].
Coastal and estuarine waters		
Karenia brevis		
≤ 1 cell/mL	> 1– < 10 cells/mL	≥ 10 cells/mL
Lyngbya majuscula, Pfiesteria spp.		
History but no current presence of organism	Present in low numbers	Present in high numbers. (For *Lyngbya majuscula* this involves the relatively widespread visible presence of dislodged algal filaments in the water and washed up onto the beach)
Nodularia spumigena: See NHMRC, Chapter 6 (Cyanobacteria and algae in fresh water) for details.		

Visual Recreation Objectives as per NHMRC (2008), including:

- recreational water bodies should be aesthetically acceptable to recreational users. The water should be free from visible materials that may settle to form objectionable deposits; floating debris, oil, scum, and other matter; substances producing objectionable colour, odour, taste or turbidity; and substances and conditions that produce undesirable aquatic life.
- cyanobacteria/algae—refer objectives for primary recreation, NHMRC (2008).

Additional testing for Nutrients and trace metals can also be conducted; these would be included in a lake management strategy, which would also detail the testing frequency.

Table 2: Nutrient water quality objectives against raw water quality

Parameter	Raw Water Quality (Range)	Water Quality Objective (95th %ile)	Unit
Total Suspended solids	1-64	25	mg/L
Total Phosphorus as P	0.02-1.45	0.025	mg/L
Total Nitrogen as N	0.1-4.4	1.5	mg/L
Ammonia as N	0.01-0.18	0.9	mg/L

The ammonia limit is based on the ANZECC guideline for the protection of 95% of aquatic species. The current ANZECC guidelines do not contain species protection limits for Total Phosphorus or Total Nitrogen; the phosphorus limit is based on maintaining nutrients below the typical algal growth thresholds, and the TN limit is based on the ammonia limit.

Based on these objectives, to maintain secondary contact recreational requirements, any treatment system will need to:

- Control and prevent algal blooms.
- Control and remove blue-green and potentially toxic algal species.
- Remove suspended solids to maintain lake clarity.
- Be able to deal with intermittent flooding.
- Be able to recover lake water quality in a reasonable timeframe after a flood.

The following sections provide an overview of the main constituents any selected treatment options will need to address.

SWL 1 will be provided with recirculation treatment and water quality monitored against the water quality objectives. If objectives are not met, then additional treatment systems will be installed until objectives are achieved robustly.

The adaptive water quality management system proposes recirculation treatment for SWL 2 and 3, based on performance monitoring and learnings from lake water quality management in SWL1. Future proposed use and interconnectivity of these latter staged lakes will also inform their on-going development.

2.1 Algae Control – Bloom Prevention & Algae Control

Algal growth is the primary driver behind the secondary contact recreational guidelines, with the biovolume of algal cells and the presence of potentially toxic species (potentially toxic phytoplankton or PTP's) being the main control factors for limiting access or closing a lake or waterbody.

As such, controlling algae is important in maintaining the lake in a usable state.

Excess algal growth will cause an algal bloom, which will have aesthetic and potentially health impacts.

Figure 13: Marine Algae Bloom (CDC)

Figure 14: Algal blooming of freshwater (Wikipedia 2016)

Blooms require sufficient nutrient concentrations to support the algal growth and sufficiently warm temperatures (typically 20^{O}C-30^{O}C); as such they tend to be common in the summer months and are less likely in winter.

Algae can be controlled by several methods, the most common of which tend to be limiting the amount of nutrients available for growth, by directly interfering with the growth or propagation, or using algaecides to directly destroy or inhibit their growth.

Not all methods need to be applied; systems can rely on only one method for control, such as nutrient removal or algaecide dosing, however a multi-faceted approach will generally be more reliable and effective, as the control techniques are able to support each other.

Dealing with a bloom will usually require heavy dosing of an algaecide to kill algae, and removal of the algal cells, via skimming or filtration.

2.2 Suspended Solids Removal & Maintaining Lake Clarity.

Suspended Solids consist of particles that float within the waterbody. These can range from organisms such as bacteria and algae, to inorganic materials such as dirt, clay, or silica.

Solids can cause issues with fish kills, with the solids clogging fish gills, plant growth and general aesthetics of the waterbody; high suspended solids will make the water murky, discoloured, and dark, impacting light penetration and the overall aesthetic appearance of the lake.

Suspended solids may enter the lake via stormwater runoff, in top-up water, via direct dust deposition or from the growth and decay of waterborne organisms such as algae and bacteria. They are typically removed via sedimentation or filtration processes, and the saltwater nature of the lake should help to maintain clarity.

2.3 Flood Recovery

The site is subject to infrequent flooding, and generally local floodwaters will tend to flow away from the site due to the changed landform, however the lake does accept stormwater from part of the site, and as such may be subject to localised flooding in extreme weather events.

Recovering from floods generally involves the removal of sediment to restore lake aesthetics, especially clarity and colour. The level in the lake is also likely to be higher for short periods than would typically be maintained, given the control over the lake level available.

Removal of sediment from the lake may be via natural sedimentation (which will eventually require the lake to be dredged), which may require the addition of a coagulant if there is significant clay present in the soil in the catchment, or by coagulation and filtration if a suitable system is available. Suspended Solids removal is discussed in Section 3.4 below.

The use of salt-water in the lake system will result in a separation between the floodwaters and the lake water based on density (with salt water being denser than freshwater), depending on the amount of mixing energy present at the water inlets.

Recovery time depends generally on turn-over rates.

2.4 Monitoring

The waterbody will require regular monitoring and testing. This will include algae enumeration and classification, to identify whether any of the species of concern are present and in what amounts, bacteriological testing for enterococci, potentially faecal coliforms, and E.coli (although as an open lake these are likely to be present through environmental contamination), and for pH.

Further testing for heavy metals and trace elements should also be conducted, however the treatment system is not designed to control these elements specifically, and they are likely to be significantly impacted by the source water and storm water entering the lakes.

The test results allow for both the management of any active control measures provided (such as tuning the ultrasonic programs), and also allows for the management of the waterbody, allowing the appropriate decision makers to make decisions on whether the lake is suitable for secondary contact recreation, or whether control measures need to be applied (such as changes to the treatment systems or administrative measures such as closing the lake). This is usually achieved using different alert levels as referenced in Section 2.

Each alert level is linked to quick identification of measures that need to be undertaken, such as signage and public announcements, and corrective actions. These actions are typically developed following risk assessment during detailed design.

The monitoring frequency varies based upon the risk presented by the waterbody. Typically, we would recommend monthly water quality monitoring considering the nature of the site and the importance of the waterbody to the overall site aesthetics.

3. TREATMENT METHODS

The following sections provide an overview of potential treatment processes that could be applied to the lake.

3.1 Nutrient Control

The presence of nutrients doesn't directly cause an impact on a lake system, however excess nutrient concentrations will support the growth of algae and bacteria that are likely to cause an impact.

Impacts include direct aesthetic impacts, such as slimes, scums, discolouration and reduction in water clarity, and odour. It can also cause oxygen depletion caused by either the algal life cycle or bacterial respiration can cause fish kills, further causing aesthetic impacts. Finally, the growth of potentially toxic algae can have a direct health affect.

Limiting nutrients will tend to limit algae growth. The primary nutrients of concern are Nitrogen, Phosphorus and Carbon. These three nutrients tend to be the main driving factors behind algal growth and are often the root cause of algal blooms (combined with sufficiently warm temperatures).

Nutrients will primarily enter the lake are via stormwater runoff, or from top-up water from a eutrophic (i.e. has high nitrogen and phosphate concentrations already) source. The decay of plant matter can also introduce additional nutrients into the waterbody.

3.1.1 Nutrient Removal

Nutrients may be treated biologically or chemically.

Biological treatment relies on promoting the growth of an alternative lifeform to absorb the nutrients. This is quite often plant growth (the main driver behind the relatively common use of wetlands for freshwater lake treatment), but can be bacterial growth (either using dedicated treatment processes, or dosing systems such as lakepak or diatomix). Biological systems will tend to absorb both Nitrogen and Phosphorus, and growth will typically limit one or the other depending on the relative abundance in the source water.

Chemical treatment typically targets phosphorus, using a chemical coagulation reaction, which is commonly utilised for phosphate removal in wastewater treatment. Low concentrations can be achieved but will usually requires significant dosing rates. Chemical coagulation has an added benefit of also helping remove turbidity, which will improve lake water clarity.

3.1.2 Nutrient Sources

There are two main sources of nutrients for the lake: the incoming lake water and stormwater entering the lake.

Chapman Creek is approximately 2.5 km from the outlet for Thompson Salt Creek, a highly modified creek that accepts significant discharges from local horticulture, the Bolivar HSP (high salinity wastewater treatment plant), stormwater runoff and other various inputs.

As noted, it is likely that Chapman Creek is within the near-shore zone of influence of the Thompson Salt Creek outfall, and as such, may feature elevated nutrient concentrations.

To help to stabilise nutrient concentrations, sea water may be treated either as it enters the lake, within the lake, or a combination of the two.

The lakes are intended to provide stormwater detention as part of the overall stormwater management system. While the implementation of WSUD practices are intended for the site for the control of stormwater, there is the potential for the nutrient loading to be sufficient to support algae growth, even if load reduction targets are met.

Significant reduction will be achieved in the WSUD systems prior to stormwater being discharged to the lakes, however there may be sufficient residual nitrogen and phosphorus to lead to algal growth. This would need to be treated via an in-lake system.

3.2 Algaecide Dosing

Algaecide dosing is a relatively simple method for algae control and involves the dosing of a compound toxic to algae. This is typically a copper-based substance.

Algaecide dosing needs to be conducted carefully; heavy dosing will result in mass algal death, resulting in significant cell rupture. This will release any algal toxins present and can have a further aesthetic impact beyond that caused by the algae in the first place.

Chronic dosing of a low concentration of algaecide during the growth season however can help to reduce algal growth rates while avoiding issues associated with heavy dosing.

Algaecide dosing however needs to be maintained as a “last resort” measure to treat significant blooms.

3.3 Algal Disruption

Alge require specific conditions to thrive, beyond adequate temperature and nutrient availability. Applying methods that disrupt these conditions limits algal growth and can prevent blooms even with sufficient nutrient availability.

The species that will generally contribute to aesthetic issues and toxin production are able to float in the water column; they float to the surface during the day to photosynthesise, and then sink lower into the water column during the evening to respire using the oxygen they’ve created. Disrupting this mechanism will reduce the growth rate of the algae.

The two main methods for achieving this are lake mixing and Ultrasonic systems.

Lake mixing provides vertical mixing of a lake, this helps to prevent the creation of a thermocline (a distinct change in temperature within the lake) and also improves oxygen saturation throughout the waterbody. This improves overall lake water quality by stabilising the water chemistry, and the mixing can help to reduce algal growth, although the energy input is not typically sufficient to deter growth, especially at high nutrient availability.

Ultrasonic systems consist of either low-power or high-power. Low power systems utilise low power ultrasonic waves that disrupt the gas vacuoles within the algal cells, preventing their ability to float. This then causes them to sink to the base of the lake and decay. High power systems rely on micro-cavitation on the algae surface, which will result in the agal cell being ripped apart.

Low power systems have had good results in European countries although here is limited local experience. They require tuning to the algae present, which requires sophisticated control to achieve good effect, but have been reported to have minimal effect on other aquatic life.

3.4 Suspended Solids Removal

Removal is typically via sedimentation or direct filtration, although these may not always be possible without a supporting process. Clays especially cause stable colloidal suspensions that are impossible to settle and can be very difficult to filter; in this case, a coagulant and potentially a flocculant may be required to make the particles settleable and/or filterable.

Coagulation neutralises surface charges that stabilise suspensions like clay, allowing for the particles to clump together. Coagulants will also react with phosphates present, which causes them to precipitate and become removable via either sedimentation or filtration.

The use of saltwater in the lakes should assist with solids removal, as the saltwater will support coagulation when mixed with fresh stormwater runoff.

Sedimentation utilises large, still waterbodies to allow solids to settle out under gravitational forces. A degree of sedimentation is likely to occur within the lake itself depending upon the amount of mixing energy available, which will eventually cause the siltation of the base of the lake (which is commonly seen and typically accounted for in the lake design). Sedimentation is typically required for high concentrations of solids.

Filtration uses various methods to directly sieve particles from the water and is suitable for lower concentrations of suspended particles (and often follows a sedimentation process as it will achieve a lower TSS concentration than sedimentation), the concentrations need to be lower as too many solids will rapidly clog the filter medium, drastically increasing the amount of cleaning that is required.

The generally expected TSS concentrations within the lake should be suitable for direct filtration.

3.5 Stormwater Treatment

The lakes are intended to act as detention for stormwater, and it has been indicated that some of the stormwater generated on site will be directed to the lakes.

This stormwater needs to be treated prior to entering the lakes to reduce Solids, Phosphorus and Nitrogen.

This may be by using standard water sensitive urban design (WSUD) and stormwater quality improvement devices (SQID's) such as raingardens or bioretention basins, or by using specifically engineered treatment devices.

Raingardens or bioretention basins have been very successfully integrated into the streetscapes of developments, however the current proposal is to utilise advanced filtration units, specifically for this development the Atlan Flow Filter unit. These units utilise a combination of GPT's and membrane filtration to provide a high degree of particulate removal, removing significant particulate solids, which also removes associated bound or particulate nutrients.

These units provide nutrient removal as well as acting as a pollutant trap and can be built under carparks and other more industrial structures.

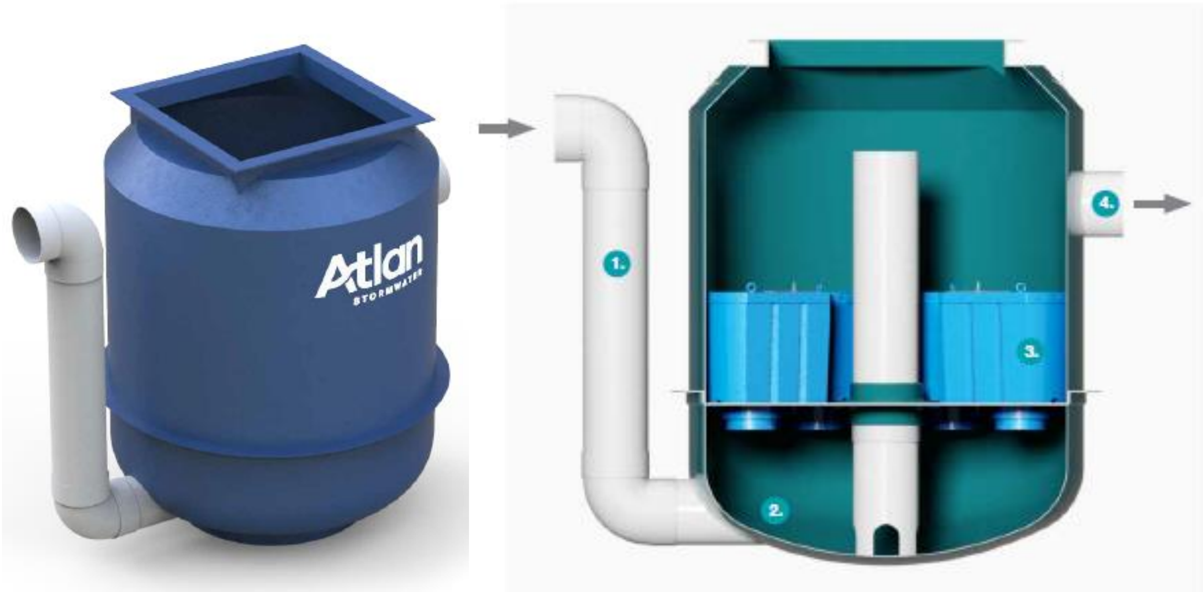


Figure 15: Atlan Flow filter

It will be far simpler (and cheaper) to lower nutrient concentrations of the stormwater entering the lake, than it will be to provide treatment for significant nutrient concentrations that the stormwater is likely to cause.

4. PROGRESSIVE ADAPTIVE WATER QUALITY MANAGEMENT STRATEGY

The progressive adaptive water quality (WQ) management strategy focuses on the construction and provision of treatment assets based on water quality and treatment performance as opposed to simply building out treatment assets as the lakes are constructed.

The progressive strategy consists of initially the fill and recirculation systems, and if necessary, will progress through additional treatment items. Implementation of additional treatment processes will be based on ongoing lake water monitoring, nominally over a 12 month or longer period. This monitoring will both determine the need for additional treatment, and underpin the design for any additional treatment processes.

While the implementation of subsequent treatment units will be based on scientific analysis and good design, in general the sequence would be expected to be:

- Lake top-up & local lake recirculation systems
- Nutrient Removal treatment train
- Chemical dosing for enhanced coagulation & phosphate removal
- Ultrasonic algae removal systems
- Lake mixers
- Direct Algaecide dosing

The subsequent sections provide further detail on each of the major treatment items considered as part of the management strategy.

4.1 Lake Fill & Recirculation Systems

Proactive management lake water quality to achieve secondary contact WQ objectives, will require an active water quality treatment system to ensure a healthy lake system.

Reactive management though may be sufficient, to deal with infrequent WQ exceedances and as such the initial phase of the strategy is to utilise a turnover and circulation system, relying on the salinity of the water and hydraulic mixing/turnover to manage biological growth and aesthetic WQ.

This minimises both capital and operating costs, and is required as a base design to support any other future upgrades to the management system.

The initial phase will consist of the supply of raw water to the lakes, and the use of a lake recirculation system, targeting a joint turnover rate of 80 days, a total flow of between 55 and 70 L/sec.

Lake/Phase No	Approx Volume	Turnover Time	Required Flowrate
Phase 1	407 ML	80 days	70 – 125 L/sec
Phase 2	386 ML	80 days	67 - 120 L/sec
Phase 3	317 ML	80 days	55 - 100 L/sec

Pump rates are based on a nominal run period of 12 – 20 hrs, with the 12 hr (producing the larger flow) being the current planned rate.

The recirculation system should also be capable of providing between 50 and 150 L/sec of flow, matching the raw water flow. This allows for the total turnover to be reduced to 40 - 60 days if necessary to help recover from an algal bloom.

The raw water pump rate also provides for makeup water lost by evaporation and infiltration.

Evaporative loss from the lakes is likely to be in the order of 1400m3/day averaged across the year, ranging from a low of 400m3/day in winter (June) to 2500m3/day peak in summer (January).

Infiltration is a very minor loss due to the lakes being lined and only accounts for 0.5L/sec across all lakes.

The provision of local recirculation reduces the size of the lift pumps and reduces the flow being directed to Thompson salt creek. While the recirculation rates are of a similar magnitude to the raw lift system, the head required for the pumping systems should be significantly less due to the shorter pumped distance.

Pump station placement and sizing will vary depending on final lake layout and will be configured to take water from terminus or overflow points and pump it back to the inlet. This will create a flow through the lakes that improves lake mixing. Lakes may require two pumping stations to ensure that there are no dead-zones within the lake. In this instance the pumped capacity will be split between the pumping stations, that is, if a pumping rate of 100 L/sec needed, with two pumping stations required to cover the lake area, each station should be installed with 50 L/sec worth of pumping capacity.

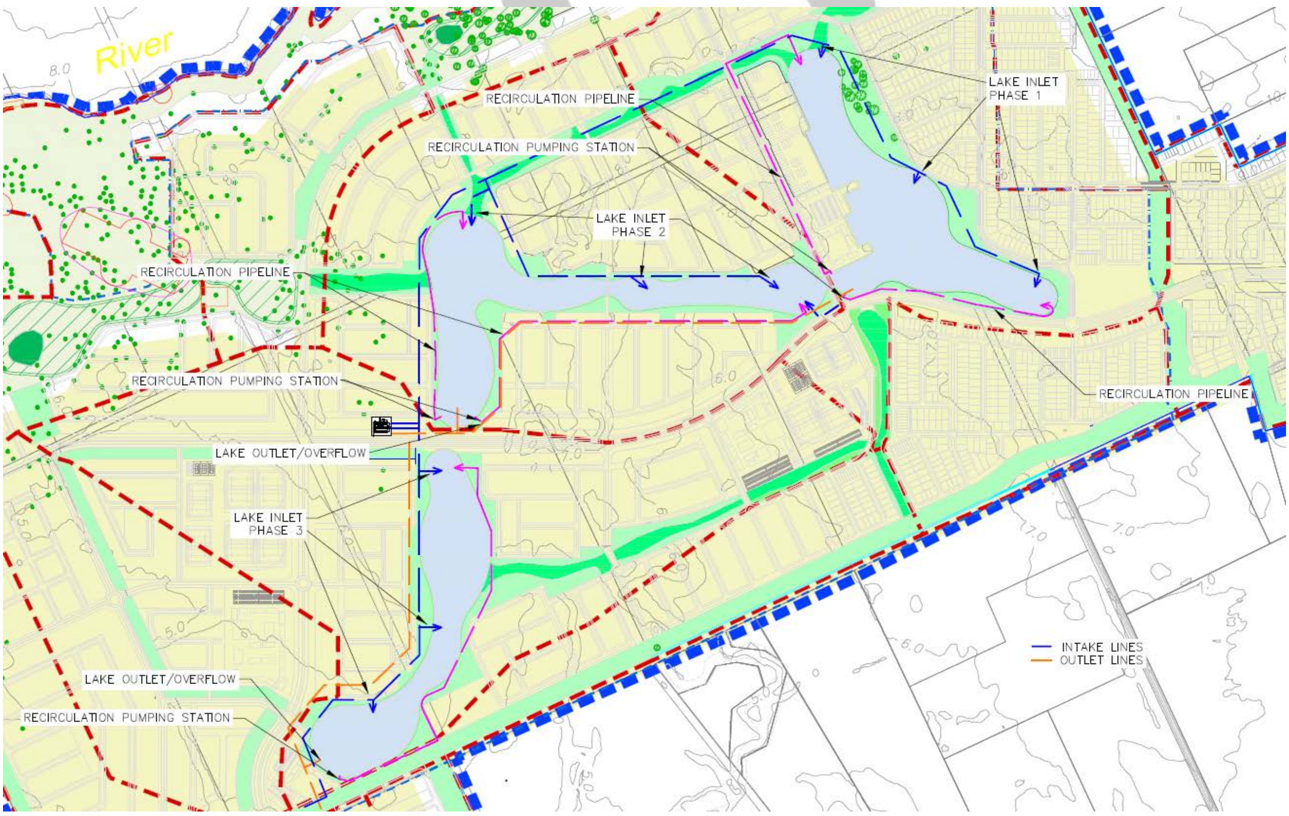


Figure 16: General Recirculation Layout

4.2 Nutrient Removal Treatment Trains

If the recirculation system is not able to maintain adequate water quality to prevent algal blooms and maintain the requirements for secondary contact recreation, a water treatment plant will be constructed to improve nutrient removal.

The treatment plants will be centrally located to allow for simplified maintenance and operation. This will be near the raw lift water route, allowing water to be directed from the raw lift system into the treatment plants.

Additionally, the recirculation pumping stations will be able to direct water to the treatment plants to allow for re-treatment of recirculation water to reduce in lake nutrient loads.

It is expected that one plant will be required per lake, however the central location of the plants provides the option to build out the treatment asset sequentially, this could allow one or two plants to cover all 3 lakes, so long as water from all 3 lakes can be directed to the plants, as described above.

The treatment plants should have a nominal sizing of 75-150 L/sec. This allows for treatment of either the raw water, or recirculation water, or a combination of both depending on current pumping rates. This sizing should be able to be optimised with appropriate detailed design and water quality data.

The treatment system consists of a nitrogen removal system, consisting of a staged nitrification, de-nitrification reactor, and a cloth disk filter for particulate removal. The systems provide direct removal of Nitrogen, with removal of phosphorus as a side-effect (as phosphorus is a nutrient required for bacterial growth), and removal of suspended solids via direct filtration.

The water plant would be located centrally, and as the process will require re-pumping to reach all lakes, large, deep tanks can be used to significantly reduce the footprint over the in-ground reactors considered for the options previously.

The reactors consist of 5 m deep open top tanks, which results in each aerobic reactor being approximately 5 m x 10 m x5 m deep and the anoxic reactor being 5 m x 15 m x 5 m deep. Including the CMDF systems and sludge handling the total WTP complex should fit in a roughly 50 m x 50 m footprint, although this excludes the area needed for a plant building, parking, etc.

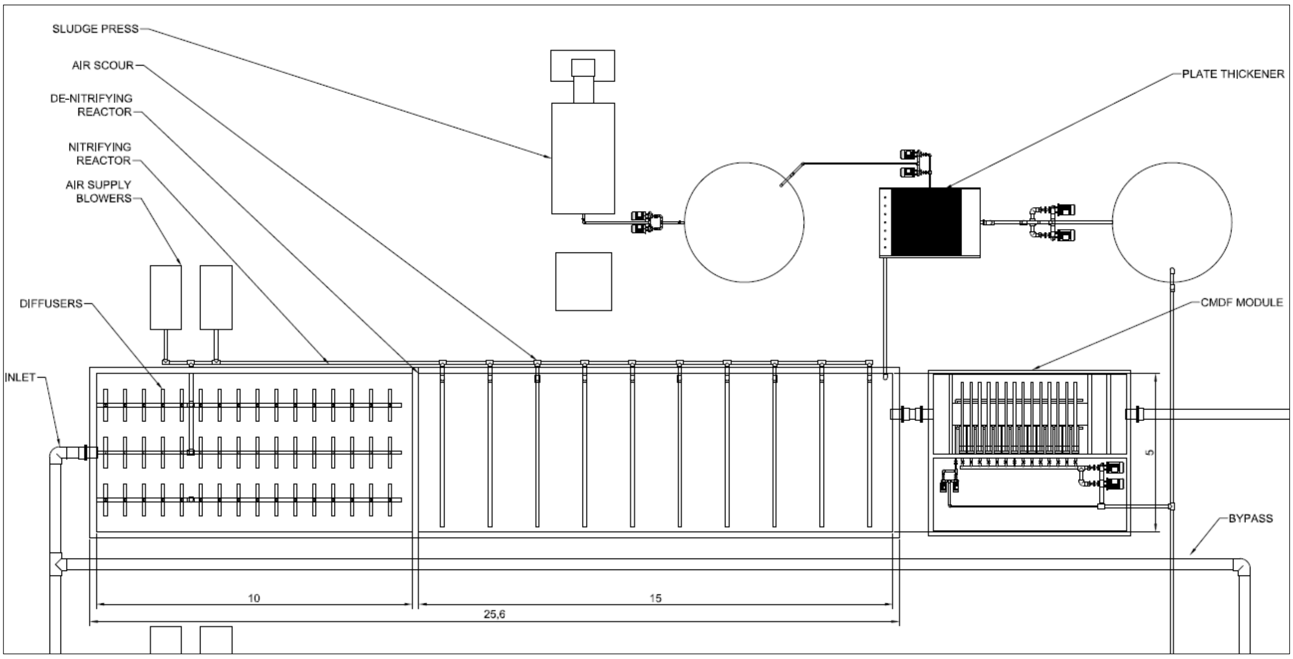


Figure 17: WTP Single Train layout.

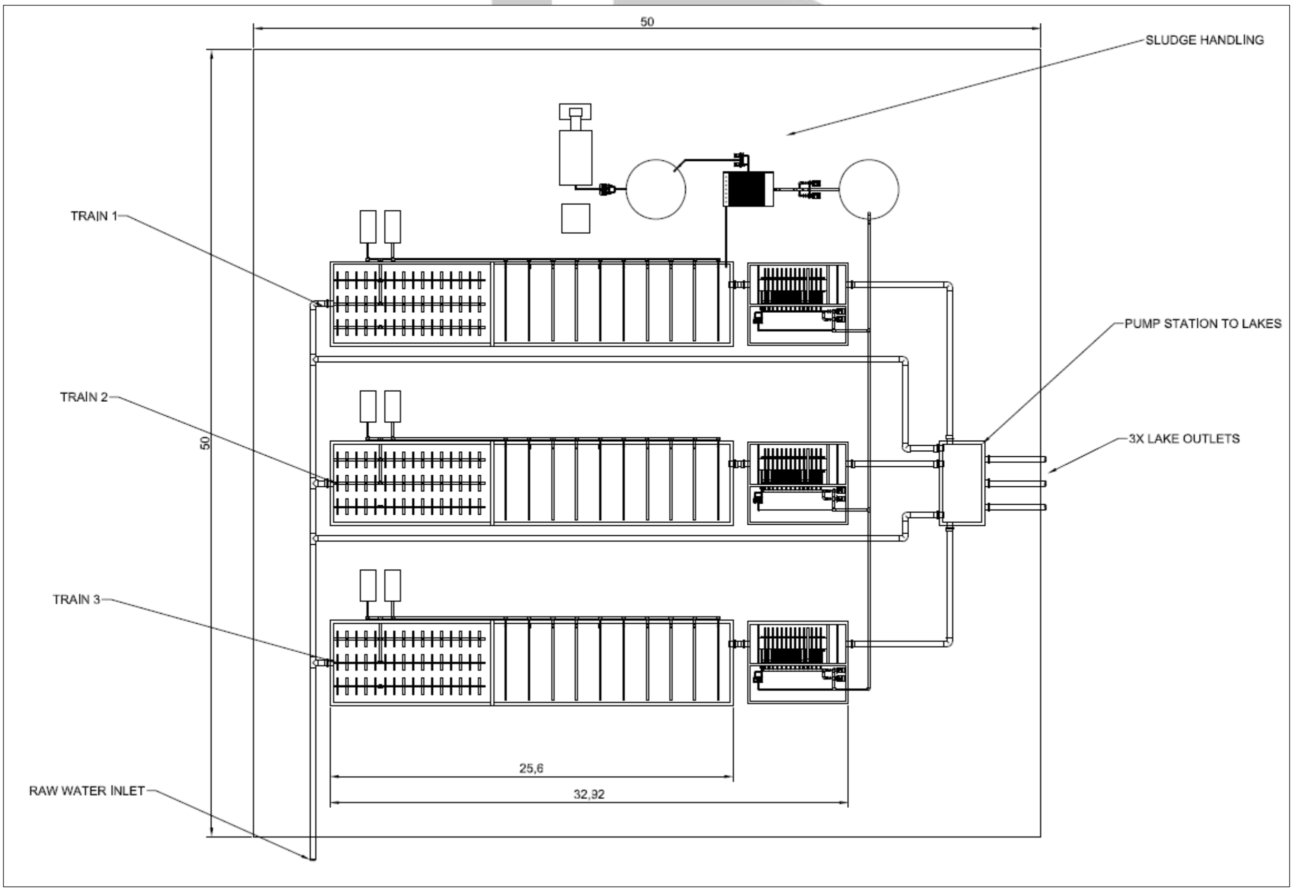


Figure 18: WTP General Compound Layout

The location proposed, at the southern end of Lake 3, should have sufficient space for the treatment plant, including a plant building, parking area and other access provisions.

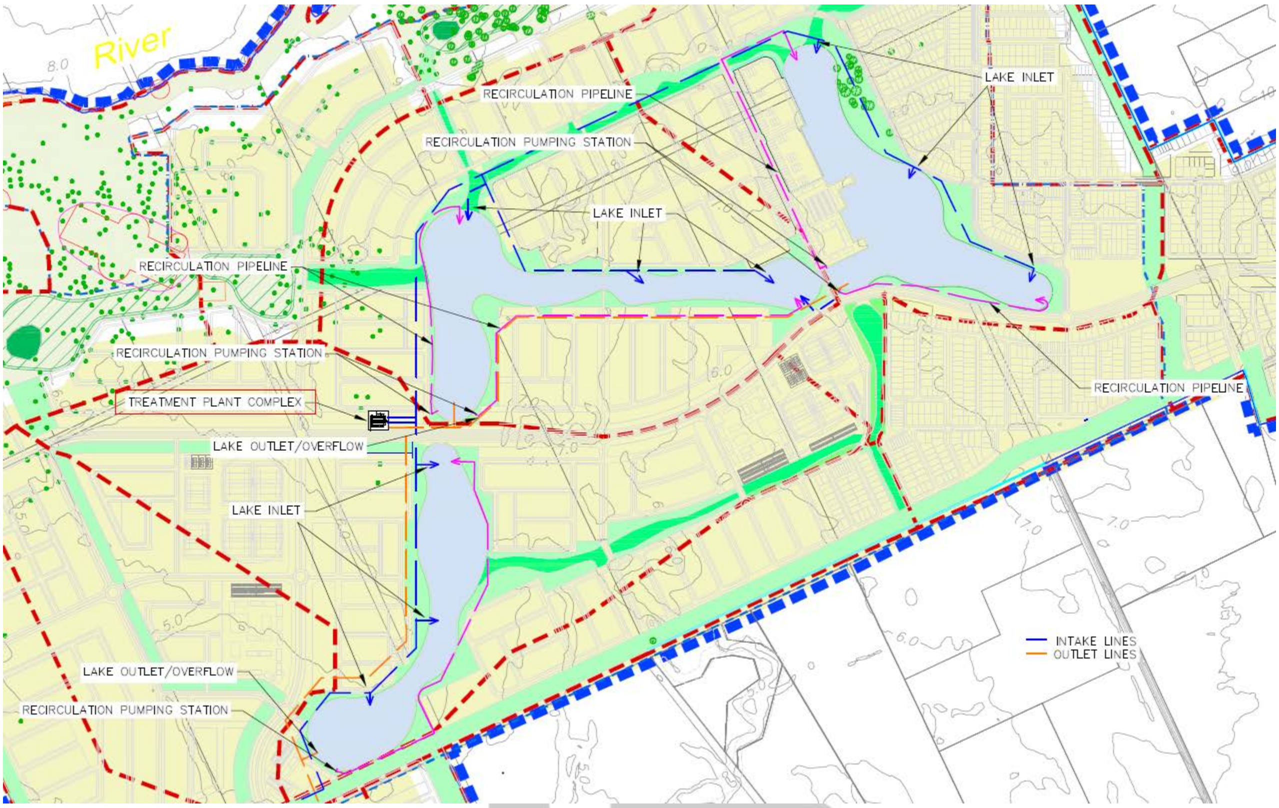


Figure 19: Provisional Treatment Complex Location

4.2.1 Chemically Enhanced Filtration

Chemically enhanced filtration improves both turbidity removal and phosphorus removal and would be employed if the system were having problems maintaining either turbidity or phosphorus water quality objectives.

The system is a relatively simple retrofit to the filtration process, and includes the addition of a coagulant dosing system, likely dosing Aluminium Sulphate or a similar coagulant.

4.2.2 Ultrasonic Algae Control

Ultrasonic algae control directly impacts algal growth by interfering with their growth cycle. It won't eliminate algae entirely, which can be useful for maintaining the local food web, but it will generally significantly reduce blue-green algae blooms.

Discussion with LG Sonic has indicated that the E-Line product may be suitable. The E-Line system can be installed at or near the shoreline and generates an ultrasonic into the waterbody. This has the advantage of having much less aesthetic impact compared to the more traditional floating Bouy systems.

Figure 20: LG Sonic E-Line

A series of these ultrasonic transceivers would be installed to each lake, generating an ultrasonic layer at the surface of the lake, interfering with the algae's ability to float, impacting their growth.

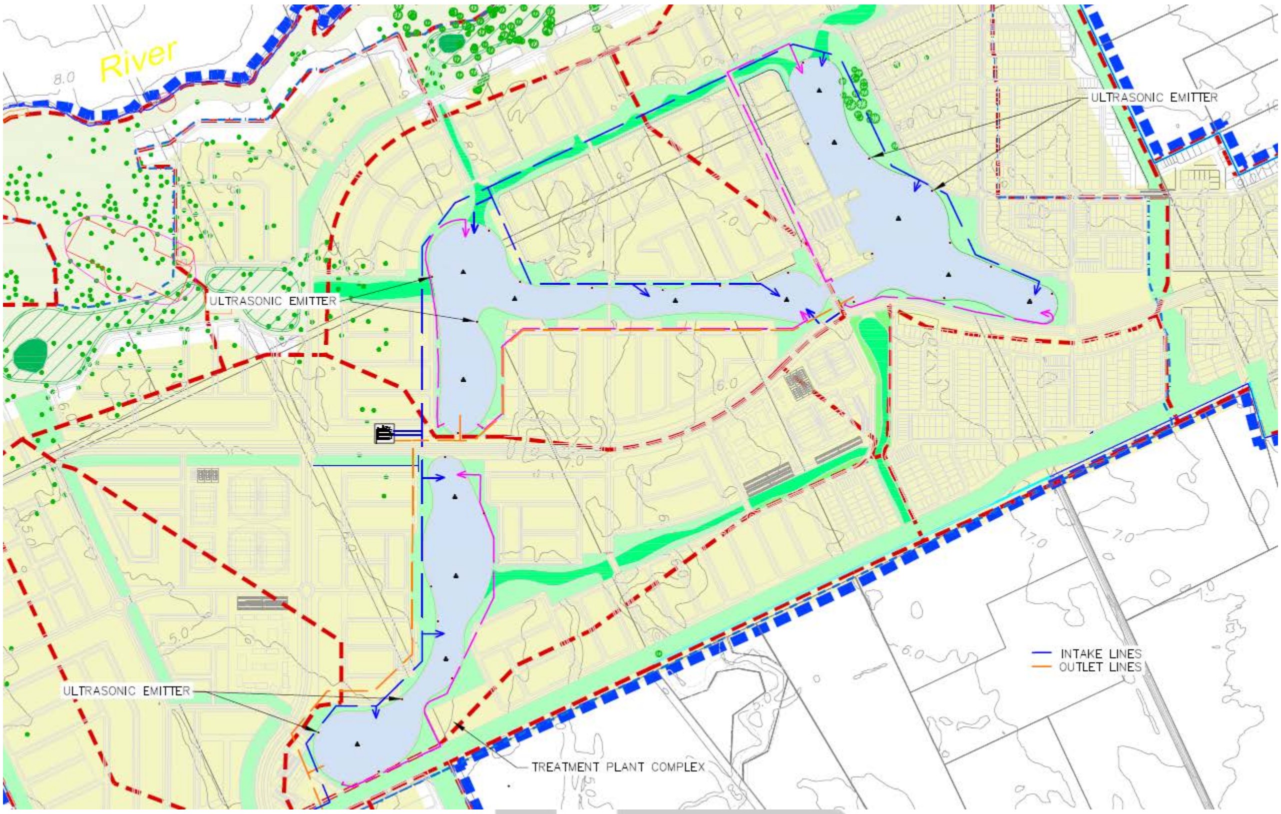


Figure 21: General ultrasonic transceiver layout

4.2.3 Lake Mixing

Lake Mixing helps to stabilise water quality and would be implemented if ongoing testing found that the lake waterbody was stratifying, if there were significant dissolved oxygen issues, or if lake water quality was found to be unstable (i.e. significant variations in nutrients or other parameters over time or spatially over the area of the lake).

Mixing stabilises lake water quality by homogenising the water column. This helps to reduce algae growth by also disrupting their growth cycle, but mixing is more targeted at stabilising the lakes.

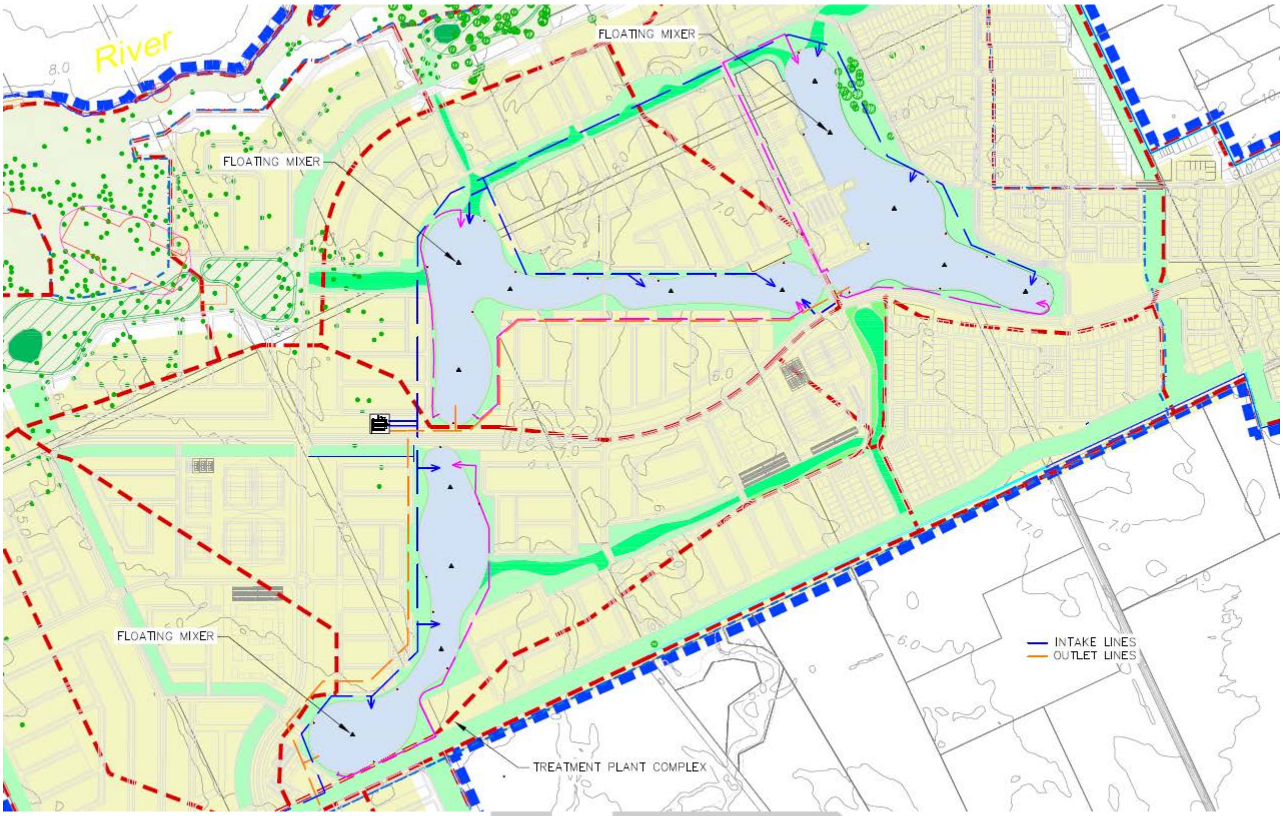


Figure 22: Provisional lake mixer layout

4.2.4 Algaecide Dosing

Algaecide would be implemented either as a last-resort, or as a spot-dose to treat a bloom in progress.

If implemented in an ongoing fashion, the system would be installed into the recirculation system allowing for an automatic dose. Spot doses to treat specific blooms may be simply dosed into the lake manually.

As previously proposed, a low concentration of a highly dispersive copper-based algaecide such as Earth Tec would be used.

5. BUDGET ESTIMATES

Budget costs are high level estimates only, based on previous work for similar projects. Further design and equipment selection will need to be conducted to provide more accurate pricing.

The following table provides a summary of the budget estimates for the discussed treatment solution, excluding raw water and recirculation pipelines and pumping equipment.

The staging reduces up-front capital costs, however a nutrient removal system, recirc pumping station and inlet screening for the lift pumps are by far the largest cost components, and as such the first phase is still significantly expensive.

The plants are of similar size per phase, as the inlet flowrates are similar.

It should be noted that the costs below include provisions for design, contractors margin, contingency costs and other allowances that approximately double the M&E costs for the equipment. Further design, tendering and assessment may reduce these margins.

Provisional costs for the lift system, outfall and recirculation have been provided from WM Developments and are summarised below. WM Developments reporting provides more detail on these estimates.

Table 3: Lift, Recirculation and Outfall Estimate – SWL1

Item	Cost Estimate
Intake Facility	$ 200,000
Lift Pumps	$ 1,410,000
Supply Line	$ 5,143,325
Lake Discharge Chamber	$ 60,000
Outfall Line	$ 2,984,355
Total	$ 9,797,680

Table 4: Lift, Recirculation and Outfall Estimate – SWL2

Item	Cost Estimate
Supply Line	$ 250,210
Outfall Line	$ 294,850
Total	$ 545,060

Table 5: Lift, Recirculation and Outfall Estimate – SWL3

Item	Cost Estimate
Supply Line	$ 304,850
Outfall Line	$ 41,650
Total	$ 346,500

Table 6: WTP System Cost Estimate – Single Unit

Item Description	Estimated Cost
Mechanical – Electrical Equipment	$ 1,875,000
Civil Construction	$ 981,000
Margins and Allowances	$ 2,281,000
Total	$5,138,000

Table 7: Enhanced Coagulation Dosing – Single Unit

Item Description	Estimated Cost
Mechanical – Electrical Equipment	$ 37,000
Civil Construction	$ 5,000
Margins and Allowances	$ 35,000
Total	$ 77,000

Table 8: Ultrasonic System – Single Lake

Item Description	Estimated Cost
Mechanical – Electrical Equipment	$ 563,000
Civil Construction	$ 20,000
Margins and Allowances	$ 493,000
Total	$ 1,076,000

Table 9: Lake Mixing Systems – Single Lake

Item Description	Estimated Cost
Mechanical – Electrical Equipment	$ 563,000
Civil Construction	$ 20,000
Margins and Allowances	$ 493,000
Total	$ 1,075,000

Table 10: Algaecide Dosing System – Single Lake

Item Description	Estimated Cost
Mechanical – Electrical Equipment	$ 13,000
Civil Construction	None (installed in WTP)
Margins and Allowances	$ 11,000
Total	$ 24,000

Operational costs vary. Power costs are the primary component for the raw lift and recirculation system, while chemical costs become higher with the addition of subsequent equipment items.

Table 11: Raw Lift OPEX Estimate

Phase	Estimated Annual Cost
All Phases	$ 160,000

Table 12: Lake Recirculation System OPEX

Phase	Estimated Annual Cost
Phase/Lake 1	$ 55,000
Phase/Lake 2	$ 56,000
Phase/Lake 3	$ 45,000

Table 13: Water treatment system OPEX Estimate

Phase	Estimated Annual Cost
Phase/Lake 1	$ 88,000
Phase/Lake 2	$ 88,000
Phase/Lake 3	$ 88,000

Table 14: Additional Coagulant Dosing OPEX Estimate

Phase	Estimated Annual Cost
Phase/Lake 1	$ 47,000
Phase/Lake 2	$ 47,000
Phase/Lake 3	$ 47,000

Table 15: Ultrasonic Systems OPEX Estimate

Phase	Estimated Annual Cost
Phase/Lake 1	$ 10,000
Phase/Lake 2	$ 10,000
Phase/Lake 3	$ 10,000

Table 16: Lake Mixing Systems OPEX Estimate

Phase	Estimated Annual Cost
Phase/Lake 1	$ 20,000
Phase/Lake 2	$ 20,000
Phase/Lake 3	$ 20,000

6. CONCLUSIONS

The Riverlea development is a large residential development being constructed to the northwest of Adelaide. The site includes a series of 3 salt-water lakes, intended to provide stormwater attenuation and detention, as well as aesthetic and secondary contact recreation opportunities.

Walker is seeking advice regarding the maintenance of lake water quality and the establishment of a practical water quality maintenance strategy.

Simmonds & Bristow were engaged to provide advice on active water quality treatment options, and have completed a systems and technology review. Based on this review, an adaptive progressive management scheme has been developed.

Salt Water Lake (SWL) 1 will be maintained at a level suitable for secondary contact recreation, with the remaining two lakes (SWL 2 and SWL 3) allowed a lesser water quality, primarily aimed at maintaining lake aesthetics. This may change depending on the performance of SWL 1 and the direction of the development at the time these lakes are established.

As SWL1 is intended to be used for secondary contact recreation purposes, this requires control of algal counts and potentially toxic species as well as aesthetic and general microbiological water quality. This can be achieved using a variety of methods including recirculation/mixing, direct control algaecides, limiting available nutrients, sedimentation, and filtration.

The adaptive management strategy has been proposed for adoption initially utilises a turn-over strategy, using raw water and an internal recirculation system to push salt-water through the lakes. This provides lake mixing and turn-over.

Water quality will be monitored over a 12 month period, and the decision to deploy or construct further treatment systems will be made based on the results of the ongoing monitoring.

Whilst additional treatment systems will be required to proactively maintain lake quality at a level suitable for recreation, for all lakes, the adaptive management approach will inform if and what systems ultimately should be installed to maintain the intended water quality without frequent reactive management water quality interventions.

The specific quality improvement measures will be designed at the time, based on monitoring data and lake performance. Based upon the review work conducted, the following could potentially be installed to improve lake water quality.

- Dedicated water treatment plant providing nutrient removal
- Filtration provided turbidity and particulate removal
- Algal disruption technologies, including Ultrasonic and Lake mixing
- Algaecide dosing

It is expected that a water treatment plant would be first installed. The system detailed in this report consists of an initial single treatment train, provisionally treating the water for SWL1. The train will be designed and sized based on monitoring data. The trains are intended to be modular, allowing for additional trains to be installed if it is decided that SWL2 and SWL3 also require nutrient removal treatment to maintain the lake water quality objectives.

If the water treatment system proves to be insufficient, additional algal disruption technologies, such as ultrasonic dosing, will be added to the lake. The specific equipment will be selected and sized based on lake water quality monitoring data.

7. REFERENCES

ASCE, AWWA, & CSSE. (1969). *Water Treatment Plant Design.* New York: American Waterworks Association.

Cengal, Y., & Boles, M. (2002). *Thermodynamics, An Engineering Approach.* New York: McGraw Hill.

Chanson, H. (1999). *The Hydraulics of Open Channel Flow.* Oxford: Butterworth-Heinemann.

Degremont. (n.d.). *Water Treatment Handbook vol. 1.* France: Degremont.

Degremont. (n.d.). *Water Treatment Handbook vol. 2.* France: Degremont.

Metcalf, & Eddy. (2003). *Wastewater Engineering, Treatment and Reuse 4th Edition.* New York: McGraw Hill.

Perry, R., & Green, D. (1997). *Perry's Chemical Engineers' Handbook, 7th edition.* New York: McGraw Hill.

Rawlinsons. (2008). *Construction Cost Guide for Housing, Small Commercial and Industrial Buildings.* Perth: Rawlinsons Publishings.

Rawlinsons. (2009). *Process Engineering Handbook, 1st edition.* Perth: Rawlinsons Publishings.

Sanks, R. (1978). *Water Treatment Plant Design.* Michigan: Ann Arbor Science.

Young, D., Munson, B., & Okiishi, T. (2001). *A Brief Introduction to Fluid Mechanics, 2nd edition.* New York: John Wiley & Sons.

7.1 GLOSSARY OF TERMS

Term	Definition
ADWF	Average dry weather flow
Alum	Aluminium sulphate ($Al_2SO_4.14H_2O$)
BOD_5	5-day biochemical oxygen demand
BTEX	Benzene, Toluene, Ethylene and Xylene. A test group for Aromatic hydrocarbons
CCP	Critical control point
Coagulation	The act of breaking a colloid emulsion using a coagulant chemical. Generally achieved by charge neutralisation, which allows smaller particles to 'clump' together via van-der-waals forces.
Coagulant	A chemical that causes coagulation.
COD	Chemical oxygen demand – a measure of all oxidisable material within a sample of water.
Colloid	Solid particles that generally will not settle under gravity settling.

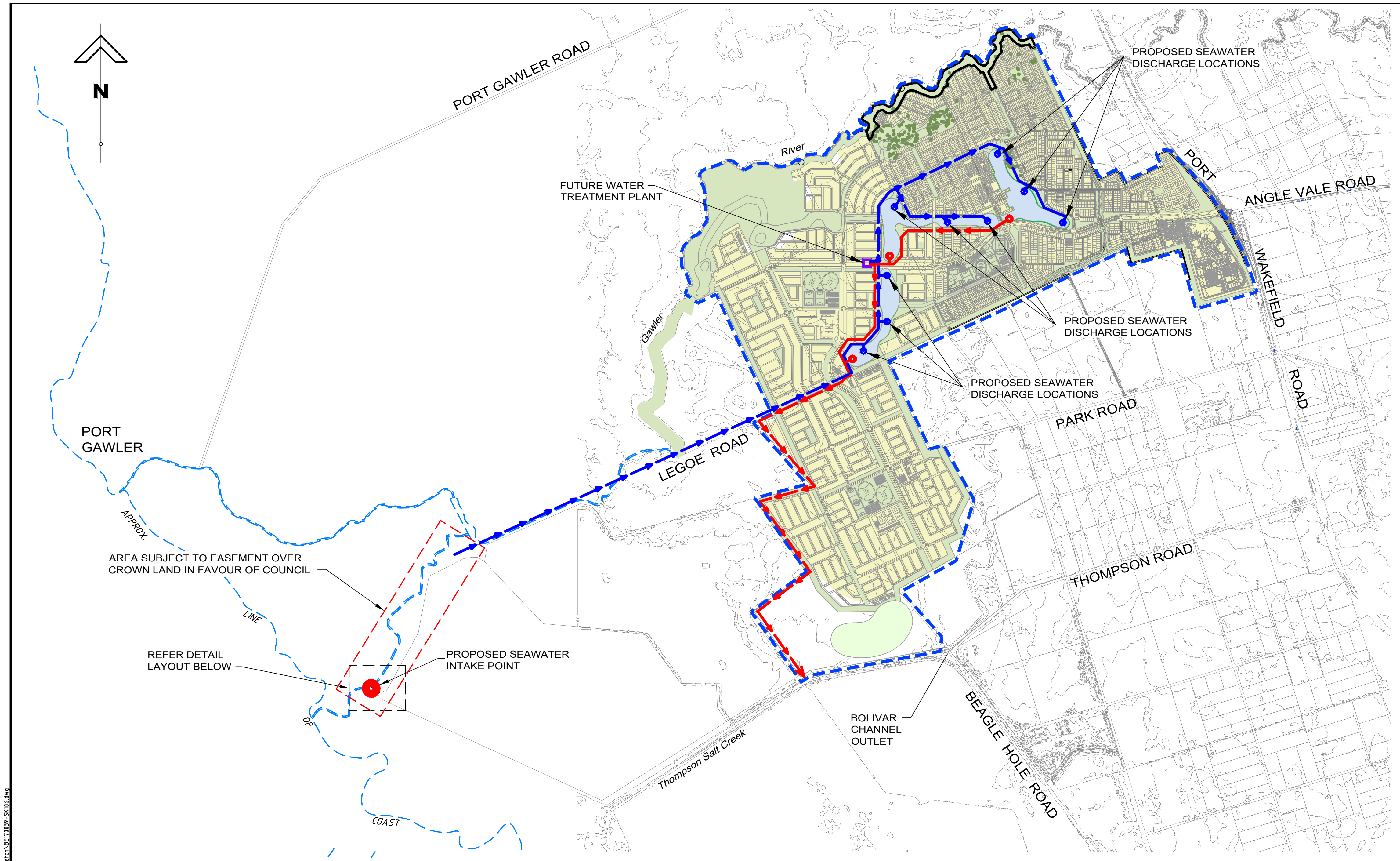
Term	Definition
Conductivity	A measure of the salt content of a water sample
CST	Capillary suction time
DAF	Dissolved air floatation
DCS	Distributed control system
DNA	Deoxyribonucleic acid, a macromolecule found within a cell that carries the majority of information that controls cellular development, function and growth
DO	Dissolved oxygen
DOL	Direct online – a form of motor starter whereby power is directly connected to the motor. This kind of motor starter has a large current draw on start-up limiting its use to smaller motors.
E. coli	*Escherichia coli*, a Gram-negative, facultatively anaerobic, rod-shaped bacterium of the genus *Escherichia* that is commonly found in the lower intestine of warm-blooded animals (e.g. Humans). Used as an indicator of faecal contamination
EIS	Environmental impact assessment
EMPs	Environmental management programs
Emulsion	Suspension of colloidal particles
EPPs	Environmental protection policies
ERA	Environmentally relevant activity (Specific to Queensland legislation, may also be used for Environmental Risk Assessment)
ES	Effective size (of granular media)
Thermotolerant Coliforms	A range of coliform bacteria generally used as an indicator of faecal contamination.
Flocculate/ Flocculation	The act of solid particles clumping together to form larger settleable aggregates, often referred to as 'flocs'.
Flocculant Aid	A polymer-based chemical utilised to enhance flocculation. The polymer forms a 'net' like complex when diluted, which acts to capture many smaller particles, creating a larger, generally more stable floc. Various flocculant aid exist, generally grouped based upon charge (Cationi Anionic or Non-ionic). Best type of flocculant aid is usually selected via jar test.
FRP	Filterable reactive phosphorus

Term	Definition
HDG	Hot dipped galvanised
HDPE	High density polyethylene – a form of plastic often used in the construction of pipes and tanks.
HMI	Human machine interface
Jar Testing	Jar Testing, sometimes referred to as coagulation testing or flocculation testing (depending upon what is being optimised) is a scaled-down lab test simulating the coagulation and flocculation reactions occurring within the clarifier of a water plant. This test allows for the evaluation of new flocculant aids, new coagulants, or the assessment of varied dose rates.
Macromolecule	A large molecule commonly made up of polymer sub-units. A term commonly used in genetics and biology.
MCC	Motor control centre
MCRT	Mean cell residence time. The average time a bacterial cell can expect to remain within the process. Another measure of 'sludge age'.
ML	Mixed liquor
MLSS	Mixed liquor suspended solids – a measure of the biomass within a treatment plant using total solids as a proxy.
NFR	Non filterable residue, analogous to total suspended solids.
Nitrate	An oxide of nitrogen with the molecular formula NO_3^-
Nitrite	An oxide of nitrogen with the molecular formula NO_2^-
Nm^3/hr	"Normal" cubic meters per hour – a measure of air flow normalised to $20^{O}C$ and one atmosphere of pressure
Orthophosphate	A form of phosphorus with the formula PO_4. It is biologically available for use by plants, algae and bacterium.
PAC	Powdered activated carbon
PDWF	Peak dry weather flow – the peak flow that is expected to enter the plant during dry weather. Is often assumed to be 3x the ADWF.
PLC	Programmable logic controller - an electronic device that allows for logical control over a piece of equipment.
POEO	Protection of the environment operations (part of the NSW acts governing sewage treatment plants)

Term	Definition
PVC	Polyvinyl chloride – a form of plastic used for a variety of the construction of pipes. Various forms are commercially available including unplasticised (upvc), oriented (opvc) and modified (mpvc).
PWWF	Peak wet weather flow – the flow that is expected to enter the plant during a wet-weather event. Is often assumed to be 5x the ADWF
QA	Quality assurance
REF	Review of environmental factors
RNA	Ribonucleic acid – a macromolecule found within in a cell, is an intermediary between gene coding and protein synthesis.
RPZ	Reduced pressure zone device. A type of backflow prevention device used to protect water supplies from contamination.
RTU	Remote telemetry unit
SBR	Sequencing batch reactor – a form of suspended growth wastewater treatment technology
SCADA	Supervisory control and data acquisition. A system operating with coded signals over communication channels to provide control of remote equipment and the acquisition of equipment and sensor data.
SDS	Safety data sheet
Sludge Age	Refers to the average 'age' of the sludge in an activated sludge wastewater treatment system. The sludge within the system will, on average, be refreshed once every sludge age.
SOP	Standard operating procedure
SRT	Sludge/solids retention time. Also referred to as the 'sludge age'.
STP	Sewage treatment plant (nay also refer to Standard Temperature and Pressure)
TDS	Total dissolved solids. Generally, a measure of salt concentration or salinity. May be converted to conductivity using a conversion factor
TKN	Total kjeldahl nitrogen – a measure of the Organic nitrogen plus Ammonia nitrogen
TN	Total nitrogen - the concentration of organic plus inorganic nitrogen
TOG/FOG	Total oil and grease/ Fats, oil and grease

Term	Definition
TP	Total phosphorus - the concentration of organic plus inorganic phosphorous
TPH	Total Petroleum Hydrocarbons. A measure of (generally polar) hydrocarbons in water. Non-polar hydrocarbons are removed using silica gel
TRH	Total Recoverable Hydrocarbons. A measure of all hydrocarbons (both polar and non-polar) in water.
TRH-Silica	Same as TPH
TSS	Total suspended solids
UV	Ultraviolet light – an invisible light at a wavelength ranging between 10nm to 400nm
VDC	Volts direct current
VSD/VFD	Variable speed drive/ variable frequency drive - a form of motor control that allows for AC motor speed to be ramped up and down electronically, without the use of a gearbox.
VSS	Volatile suspended solids
WTP	Water treatment plant
WWTP/WwTP	Wastewater treatment plant

APPENDIX A:
Development Drawings



SEAWATER INTAKE AND OUTLET LINES GENERAL ARRANGEMENT

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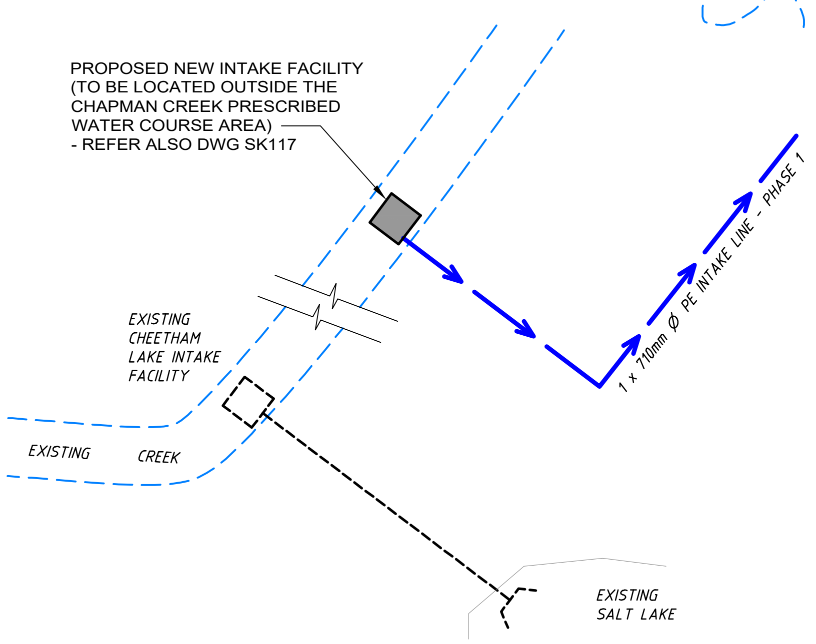

SEAWATER INTAKE LINE SCHEMATIC ARRANGEMENT

NOT TO SCALE

LEGEND

- DEVELOPMENT EXTENTS
- PROPOSED SEAWATER INTAKE LINES
- OUTLET LINES (PHASE 1 & 2)

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NOTE:

- REFER ALSO DWG SK113 FOR DETAILED INTERNAL CIRCULATION STRATEGY
- CONCEPTUAL SEAWATER CIRCULATION STRATEGY SHOWN ON THESE DRAWINGS ARE AS ADVISED BY MIKE WILLOUGHBY AND ARE INTENDED AS INDICATIVE ONLY AT THIS STAGE, SUBJECT TO DETAILED ASSESSMENT AND HYDRAULIC MODELLING.
- PHASING OF OUTLET LINES CONSTRUCTION IS ALSO SUBJECT TO DETAILED DESIGN AND ENVIRONMENTAL CONSIDERATIONS.

PRELIM CONCEPT PURPOSES ONLY

RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
O	SWL CIRCULATION STRATEGY MODIFICATION	09-10-24
N	OUTLET LINE EXTENDED	28-05-24
M	INTAKE / OUTLET LINES MODIFIED	24-05-24
L	MASTER PLAN UPDATE / SWL LINES	20-09-23
K	PROPOSED EASEMENT LOCATION ADDED	18-01-23
J	CONCEPT LAYOUT UPDATE	18-08-22
A	ORIGINAL ISSUE	09-10-24

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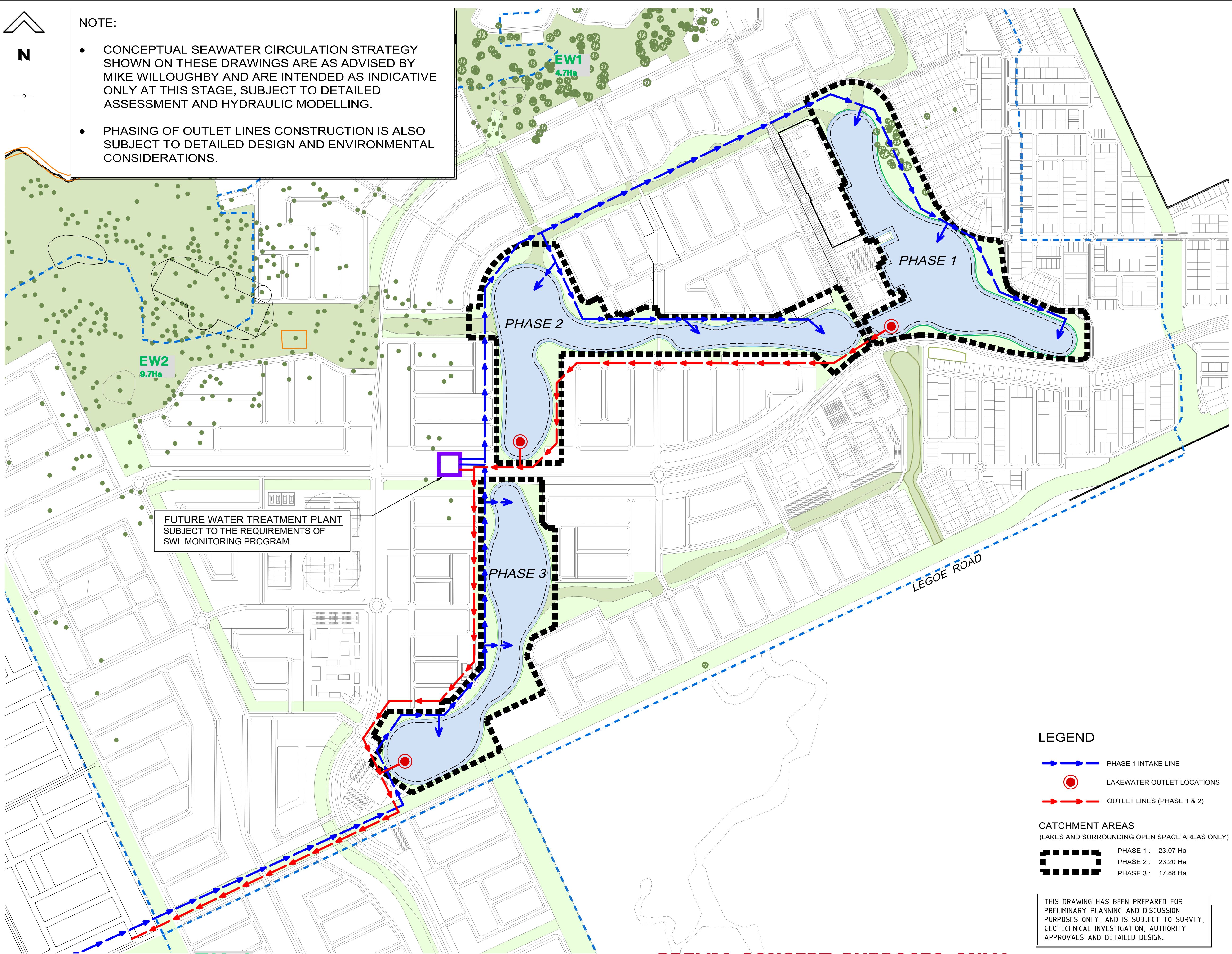
BURCHILLS ENGINEERING SOLUTIONS
Level 2, Connaught Centre
26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:
GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :
SEAWATER INTAKE LINES GENERAL ARRANGEMENT & OPTIONS

DEVEL. APPLIC. No. : - DATE : 09-10-24
PROJECT LEADER : PAUL KELLY
DESIGNER : NILL - DRAFTING ONLY
DRAFTSPERSON : ADAM COOPER
CHECKED :
APPROVED FOR AND ON BEHALF OF BURCHILLS ENGINEERING SOLUTIONS ABN 76 166 942 365
RPEQ No. :
SCALE : AS NOTED DATUM : AHD FULL SIZE : A1
PROJECT No.: BE170039 DRAWING No. : SK106 VERSION: O



NOTE:

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LEGEND

PHASE 1 INTAKE LINE

LAKEWATER OUTLET LOCATIONS

OUTLET LINES (PHASE 1 & 2)

CATCHMENT AREAS
(LAKES AND SURROUNDING OPEN SPACE AREAS ONLY)

PHASE 1 : 23.07 Ha
PHASE 2 : 23.20 Ha
PHASE 3 : 17.88 Ha

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PRELIM CONCEPT PURPOSES ONLY

SCALE 50 0 50 100 150 200 250 (metres)
1 : 5000 (FULL SIZE)

RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
G	SWL CIRCULATION STRATEGY MODIFICATION	17-09-24
F	SWL CIRCULATION STRATEGY MODIFICATION	24-05-24
E	MASTER PLAN UPDATE / SWL LINES	20-09-23
D	CONCEPT UPDATED	18-08-22
C	INTAKE LINE DIA AMENDED	09-02-22
B	CONCEPT LAYOUT UPDATE	02-02-22
A	ORIGINAL ISSUE	25-11-20

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Level 2, Connaught Centre
26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:
GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :
CONCEPTUAL SEAWATER CIRCULATION STRATEGY LAYOUT PLAN (PHASES 1 & 2)

DEVEL. APPLIC. No. : - | DATE : 17-09-24
PROJECT LEADER : PAUL KELLY
DESIGNER : NILL - DRAFTING ONLY
DRAFTSPERSON : ADAM COOPER
CHECKED :
APPROVED FOR AND ON BEHALF OF BURCHILLS ENGINEERING SOLUTIONS ABN 76 166 942 365
RPEQ No. :
SCALE : AS NOTED | DATUM : AHD | FULL SIZE : A1
PROJECT No.: BE170039 | DRAWING No. : SK113 | VERSION: G

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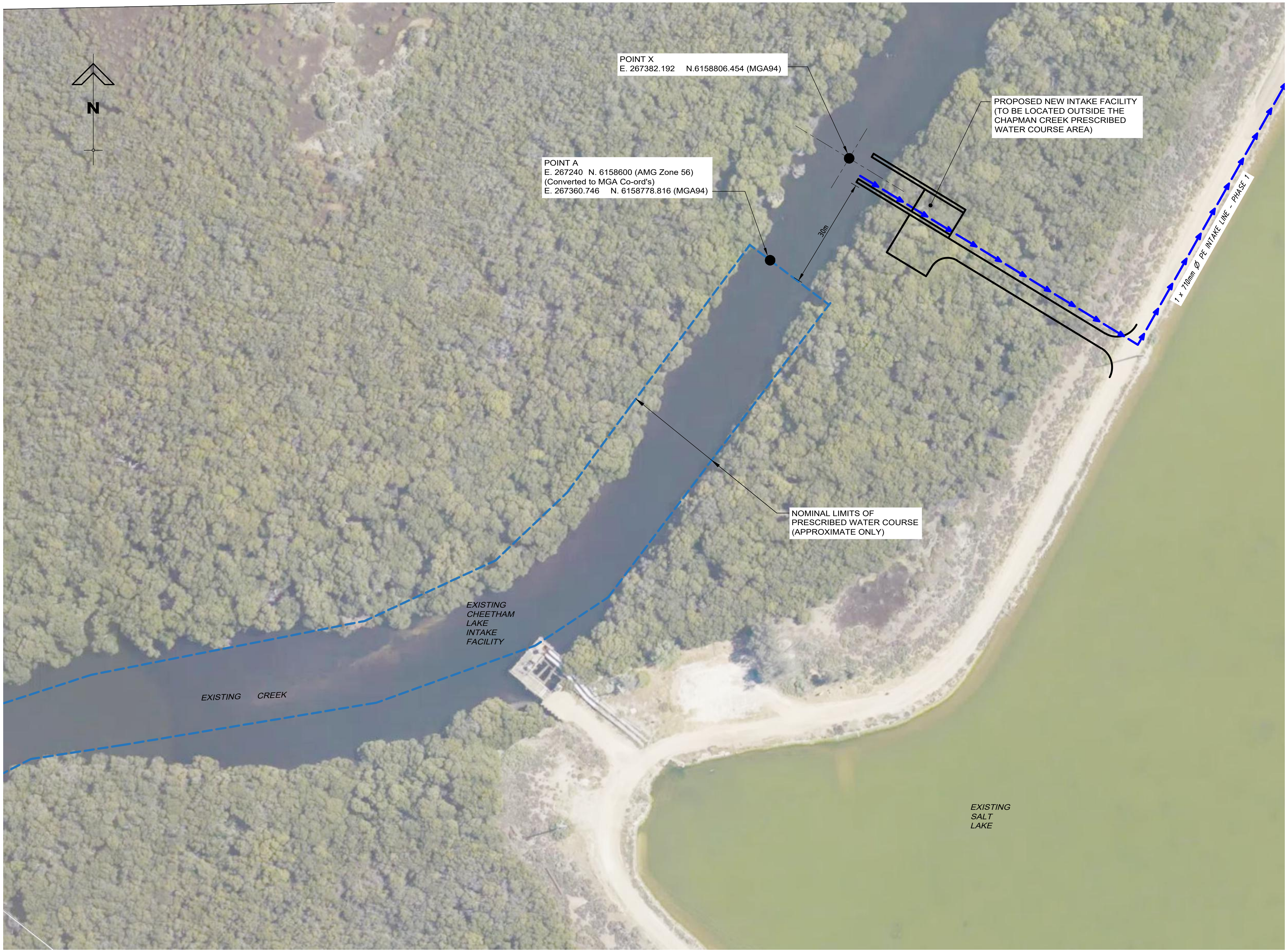

PRELIM CONCEPT PURPOSES ONLY

SEAWATER INTAKE LINE
SCHEMATIC ARRANGEMENT

SCALE 5 0 5 10 15 20 25 (metres)
1 : 500 (FULL SIZE)

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RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
F	INTAKE LINE MODIFIED	24-05-24
E	INTAKE LINE ALIGNMENT AMENDED	11-02-22
D	INTAKE LINE DIA AMENDED	09-02-22
C	INTAKE LINE DIA AMENDED	02-02-22
B	MINOR AMENDMENTS, CO-ORDINATES ADDED	27-01-22
A	ORIGINAL ISSUE	27-01-22

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26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:

GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :

SEAWATER INTAKE LINE GENERAL ARRANGEMENT

DEVEL. APPLIC. No. : - DATE : 24-05-24
PROJECT LEADER : PAUL KELLY
DESIGNER : ADAM COOPER
DRAFTSPERSON : ADAM COOPER
CHECKED :
APPROVED FOR AND ON BEHALF OF BURCHILLS ENGINEERING SOLUTIONS ABN 76 166 942 365
RPEQ No. :
SCALE : AS NOTED DATUM : AHD FULL SIZE : A1
PROJECT No.: BE170039 DRAWING No. : SK117 VERSION: F

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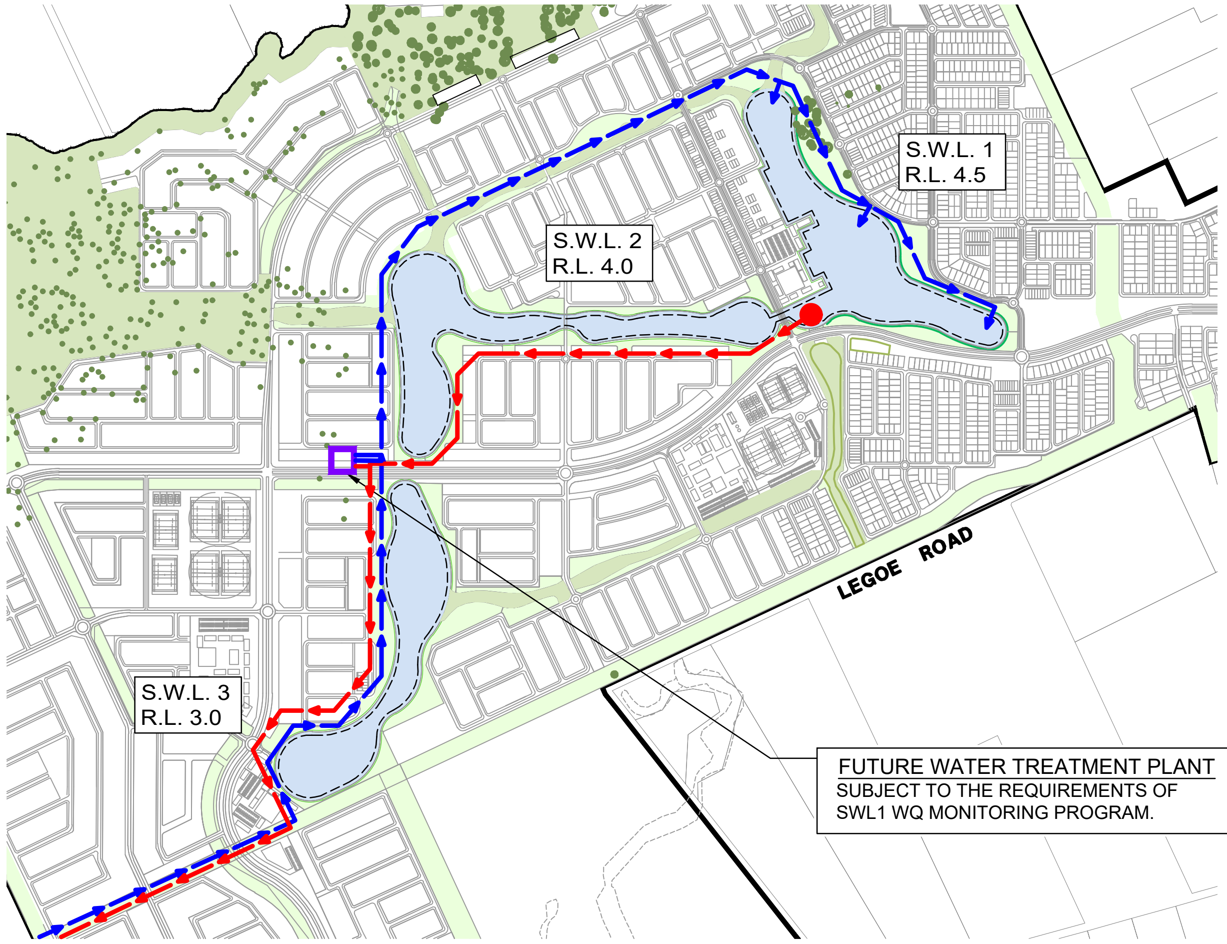
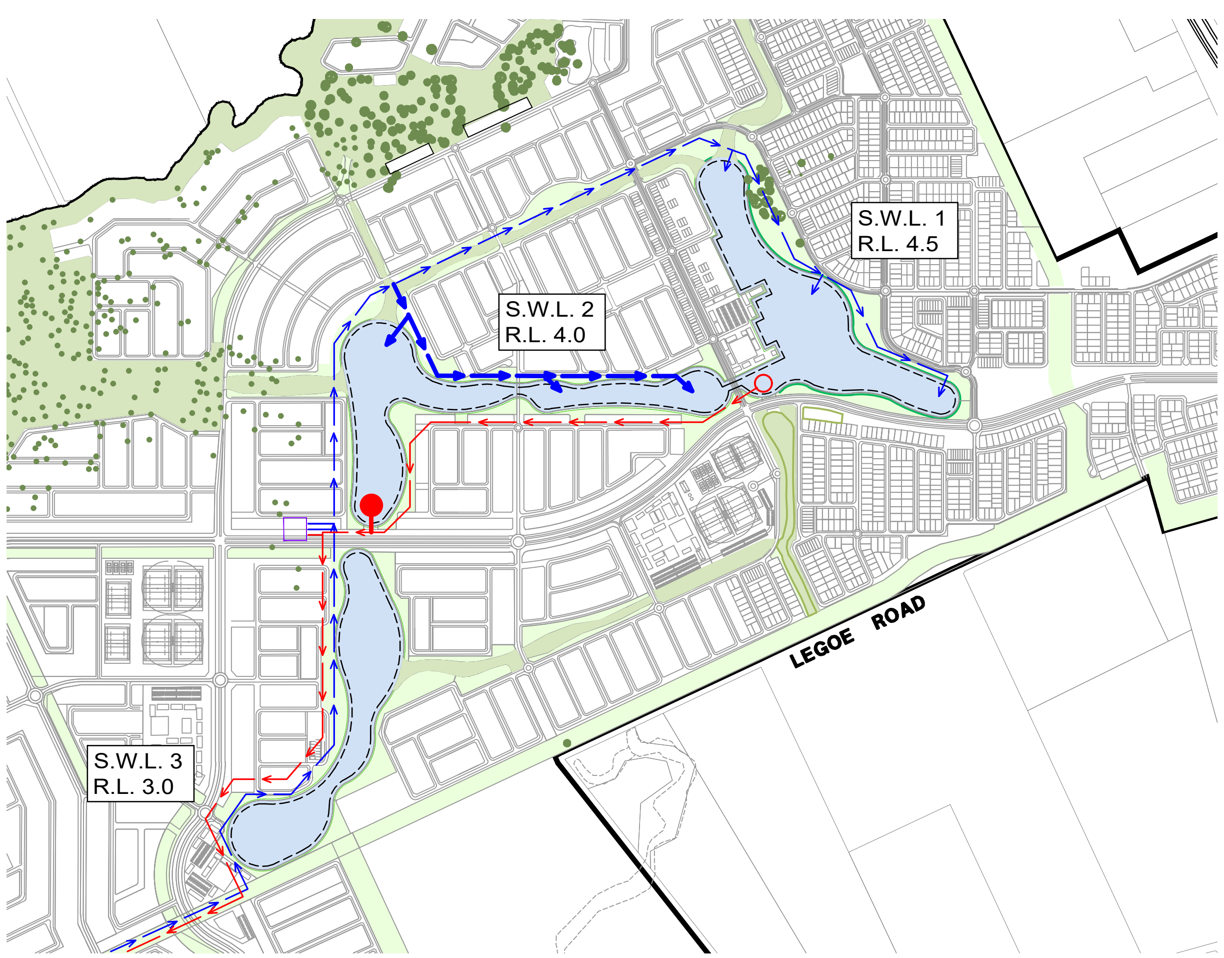
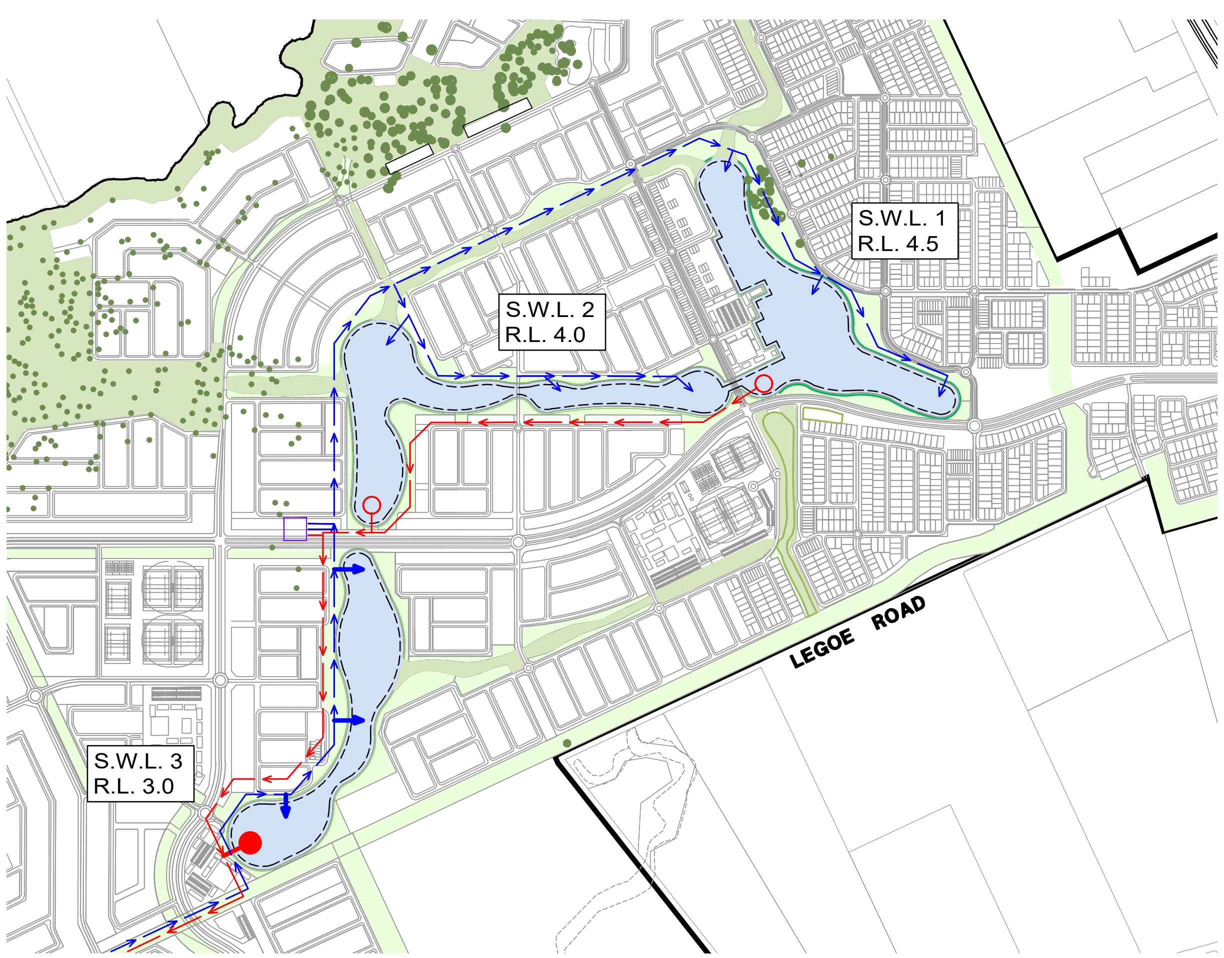


PHASE 1 - SWL 1 CIRCULATION



PHASE 2 - SWL 1 & 2 CIRCULATION



PHASE 3 - SWL 1, 2 & 3 CIRCULATION

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SCALE 100 0 100 200 300 400 500 (metres)
1 : 10000 (FULL SIZE)

RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
G	SWL CIRCULATION STRATEGY MODIFICATION	17-09-24
F	SWL CIRCULATION STRATEGY MODIFICATION	24-05-24
E	MASTER PLAN UPDATE / SWL LINES	20-09-23
D	SWL 1 R.L. AMENDED	24-02-23
C	SWL 3 INTAKE PIPE DIA AMENDED	13-10-22
B	CONCEPT MASTERPLAN UPDATED	01-08-22
A	ORIGINAL ISSUE	07-06-22

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Level 2, Connaught Centre
26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:

GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :

CONCEPTUAL SALTWATER LAKES CIRCULATION SYSTEM PHASING PLANS

DEVEL. APPLIC. No. : - DATE : 17-09-24

PROJECT LEADER : PAUL KELLY

DESIGNER : NILL - DRAFTING ONLY

DRAFTSPERSON : ADAM COOPER

CHECKED :

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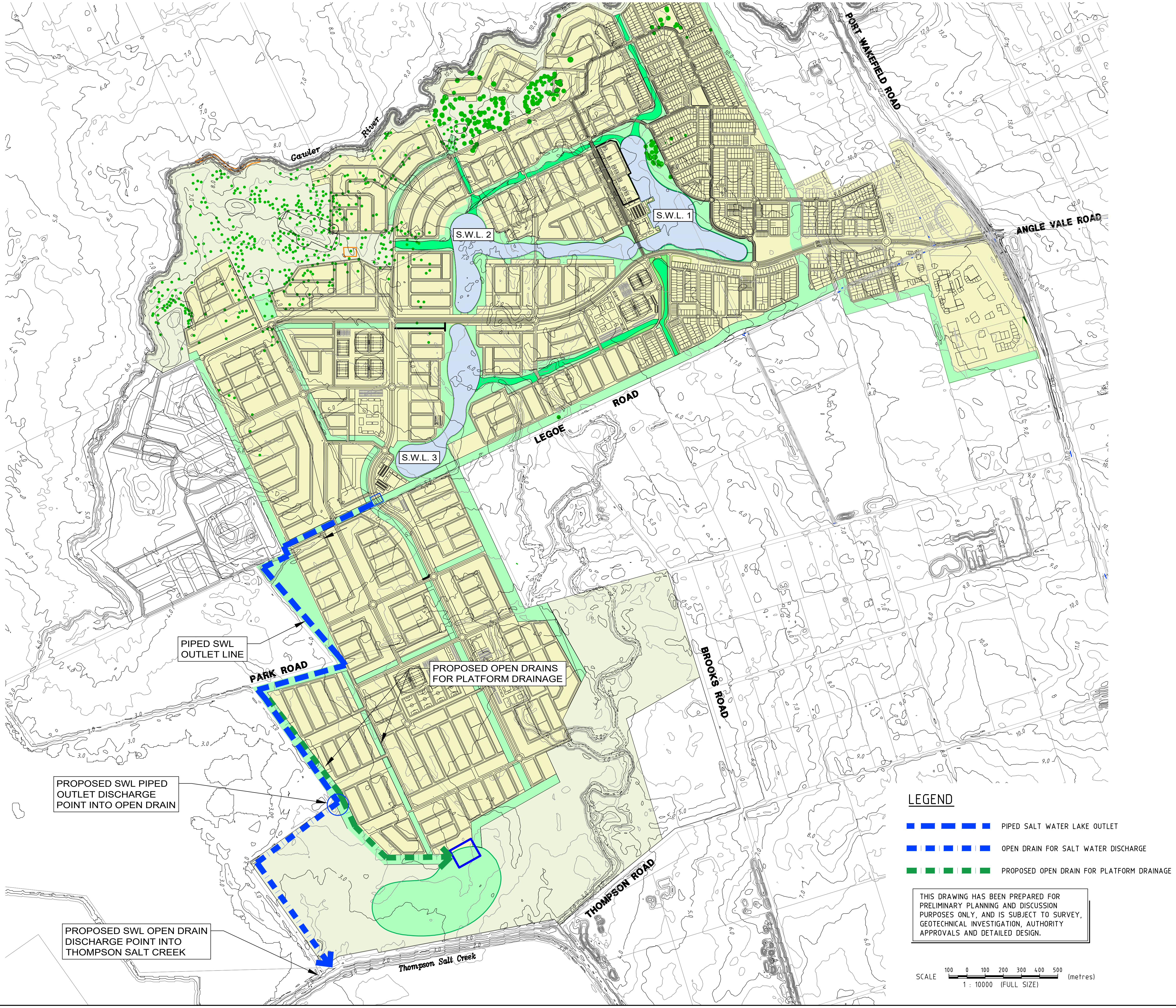
RPEQ No. :

SCALE : AS NOTED | DATUM : AHD | FULL SIZE : A1

PROJECT No.: BE170039 | DRAWING No. : SK138 | VERSION: G



RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
D	MASTER PLAN UPDATE / SWL OUTLETS	29-11-23
C	MASTER PLAN UPDATE / SWL OUTLETS	20-09-23
B	STORMWATER DISCHARGE MODIFIED	25-01-23
A	ORIGINAL ISSUE	01-08-22

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PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
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PROJECT:

GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :

SALT WATER LAKES OUTLET PLAN

DEVEL. APPLIC. No. : - DATE : 29-11-23

PROJECT LEADER : PAUL KELLY

DESIGNER : ADAM COOPER

DRAFTSPERSON : ADAM COOPER / LUIS MACIEL

CHECKED :

APPROVED FOR AND ON BEHALF OF BURCHILLS ENGINEERING SOLUTIONS ABN 76 166 942 365

RPEQ No. :

SCALE : AS NOTED | DATUM : AHD | FULL SIZE : A1

PROJECT No.: BE170039 | DRAWING No. : SK147 | VERSION: D

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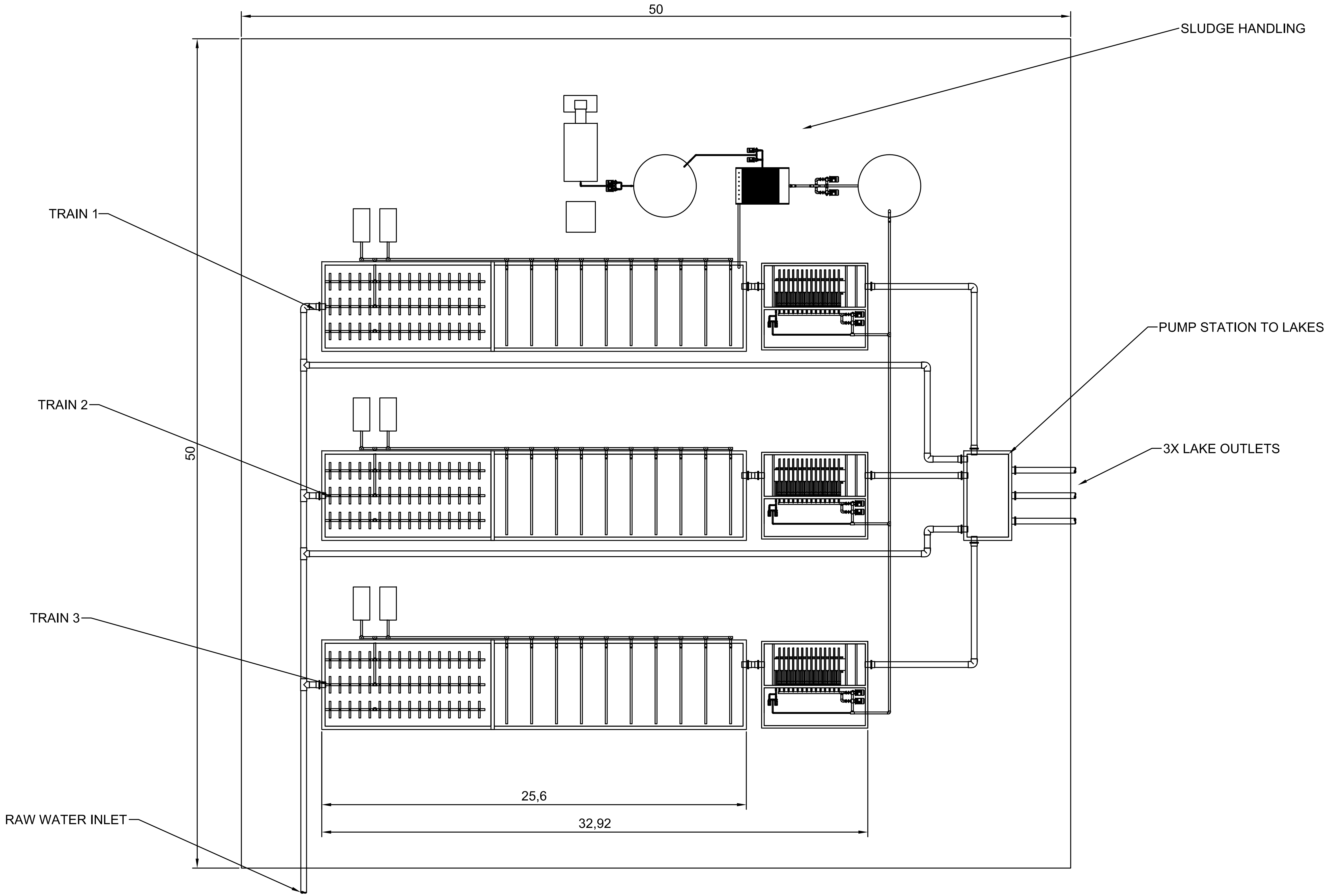
APPENDIX B:

Treatment Options General Layouts & Footprints



CLIENT DETAILS	JOB NAME	DRAWING TITLE	SCALE
WALKER CORPORATION	RIVERLEA LAKE TREATMENT SYSTEM	TREATMENT PLANT ARRANGEMENT	NONE

REVISION SCHEDULE

REV	DATE	COMMENTS	INITL.
0	01/02/24	FOR INFORMATION ONLY	TA

DATUM	-- --
DESIGNED	
DRAWN	TA
CHECKED	
SIGNED.	
DATE	

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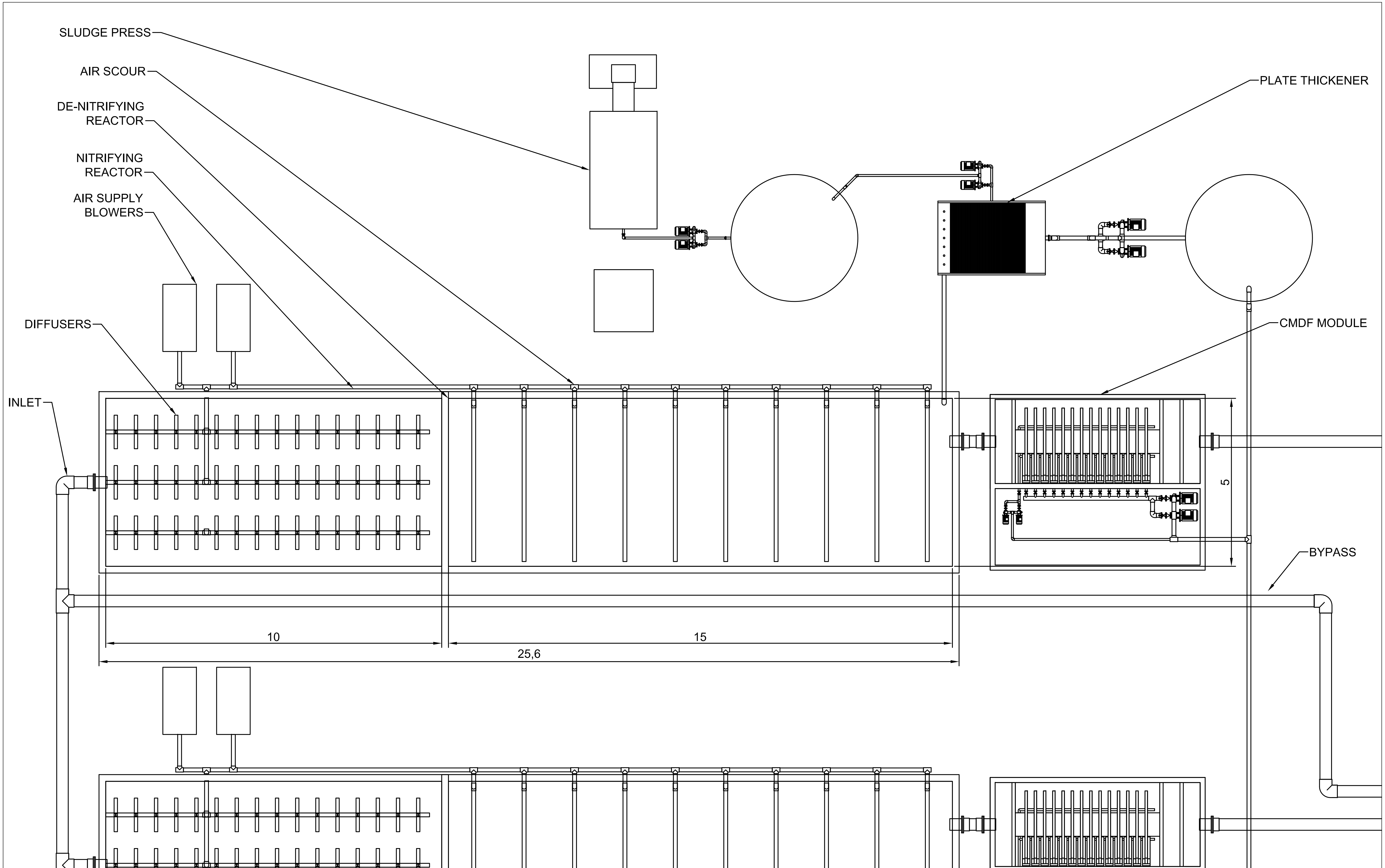
2. DO NOT SCALE
3. Dimensions, levels, etc. to be verified on site prior to the commencement of work.
4. Any discrepancies to be reported to S & B for resolution before carrying out the work.
5. All dimensions in mm unless otherwise stated

Simmonds & Bristow Pty. Ltd.
The Regional and Remote Water Specialist
HEAD OFFICE: 40 REGINALD STREET, ROCKLEA 4108
PO BOX 3160 YERONGA QLD 4104 AUSTRALIA
1800 620 690 | FAX (07) 3710 9199
info@simmondsbristow.com.au | www.simmondsbrsitow.com.au
ABN: 38 020 252 415

JOB/PROPOSAL No.	
DRAWING STATUS	FOR INFORMAITON
PLOT NUMBER:	DATE: 01/02/2024
DWG. No.	LAY-401
REV.	0



CLIENT DETAILS	WALKER CORPORATION	
JOB NAME	RIVERLEA LAKE TREATMENT SYSTEM	

REVISION SCHEDULE

REV	DATE	COMMENTS	INITL.
0	01/02/24	FOR INFORMATION ONLY	TA

DATUM	-- --
DESIGNED	
DRAWN	TA
CHECKED	
SIGNED.	
DATE	

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5. All dimensions in mm unless otherwise stated

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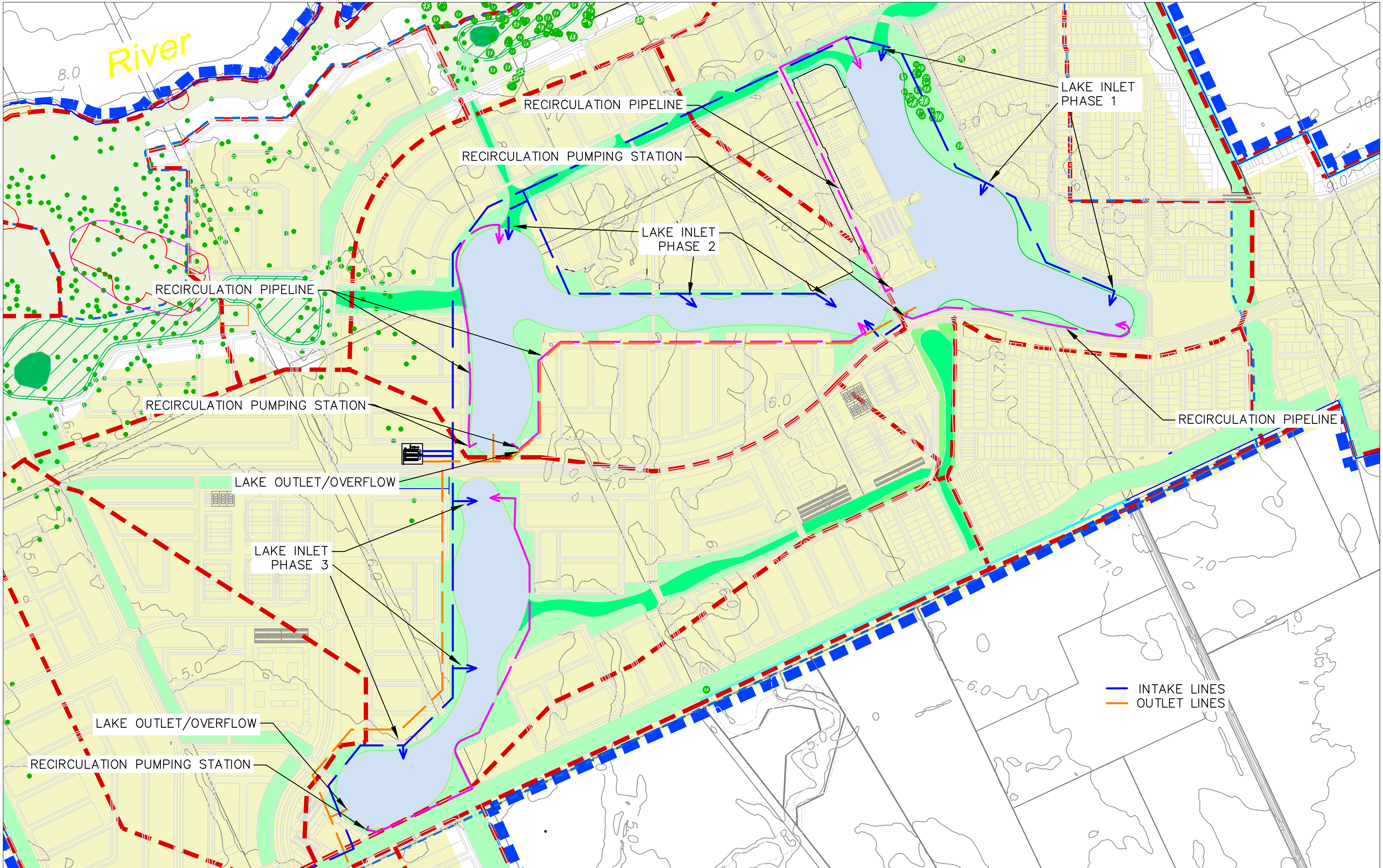
The Regional and Remote Water Specialist

DRAWING TITLE	TREATMENT PLANT - SINGLE TRAIN
DRAWING STATUS	FOR INFORMAITON
PLOT NUMBER:	DATE: 01/02/2024
SCALE	NONE
JOB/PROPOSAL No.	
DWG. No.	LAY-402
REV.	0



CLIENT DETAILS	JOB NAME
WALKER CORPORATION	RIVERLEA LAKE TREATMENT SYSTEM

REVISION SCHEDULE

REV	DATE	COMMENTS	INITL.
A	10/10/24	UPDATE WTP/PIPE LOCATIONS	RK
0	01/02/24	FOR INFORMATION ONLY	TA

DATUM	-- --
DESIGNED	
DRAWN	TA/RK
CHECKED	
SIGNED.	
DATE	

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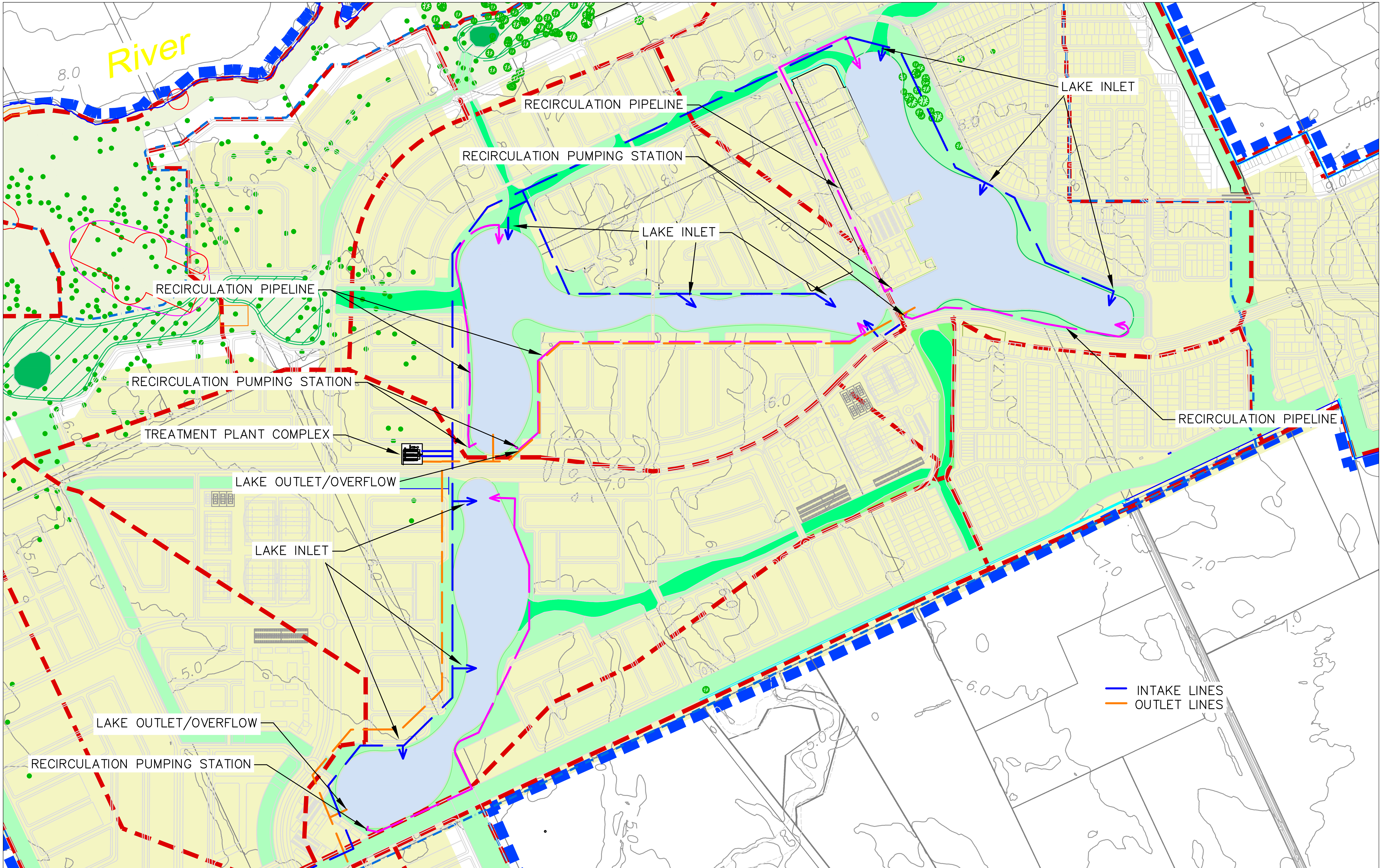
Simmonds & Bristow Pty. Ltd.
The Regional and Remote Water Specialist
HEAD OFFICE: 40 REGINALD STREET, ROCKLEA 4108
PO BOX 3160 YERONGA QLD 4104 AUSTRALIA
1800 620 690 | FAX (07) 3710 9199
info@simmondsbristow.com.au | www.simmondsbrsitow.com.au
ABN: 38 020 252 415

DRAWING TITLE	RECIRCULATION SYSTEM GENERAL LAYOUT
SCALE	NONE
JOB/PROPOSAL No.	
DRAWING STATUS	FOR INFORMAITON
DWG. No.	LAY-403
REV.	A
PLOT NUMBER:	
DATE:	10/10/2024



CLIENT DETAILS	JOB NAME	REVISION SCHEDULE			
WALKER CORPORATION	RIVERLEA LAKE TREATMENT SYSTEM	A	10/10/24	UPDATED WTP/PIPE LOCATIONS	RK
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		REV	DATE	COMMENTS	INTL.

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The Regional and Remote Water Specialist

HEAD OFFICE: 40 REGINALD STREET, ROCKLEA 4108
PO BOX 3160 YERONGA QLD 4104 AUSTRALIA
1800 620 690 | FAX (07) 3710 9199
info@simmondsbristow.com.au | www.simmondsbrsitow.com.au
ABN: 38 020 252 415

DRAWING TITLE: WTP LOCATION

DRAWING STATUS: FOR INFORMAITON

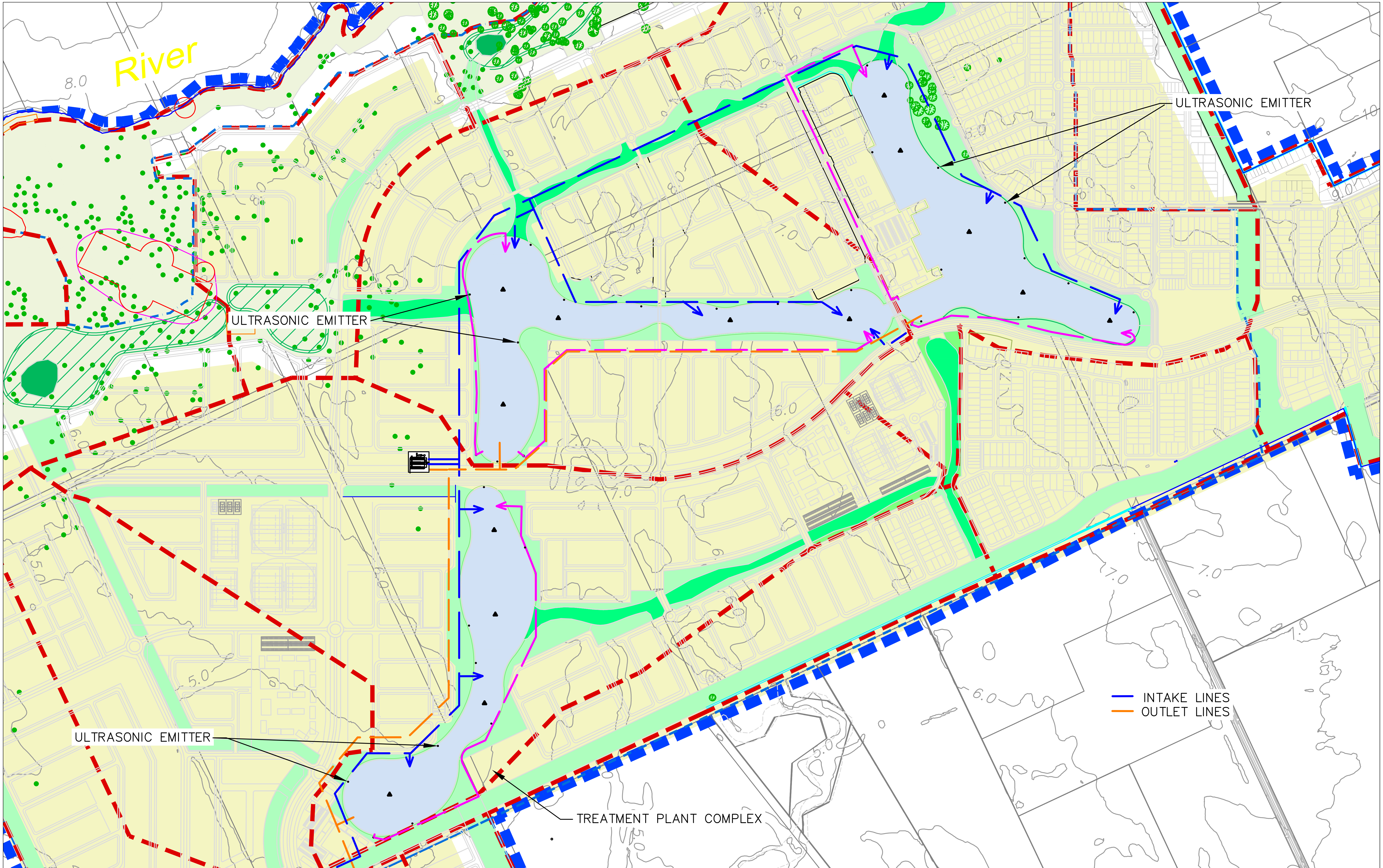
PLOT NUMBER:
DATE: 10/10/2024

SCALE: NONE

JOB/PROPOSAL No.

DWG. No.: LAY-404

REV.: A



CLIENT DETAILS	JOB NAME
WALKER CORPORATION	RIVERLEA LAKE TREATMENT SYSTEM

REVISION SCHEDULE

REV	DATE	COMMENTS	INITL.
A	10/10/24	UPDATED WTP/PIPE LOCATIONS	RK
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PO BOX 3160 YERONGA QLD 4104 AUSTRALIA
1800 620 690 | FAX (07) 3710 9199
info@simmondsbristow.com.au | www.simmondsbrsitow.com.au
ABN: 38 020 252 415

DRAWING TITLE
ULTRASONIC SYSTEM LAYOUT

DRAWING STATUS
FOR INFORMAITON

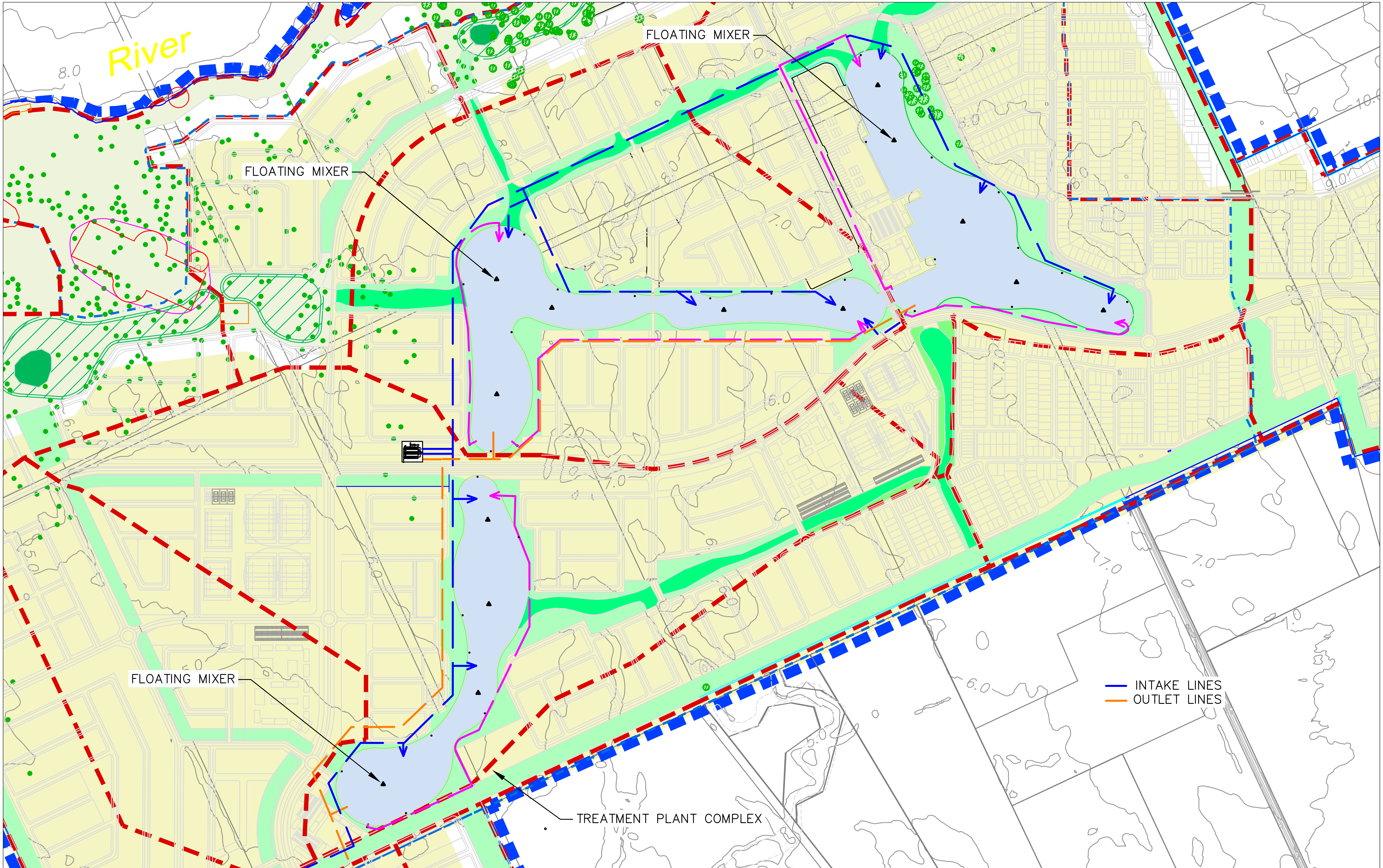
PLOT NUMBER: DATE: 10/10/2024

SCALE
NONE

JOB/PROPOSAL No.

DWG. No.
LAY-405

REV.
B



CLIENT DETAILS	JOB NAME	REVISION SCHEDULE				DATUM	
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						DESIGNED	
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		A	10/10/24	UPDATED WTP/PIPE LOCATIONS	RK	CHECKED	
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HEAD OFFICE: 40 REGINALD STREET, ROCKLEA 4108
PO BOX 3160 YERONGA QLD 4104 AUSTRALIA
1800 620 690 | FAX (07) 3710 9199
info@simmondsbristow.com.au | www.simmondsbrsitow.com.au
ABN: 38 020 252 415

DRAWING TITLE	SCALE	
LAKE MIXER SYSTEM LAYOUT	NONE	
	JOB/PROPOSAL No.	
DRAWING STATUS: FOR INFORMAITON	DWG. No.	REV.
PLOT NUMBER: DATE: 10/10/2024	LAY-406	A

APPENDIX C:

Algae General Information

1. ALGAE – GENERAL INFORMATION

Algae is a broad term used to describe organisms of widely varying sizes, growth rates and nutrient requirements.

The photosynthetic pigments in the algal cells determine the colour of the algae, and are often a greenish colour, but they can also be a wide variety of other colours such as yellow, brown or red, depending on the species of algae and the type of pigments contained in their cells.

Bright green blooms in freshwater systems are frequently a result of cyanobacteria (colloquially known as blue-green algae). Species of blue-green algae in particular can tend to release toxins that are poisonous to animals (typically referred to as Toxic BGA species), but not all algae are toxic.

Figure 1: Algal blooming of freshwater (Wikipedia 2016)

Sea-water or marine systems tend to favour diatom or dinoflagellate growth, but can also suffer from cyanobacterial growth; marine cyanobacteria range in colour from blue-greens to browns or reds.

Figure 2: Marine Algae Bloom (CDC)

They may be individual cells, single chains of cells or branching chains of cells. Various species of algae can range in size from 1 micron to over 25 micron each organism.

Some algae will always be present in waterbodies and form an important part of the food chain.

An excess of growth is normally referred to as an Algal bloom. Algal blooms will tend to cause significant aesthetic impacts, often resulting in a scum forming across the top of the lake, slime formations on the waters edge, poor water clarity and odours.

Aside from the aesthetic impacts, algal blooms can also present serious problems for ecosystems due to oxygen depletion of the water column from cellular respiration and cellular degradation, contamination of fish or shellfish, and the production of toxins that can cause health problems in humans and animals, including aquatic life.

Algae can grow very quickly under high nutrient availability, but each cell is short-lived, which results is a high concentration of dead organic matter which starts to decay. The decay process consumes dissolved oxygen in the water, resulting in anoxic conditions. Healthy aquatic ecosystems require sufficient dissolved oxygen to be present in the water.

Cyanobacteria gain their green pigment from chlorophyl, allowing them to photosynthesise in a similar manner to plants. They will tend to reside in the warmer upper water layers that have access to sunlight for photosynthesis and will sink back down during the evening, switching respiratory pathways and consuming the oxygen created via photosynthesis.

Additionally, the upper water layers also typically provide the optimal temperature range of 20° – 30°C for algae growth.

2. WATER TREATMENT TECHNOLOGIES

A range of treatment technologies and techniques are available in the industry. The lake system proposed for Riverlea utilises salt water, which does reduce the available technologies as vast majority of treatment processes and technologies have been developed for use on freshwater lakes.

The following section provides a general overview of the options considered.

Generally, a range of technologies provides a better solution than a single technology option, as it allows for both a degree of flexibility/contingency/redundancy, and for more specific targeting of water quality management.

Several of the options discussed below are unlikely to be suitable for use with a saltwater lake system. They are included for completeness.

2.1 External Wetlands

Wetlands are widely used for the control of lake water quality, especially for the removal of algae.

They are typically configured as a water body external to the lakes, with guidelines indicating up to 150% of the area of the lakes should be provided as wetland area. This can affect yield, but the wetlands can be configured to provide green spaces or aesthetic benefits.

Wetlands provide an ecosystem for the growth of various macrophytes, including emergent and floating species, and for the growth of various aquatic organisms. This usually allows the wetland to effectively remove nutrients from the water applied to them.

In addition to the removal of nutrients, the movement of water through the waterbodies also tends to disrupt algal life cycles, further assisting in algae control.

Wetlands are generally low maintenance but do require significant land area and regular harvesting of plants and dead fall as plant matter will tend to decay and release any stored nutrient back into the waterbody, negating the nutrient removal provided by the wetland.

Figure 3: Stormwater Treatment Wetland – Melbourne Water

Wetlands are extensively used in freshwater systems but are not commonly applied to saltwater systems.

It is unlikely that wetlands will be suitable for the saltwater lake system.

2.2 Floating wetlands

Floating wetlands is a relatively new lake water treatment technology. As their name suggests they consist of floating pods that contain soil and are planted with macrophytes.

Figure 4: Floating Wetland Pod – Speil Stormwater

These pods float on top of a waterbody, such as a lake or wetland, with plant roots extending into the water below, allowing them to absorb nutrients directly. This allows the wetlands to act like a hydroponic system, which can drastically increase the growth rates, which also increases nutrient absorption.

Case studies conducted by suppliers indicate that floating wetlands can reduce the required area by about 3 or 4 times in comparison to ephemeral or external wetland requirements. This allows for either the upgrading of existing wetland systems, or the reduction in size of systems.

The floating nature of allows the wetland area to be located within a lake, which can help to reduce recirculation requirements (although mixing is still recommended) and removes the need for the construction of external wetlands.

The main issues with the system are the aesthetic impact and high construction costs, although the development of locally constructed flotation pods may reduce costs in the medium to long term.

As a constructed system the wetlands can tend to look very industrial in nature, often with sharp lines and edges. Unless accounted for in the overall aesthetic design of the lakes themselves, these edges can interfere with the 'natural' looks and lines of lake banks, making them harder to unobtrusively integrate into an aesthetic lake system.

Figure 5: Floating Wetlands – Hunterville – Spel Stormwater

Like the constructed wetlands, floating wetlands are utilised in freshwater systems but have not been applied to salt-water systems.

The use of floating wetlands is unlikely to be suitable for the saltwater lake system.

2.3 Lake mixing

Lake mixing is used to reduce algal growth, stabilise general water quality, reduce stratification and increase oxygen concentrations throughout the water column. Mixing does not generally remove nutrients or solids directly but can improve other processes or systems that do.

A wide variety of mixing technology exists. The exact selection will usually be determined by whether just mixing is required, whether other effects, such as aeration, are also necessary.

If aeration is required, high speed surface aerators, diffused aeration or fountains are typically employed. These tend to have higher energy requirements and can cause aesthetic impacts but can be quite effective at inducing oxygenation. Fountains, in particular, can be turned into an aesthetic feature if correctly designed and located.

If only mixing is required, low speed draught mixers, propeller mixers, mixing pumps, or similar, can be utilised. They typically provide good mixing over a large area with far lower power requirements and typically lower aesthetic impacts than large aerators. These units are not designed to specifically provide aeration but can result in the movement of oxygenated water from the surface of a lake to the deoxygenated zone at the bottom.

Most blue-green algal species require sunlight as part of their growth mechanism. Mechanical mixing is a common approach for algae bloom prevention, as the turbulence can help disrupt their ability to photosynthesise.

Figure 6: Mechanical surface aerator on a wastewater treatment lagoon (photo Simmonds & Bristow Jan 2016)

Figure 7: Solar Be floating Mixer

As the lake should not require significant aeration, draught mixers are likely to be more appropriate. A range of solar powered draught mixers are available from various manufacturers, with the Solar Bee being one of the original suppliers to the market segment.

Solar bees tend to be less intrusive than large mechanical surface aerators, although they can still have an aesthetic impact depending upon your tolerance for mechanical equipment. Improvements in solar and battery technology allows the unit to be completely self-powered, not requiring intrusive cabling or connections to the shore, improving aesthetics and ease of installation.

The units will still require anchoring to prevent their movement. Anchoring needs to consider potential level changes that might be caused by flooding.

Benefits:

- Mixing helps to stabilise water quality
- Should help to reduce algal growth by interrupting life cycle

- Approximate methods can be self-powered using solar panels and batteries (won't provide aeration, which should be appropriate for this application, can increase cost)

Drawbacks:

- May have a minor aesthetic impact
- Is a supporting technology – will require other technologies to ensure water quality control
- Some processes may require large amounts of power (but shouldn't for this application)

Mixing will be useful to stabilise lake water quality. Smaller mixers should have less of an aesthetic impact, although the perception of this may vary from person to person.

2.4 Filtration – Sand or Multimedia Filters

Filtration removes small particles from the water.

Sand filtration relies on particulate media to sieve out particles within water being passed through the filter media. There are a variety of configurations, however the rapid sand filter (RSF) is probably the most common. Sand filters may be driven by gravity or pumped pressure, with different design considerations for each.

Sand filters may be further categorised based on the filtration media configuration, e.g. single-media, dual-media, multi-media, etc.

Single media filters are the simplest and tend to use a single bed of filter sand. Particles are trapped within this bed as water flows through it and are removed intermittently by passing water through the bed in the reverse direction, referred to as backwashing.

Dual-media (or multi-media) filters utilise more than one media layer to improve filtration performance.

Dual media filters typically use two layers of media to improve solids removal, with a coarse layer removing larger particles and a fine layer removing small particles. Media is usually chosen based on density to prevent mixing during backwash, with Anthracite coal over quartz sand being a common combination.

Multi-media filters typically have three active filtration layers, further improving solids removal. Again, each layer removes progressively smaller particles, improving overall removal efficiency. Anthracite over Sand over Garnet is a common arrangement.

Filters will often have support layers below the active filtration layer. These help to ensure good performance of the filter and prevent the media from entering or clogging the under-drain mechanisms.

Multi-media filters require better backwash design to ensure that media is adequately washed while preventing it from being removed from the system. This will often employ an air-scour system to improve cleaning performance.

In addition to anthracite, sand and garnet, other media is available, ranging from zeolite, which can help to improve ammonia removal is it will tend to absorb ammonia (although this is limited as the media will eventually exhaust it's absorption capacity) to specialty glass media, which claims to improve over traditional filter sand by various surface modifications or by improving backwash dynamics.

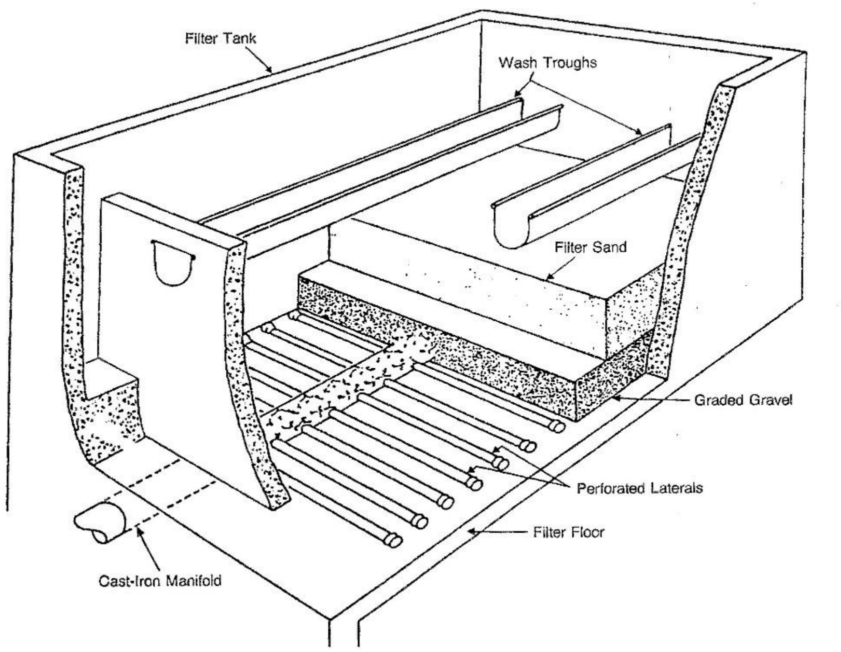


Figure 8: Rapid Gravity Sand Filter

In comparison to more advanced filtration technology, including Cloth media filters and membrane filters, traditional sand filters tend to have a poorer particle removal performance, and tend to be much larger. Backwash water volumes also tend to be higher, and backwash rates tend to be much higher, requiring lager backwash pumps. They tend to be cheaper than more advanced technology.

Benefits:

- Established, proven technology
- Can be comparatively cheap if well designed

Drawbacks:

- Poorer performance when compared to more recent technology
- Higher backwash water generation
- Higher backwash water flowrates
- Requires air scour for good operation, increasing power use
- Algae can potentially colonise sand filters that aren't well maintained or washed

The footprint required for sand filters likely precludes them from use in this treatment system. Salt water may also be more prone to attacking the physical structures, requiring special consideration which is also likely to increase the price of the system.

2.5 Filtration – Disk Filters

Disk filters are a newer technology that utilise a cloth media for separation. The media is typically a pile cloth that has a filtration depth of a few mm, which allows for the capture of particulate material. Due to the filtration depth offered by the cloth system, the filters are not a true surface filter.

Cloth Media Disk Filters or CMDF's tend to have a much smaller footprint than sand filters, and usually offer a higher degree of particle separation, although they are not as effective as a membrane filter.

CMDF backwashing is typically achieved by drawing water back through the cloth media from the 'clean' side using a suction scanner. When backwash occurs either the disks are rotated past a fixed scanner, or a moving scanner is rotated around a fixed disk (with rotating disks tending to be more common as the mechanics are simpler).

This configuration simplifies the backwash arrangements in comparison to a sand filter (although individual control valves for suction scanners can increase complication), reduces the size of the pumps (as a media bed no longer needs to be fluidised), and removes the need for a backwash storage tank after the filter, as the water for backwash is provided by the 'clean' side of the filter itself.

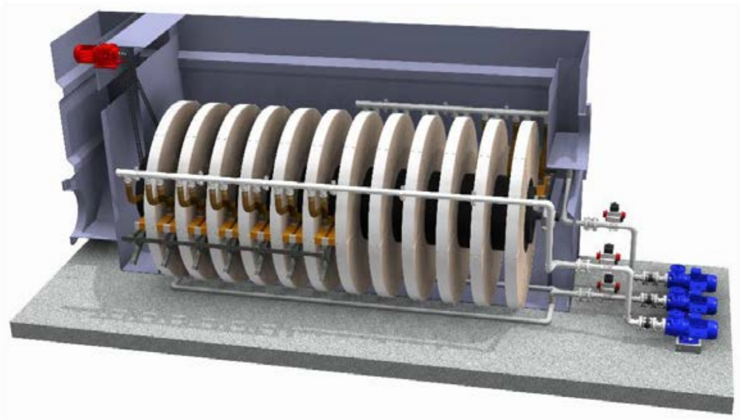


Figure 9: Typical Cloth Media Disk Filter

While they have significant benefits in simplification of the backwash circuit, the filters themselves are more complicated, due to the need to move the filter array (or the suction scanners), and the control systems for the scanners themselves.

CMDF's may be installed into a concrete tank or supplied as a steel package unit. The choice of construction materials will be important, as saltwater service will increase corrosion of typical construction materials used in the water industry (e.g., 316 stainless steel)

They can also tend to be more expensive than sand filters.

It is our observation that disk filters are becoming commonly recommended as an alternative to rapid gravity sand filters, especially in wastewater applications.

Benefits:

- Greatly reduced backwash water usage
- Simplification of backwash circuit

- Improved particulate removal in comparison to sand filters
- Reduction in footprint
- At this point it is a proven technology

Drawbacks:

- Tends to be more expensive than RSF's
- More mechanically complicated than an RSF
- Materials selection will be important for salt-water use

Disk filters should be suitable for use as they have a relatively low footprint. Systems are usually provided with steel tanks, materials design will need to ensure that the equipment is suitable for use in a salt water environment.

2.6 Filtration –Membrane Filters

Membranes are a surface filtration technology that uses a thin film of material with very small holes to remove very small particles. Membrane filters are typically defined by their pore size, with the two most common particulate removal membrane technologies being Microfiltration (MF) or Ultrafiltration (UF). A Microfilter has a pore size of around 0.1 to 10 µm, ultrafilters are finer, with a pore size of between 0.02 to 0.05 µm.

Microfilters are good at removing large solids, bacteria, and other particles. Ultrafilters can remove much smaller particles, including some colloids and viruses (although not all). Ultrafilters require higher pumping pressures and can be more prone to fouling.

A variety of materials and configurations have been developed to suit specific purposes, and membranes are commonly used in water treatment and wastewater treatment processes.

Active layers typically consist of polymer substances, (e.g., including Polyvinylidene fluoride (PVDF), Polyethersufone (PES), etc.), which tend to provide a good balance of cost, strength and fouling characteristics.

Ceramic based separation layers are less common but have a far greater fouling resistance than polymeric materials; as such they have a significant advantage in situations where fouling can be an issue. They also tend to be mechanically stronger than typical PVDF or PES membranes. Ceramic membrane tend to have a lower packing density than polymeric membranes, making them larger for the same surface area, requiring much larger tanks for installation.

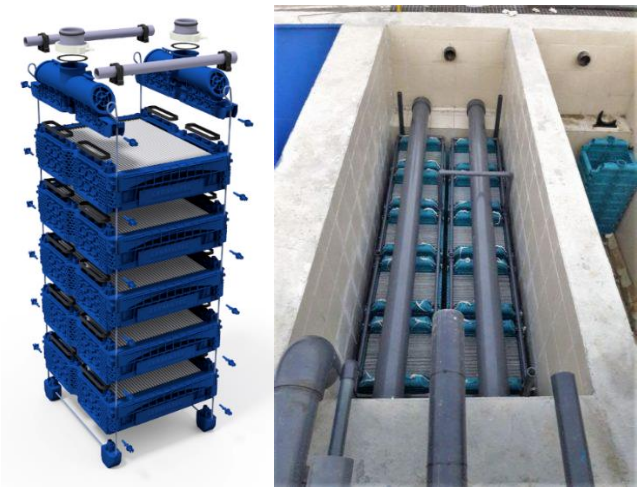


Figure 10: Ceramic Membrane Filters

Membrane based systems provide class leading solids removal, and in a lake water treatment application will be able to directly filter algal cells from the water. Even though Ceramic membranes have a larger footprint than polymer membranes, the footprint is still far smaller than sand or cloth media filtration.

They are, however, significantly expensive in comparison to other filtration technology. Membrane filters also run at comparatively high pressure, and typically require an air scour system, which runs constantly. This increases their overall power requirements. They also require regular chemical cleaning and tend to use more backwash water.

Backwash water can be high and the membranes require regular chemical cleaning. Backwash water would typically be recovered, with solids being settled or otherwise removed, with the sludge either de-watered and sent to landfill or sent to sewer. Waste from chemical cleaning would need to be sent to sewer for disposal.

Benefits:

- Excellent solids removal
- Small footprint

Drawbacks:

- High power usage
- Requires chemical cleaning
- High backwash water usage
- Very expensive

Membrane filters should be suitable for use and provide excellent solids removal, although this comes at a cost increase. Again, materials selection for the construction is important, with salt water being more aggressive than freshwater.

2.7 Chemical Dosing – Coagulants

Coagulants are a class of chemicals that cause stable solids suspensions (e.g. colloids, emulsions) to de-stabilise, allowing the particles to clump together and be removed via sedimentation or filtration. They also cause the precipitation of soluble materials, such as dissolved metals or phosphates.

Coagulant chemicals are typically a metal salt, most commonly of Iron or Aluminium. Various chemicals are available, with Aluminium based chemicals being more common in Australia due to their lower cost. Of the aluminium products, Aluminium Sulphate, Poly Aluminium Chloride and Aluminium Cryohydrate are the three most common. Aluminium sulphate is the cheapest but tends to cause pH problems, ACH is the most expensive but does not typically require pH correction, which results in the two chemicals generally being reasonably comparable in cost.

Ferric Chloride can be useful when membranes are being used, as aluminium based coagulants can increase increased membrane fouling.

The main drawbacks of chemical dosing are the need to store and handle the chemical and the ongoing cost of the chemicals themselves.

Benefits:

- Will help increase turbidity removal
- Will provide some phosphate removal

Drawbacks:

- Significant phosphate removal may require significant doses
- Requires chemical handling and storage
- Ongoing operational cost

The salt water used in the lake is likely to cause a degree of coagulation for incoming suspended solids in fresh stormwater runoff, which will generally be freshwater.

Some additional coagulant dosing might be required to meet turbidity requirements, the main consideration is how and where it should be applied. Coagulant will also help remove some phosphate.

2.8 Chemical Dosing – Diatomix

Diatomix is a nutrient supplement that attempts to select for the growth of diatomaceous algae over blue-green species. Diatom algae (‘diatoms’) are a silica-based organism, requiring a small amount of silica to grow. The presence of silica tends to allow the algae to settle instead of suspending, so long as they have sufficient nutrient available, which means they do not tend to contribute to algal blooms and aesthetic issues.

The chemical selects for diatom growth, allowing them to out-compete blue-green species.

The chemical is initially applied as an inoculation dose to establish a population of diatoms, and a maintenance dose to maintain a healthy population. When stormwater inflows are experienced, the dose is increased to allow the diatoms to out-compete any blue-green species present as additional nutrient enters the lake.

Case studies are promising, and the chemical is generally reported to work quite well, although there is some reports of the system occasionally getting out of balance, requiring a re-set using algicide.

The chemical has been used successfully in freshwater systems, and diatoms appear to be reasonably common in marine algae outbreaks, but application in salt water is limited and as such it is uncertain as to whether it could be successfully applied to the salt-water lake.

As such Diatomix is unlikely to be suitable for this process without further pilot testing or research.

2.9 Chemical Dosing – Earthtec

Earthtech is a copper-based algaecide. The material is highly dispersive, allowing for low concentrations to rapidly disperse throughout a waterbody, making it much easier to dose effectively than old copper sulphate solutions.

As an algaecide, it will directly kill algal cells. However, it is still copper based, which can lead to potential contamination of lake sediment.

The material can be very simply dosed by pouring into the lake, although the use of a dosing system would be more appropriate.

The material may be dosed as a shock-dose to kill an outbreak, and at a low concentration to help deter algal growth.

Benefits:

- Highly dispersive algaecide is simple to dose
- Comparatively inexpensive
- Can provide acute dosage to help with outbreaks or blooms

Drawbacks:

- Still copper based – may be some concerns with contamination of sediments
- If used for an outbreak control means other treatment systems have failed.

Based on the comparatively low cost and seeming effectiveness of the product, earthtec should be included, even if only as the final contingency option to help deal with an algae outbreak.

2.10 Biological Nutrient Removal

Biological treatment systems for wastewater are commonly utilised to reduce nitrogen and phosphorus in sewage.

These processes can be applied to treat water in the lake, although care needs to be taken with their application, as the concentrations encountered in the lake water are far lower than those encountered in sewage. This impacts reaction rates which in turn increases the size of reactors and equipment.

However, these processes can be utilised to help reduce nutrient loading within the lake.

This would be achieved using a nitrification reaction, which converts Ammonia present in the water to Nitrate and Nitrate, and the de-nitrification reaction, which reduces nitrates to nitrogen gas. Each of these reactions have different requirements and require purpose-built reactor vessels.

Nitrification requires the presence of oxygen and ammonia, with bacteria oxidising the ammonia to Nitrates. Typically a trickling filter style system would be utilised, although this will depend upon where the equipment is located; active aeration using compressed air may be necessary depending upon footprint. The nitrification reactor would be packed with media that supports the growth of attached biomass, essentially a biological slime, that houses the bacteria that provides treatment.

De-nitrification involves the reduction of the nitrates created in the nitrification process to nitrogen gas. To achieve this bacteria require an environment with no oxygen, but with BOD, or available carbon, and Nitrate present. Again, there are various techniques, with the use of a packed nitrification system or a nitrification filter being the most likely. Specifically, a packed up-flow nitrification system has been chosen, which utilises plastic packing, which provides a surface for the development of a biofilm similar to the trickling filter. The biofilm uses the nitrate present for growth, expelling nitrogen gas. Carbon will need to be dosed to support the process, with sucrose solutions or methanol being relatively common.

Both processes utilise some phosphate for growth, as it is a required nutrient. This can often lead to significant phosphate reduction through these types of systems, with post-anoxic de-nitrification systems commonly being phosphorus limited as opposed to nitrogen limited in wastewater applications.

Remaining phosphate may be removed by precipitation, plant growth or similar biological processes.

Benefits:

- Small footprint
- Industrial process should be relatively controllable

Drawbacks:

- Requires regular operation and maintenance
- Chemical costs
- May be less effective at very low concentrations (although it may not have to be)

2.11 Ultrasonic Algae Control

Ultrasonic systems are a comparatively new technology for algae control. The systems do not provide nutrient removal or affect nutrient concentrations, and instead rely on directly affecting algal cells, either destroying them or disrupting their growth cycle. Modes of action vary depending upon the specific technology, with both low and high energy systems available.

Low power systems disrupt gas vacuoles within the algal cell, disrupting the algae's ability to regulate their depth in the water column. This removes their buoyancy, which causes the cells to sink to the bottom of the lake, where they cannot photosynthesise, which eventually results in cellular death. As the process does not disrupt the cell itself it tends to cause less toxin release (the cells will eventually be broken down by environmental bacteria which will usually degrade the toxins as well).

Higher power systems rely on cavitation to destroy algal cells. The high-power pulses cause microbubbles to form, the collapse of these bubbles cause intense heat and pressure fluctuations; essentially microscopic explosions that exist on a nanosecond timescale, creating significant mechanical stresses (cavitation can easily eat away at a metallic pump impellor). This rips apart algal cell structures, directly killing the organism.

Low power systems have a range of advantage over high power systems, including lower power usage, far less affect on the environment (literature to date generally agrees that low powered ultrasonic systems have no affect on other organisms) and a significant reduction in algal toxin release.

For a large lake, low power systems are deployed as buoy's and can be solar powered. They need to be accurately designed to ensure that the ultrasonic waves cover the entirety of the lakes surface, otherwise pockets of algae will form.

Figure 11: LG Sonic Ultrasonic Bouy

The systems do need to be tuned to target algal species, as the resonance frequencies required to effectively disrupt the algal cell vacuoles can vary between species.

While locally produced equipment can be cost effective, there is a general lack of performance data for locally produced equipment, with observations being anecdotal in nature. There is more data available for equipment from Europe, but European sourced equipment tends to be very expensive in comparison to local equipment.

Benefits:

- Low chemical usage
- Direct control, can provide treatment without extensive nutrient control

Drawbacks

- New technology, local suppliers lack performance data
- International supplied equipment can be expensive
- Does not limit nutrient concentrations

- May need tuning or adaption for changing algal species makeup or balance

2.12 UV Irradiation

Bombardment of water with UV light at specific wavelengths has a proven track record of inactivating bacteria and is commonly utilised for disinfection for water and wastewater.

Cyanobacteria can be especially vulnerable to UV light, making UV a reasonably effective method for killing off algal cells.

The primary issue with UV is that it requires very clear water to be particularly effective; the presence of suspended solids or 'turbidity' will result in the scattering of the light applied to the water, protecting or shielding the organisms present. UV would typically only be applied if the water were well filtered to ensure good dosage can be obtained.

Due to its nature, UV would be more appropriately to be applied to a side-stream, recirculation pipework or the inlet pipework for the lake, just sinking a UV light into the lake is unlikely to be particularly effective.

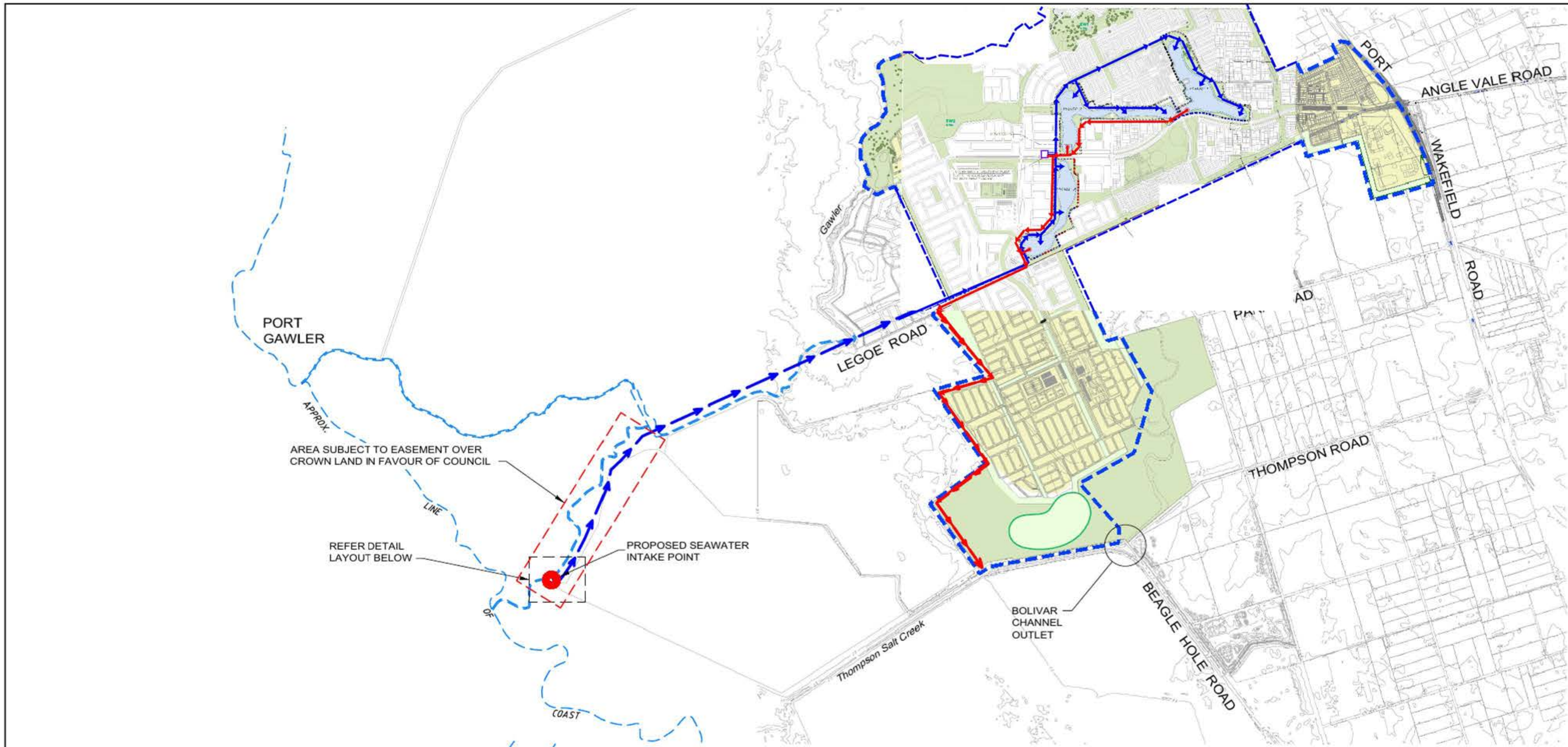
Benefits

- Effective algae control

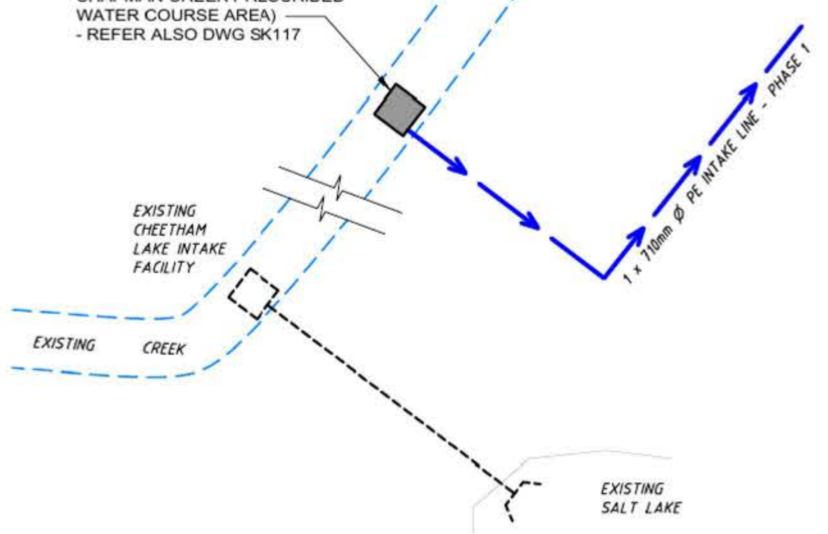
Drawbacks

- Requires very clear water
- Will require an enclosed channel or recirc
- May result in release of toxins on cell death

Appendix B Preliminary Design Drawings by Burchill



SEAWATER INTAKE AND OUTLET LINES GENERAL ARRANGEMENT



SEAWATER INTAKE LINE
SCHEMATIC ARRANGEMENT
NOT TO SCALE

NOTE:

- REFER ALSO DWG SK113 FOR DETAILED INTERNAL CIRCULATION STRATEGY

LEGEND

DEVELOPMENT EXTENTS

PROPOSED SEAWATER INTAKE LINES

OUTLET LINES (PHASE 1 & 2)

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PRELIM CONCEPT PURPOSES ONLY

Data Source:
Burchills Engineering Solutions - Riverlea Development
Adapted from Drawing: BE170039-SK138-H and BE170039-SK106-N

Coordinate System: GDA94 / MGA zone 54

Water Engineering Plus endeavours to ensure that the information provided in this map is correct at the time of publication. Water Engineering Plus does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

PROJECT: Riverlea Lake Concept Design	TITLE: Proposed Development at Buckland Park		
CLIENT: Walker Corporation	WATER ENGINEERING plus WWW.WEP.COM.AU	SCALE: 0 500 1,000 m	FIGURE NUMBER: 3-1 REVISION:
			DATE: 01-October-2024

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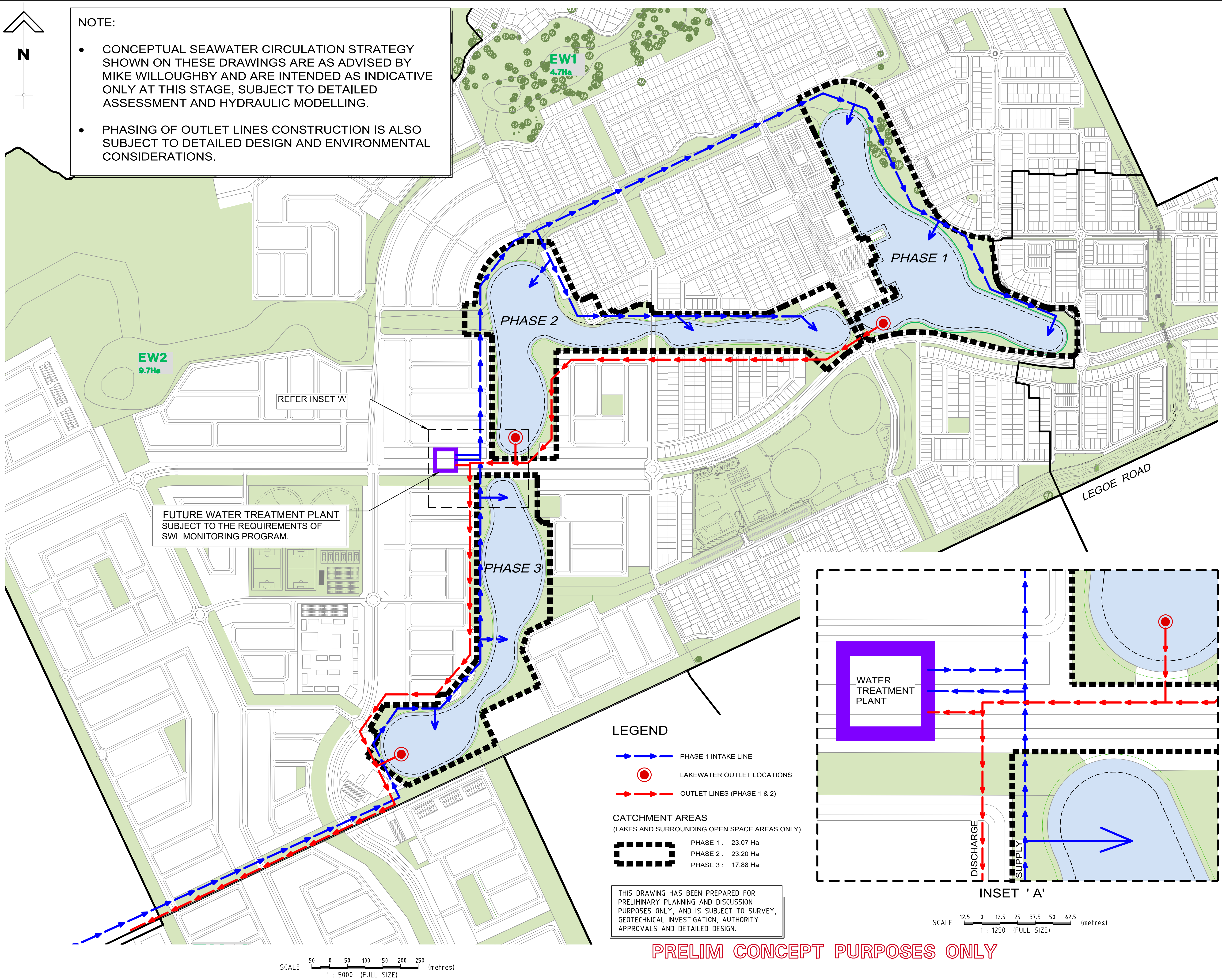

PRELIM CONCEPT PURPOSES ONLY

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RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
H	WATER TREATMENT PLANT DETAIL ADDED	20-09-24
G	SWL CIRCULATION STRATEGY MODIFICATION	18-09-24
F	SWL CIRCULATION STRATEGY MODIFICATION	24-05-24
E	MASTER PLAN UPDATE / SWL LINES	20-09-23
D	CONCEPT UPDATED	18-08-22
C	INTAKE LINE DIA AMENDED	09-02-22
B	CONCEPT LAYOUT UPDATE	02-02-22
A	ORIGINAL ISSUE	25-11-20

BURCHILLS ENGINEERING SOLUTIONS
Level 2, Connaught Centre
26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:

GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :

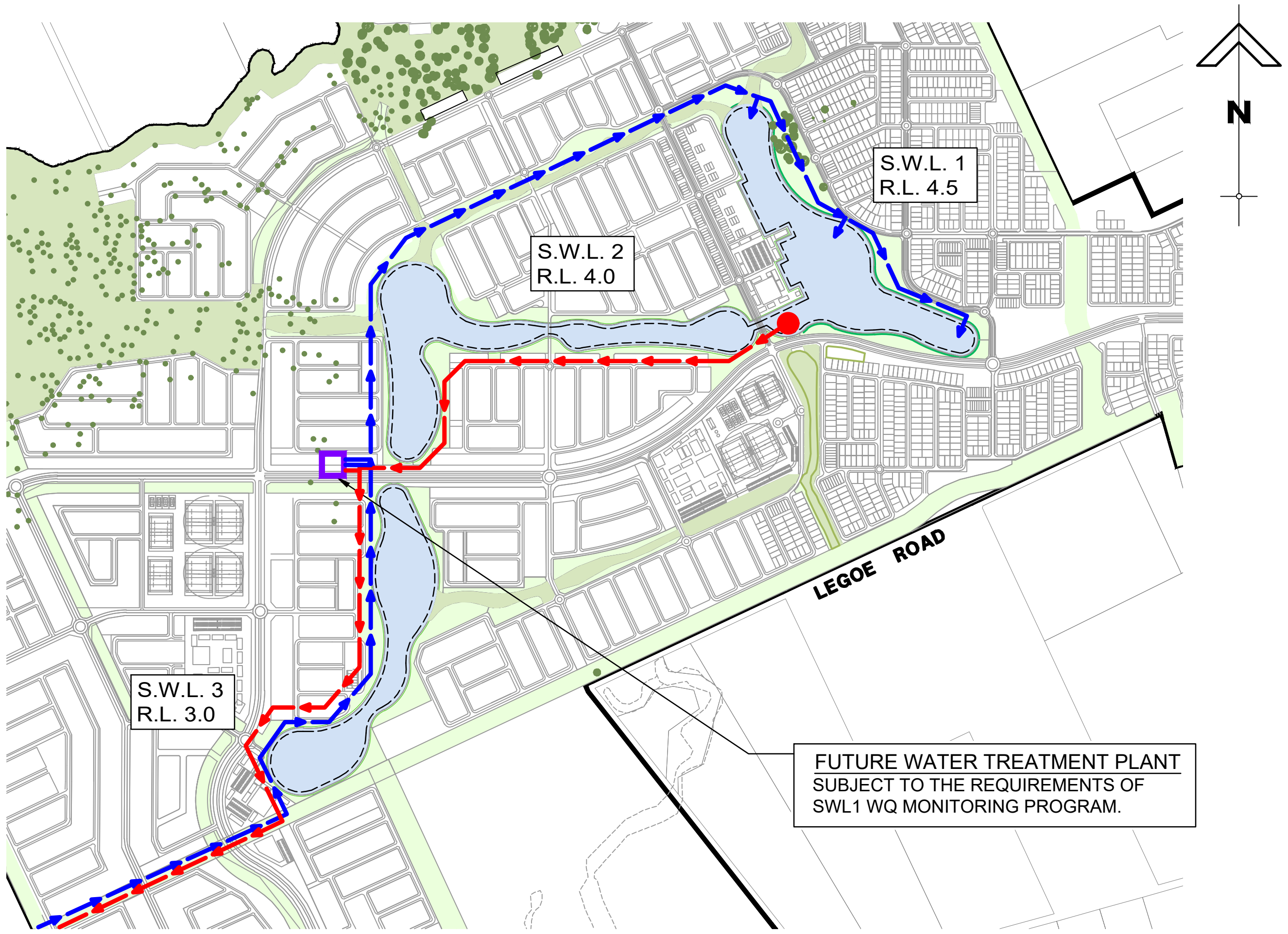
CONCEPTUAL SEAWATER CIRCULATION STRATEGY LAYOUT PLAN (PHASES 1 & 2)

DEVEL. APPLIC. No. : -	DATE : 20-09-24
PROJECT LEADER : PAUL KELLY	
DESIGNER : NILL - DRAFTING ONLY	
DRAFTSPERSON : ADAM COOPER	
CHECKED :	

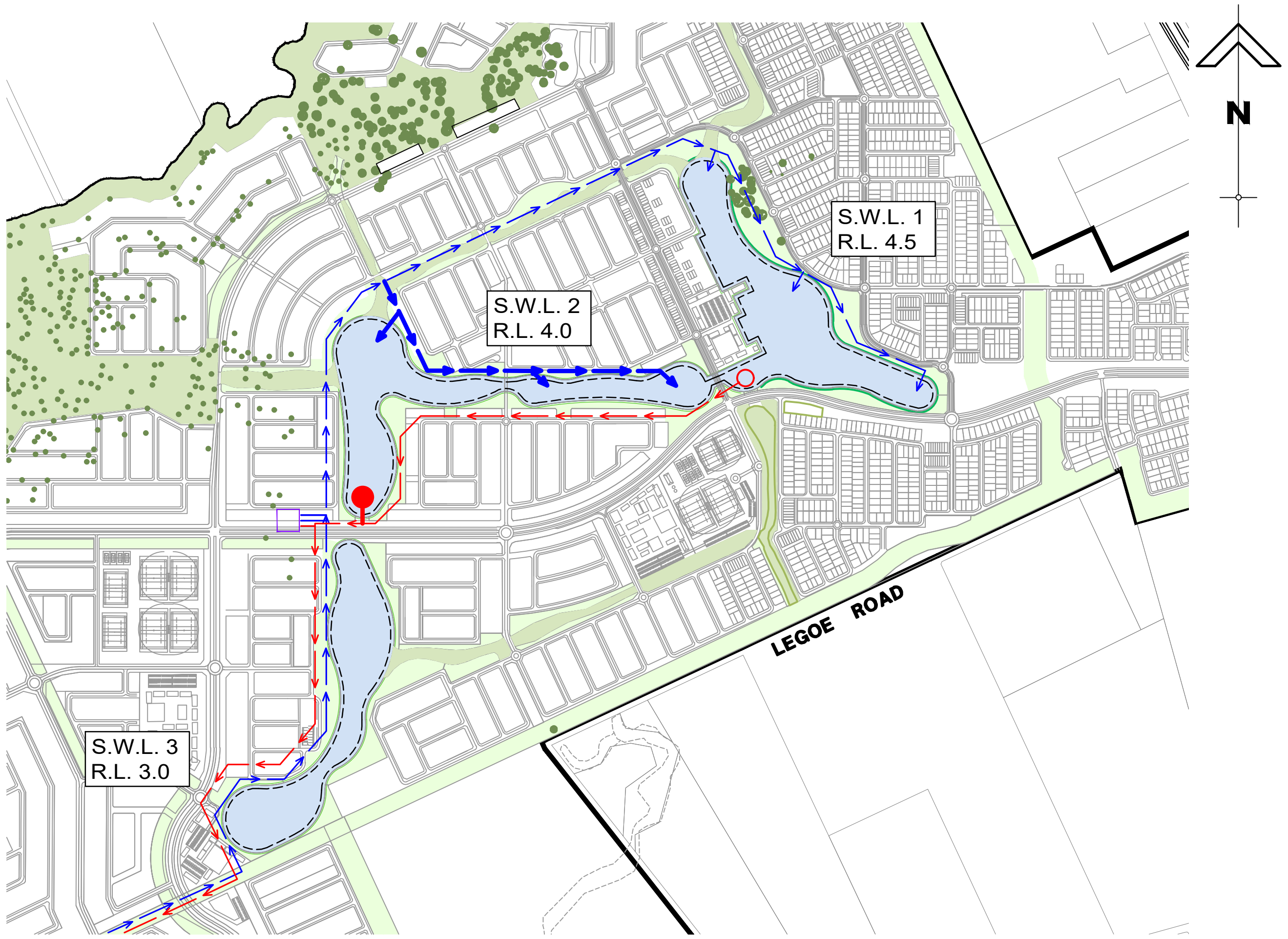
APPROVED FOR AND ON BEHALF OF BURCHILLS ENGINEERING SOLUTIONS ABN 76 166 942 365

RPEQ No. :

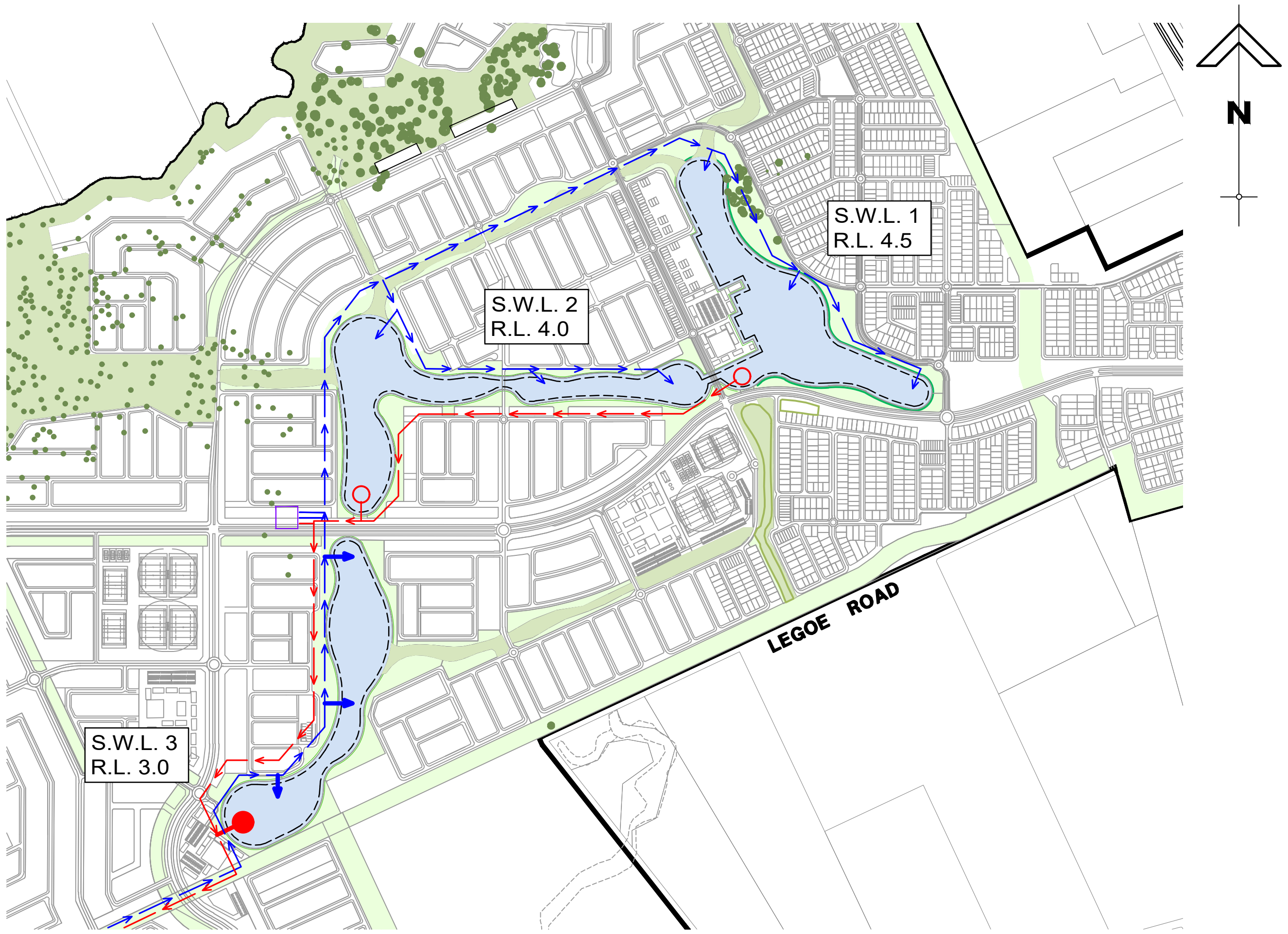
SCALE : AS NOTED	DATUM : AHD	FULL SIZE : A1
PROJECT No.: BE170039	DRAWING No. : SK113	VERSION: H



PHASE 1 - SWL 1 CIRCULATION



PHASE 2 - SWL 1 & 2 CIRCULATION



PHASE 3 - SWL 1, 2 & 3 CIRCULATION

NOTE:

- CONCEPTUAL SEAWATER CIRCULATION STRATEGY SHOWN ON THESE DRAWINGS ARE AS ADVISED BY MIKE WILLOUGHBY AND ARE INTENDED AS INDICATIVE ONLY AT THIS STAGE, SUBJECT TO DETAILED ASSESSMENT AND HYDRAULIC MODELLING.
- PHASING OF OUTLET LINES CONSTRUCTION IS ALSO SUBJECT TO DETAILED DESIGN AND ENVIRONMENTAL CONSIDERATIONS.

PRELIM CONCEPT PURPOSES ONLY

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SCALE 100 0 100 200 300 400 500 (metres)
1 : 10000 (FULL SIZE)

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PLOTTED: 17.09.2024 at 12:06

RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
G	SWL CIRCULATION STRATEGY MODIFICATION	17-09-24
F	SWL CIRCULATION STRATEGY MODIFICATION	24-05-24
E	MASTER PLAN UPDATE / SWL LINES	20-09-23
D	SWL 1 R.L. AMENDED	24-02-23
C	SWL 3 INTAKE PIPE DIA AMENDED	13-10-22
B	CONCEPT MASTERPLAN UPDATED	01-08-22
A	ORIGINAL ISSUE	07-06-22

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BURCHILLS ENGINEERING SOLUTIONS
Level 2, Connaught Centre
26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:

GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :

CONCEPTUAL SALTWATER LAKES CIRCULATION SYSTEM PHASING PLANS

DEVEL. APPLIC. No. : -
DATE : 17-09-24
PROJECT LEADER : PAUL KELLY
DESIGNER : NILL - DRAFTING ONLY
DRAFTSPERSON : ADAM COOPER
CHECKED :
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DATUM : AHD
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PROJECT No.: BE170039
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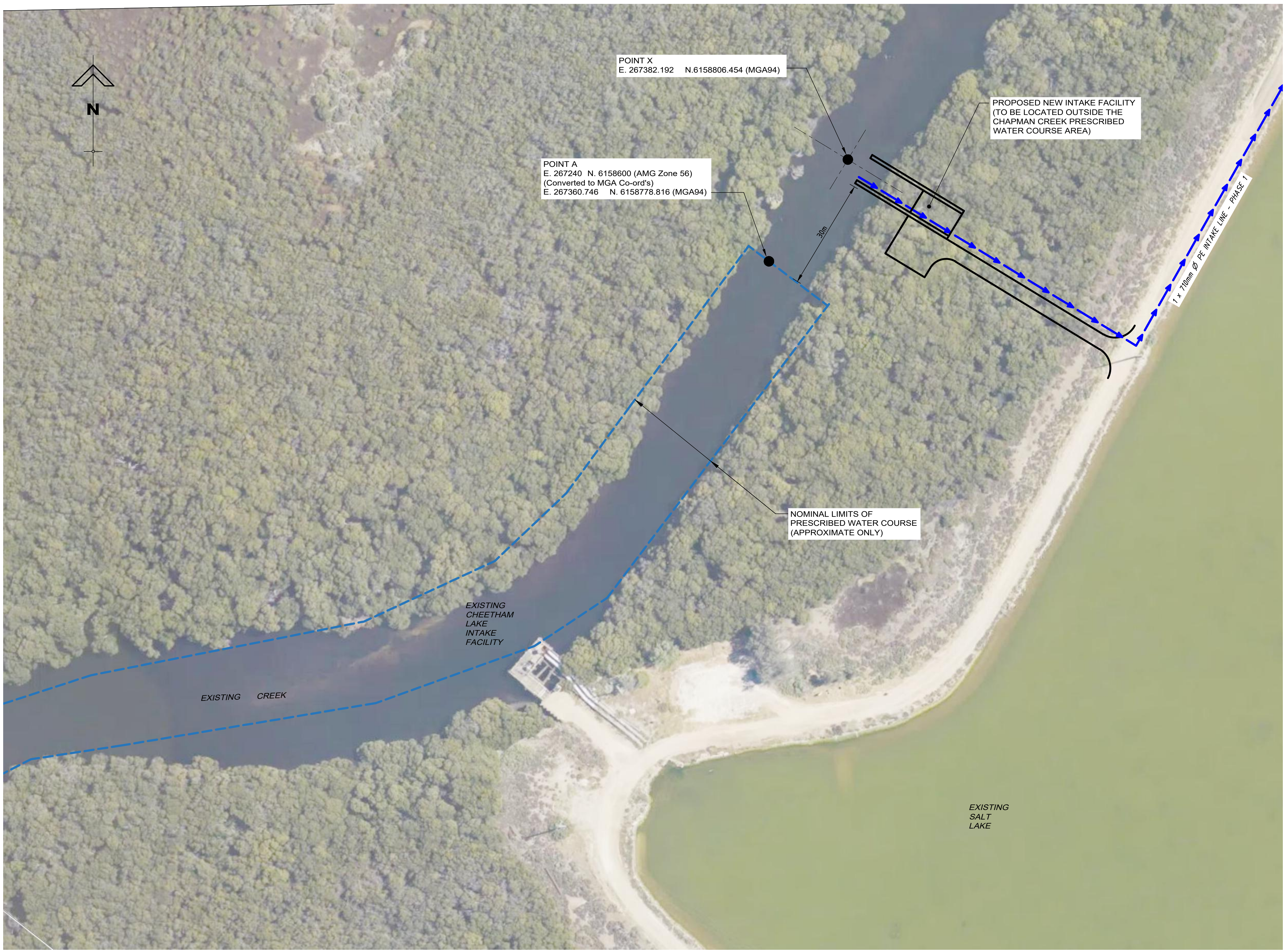

PRELIM CONCEPT PURPOSES ONLY

SEAWATER INTAKE LINE
SCHEMATIC ARRANGEMENT

SCALE 5 0 5 10 15 20 25 (metres)
1 : 500 (FULL SIZE)

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RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
F	INTAKE LINE MODIFIED	24-05-24
E	INTAKE LINE ALIGNMENT AMENDED	11-02-22
D	INTAKE LINE DIA AMENDED	09-02-22
C	INTAKE LINE DIA AMENDED	02-02-22
B	MINOR AMENDMENTS, CO-ORDINATES ADDED	27-01-22
A	ORIGINAL ISSUE	27-01-22

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BURCHILLS ENGINEERING SOLUTIONS
Level 2, Connaught Centre
26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:
GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :
SEAWATER INTAKE LINE GENERAL ARRANGEMENT

DEVEL. APPLIC. No. : - DATE : 24-05-24
PROJECT LEADER : PAUL KELLY
DESIGNER : ADAM COOPER
DRAFTSPERSON : ADAM COOPER
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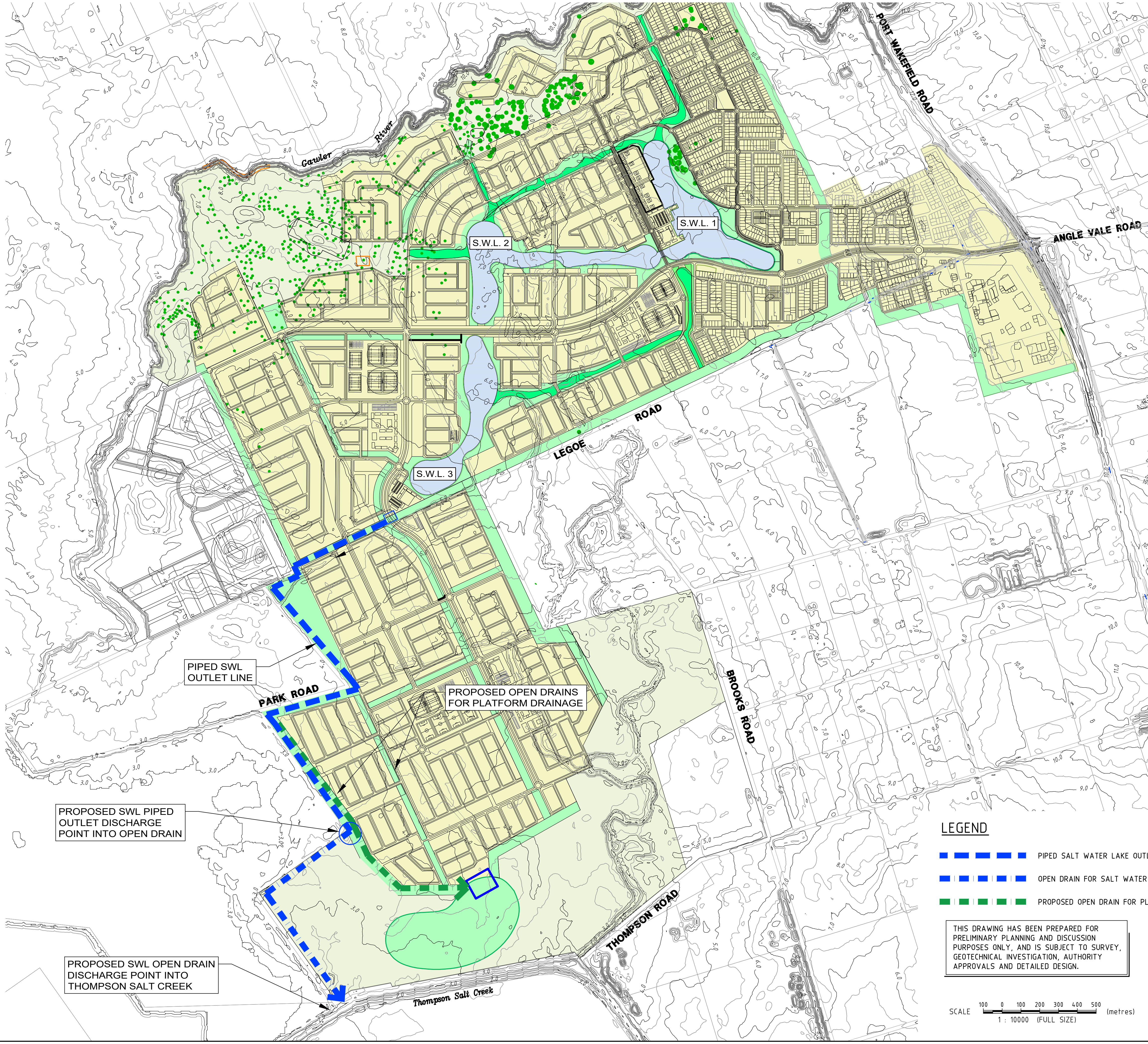

LEGEND

- PIPED SALT WATER LAKE OUTLET
- OPEN DRAIN FOR SALT WATER DISCHARGE
- PROPOSED OPEN DRAIN FOR PLATFORM DRAINAGE

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SCALE 100 0 100 200 300 400 500 (metres)
1 : 10000 (FULL SIZE)

RIVERLEA DEVELOPMENT

PROPOSED DEVELOPMENT AT BUCKLAND PARK SOUTH AUSTRALIA

A1 ORIGINAL SIZE BEFORE REDUCTION

VER.	DESCRIPTION	DATE
D	MASTER PLAN UPDATE / SWL OUTLETS	29-11-23
C	MASTER PLAN UPDATE / SWL OUTLETS	20-09-23
B	STORMWATER DISCHARGE MODIFIED	25-01-23
A	ORIGINAL ISSUE	01-08-22

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BURCHILLS ENGINEERING SOLUTIONS
Level 2, Connaught Centre
26 Marine Parade, Southport QLD 4215
PO Box 3766, Australia Fair, Southport QLD 4215
Phone: +61 7 5509 6400
Fax: +61 7 5509 6411
Email: admin@burchills.com.au
Coote Burchills Engineering Pty Ltd
ABN 76 166 942 365

PROJECT:
GENERAL SITE EARTHWORKS PRE-DESIGN AND CONCEPTUAL

DRAWING TITLE :
SALT WATER LAKES OUTLET PLAN

DEVEL. APPLIC. No. : - DATE : 29-11-23
PROJECT LEADER : PAUL KELLY
DESIGNER : ADAM COOPER
DRAFTSPERSON : ADAM COOPER / LUIS MACIEL
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PROJECT No.: BE170039 | DRAWING No. : SK147 | VERSION: D

Appendix C Cost Estimate Commentary

SALTWATER LAKE WATER CIRCULATION AND TREATMENT MANAGEMENT COST ESTIMATES

Cost Estimates for both the Capital and Operational Expenditure are provided below: -

The estimates are based on a Refined Management System incorporating both significant Saltwater Lake (SWL) Circulation capacity and Water Quality Treatment Capability SWL 1 initially.

The proposal is appropriately named the as a Progressive Adaptive Water Quality Management Scheme detailed below: -.

1. The capacity of the primary circulation pipework provided for an 80-day lake volumetric turnaround.
2. over-sizing the SWL 1 local pipework to reduce the lake turn over from 80-days to 40-days.
3. SWL 1 will be constructed, and circulation infrastructure installed, the system commissioned incorporating a full-scale water quality monitoring and reporting regime.
4. Varying the lake volumetric circulation frequency forms the starting point for the trials.
5. The installation of in-lake mixer, blowers, and UV treatment are the further initial system add-ons.
6. Subject to the success or otherwise of Items 4 and 5, contingency planning provides for additional water quality management support via the provision of a Water Treatment Plant (WTP – a single denitrification train initially). A decision as to the optimal manage strategy to deliver secondary standard water quality for the lake will be made thereafter.
7. Item 2 provides additional up-front SWL 1 (new water) circulation capacity. This temporary new water coverage provides for the 'WTP delivery time', and whatever additional WQ Management capability is required from Item 5 and 6.
8. We remain confident that Items 1 and 2 will provide the Water Quality required, however, we have contingency coverage in addressing any unexpected risk associated with poorer lake water quality than expected.
9. There remain several lake circulation and WTP permutations that should allow the SWL System to be advanced to completion economically, subject to detailed design.

CAPEX and OPEX Cost Estimate Reconciliation.

Original Budget Cost Estimates (for the full SWL circulation only system), were:

CAPEX	$ 15,000,000.
OPEX	$ 420,000.

Revised Circulation + Single WTP Train (de-nitrification only) Cost Estimate:
The revisited SWL circulation capacity has delivered significant system savings, whilst maintaining additional short-term circulation capability.

Primary Circulation (Lakes SWL 1, 2 and 3):

CAPEX Estimate	$ 10,689,240
OPEX	$ 217,850

Adding the WTP Costs (SWL 1):

CAPEX Estimate $ 7,389,000 (Simmonds and Bristow average).

OPEX $ 220,000 (Simmonds and Bristow Average).

Revised Budget Cost Estimates (for the combined system assuming full lake water treatment through WTP):

CAPEX Estimate $ 18,399,240

OPEX $ 868,850

There are possible savings, dependent upon WTP 1 delivering spare circulation water for SWL3 circulation, with limited treatment, of $160,000 CAPEX cost and $210,000 for OPEX cost.

wm developments pty ltd

Mike Willoughby
MIE Aust CPEng NER APEC Engineer IntPE(Aus) RPEQ
3690
Mobile 0417 073632