

SOVEREIGN WATERS ESTATE

Lake Management Plan

Prepared for:

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1 Overview

1.1 BACKGROUND

This Lake Management Plan (LMP) has been prepared for the Sovereign Waters Estate lake system. Its preparation was commissioned by the Redland City Council (RCC) and it has been prepared by Kellogg Brown & Root Pty Ltd (KBR).

The Sovereign Waters Estate lake is situated between Birkdale and Wellington Point, north of Birkdale Road. The lake and associated wetland system are part of a water sensitive urban design (WSUD) as the constructed system provides influent water and urban run-off treatment for a developed catchment which is approximately 2 km².

Upstream of the wetland area there are several ponds built between 2005 and 2011 on the southern side of Birkdale Road in EGW Wood Park. These feed into the Sovereign Waters wetland area via five reinforced concrete box culverts (RCBCs). The wetland area consists of two ponds, which act as treatment areas for the removal of sediments and nutrients from the influent water. The water enters the lake from the wetlands via two RCBCs controlled by submerged one way top hinged flap gates.

The lake is designed to be brackish due to the tidal exchange system. Volumetric turnover of the lake is achieved within approximately 24 days and if required the turnover frequency can be reduced to 10 days using a manually operated emergency outlet (Redland Shire Council, 2000).

In August 2000 filling of the lake with water began and construction of over 80% of the surrounding housing had been completed. The development then moved into its operational phase.

In July and August 2000 RCC implemented an operations and maintenance manual and Lake and Wetland Management Plan respectively. These documents identified post construction and continued management requirements and operations and maintenance tasks which should be conducted to ensure the site maintains its designed functions and water quality objectives. As a result several surveys, observational and water quality studies were carried out during construction and throughout operations to present date.

RCC has identified the requirement to update the existing LMP. To do this existing data and documents have been reviewed, a sedimentation study was undertaken and a management framework and maintenance model has been developed.

This technical investigation of the lake was completed as an input to the preparation of this LMP. This was documented in report, BEJ252-TD-MN-REP-0001 – *Sovereign Waters Estate Sedimentation Study* (KBR, 2012).

1.2 PURPOSE

The scope of this LMP is to provide a guide for the management of the Sovereign Waters lake system. This includes the wetlands and lake, tidal exchange system, pollutant control devices and parkland areas.

The LMP is an asset based management plan which:

- Identifies the components of the lake and describes their functions.
- Provides a water level and water quality monitoring program guideline.
- Identifies management requirements and inspection frequencies for the components.
- Provides sediment removal and disposal options based on information gathered from the sediment study.
- Includes a 10 year scheduled and costed capital plan. This costed plan is an operations and maintenance schedule which is an addendum to the original Operations and Maintenance Manual (Redlands Shire Council, 2000).
- Reviews mitigation options which include plausible upstream treatment options and recommendations to improve the system.

1.3 PLAN CONTEXT – LEGISLATION AND GUIDELINES

Legislation and guidelines which are of relevance to the Sovereign Water Lake and its management are identified below:

- Marine Park (Moreton Bay) Zoning Plan 2008
- Marine Park Act 2004
- Aboriginal Cultural Heritage Act 2003
- Environment Protection and Biodiversity Conservation Act 1999 (Cth)
- Sustainable Planning Act 2009
- Coastal Protection and Management Act 1995
- Environmental Protection Act 1994
- Nature Conservation Act 1992
- Environment Protection (Sea Dumping) Act 1981 (Cth)
- Brisbane City (2005). Water Sensitive Urban Design Engineering Guidelines: Stormwater
- Healthy Waterways (2006) Water Sensitive Urban Design Technical Guidelines for South East Queensland.

RCC and their contracted parties are to give due consideration to legislation, requirements and guidelines when proceeding with any planning, implementation and operations within the Sovereign Waters wetland and lake system.

2 Introduction

2.1 LOCATION

The Sovereign Waters development is situated in South East Queensland, on the coastline of Waterloo Bay. The urban development is between Birkdale and Wellington Point, on the northern side of Birkdale Road (refer to Figure 2.1). It is situated in the Tarradarapin Creek catchment (Redland City Council, 2008). The lake and wetland facilitates treatment of a subcatchment area of approximately 2 km². The subcatchment is the area of land defined by topographical and man made features which drain rainfall runoff into the lake. The main stream length of the catchment is approximately 1.7 km. The subcatchment for Sovereign Waters has been derived by assessing influent water drainage plans and land contours provided by RCC and is shown in Figure 2.2.

2.2 GENERAL ARRANGEMENT

The primary hydrodynamic components which influence the system can be seen in Figure 2.3 and consist of the following:

- upstream ponds (EGW Wood Park)
- gross pollutant traps (GPTs) and influent water inlets
- wetland with two zones; one inlet zone and one macrophyte zone
- the Sovereign Waters Lake
- boat ramp and overflow channel for flood events
- piped tidal exchange system connected to the adjacent tidal perimeter channel which is in turn open to Waterloo Bay.

2.3 LAND TENURE

The lake and wetland system and areas within the vicinity which may be used during operations or maintenance work is identified in this section for planning purposes. This information has been based on GIS data provided in June 2012.

The ponds upstream of Birkdale Road, the wetland system, lake, overflow channel, the connecting foreshore and parkland to the left of the Sovereign Waters Lake are under the control of RCC as trustee to the State of Queensland. If the use of this land is required for any operations or maintenance tasks, this should be planned with RCC.

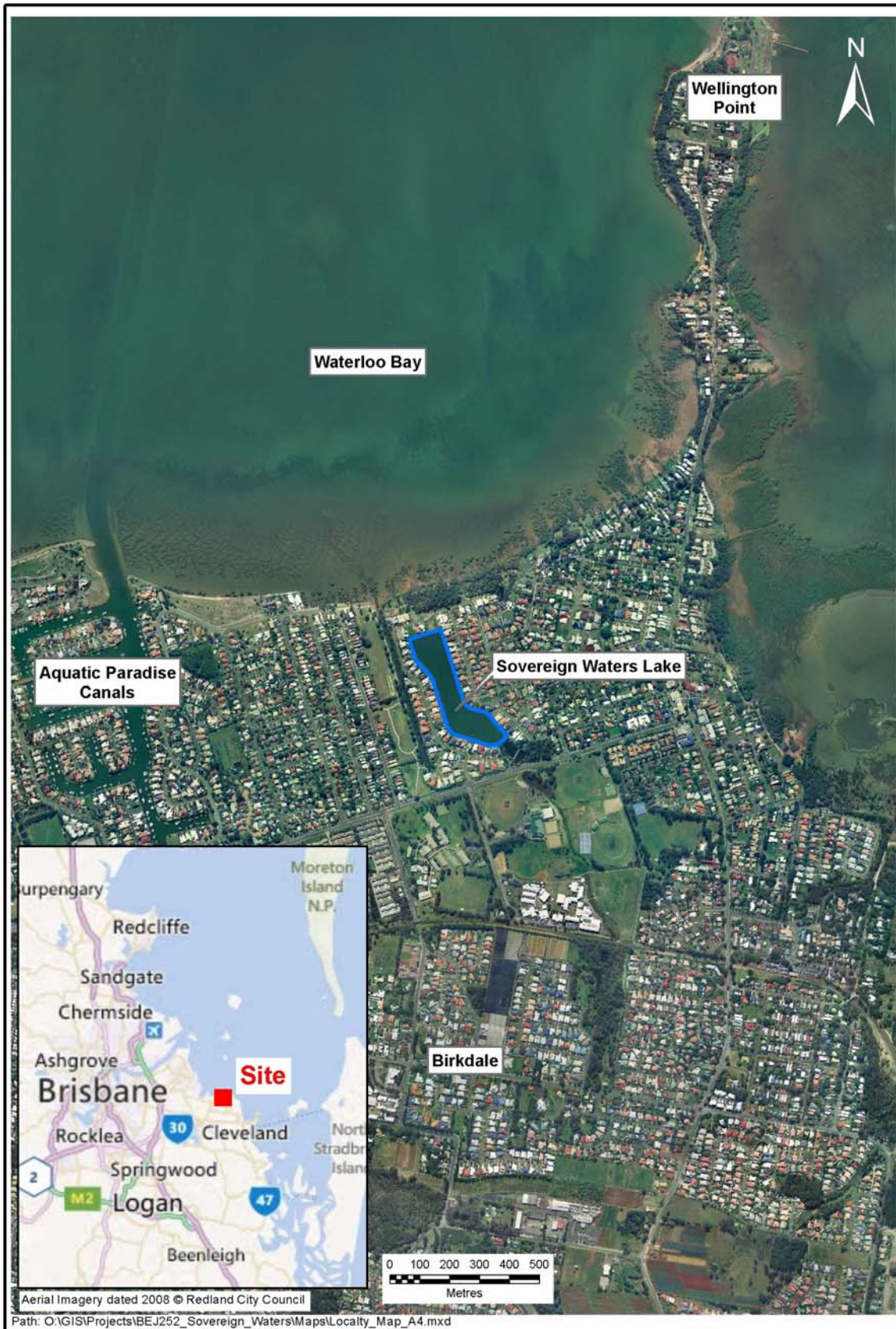


Figure 2.1
SOVEREIGN WATERS LOCATION

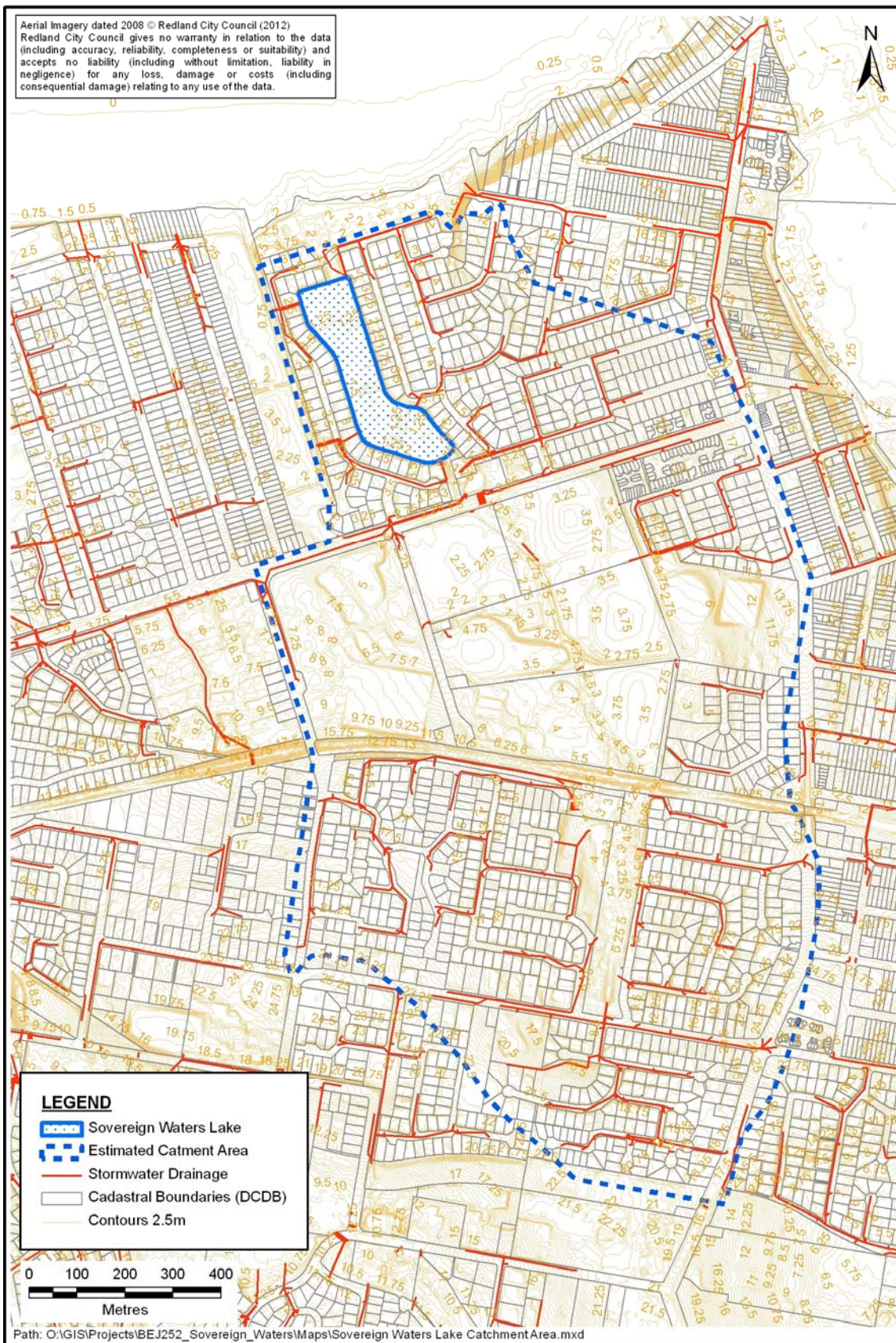


Figure 2.2
SOVEREIGN WATERS SUBCATCHMENT AREA

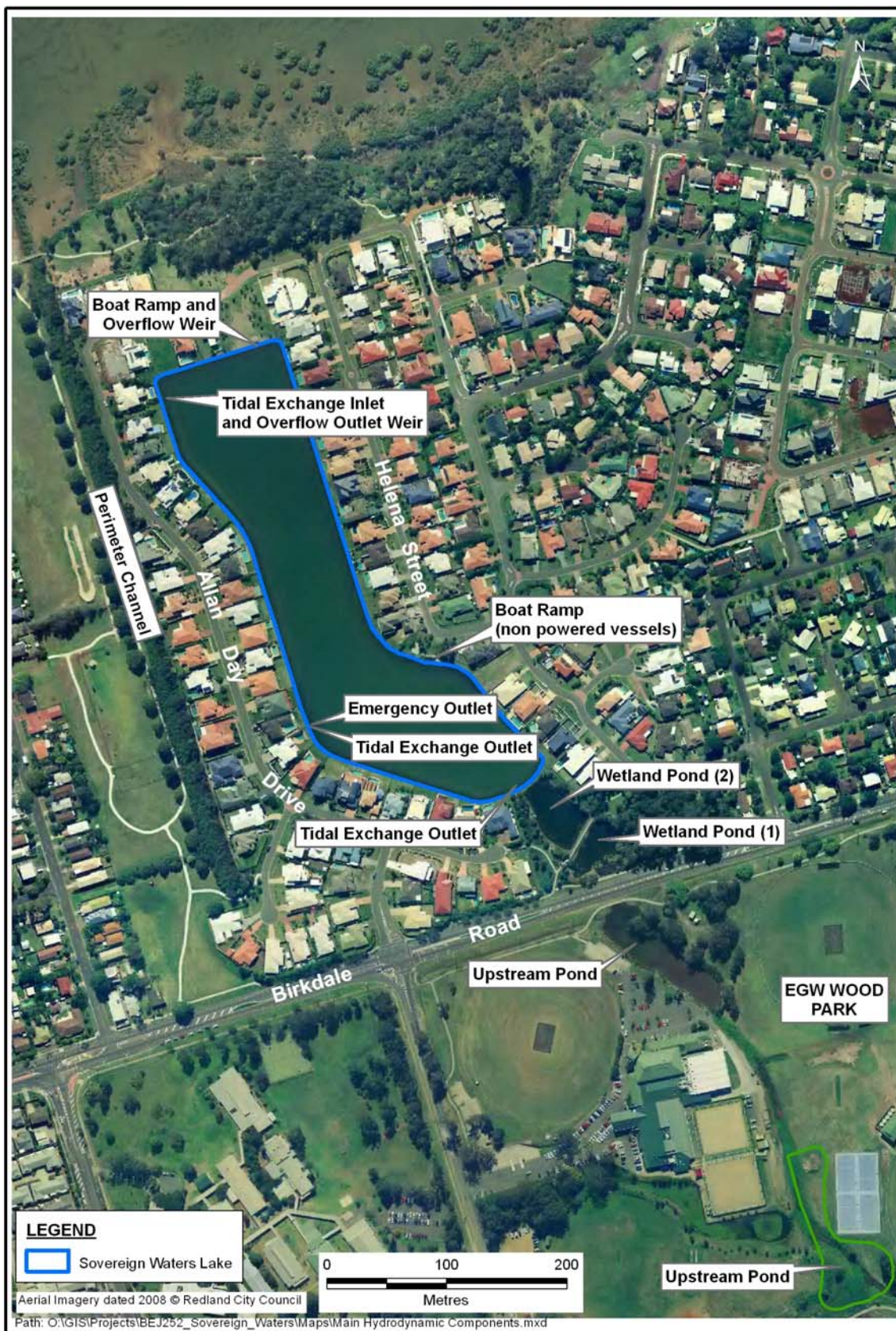


Figure 2.3
SOVEREIGN WATERS MAIN HYDRODYNAMIC COMPONENTS

3 Management framework

The management of the constructed wetland and Sovereign Waters Lake generally consists of four high level tasks. These are included below, with examples:

1. Monitoring: water quality, habitat, flora and fauna performance
2. Operational control: water levels
3. Inspection: checking of structures, embankments and exchange system components
4. Maintenance: Repair/replace damaged structures, vegetation and sediment control.

The LMP has been laid out with this framework at its core. The monitoring of the system has been detailed in Chapter 5 and following this each component of the system has been separated (Chapters 6–12). Management requirements have been detailed where applicable using the management framework adopted.

The costed maintenance model has, where possible, costed the inspection/checks that have been recommended within the management plan. The ‘inspection/action’ frequency relates the ‘Program’ section of the costed maintenance model.

Where maintenance items are known they have been detailed. However, in various cases the time and cost of maintenance for a specific component has been an estimate.

In many cases scheduled inspections and checks will determine the maintenance requirements. The management plan is intended to be adaptable, editable and non-prescriptive and therefore provide a framework to assist in managing the system.

4 Water quality

The required water quality to be maintained is directly linked to the uses of the lake and wetland system. This section identifies the functionality, and thus the water quality objectives of the system.

4.1 OBJECTIVES

The lake has been designed to provide for passive non-contact recreation (i.e. amenity and visual aesthetics) and secondary contact recreational activities (i.e. use of kayaks, canoes and other small non-powered vessels). The lake is not intended to support primary contact recreation (such as swimming) or recreational fishing, although it is reported that these activities do sometimes occur.

Lake uses and associated water quality requirements were discussed at a community consultation meeting in August 2012. The water quality standards to be maintained for the lake remain to be Australian and New Zealand Guidelines for Fresh and Marine Water Quality: secondary contact recreational standards (ANZECC, 2000) until superseded by updated guidelines.

The two wetland areas help maintain lake water quality. They are not intended for recreational activities and should only be accessed during inspection and maintenance activities by authorised persons. Given this, the water quality objectives applied to this part of the system should be those relating to amenity and aesthetic condition.

The lake water surface should be free from floating debris and weeds, the water should be relatively clear and algal blooms should be prevented by ensuring tidal mixing of the water minimises the risk of nutrient build up.

4.2 GUIDELINES

In accordance with the National Water Quality Monitoring Strategy (NWQMS) and National Health and Medical Research Council (NHMRC) procedures, the ANZECC Section 5 'Guidelines for recreational water quality and aesthetics' are currently under review. It has been identified that there is a need for a single guideline document to supersede earlier sets of guidelines historically published, creating a sole source of information for Australian users. In the interim the endorsed and validated ANZECC guidelines can be used. According to Section 5 'the eventual guidelines that result from the NHMRC's current revision will be the definitive guidelines' (ANZECC, 2000).

A regional framework has been identified based on the NHMRC (2008) Guidelines and Healthy Waterways publications. This framework derives a 'Regional Management Response Flow Chart' for 'Microbial Testing of Recreational Waters'.

This flow chart can be used across the catchment and works on a trigger and response mechanism, specifically for analysis of Enterococci. The World Health Organisation (WHO) advocates the use of Enterococci as the single preferred faecal identifier (WHO, 2003). The flowchart applies to the Sovereign Waters site and has been adopted for use in conjunction with routine sampling and can be found in Appendices C.

It should be noted that the routine sampling section of the flowchart does not directly apply to Sovereign Waters (which is secondary contact only) and the monitoring frequency should be taken from Section 5.1 of this Lake Management Plan.

The guidelines for recreational secondary contact focus on less frequent body contact with the water. The third recreational category of visual aesthetics also applies to the Sovereign Waters site and does not include any contact with the water body. Table 4.1 has been extracted from the guidelines and broadly identifies the characteristics relevant to these levels of recreational use.

Table 4.1 Water quality characteristics relevant to recreational use (extract from ANZECC, 2000. p.5-2)

Characteristics	Secondary Contact (e.g. boating)	Visual Use (no contact)
Microbiological guidelines	X	
Nuisance organisms (e.g. algae)	X	X
Physical and chemical guidelines:		
• Aesthetics	X	X
• Clarity	X	X
• Colour	X	X
• pH		
• Temperature		
• Toxic chemicals	X	
• Oil, debris	X	X

Specifically, the guidelines recommend the parameter values in Table 4.2.

Table 4.2 Water Quality parameters guidelines for secondary and tertiary recreational standards

Parameter	Guideline Value
pH	6.5–8.5
DO	>6.5 (>80% saturation)
Total Phosphorous	70 µg/L
Total Nitrogen	650 µg/L
Total Suspended Solids (TSS) - combined wet and dry periods	15 mg/l
Total Suspended Solids (TSS) - wet periods	90 th percentile<100 mg/l
Enterococci	230 organisms/100 ml*^

*median bacterial content that should not be exceeded (ANZECC, 2000)

^ Maximum number that should not be exceed in any one sample: 450-700 organisms/1000ml (ANZECC, 2000).

The maintenance regime within this LMP has been developed with consideration to the water quality objectives and lake functions detailed in this section.

5 Monitoring

Monitoring assesses the present state of a component, its functionality and system performance and usually provides opportunity to plan preventative maintenance measures. For this reason the management framework adopted identifies monitoring as the first framework task.

This chapter details the types of monitoring to be undertaken. The monitoring task and frequency for each task has been detailed in the component sections of the plan. The associated costs of monitoring at the proposed frequencies have been included in the costed maintenance model in Appendix B.

5.1 WATER QUALITY MONITORING

Monitoring water quality of the wetlands, lake and perimeter channel waters provides an indication of performance of the aquatic habitat and system for sediment and nutrient removal.

The lake is designed to fluctuate in salinity during peak catchment flows and after storm events and this will cause periodic salinity related to layering followed by re-mixing. Therefore, studying the composition of the water profile through the water column is integral to understanding whether the lake is performing as it should do to prevent adverse water quality effects and provide for the intended uses.

A consistent water quality monitoring program allows data analysis of historical results to identify trends and possible areas of improvement for the system.

A monitoring approach has been detailed below and this methodology should be adopted when developing a water quality monitoring program. Costs have been incorporated into the maintenance model based on this monitoring program, which can be found in Appendix B.

- Routine monitoring: once every quarter at a minimum. If there is a requirement to understand the system and its physiochemical changes over a year of seasonal change, a program can be developed which has monthly monitoring for a year followed by a data review. After this an agreed change to the water quality monitoring frequency could be adopted.
- Event based monitoring: monitoring will be triggered by high rainfall events. The rainfall trigger for event-based monitoring in RCC is 50 mm over a 24 hour period. The event-based monitoring program and cost allowance is limited to three times per year.
- Depth profiles should be taken for the lake using direct measuring equipment, at 0.50 m increments at a minimum of three locations throughout the lake. In addition, secchi disk measurements at all locations should be taken. Surface

measurements would be sufficient for the EGW Wood pond upstream, Sovereign Waters wetland ponds, and the perimeter channel.

- The direct field measurement results obtained should be for temperature (°C), conductivity (ms/cm), pH, DO (% saturation) and turbidity (NTU) as a minimum to understand physical conditions and provide the basis for comparison with ANZECC (2000) guidelines.
- Samples should be sent for laboratory testing for
 - Microbial testing, assessing levels using the NHMRC guidelines for Managing Risks in Recreational Water (NHMRC, 2008)
 - TN, TP, TSS (mg/L) and faecal coliforms (CFU/100 mL) as a minimum, for comparison with ANZECC (2000) guidelines.
- Observational field notes should be taken whilst sampling which state the aquatic and environmental conditions, including qualitative observations fauna presence (birds especially), debris, litter, floating scums, algal mats, or evidence of spills or floating films.
- Observation should also include any dead fish found in any of the water bodies, these should be reported and logged – whether observed by RCC or as information received from a resident. Fish mortality may be an indication of water quality problems and should be assessed appropriately, if occurring.
- The Regional Management Response Flowchart set out in Appendix C should be followed based on field and laboratory results for every sampling event.

5.2 WATER LEVEL MONITORING

Water level monitoring allows the operations staff to identify if there is any potential clogging up or reduced efficiency of the hydrodynamic components of the system, such as the wetland outlet structure to the lake and tidal exchange system.

Water level gauges would need to be installed in both wetland ponds and the lake. The gauges would need to relate to a specific datum, such as Australian Height Datum (AHD). This installation has been detailed in Chapter 15 and estimated cost incorporated into the maintenance model.

Inspection of water levels of the Sovereign Waters wetlands are to be completed every three months as a minimum and inspection checklists should be logged and stored. The checklists should include sections for logging information, such as:

- environmental conditions, i.e. temperature and weather conditions
- observed water quality
- tidal levels at the time of monitoring and for the entire day
- summarised rainfall data for a minimum of five days (including the day of survey).

Tide levels and rainfall data can be obtained from the Bureau of Meteorology.

Water level monitoring has been brought forward as a management action for each water body in this plan. The cost of water level monitoring has been included in the

maintenance model spreadsheet as a cost item, allocated as the time required for one operations staff to conduct 8 hours of monitoring per quarter.

5.3 SEDIMENTATION MONITORING

Monitoring sediment accumulation in the wetland ponds, the lake and the GPTs will provide indicative information on the rate of sediment accumulation. Having incremental data on sediment accumulation will allow foreword planning of small to large scale sediment removal maintenance tasks well in advance.

The sedimentation study conducted (*Sovereign Waters Estate Sedimentation Study* (KBR, 2012)) identified the total accumulation in most areas of the wetland and lake system. However, the construction of the EGW Wood Park upstream ponds may have had a large influence on the rate of total suspended sediments entering the lake from the catchment. For example, the sediment accumulation may have slowed down since the development of the detention ponds. Consistent data will provide insight into trends imposed on the system from external sources.

Sedimentation surveys have been recommended for the wetland ponds and the lake in the management activities and have been included as an item in the costed maintenance plan. The model has allowed for 5 yearly bed surface monitoring of the wetlands and lake.

The number of samples, equipment used, frequency and methodology should be well planned prior to implementation. It is difficult to acquire accurate sedimentation data without costly equipment. However, the use of adequate tools and good, consistent methods will reduce data inaccuracies. The upper most layer of sediment on a bed surface in slow moving water bodies is usually an unconsolidated very fine fluid mud, which is difficult to account for.

The proposed method of monitoring is similar to the method used in the *Sovereign Waters Estate Sedimentation Study* (KBR, 2012). Sediment sampling conducted using a piston sampler provides qualitative and quantitative data for both the wetlands and lake with accuracy to 0.05 m per core. To do this a boat and a minimum of two staff plus sampling equipment is required.

A simple and cost effective method to conduct bed surface surveys for the wetland inlet zone, macrophyte zone and lake is by use of a large diameter weighted plastic disc at the end of measured cord. The water depths are taken relative to the water level. If deemed suitable more extensive sediment sampling using sonar equipment will provide very accurate results.

6 EGW Wood Park upstream ponds

The lake and wetland is at the end of a system of WSUD features. Upstream of the wetlands on the southern side of Birkdale Road there are several detention ponds (water basins) in EGW Wood Park. In 2002 a Waterway Enhancement Master Plan was drafted (Redland Shire Council, 2002) which included computational modelling of catchment flows under several annual recurrence intervals, proposed improvements and design drawings. The document is essential background information for a study undertaken on the Sovereign Waters Estate water system and can be obtained from RCC if required.

The upstream pond has a direct influence on the Sovereign Waters wetland and lake system. Water quality monitoring of the pond upstream of Birkdale Road has been conducted previously and it is recommended that this continue (see Chapter 5). However, management of the EGW Wood ponds is not within the scope of this plan as they are managed under another framework.

During water quality monitoring of the upstream pond it would be preferential if visual observation and assessment is conducted to ensure the upstream pond is being managed effectively. For example, checking for sediment and gross pollutant build up.

7 Parkland areas

7.1 DESCRIPTION

A portion of the areas surrounding the Sovereign Waters Lake and wetland provide public recreational and scenic amenities. These include:

- terrestrial and wetland vegetation
- shared bike and path ways in the wetland area
- the boardwalk between the two wetland ponds
- maintenance access channels from Allan Day Drive to the lake and to the perimeter channel from Allan Day Drive
- overflow channel at the northern end of the lake.

Two grassed maintenance access channels from Allan Day Drive to the lake are accessed through a locked gate. These continue over the other side of Allan Day Drive to the perimeter channel, but are open access. At the northern end of the lake the overflow channel and boat ramp access area is open to community use during certain hours.

Some of these areas also act as operations and maintenance service areas and have subsurface local influent water drainage and GPT infrastructure. Maintenance is required for continued use and to ensure the surrounding areas of the system contribute positively to the objectives of the entire system.

7.2 FUNCTION

Access ways to system components provide serviceable areas for any maintenance requirements that need to be carried out. Pathways, bikeways and boardwalks for recreational purposes need to be maintained to ensure they remain safe, useable and aesthetic. The overflow channel provides launching access for kayaks and canoes and also acts as a suitable launching ramp for powered maintenance or monitoring vessels, only under the authorisation of the responsible council representative.

The landscaped and open vegetation areas also provide some run-off, filtering and infiltration values, as well as habitat values.

7.3 MANAGEMENT REQUIREMENTS

Parkland area maintenance is beyond the scope of the LMP and management occurs under a different framework.

8 Local pollutant controls

8.1 DESCRIPTION

There are five GPTs installed in the local influent water piping infrastructure. The model type and inlet/outlet dimensions of the installed GPTs can be seen in the RCC (2000) Operations and Maintenance Manual. The GPTs are buried concrete structures which are accessible via a hatch or manhole at ground level. There are three GPTs in local influent water piping and two GPTs in the tidal exchange system piping which adjoins the perimeter channel to the lake. Approximate locations of these devices are shown on Figure 8.1.

There were two trash racks installed in the system and described in the original Operations and Maintenance Manual (Redland Shire Council, 2000). The first is situated in the inlet zone of the wetland bolted to the culverts under Birkdale Road, which has vertical bars, evenly spaced and spanning across all culverts. The second is a cubic rack over the tidal exchange inlet which has a square gridded mesh to prevent marine animals, seaweed, trash and debris of larger than the gridded mesh entering the system.

8.2 FUNCTION

GPTs prevent coarse sediments, litter and urban debris from entering the wetland and lake via influent water infrastructure. The trash racks prevent litter and large debris entering the tidal system, wetland and lake.

8.3 MANAGEMENT REQUIREMENTS

Regular checks should be undertaken on pollutant control devices. The Humegard Manual (RCC (2000) Operations and Maintenance Manual) specifies inspection and maintenance frequencies.

The need for maintenance is determined through inspection, which is recommended every three months in the Humeguard manual. It is recommended to initially remove litter every three months and inspect sediment depth. Depending on the amount of pollutants captured the inspection frequency can be increased or decreased. A sediment depth of 0.3 m indicates cleaning may be required. Refer to the Humeguard Manual for more detail, such as cleaning instructions.

The tasks identified have been tabulated with frequency and description in Table 8.1. These maintenance tasks have also been included in the costed maintenance plan (Appendix B).



Figure 8.1
LOCATION OF SOVEREIGN WATERS GPT DEVICES

Table 8.1 Pollutant control device management requirements

Objective	Zone/ Component	Function	Management Activity	Inspection/Action Frequency
Water quality and amenity	Inlet zone/ Trash rack	Inflow structure – trash rack	Remove litter and debris from trash rack.	3 months and after high flow events
	Macrophyte zone/ influent water infrastructure	GPT 3 – trap large sediment, litter and debris	Remove litter and debris from GPTs.	3 months and after high flow events
			Inspect depth of accumulated sediment. Inspect GPT lid/manhole cover, locks, chains and hinges for rust or damage.	If sediment depth is greater than 30 cm then action sediment removal operation
	Lake/ influent water infrastructure	GPT 2 – trap large sediment, litter and debris	Remove litter and debris from GPTs.	3 months and after high flow events
			Inspect depth of accumulated sediment. Inspect GPT lid/manhole cover, locks, chains and hinges for rust or damage.	If sediment depth is greater than 30 cm then action sediment removal operation
		GPT 1 – trap large sediment, litter and debris	Remove litter and debris from GPTs.	3 months and after high flow events
			Inspect depth of accumulated sediment. Inspect GPT lid/manhole cover, locks, chains and hinges for rust or damage.	If sediment depth is greater than 30 cm then action sediment removal operation
	Lake/tidal exchange system	GPT 5 – trap large sediment, litter and debris	Remove litter and debris from GPTs.	3 months and after high flow events
			Inspect depth of accumulated sediment. Inspect GPT lid/manhole cover, locks, chains and hinges for rust or damage.	If sediment depth is greater than 30 cm then action sediment removal operation
		GPT 4 – trap large sediment, litter and debris	Remove litter and debris from GPTs.	3 months and after high flow events
			Inspect depth of accumulated sediment. Inspect GPT lid/manhole cover, locks, chains and hinges for rust or damage.	If sediment depth is greater than 30 cm then action sediment removal operation
	Perimeter channel/tidal exchange system	inflow structure – trash rack	Remove litter and debris from trash rack.	3 months and after high flow events

9 Sovereign Waters wetlands

9.1 OBJECTIVES

The wetland system should:

- achieve removal of TSS to ANZECC recreational secondary contact standards to achieve the targets required for the lake
- have 70–80% macrophyte cover in the macrophyte zone for algal epiphyte and biofilm growth (Brisbane City Council, 2005)
- have a hydraulic efficiency (λ) of no less than 0.5 and preferably be greater than 0.7 (Persson *et al*, 1999)
- have open water zones with water depths greater than 1 m (Brisbane City Council, 2005).

Brisbane City Council (BCC) guidelines (Brisbane City Council, 2005) recommend de-silting an inlet zone every five years, or once the sediment accumulates to half the design depth.

The inlet zone de-silting frequency of every five years has been adopted. It is not possible to determine the de-silting frequency from the data available. Therefore, a high frequency has been adopted. Annual surveys will identify an appropriate frequency in advance and amendments can be made to the costed maintenance plan by the user to suit.

9.2 DESCRIPTION

The wetlands have been designed as a passive recreation and aesthetically pleasing area. They have also been designed to achieve the expected water quality parameters in the Sovereign Waters lake and as such improve water quality, reduce metal, fluvial nutrient and sediment loads entering the lake that may jeopardise lake water quality.

There are two wetlands on the northern side of Birkdale Road which are separated by a rip rap rock revetment and raised boardwalk at RL 0.80 m AHD and RL 1.80 m AHD respectively.

The first wetland area is an inlet zone which receives catchment run-off from three inlet structures:

- the EGW Wood Park ponds through five reinforced concrete box culverts (RCBCs – dimensions: 2.40 m by 0.75 m) situated under Birkdale Road
- directly from Birkdale Road influent water infrastructure east of the development

- directly from Birkdale Road influent water infrastructure west of the development.

Inflow from the inlet zone is spread throughout the rip rap revetment and into the second wetland.

The second wetland is deeper and has verges planted with macrophytes on constructed submerged ridges approximately 1 m from the wetland edge. There is also influent water infrastructure which discharges drainage from a small area of local roads west of the wetland to the macrophyte zone.

The physical characteristics of both wetlands are identified in Table 9.1 and presented schematically in Figure 9.1.

Table 9.1 Physical Characteristics of the Wetlands (Redland Shire Council, 2000)

Description	Unit	Inlet Zone (Wetland 1)	Macrophyte Zone (Wetland 2)
Top Water Level	(m AHD)	0.60	0.60
Bed Level	(m AHD)	0.35	-0.65
Operational Depth	(m)	0.25	1.25
Bank Slopes	(V:H)	1:4	1:4
Surface Area (approx)	(m ²)	1700	1900
Volume (approx)	(m ³)	375	1250

9.3 INLET ZONE

9.3.1 Function

The inlet zone (wetland 1) is designed to:

- provide an aesthetic and functioning habitat
- screen gross pollutants, heavy metals and coarse sediments
- dissipate the inflow energy through an energy dissipater, in this case a rip rap rock revetment.

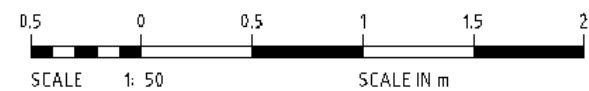
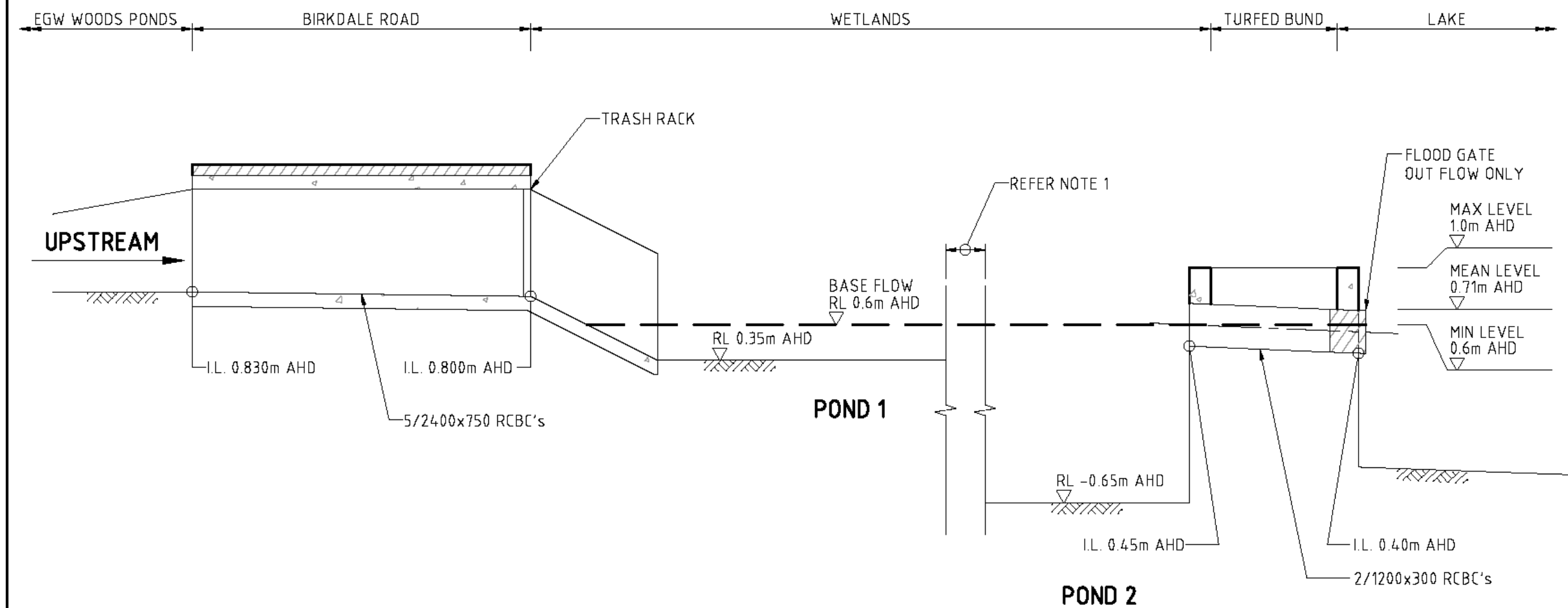


FIGURE 1: BIRKDALE RD TO LAKE INFLOW
SCALE 1:50

NOTE:
2 PONDS DIVIDED BY A BOARDWALK
(1.8m AHD) AND RIP RAP ROCK REVETMENT

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Figure 9.1
LEVELS AND DIMENSIONS OF THE UPSTREAM INFLOW TO THE WETLAND OUTLET STRUCTURES

9.3.2 Management requirements

The tasks identified have been tabulated with frequency and description in Table 9.2. The associated maintenance costs have also been included in the costed maintenance plan (Appendix B).

Table 9.2 Wetland: Inlet zone management requirements

Objective	Zone/ Component	Function	Management Activity	Inspection/Action Frequency
Influent water Treatment	Inlet zone/ detention pond	Hydraulic residence Removal of gross pollutants, heavy metals and bacteria	Survey accumulation of sediment	60 months
Water quality	Inlet zone/ detention pond	Temporarily hold runoff Screen gross pollutants, heavy metals and bacteria	Litter collection Inspect banks for erosion and slumping	3 months and after high flow events
			Water quality monitoring	3 months
Habitat	Inlet zone/ detention pond	Provide for fauna Provide refuge area during dry periods	Algae/undesired weed removal	3 months (season dependent)
			Complete vegetation performance checklist	6 months and after high flow events
			Control water levels at dry periods	event based
Recreational and Visual Amenity	Inlet zone/ detention pond	Scenic area	Litter collection Mosquito and waterbird control	3 months and after high flow events

9.4 MACROPHYTE ZONE

9.4.1 Function

The deeper ‘open water’ area reduces the hydraulic flow, increases residence time and settling of finer sediments, nutrients, heavy metals and bacteria not captured in the inlet zone. The fringing macrophyte areas divert flows and reduce velocities to accrete sediments and nutrients further.

9.4.2 Management requirements

The tasks identified have been tabulated with frequency and description in Table 9.3. The associated maintenance costs have also been included in the costed maintenance plan (Appendix B).

Table 9.3 Wetland: Macrophyte zone management requirements

Objective	Zone/ Component	Function	Management Activity	Inspection/Action Frequency
Influent water Treatment	Macrophyte zone/open water	Hydraulic residence Removal of gross pollutants, heavy metals and bacteria	Survey accumulation of sediment	60 months
Water quality	Macrophyte zone/all areas	Temporarily hold runoff Screen gross pollutants, heavy metals and bacteria	Litter collection Inspect banks for erosion and slumping Water quality monitoring	3 months and after high flow events 3 months
Habitat	Macrophyte zone/all areas	Provide for fauna Provide refuge area during dry periods	Algae / undesired weed removal complete vegetation performance checklist Control water levels at dry periods	3 months (season dependent) 6 months and after high flow events event based
Recreational and Visual Amenity	Inlet zone/ detention pond	Scenic area	Mosquito and waterbird control	3 months and after high flow events (season dependent)

9.5 OUTLET STRUCTURE

9.5.1 Function

The outlet structure allows one way flow from the wetland to the lake.

9.5.2 Management requirements

The tasks identified have been tabulated with frequency and description in Table 9.4. The associated maintenance costs have also been included in the costed maintenance plan (Appendix B).

Table 9.4 Wetland: Outlet structure management requirements

Objective	Zone/ Component	Function	Management Activity	Inspection/Action Frequency
Functionality	Outlet structures	Water level control – plant establishment, weed and pest control	Inspect integrity of structure Inspect moving components for damage or restrictions Inspect both entrance and exit are not obstructed by plant growth, sediment accumulation, litter and other debris	6 months and after high flow events

10 Sovereign Waters lake

10.1 DESCRIPTION

The lake is predominantly brackish and during periods of low catchment flow, salinity increases to approach average sea water salinity through the dominance of tidal exchange. During periods of rainfall sufficient to generate runoff and particularly after large runoff events the salinity of lake waters will decrease. In general, the lake is well mixed with respect to depth when water salinity is high and tidal exchange is dominant, and becomes stratified (layered) when freshwater runoff enters the lake.

The geometry of the lake is typical of constructed lake systems, which are designed upon many factors, one being hydraulic efficiency (λ). The lake is approximately 450 m in length and 110 m in width at its longest and widest points.

Water levels are controlled by a tidal exchange system which has one inlet and two outlet pipes which transfer seawater to and from Waterloo Bay via the perimeter channel adjacent to the west of the lake. Tidal exchange inflow and outflow is controlled by one way top hinged tidal flap valves and complete lake turnover is achieved within 24 days (based upon volumetric exchange), while maintaining a lake level between 0.6 m AHD and 1.0 m AHD.

There are two influent water inlets into the lake which have GPTs housed in the influent water drainage infrastructure which services the roads directly to the east of the lake.

There are two boat access ramps to the lake, one at the northern end of the lake and one located in the park off Helena Street. These are for public access and use of non-powered vessels. Under approval from RCC powered vessels can enter for operations and maintenance purposes from Allan Day Drive.

The physical characteristics of the lake are identified in Table 10.1.

**Table 10.1 Physical Lake Characteristics to design levels
(extract from Redlands Shire Council, 2000)**

Characteristic	Unit	Value
Max water level under 100 yr ARI	m AHD	2.40
Max water level under HAT	m AHD	1.00
Min water level	m AHD	0.60
Mean water level	m AHD	0.70
Bed level	m AHD	-1.60
Over excavated bed level	m AHD	-3.00
Batter/bank slope (1)	m	1:10
Batter/bank slope (2)	m	1:4
Surface area	m ²	42,000
Volume*	m ³	84,000

* Approximation

10.2 FUNCTION

The lake serves several functions of importance:

- secondary contact recreational water body for vessels such as kayaks and canoes
- visual and aesthetic amenity for the surrounding residential areas and the community
- provide a habitat for fauna.

10.2.1 Management requirements

The tasks identified have been tabulated with frequency and description in Table 10.2. The associated maintenance costs have also been included in the costed maintenance plan (Appendix B).

Table 10.2 Lake management requirements

Objective	Zone/ Component	Function	Management Activity	Inspection/Action Frequency
Influent water treatment	Lake/open water	Long detention of water Removal of gross pollutants, heavy metals and bacteria	Survey accumulation of sediment	12 months
Water quality	Lake/open water	Secondary contact recreational standards Influent water treatment and sediment and nutrient removal	Litter collection	3 months and after high flow events
			Water quality monitoring	3 months
Habitat	Lake/all areas	Provide a habitat for fauna	Water quality monitoring	3 months
Recreational and visual amenity	Lake/all areas	Scenic area	Check water surface is free from plant growth	3 months
Safety	Lake/access ramp	Provide access area for canoes and kayaks	Inspect ramp condition, able to be safely operable	6 months
	Submerged piping	Tidal exchange	Inspect signage highlighting position of submerged structures	12 months

11 Tidal exchange system

11.1 DESCRIPTION

The lake has been designed to achieve volumetric turnover through its tidal exchange system within 24 days (Redland Shire Council, 2000). This detention period of the total volume can be decreased to 10 days. There is a submerged emergency outlet which can only be manually operated by qualified persons.

In the north-western corner of the lake there is an overflow outlet weir designed at 1.00 m AHD and a submerged tidal inlet which has a one way valve allowing inflow only to the lake. The overflow outlet and tidal inlet uses the same piping system and the piping can be used for inflow or outflow. The regulation of levels and direction of flow is dominated by the hydraulic head and one way flow using tide valves.

There are two operational discharges and one emergency outlet. The discharge of the lake is governed by the level of the pipe within the manhole at Allan Day Drive, which is at 0.4 mAHD (see Figure 11.1). This component serves as an outlet weir, stopping emptying of the lake and controlling outflow and inflow via the tidal inlet. The system is self-regulating and does not require operational interaction. There are some management tasks, and standard checks on the system components which are needed as part of the overall management of the lake and wetland system.

Figure 11.1 and Figure 11.2 show the design levels of the tidal inlet and discharge system.

11.2 FUNCTION

The system design ensures that turnover of lake water volume is achieved even under dry periods by tidal exchange. The lake water level varies between a minimum 0.6 m AHD and maximum 1.0 m AHD due to tidal influence and does not exceed this range even under HAT (Redland Shire Council, 2000). This regulation of lake water by the tidal exchange:

- ensures lake water does not become stagnant
- creates variable lake water salinity, minimising plant and algae establishment
- prevents nutrient build up in the water column.

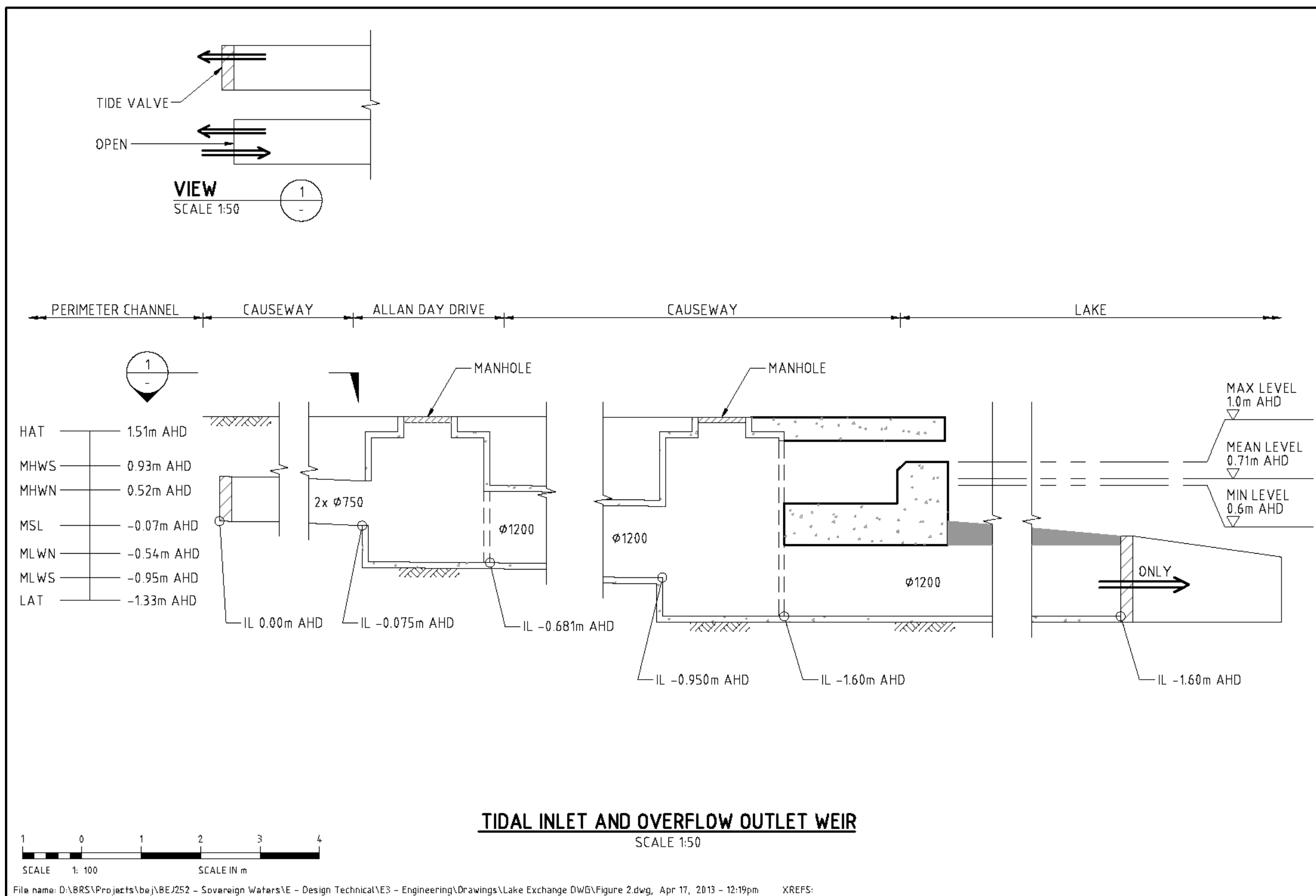


Figure 11.1
LAKE TIDAL INLET AND OVERFLOW WEIR

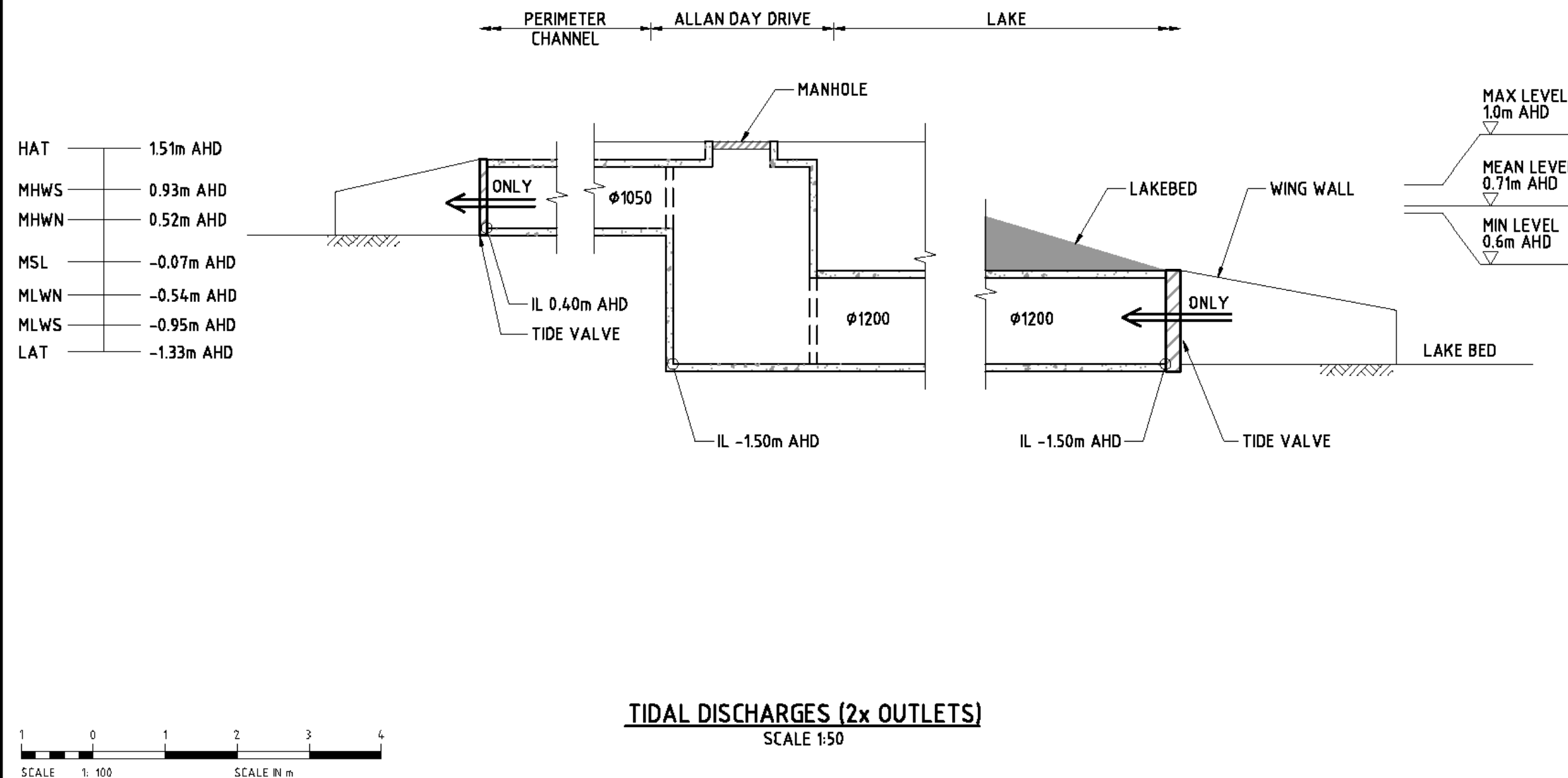


Figure 11.2
LAKE TIDAL DISCHARGES

11.3 MANAGEMENT REQUIREMENTS

The tidal exchange system is self-regulating. However, there are inspections that can be done which ensure the system works at its optimum (Table 11.1). The associated maintenance costs have also been included in the costed maintenance plan (Appendix B).

Table 11.1 Tidal exchange system management requirements

Objective	Zone/ Component	Function	Management Activity	Inspection Frequency
Water quality	Tidal exchange/ overflow weir	Discharge water from lake under high flow events	Inspect weir is free from debris and free from blockages	3 months and after high flow events
	Tidal exchange/ tide valves	Regulate flow direction	Inspect valves are not restricted and are free from debris	3 months and after high flow events
	Tidal exchange/ perimeter channel trash rack	Prevents trash from entering he lake via the inlet	Clear debris from trash rack	3 months and after high flow events
	Tidal exchange/ service pits	Change in pipe Internal Level - acting internal weir	Inspect for sediment accumulation	3 months and after high flow events

12 Lake perimeter wall

12.1 DESCRIPTION

The lake perimeter wall is the boundary between the waters edge and the residential properties. Details of the design can be seen in Development Consulting Pty Ltd drawing number 9729-03.

12.2 FUNCTION

The wall contains the lake water body and is only inundated if the lake water level is surcharged by runoff from a 1 year annual recurrence interval (ARI) or greater rainfall event. The hydrostatic pressure of the water and the walls footing structure prevent slope failure of the raised properties.

12.3 MANAGEMENT REQUIREMENTS

Table 12.1 Perimeter wall management requirements

Objective	Zone/ component	Function	Management activity	Inspection frequency
Safety	Lake/ perimeter wall	lake/property boundary	Conduct integrity inspection (visual observations)	60 months

13 Sediment removal and disposal

13.1 OBJECTIVES

Sediment removal in the wetland and specific lake areas near influent water inlets will be required within the design lifetime of the Sovereign Waters Estate waterway system. Reducing sediment loads serves to maintain the objectives of the system by keeping the morphology relatively unchanged and removing nutrient loads from the system. The water quality and functional objectives have been identified in Chapter 4.

13.2 PLANNING AND APPROVALS

Sediment removal operations have been identified in the costed maintenance plan spreadsheet. Sediment removal operations tasks will be low impact, where small (less than 10,000 m³) volumes of sediment will need to be removed from locations which are accessible by use of earthworks machinery. Disposal of the sediment will occur onshore, at a location to be assessed during the planning phase. Given this, the planning and approvals process is less extensive and the frameworks RCC has to work within is not as rigorous.

Legislation may be amended, repealed or new legislation introduced which can in turn alter approval pathways, assessment triggers, timeframes and other requirements for a project. To minimise the potential for this to be adverse to the project, regular reviews of legislative changes should be undertaken by RCC to take the most current legislative requirements into account, say every 5 years and more frequently where the planned activity date has been confirmed. Revisions to the project to respond to the legislative framework applicable at the time can be made accordingly.

13.3 PROPOSED METHODOLOGIES

The proposed methodologies are guidelines for planning purposes based on 2012 methods and have been derived by undertaking a methodology assessment. This process involved identifying various methodologies and working through to determine the most suitable.

The constraints, equipment and operations required for each option has been discussed. During planning more thorough assessment should identify the specific tasks. All methodologies assume that the appropriate approvals and assessment framework will have been completed.

13.3.1 Wetland sediment removal

The inlet zone is more accessible due to a service ramp and access to Birkdale Road. Sediment removal of the macrophyte zone independently would be more difficult due to restricted access.

Sediment removal in the wetlands can be achievable by either:

- using a long arm excavator which transfers to a lined truck and dumps directly at landfill
- dewatering the wetlands, excavating and trucking the spoil directly to landfill.

Table 13.1 summarises the options.

Table 13.1 Wetland sediment removal summary

Option	Constraints/Limitations	Plant/Equipment	Major operation tasks
1	Machinery access	Long arm excavator	Clear required wetland parkland for machinery access
	Disturbance to surrounding ecosystem	Earthworks machinery	Excavation of wetlands to desired depth
	Disruption to public use	Slurry tanker or lined truck(s)	Filling of trucks on Birkdale Road and transportation of spoil to landfill
	Release of nutrients and sediments into the lake		
	Potential odour and acid sulfate soils		Monitor water quality
2	Disturbance to surrounding ecosystem	Excavators	Clear required wetland parkland for machinery access
	Disruption to public use.	Earthworks machinery	Implement wetland bypass for influent water run-off
	Operation relies upon dry period or bypassing of wetlands	Lined truck(s)	Excavation of wetlands to desired depth
	Potential odour and acid sulfate soils		Filling of trucks on Birkdale Road and transportation of spoil to landfill using lined trucks
			Monitor water quality

Provided wetland rehabilitation is required Option 2 is the most feasible and cost effective, especially if both works; sediment removal and wetland rehabilitation are conducted in parallel.

The costed maintenance plan has adopted option 2 and proposes wetland rehabilitation within the five years. After this occasion, sediment removal of the inlet zone and macrophyte zone have been recommended and costed based on Option 1 in Table 13.1.

13.3.2 Influent water inlet sediment removal

The sedimentation study (*Sovereign Waters Estate Sedimentation Study* (KBR, 2012)) identified a requirement to remove accumulated sediments in approximately 20 m radius of influent water inlets into the lake by 2035.

13.3.3 Lake bed sediment removal

The sedimentation study used mean lake depths and mean annual siltation rates for the lake bed sediment accumulation projection. The area, referred to as 'Zone 1 – General zone' accretes at a very slow rate. The period until sediment removal will be required exceeds any RCC planning timeframes and the costed maintenance plan period within

this study. Refer to *Sovereign Waters Estate Sedimentation Study* (KBR, 2012) for further details.

13.4 FREQUENCY

Frequency of sediment removal operations has been assessed based on the sedimentation rates provided in the *Sovereign Waters Estate Sedimentation Study* (KBR, 2012), the importance of maintaining the functionality of the component and the effect the works have on the surrounding environment, residents and community. 'Frequency' in the 'Program' section of the maintenance model; can be amended by the user. This may be required after a review concludes that sediment removal frequencies should be altered.

13.4.1 Wetlands

BCC guidelines (Brisbane City Council, 2005) recommend de-silting an inlet zone every five years, or once the sediment accumulates to half the design depth. The maintenance model has assumed the five yearly de-silting frequency recommended in the BCC guidelines as an upper limit, monitoring of sediment accumulation will assist develop actual action frequencies.

There is no set period between macrophyte rehabilitation events recommended in BCC guidelines. However, wetland inspection checklists provide a range of criteria to assess the state of the vegetation. There should be pre-defined targets for the wetland performance which can be monitored and the checklist should be a framework for assessing the maintenance requirements and need for vegetation rehabilitation.

13.4.2 Influent water inlets

The trigger for sediment removal in the Influent water inlet areas of the lake should be when a minimum depth of 1.5 m is reached. Surveys of the lake every five years are highly recommended, these will provide prior indication as to the time sediment removal will need to occur. The mean annual sedimentation projections (*Sovereign Waters Estate Sedimentation Study* (KBR, 2012)) estimate that the first sediment removal may be required in 2035 for this area.

13.4.3 Lake

The rate of accumulation for the general lake area is slow enough that for planning and costing purposes we can assume that the option to 'do nothing' is the most suitable.

13.5 ESTIMATED SEDIMENT REMOVAL VOLUMES

The estimated sediment removal volumes for the wetlands have been provided in the costed maintenance model (Appendix B). The 'Sediment Removal Volumes' tab displays the volumes which the user can amend if required.

14 Costed maintenance plan

14.1 COSTS SUMMARY

The annual maintenance cost varies significantly between years of sediment removal and years where normal operations and maintenance tasks occur. For the ten year period of 2013–2023 the average annual maintenance cost is \$83,500.

These values represent the cost over a ten year period in 2013 dollars, where the change in the value of money over time and from inflation has not been projected.

The cost items and associated assumptions used in the estimation of the annual maintenance costs are outlined in Section 14.3 and the maintenance plans are attached in Appendix B.

14.2 FINANCIAL MODEL

To determine the annual maintenance costs, a financial model was developed. The model was prepared as Excel spreadsheets and each contain a number of worksheets. The financial model is described in detail in an explanatory report in Appendix A. The costs applied to the various maintenance activities in the financial models are outlined in the following section.

The scope set out by RCC detailed the development of a costed 10 year maintenance plan. Some appreciable maintenance tasks extend beyond this period and others are ongoing annual tasks. The costed maintenance model has provided indicative costs for these tasks in the ‘Program and Assumptions’ section in the ‘Instructions for Use’ in the Maintenance Model, Appendix B.

14.3 COST ITEMS

The following sections outline the costs used to estimate the overall annual maintenance costs. They are divided into several maintenance sections; general maintenance, sediment removal and disposal, local influent water infrastructure and tidal exchange maintenance, administration and monitoring, as per the financial model. These costs, and their basis, are also detailed in the Appendix A explanatory report and the financial model worksheets which are shown in Appendix B.

14.3.1 General maintenance costs

The general maintenance costs have been estimated on the basis of information provided by RCC and KBR’s relevant previous project experience.

The average annual general maintenance cost for all components for Sovereign Waters over the next ten years is \$14,000.

The items which make up these general maintenance costs include:

- litter collection
- aquatic vegetation removal
- cleaning of access ramps
- signage maintenance.

14.3.2 Wetland sediment removal and disposal costs

The sediment removal costs were based on the proposed methodologies presented in Chapter 13. Further to this, the sediment removal and disposal cost estimates have been based on the following assumptions as well as those set out in Section 14.4.1. The average annual wetland sediment removal and disposal costs for Sovereign Waters over the next ten years is \$20,900.

General assumptions

- surveys are undertaken prior to (pre) and following (post) each sediment removal campaign to verify the removal depths and volumes
- removed material is uncontaminated fill and is disposed of at the closest landfill
- it takes several months to complete planning and detailed design works for sediment removal of the wetlands.

Sediment removal costs summary

- Table 14.1 outlines the rates for the sediment removal and disposal maintenance items included in the financial model for each water body.

Table 14.1 Sediment removal and disposal rates summary

Item	Estimated cost
Excavation of material	\$10/m ³
Mob/demob excavator	\$2,200
Sediment removal survey (wetlands)	\$7,600
sediment removal design, approvals and monitoring	\$5,500
Wet uncontaminated spoil treatment, haulage and disposal at landfill	\$27/m ³

14.3.3 Local pollutant controls and tidal exchange maintenance costs

Maintenance costs incurred to prevent litter and debris entering the system, clogging up moving parts and flowing out to Waterloo Bay fall into this category. In particular the following components:

- wetland outlet structure to the lake
- local GPTs
- trash racks
- tidal exchange system.

The average annual costs for maintenance and repair of these components over the next 10 years is \$13,700.

The most appreciable cost which may occur is the replacement of tidal flaps and valves. The design life of the components is 25 years; therefore replacement of the components may be required by approximately 2025. This large ticket item extends beyond the models proposed schedule, however, a basic indicative estimate has been produced and inserted into the 'Raw unit rates' tab for estimating, if required. The cost estimate is a basic addition of materials and labour.

14.3.4 Administration

The overall site maintenance program will require management by RCC and there will be subsequent administration costs. The annual administrations costs are \$14,500 comprising:

- five yearly review of the maintenance model, including the financial model and siltation rates, an average annual cost of \$3,800
- RCC annual administration: \$10,700.

14.3.5 Monitoring

There are several cost items in relation to monitoring of the sovereign waters site. The annual monitoring cost is \$20,400. These include:

- annual water quality monitoring and laboratory sample analysis, including labour for sampling and event based microbial testing: \$16,150
- annual water level monitoring (includes one off installation of water level gauges): \$1,950
- annual vegetation performance monitoring: \$250
- average annual cost of five yearly wetland sedimentation survey: \$700
- average annual cost of five yearly lake sedimentation surveys: \$1,350.

14.4 FINANCIAL CALCULATION DISCUSSION

14.4.1 Important assumptions

As stated earlier in this section, there are a number of assumptions which underpin the cost estimation. There are also several important broad assumptions which include:

- All rates and costs are based on calculated estimates, precedents and provided information thus there will be some inaccuracies. Rates will change and become more certain in the future, especially once the initial round of maintenance items are undertaken and as a result they should be appropriately updated in the financial model.
- Waste disposal sites must comply with their licence agreements and the soils extracted should be checked for any potential to produce acid.
- The mean annual sedimentation rates and volumes are the essential basis for the cost estimates and the recommended sediment removal and disposal

methodologies. It is assumed that the estimates (*Sovereign Waters Estate Sedimentation Study* (KBR, 2012)) are sufficiently accurate to define the dredging, treatment and disposal costs. It should be noted that sedimentation rates are likely to change in the future which will affect the maintenance costs.

14.4.2 Accuracy of estimate

The annual maintenance costs have been presented as a range to show the possible cost fluctuations. This range is based on the 'Confidence Factor Adjustment' function on the 'Raw Unit Rates' sheet in the Financial Models. The lower limit of the range is the 'optimistic' confidence meaning there is a 90% probability of exceedance, while the upper limit of the range is the 'pessimistic' confidence meaning there is a 10% probability of exceedance. Hence the neutral (mean) position represents a 50% probability that the forecast cost will be exceeded.

Variation in the estimated maintenance costs could occur due to:

- climate variations leading to fluctuations in siltation rates
- modelling and survey inaccuracies
- variations in dredging and disposal costs.

The sensitivity variation factor does not cover items such as:

- changing legislation
- major changes in fuel costs
- change to the required maintenance dredging volumes due to incomplete siltation information.

Additional work will be required if this accuracy value is to be improved. Such work would include:

- obtaining a range of quotes from required service contractors and researching more similar precedent projects
- feasibility study and detailed design of a wetland inlet and macrophyte zone restructure.

15 Mitigation options

The options provided have the potential to improve the recreational and visual value of the wetland and lake and reduce the total volume of sediments, nutrients, organic matter and pollutants entering or exiting the system. They do not form part of the management requirements at present. They range from recommended improvements to options identified for interest and review, with the potential for RCC to expand further on the options.

Mitigation should reduce maintenance frequency or overall cost. Only options which reduce maintenance or improve the system for the foreseeable future have been discussed. Only water level gauges have been incorporated as a forecasted cost in the financial maintenance model, the feasibility of the remaining suggested options herein would have to be assessed at a later date.

15.1 RECOMMENDED IMPROVEMENTS

The items within this section are advised improvements to the system. These have been developed from site observations conducted in June and July of 2012. These items would be best implemented within the first year or two of establishing the LMP.

15.1.1 Water level gauges

Installation of water level gauges to AHD would assist in water quality monitoring, bed surface surveys and water level operations that need be conducted, as identified in Section 5.2. When there is high influent water flow into the system these can also readily be monitored. Overall, the data will provide another parameter which assists in evaluating performance of the system. Approximate costs have been identified in the maintenance model and the addition of gauges has been incorporated into the annual cost in 2014.

15.1.2 Wetland Pond 2 (macrophyte zone) overflow weir

During periods of high rainfall and high tides it is likely that water within the wetland will overtop the wetland wall. This can cause scouring, firstly of the earth bund between the wetland wall and lake perimeter wall and of the lake bed. Concreting of the most commonly overtopped area of the wall would prevent scouring of the bund, however, it would also be very expensive. Scour is very slow to occur and the added value does not outweigh the cost. Secondly, to mitigate lake bed scour rocks have been placed in the area. Provided these are kept in place and observation of the bund condition occurs annually an overflow weir is not necessary within the timeframe of this LMP.

15.2 SILTATION MITIGATION

The sediment sampling undertaken (detailed in *Sovereign Waters Estate Sedimentation Study* (KBR, 2012)) identified that the fastest accretion of sediment since operations commenced and the lake was filled in August 2000 was in the proximity of influent water inlets to the lake. Although the time until sediment removal is appreciable (approximately in 2035), hence mitigating action is not pressing.

The influents from influent water infrastructure is an appreciable source of localised sediment and organic matter deposition and the siltation mitigation option reviewed is a preventative measure to reducing organic matter and sediment loads in the system.

15.2.1 RCC silt bag trial

RCC carried out a silt bag trial on 21 influent water pits at various locations throughout the Aquatic Paradise catchment. The catchment is adjacent to the Sovereign waters sub-catchment, hence very close. The findings can be used to evaluate the possible use for the Sovereign Waters catchment.

Ecosol summary report and findings

The Ecosol Rapid Influent water Filtration (RSF) 100s were installed and commissioned on 24 December 2010 with the study operating over a 12 month period. All units were inspected monthly and at those times approximate pollutant volumes and compositions were recorded. Cleaning of the units occurred every three months.

The following points are comments from Ecosol in their summary report regarding the nature and volumes of pollutants found in the traps and the effectiveness of the Ecosol RSF 100s:

- ‘The units were found to capture approximately 41% (Average) volume of pollutants each month. This volume mainly consisted of organic/vegetative pollutants at approximately 85%.
- Due to the type of catchment (residential) it can be expected that organic pollutants will be high due to grass clippings, established trees, and shrubs, etc.
- During each inspection/clean it appeared that the organic/vegetative pollutants captured within the units were breaking down to form a heavier soil like substance. It is assumed that without the RSF 100s these same pollutants would normally breakdown within the bottom of the influent water pits and pipes in between rain events.
- It is therefore assumed that silt may not be contributing to problems downstream, but broken down organic pollutants, especially with the recorded volumes monthly.
- It should also be noted that another contribution to the pollutant volumes was the build up of concrete mix within some of the RSF 100 filter liners, due to residents renovating and/or constructing new driveways.’

Across a sample of six silt bags, the average filled volume was 58% with an average dry sediment weight of 8 kg. This gives an indication of the amount of sediment removed from the silt traps.

Evaluation

The results and summary report of the silt bag trial show that by far the largest contributor of pollutants entering the influent water drains which were fitted with Ecosol RSF 100s was organic matter. It is suggested in the summary report that this largely includes material such as grass clippings and organic debris from shrubs and trees, etc. This correlated well with the results from the sediment sampling near influent water inlets in the Sovereign Waters Estate, where the samples had a high odour, high organic matter and the sediment texture was also consistent with Ecosol's findings.

The silt bag trial in the Aquatic Paradise catchment works successfully to reduce the volume of pollutants entering the canal system, especially organic matter and debris.

The overall volume of accumulation that the silt bags trap is very small in comparison to the volume of accumulated sediment in the entire lake. However, this preventative measure may decrease annual sediment accretion rates in proximity of influent water inlets and may prolong or prevent sediment removal operations in these areas.

It is probable that the greatest benefit of using the RSF units in the Sovereign Waters sub-catchment is the improvement to water quality, since fewer pollutants would be entering the lake.

15.3 WETLAND RE-STRUCTURE AND REHABILITATION

15.3.1 Guidelines

Brisbane City Council (2005) Engineering Guidelines on water sensitive urban design provides detailed information for constructed wetlands, most of which is analogous to several other Australia based wetland design guidelines. They detail the design considerations, design process and maintenance requirements of constructed wetland systems.

Wetlands generally consist of an inlet zone, a macrophyte zone and a high flow bypass. The inlet zone is usually a sedimentation basin which is designed based upon target sediment size, design discharge, detention time and hydraulic efficiency. It is quite deep, which allows coarse to medium sediments to drop out of the water column. The target sediment size typically defines the size of an inlet zone. Dense marsh vegetation in the littoral zone provides scour and erosion protection to the batters and restricts public access to the open water.

The macrophyte zone will typically be shallower (0.25–0.50 m depending on plant species), have 70–80% macrophyte cover, a hydraulic efficiency of no less than 0.5 and open water zones with water depths greater than 1 m. The bed may undulate creating a sequence of ephemeral, shallow marsh and deep marsh zones in a geometry which promotes radial spreading of the inflow. As a result the design should remove the majority of TSS in the water and algal epiphytes and bacterial biofilms which colonise submerged plants will actively reduce nutrient loads into the downstream.

During 'above design flow' conditions it is likely that damage can be caused to the wetland plants, banks and structures by increased hydraulic energy. For this reason a bypass channel is recommended, which activates under a specific level of water.

15.3.2 Sovereign Waters wetland evaluation

Sediment sampling and water depth checks of the inlet zone identified the water depth to be quite shallow (no greater than 0.30 m). The macrophyte zone is deeper (approximately 1 m) and has less than 20% aquatic vegetation cover.

The wetlands were designed prior to the construction of the upstream EGW Wood Park ponds and thus were designed to perform a function under certain conditions which have since evolved.

The Sovereign Waters wetland ponds could be re-structured and replanted. The design process would identify the size, area and depth of the ponds. There are several advantages:

- opportunity to re-design inlet zone to have serviceability access for sediment removal
- increased removal of coarse, medium and fine sediments
- increased removal of nutrients from the water column
- environmental; increased habitat for flora and fauna
- educational; detailed signage of inlet and macrophyte zone designs, the objectives and functions, and of aquatic flora and fauna which the wetland supports.

Sediment removal of the inlet zone should be conducted every five years or when the sediment depth is 50% of the design depth. Bed surface monitoring has been suggested in the maintenance model for both wetland ponds. This will identify the requirement to remove sediments.

If re-structuring and rehabilitation of the wetland was opted for, then it would be financially beneficial to do so at the time of sediment removal due to the following reasons:

- Most of the equipment required will have been mobilised for sediment removal.
- The in situ material removed to make the inlet zone deeper could be used to reform the macrophyte zone.
- The most efficient and cost effective way to remove and dispose of sediment would be to dewater the wetlands to less than 20% moisture content and dispose of the spoil directly in lined trucks. Dewatering would also be required for macrophyte rehabilitation.
- Dewatering would require a wetland bypass channel to be constructed in the event of catchment flow during the operation. This could be constructed to double as a permanent high flow bypass channel, possibly including a GPT or trap.

The water quality monitoring data reviewed suggests the system is performing well, which may largely be as a result of several upstream detention ponds in EGW Wood Park. Therefore, wetland restructure value would have to be evaluated after more data has been acquired on the wetland system, as will be brought about by this LMP. These options are indicative and no cost estimates have been derived or provided in the maintenance model.

16 References

- Australian and New Zealand Environment Conservation Council (ANZECC), 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
- Brisbane City Council, 2005 Water Sensitive Urban Design Engineering Guidelines: Stormwater.
- Development Consulting Pty Ltd, 1999. Lake Section & Revetment Wall Details; drawing number 9729-03.
- KBR, 2012. Sovereign Waters Estate Sedimentation Study.
- National Health and Medical Research Council (NHMRC), 2008. Guidelines for Managing Risks in Recreational Water. Australian Government.
- Persson, J., Somes, N.L.G. and Wong, T.H.F., 1999. Hydraulics efficiency of constructed wetlands and ponds. *Wat. Sci. Tech.* Vol.40, No.3, pp. 291-300.
- Redland City Council, 2008, Catchment Boundaries. Produced by Redland City Council GIS Services April 2008.
- Redland Shire Council, 2000, *Sovereign Waters Estate: Operations and Maintenance Manual*. Prepared by: Lawson and Treloar Pty Ltd.
- Redland Shire Council, 2002, *EGW Wood Pak Waterway Enhancement Plan*. Prepared by: John Wilson and Partners Pty Ltd.
- WHO (World Health Organization) (2003). *Guidelines for Safe Recreational Water Environments. Volume 1. Coastal and Fresh Waters*. WHO, Geneva.

Appendix A

**SOVEREIGN WATERS ESTATE
FINANCIAL MODEL
EXPLANATORY REPORT**

Financial Model Explanatory Notes

1 Introduction

The Sovereign Waters Estate is located in Birkdale on the southern side of Waterloo Bay. The wetland and lake system is part of a water sensitive urban design (WSUD) as the constructed system provides stormwater and urban run-off treatment for a catchment which is approximately 2 km².

Kellogg Brown & Root Pty Ltd (KBR) was commissioned by Redland City Council (RCC) to develop a Costed Maintenance Plan for Sovereign Waters as part of the preparation of a Lake Management Plan (LMP). The Costed Maintenance Plan was created as a financial model in Excel which examined the long-term maintenance requirements and costs for the site. The model serves to assist Council in planning the necessary maintenance works and in forecasting the associated costs.

This financial model is described herein.

This explanatory report outlines the methodology including key assumptions, and general instructions for using the model. This report is not intended to provide the detailed technical basis of the maintenance model. It is rather a user-guide.

2 Methodology

Introduction

The Sovereign Waters maintenance model consists of two separate sections:

- A maintenance expenditure cash flow Excel (*.xls) spreadsheet that incorporates the following worksheets
 - Amendments Register
 - Instructions for Use
 - Model Summary
 - Model Cash Flow
 - Derived Unit Rates
 - Program
 - Raw Unit Rates Table
 - Sediment Removal Volumes.

- A Redland City Council generated ‘Finance Model’ that uses output from the Model Cash Flow worksheet to perform financial calculations.

Worksheet data flow

The data flow is mapped out graphically on the ‘Instructions for Use’ worksheet.

A data flow map (Figure A.1) shows that information flows in a linear progression through the model. The exception to this linear flow occurs on the ‘Model Cash Flow’ worksheet, which is the product of two previous worksheets. These worksheets, ‘Derived Unit Rates’ and ‘Program’, contain costs and quantities converted into a useable format from the raw input worksheets (see ‘Section 3 – How to Use the Maintenance Model’ for details).

Additionally, a governing equation is shown in Figure A.1. This equation shows that the cash flow is the product of costs (with a sensitivity factor), and quantities (also with a sensitivity factor).

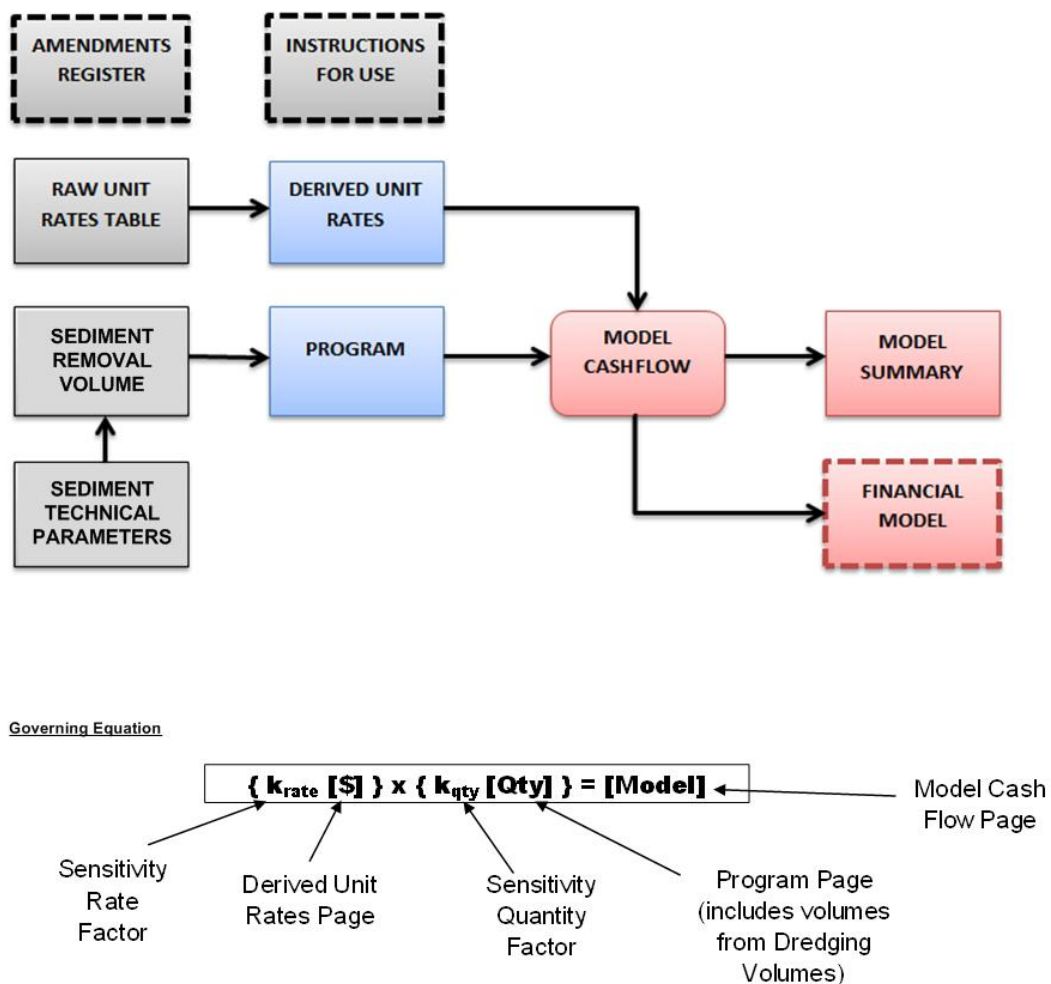


Figure A.1
WORKSHEET DATA FLOW AND GOVERNING EQUATION

Assumptions

The assumptions are detailed in the model under the following categories:

- General assumptions
- Sediment removal volumes
- Sediment removal and disposal methodology
- Raw unit rates
- Program
- Derived unit rates
- Model Cash Flow/Model Summary.

3 How to use Maintenance Model

General instructions

Prepare the model and data entry

The spreadsheet is structured so that key information is input into the ‘Raw Unit Rates Table’ and ‘Program’ worksheets. Additionally, the ‘Derived Unit Rates’ and ‘Sediment Removal Volumes’ sheets have adjustable sensitivity factors.

The ‘Sediment Removal Volumes’ sheet is where the financial model sediment volumes input occurs. The sediment volumes based on the sediment removal plan are input into the table at the bottom of the spreadsheet in Rows 40, 41 and 42. Inputs are required for Wetland; Inlet zone and macrophyte zone. The volume proportions are determined in the sediment removal plan.

Manual manipulation of the sediment volumes input is allowed (cells shown in bold blue font and shaded light green). This allows the user to view the effects of alternate sediment removal scenarios. However, care should be taken to ensure that manual input volumes are realistic. Therefore, knowledge of the proposed sediment removal plan and all sediment removal and disposal constraints is advised before attempting this.

Run and refine model

The ‘Model Cash flow’ worksheet is essentially the product of ‘Program’ and ‘Derived Unit Rates’.

The model may be refined by adding or deleting new cost items. This must be done with care as data is linked across multiple worksheets to provide relevant output. Create a new saved version of the document before attempting this.

Use adjustable sensitivity factors on ‘Derived Unit Rates’ and ‘Sediment Removal Volumes’ worksheets, and the sliding ‘confidence factor adjustment’ on the ‘Raw Unit Rates Table’ for sensitivity analysis.

When running the model ensure that all selectable functions are set correctly. These include:

- Extra volume due to increased siltation – use the check box to turn the event ‘on’ and ‘off’ and the drop down box to choose the siltation volume increase percentage (‘Sediment Removal Volumes’ – cell A20.)
- Sensitivity rates factors - (‘Sediment Removal Volumes’ – cells C9:N9)
- Confidence factor adjustment – using the slide scale (‘Raw Unit Rates Table’ – cells M15:P16)
- Confidence levels – (‘Raw Unit Rates Table’ – cells D7:D67)
- Sensitivity Rate Factor – (‘Derived Unit Rates’ – cells E10:E94)

Update ‘Amendments Register’ following model changes.

Output

‘Model Cash Flow’ and ‘Model Summary’ worksheets are output pages, showing a breakdown of costs for given cost items. The spreadsheet shows all costs in 2012 dollars, with no allowance for inflation.

General spreadsheet functions

Password protection

Password protection is applied to all linked cells to protect the document from being accidentally edited. Each worksheet is locked individually.

To unlock a worksheet, go to Tools > Protection > Unprotect Sheet (in Excel v.2003) and enter the password. When editing is completed, lock the worksheet again using the same password as shown below.

The password to unlock each worksheet is: **BEJ252**

Note the password is case sensitive.

Hidden comments

Certain cells contain hidden comments, which are marked with a red corner in the top right hand corner of the cell. Hover over the cell to view the hidden comments.

To hide any visible comments, right click and select hide from the menu.

Locking cells

As RCC develop the ‘Finance Model’ worksheet, locking cells that contain calculations while maintaining ability to modify any input cells is important. To do this, select all the cells on the worksheet, right click and select Format Cells > Protection, then uncheck ‘Locked’. Following this unlocking of all cells, select all the

cells containing calculations and repeat the steps above, however check 'Locked'. Then protect the worksheet by Tools > Protection > Protect Sheet and enter the password. Once the worksheet is protected, only those cells which are ticked as 'locked' are locked, and other cells remain active.

Sediment Removal Volumes

On the 'Sediment Removal Volumes' worksheet, user input is available in a number of areas. Any input cell containing '**bold blue**' font and light green shading is for user editing which allows manual entry of Sediment Removal Volumes. Cells in '**bold red**' font represent an adjustable quantity sensitivity factor. Additionally, one drop down boxes and a check box are also embedded in the calculations. User input areas are outlined below:

Quantity Sensitivity Factor – Row 9

This is a Sediment Removal Volumes multiplier. The factor can be used to test the effect of larger or smaller than expected dredged volumes on a year by year basis; its default value is unity.

Increase or Reduction in Dredge Volumes – Cell A22 (switch and drop down box)

A check box has been embedded into the worksheet to facilitate the inclusion of an increase or decrease in siltation. It acts as a switch to turn on/off increased or reduced volumes by the chosen percentage (chosen in the adjacent drop down box).

Raw Unit Rates table

Cells available for input are highlighted by bold red font. This includes unit rates, and the associated confidence level factor (which is used to assign an allowance to represent uncertainty in the rate). Each rate is to be given a confidence level of 0 to 5, based on the guidance provided in Table 3.1.

Table 3.1 Raw unit rates table

Confidence		Optimistic (P10)	Pessimistic (P90)	Indicative Situation
Very High	0	-2%	5%	Clear, concise scope supported by fixed quotes & labour rates, etc.
High	1	-5%	10%	Some minor uncertainty exists regarding scope and/or estimate process, etc.
Moderate	2	-10%	20%	Scope moderately clear, estimate based on mix of quotes & prices from similar jobs.
Low	3	-15%	30%	Low scope confidence. Estimate based on factoring from other non-identical jobs.
Very Low	4	-20%	40%	Vague/uncertain scope, prices factored from other similar (not identical) projects.
Order of Magnitude	5	-25%	50%	Based on the best guess of experienced employees or similar methods.

To modify the effects of this confidence factor, a confidence factor adjustment slider bar has been included (located at cells M15:P16). This slider bar calculates an adopted

confidence, which is a linear interpolation between the optimistic and pessimistic limits given in the above table.

It is possible to add additional rates in this worksheet; however integrating any new data into the rest of the model will require a password. Care must be taken including any new cost items. The suggested method for inserting a new cost item into the model is to change the definition of a redundant cost item, and replace it with the relevant costing data and program information.

The reference numbers are a code for each rate. The 'Derived Unit Rates' worksheet then references these rates in the 'Source' column.

It is important to note the units used for each cost item.

Program

As discussed in Section 2.2, the 'Program' and 'Derived Unit Rates' are multiplied together to yield the 'Model Cash Flow'. When using the 'Program' worksheet, special attention must be paid to the units used.

Cells in light brown are locked calculations which are inputs from other sheets.

Cells in light blue are for user input. They are generally at the discretion of the user in how and when to be applied. However knowledge of the sediment removal plan and constraints is recommended before alterations are made to the default program. In the event that cost items are shared between sections, place a fraction in each cell for distribution of costs (to sum to 1).

Derived Unit Rates

On the 'Derived Unit Rates' worksheet, only the Rate Sensitivity Factor is unlocked for editing. The derived rates shown here are calculated as follows:

$$\text{Derived Rate} = \text{Sensitivity Factor} \times [\text{Raw Unit Rate} \times (1 + \text{Adopted Confidence \%})]$$

As these derived rates include calculations, they are locked. Also included in this table is a 'Source' column which references the appropriate raw unit rate on the 'Raw Unit Rates Table'.

This worksheet essentially serves the function of converting raw data into usable forms to then be multiplied with the 'Program' worksheet.

Model Cash Flow

'Model Cash Flow' is simply the product of the 'Program' and 'Derived Unit Rates'.

This entire worksheet is output and is therefore locked. There is no user input required.

Model Summary

'Model Summary' is a concise version of the 'Model Cash Flow'.

This entire worksheet is output and is therefore locked. There is no user input required.

Finance model

This sheet is left blank and is available for use by the RCC accounting services department. This sheet is where calculations regarding net present value and levy rates for wet block residents etc can be determined.

Instructions for use

This worksheet provides user information, including instructions for use and 'built in' assumptions.

RCC is encouraged to update and populate this sheet with any new information as the Finance Model is developed.

Amendments Register

The first worksheet in the maintenance model spreadsheet is the 'Amendments Register' which is included to help track any changes to the maintenance model. Users who edit the spreadsheet are required to include their name, date and details of the changes made.

It is also encouraged that the spreadsheet be saved with a new filename following each update, and that the filename includes the revision code and date.

Appendix B

SOVEREIGN WATERS ESTATE COSTED MAINTENANCE MODEL

SOVEREIGN WATERS MAINTENANCE MODEL

AMENDMENTS REGISTER

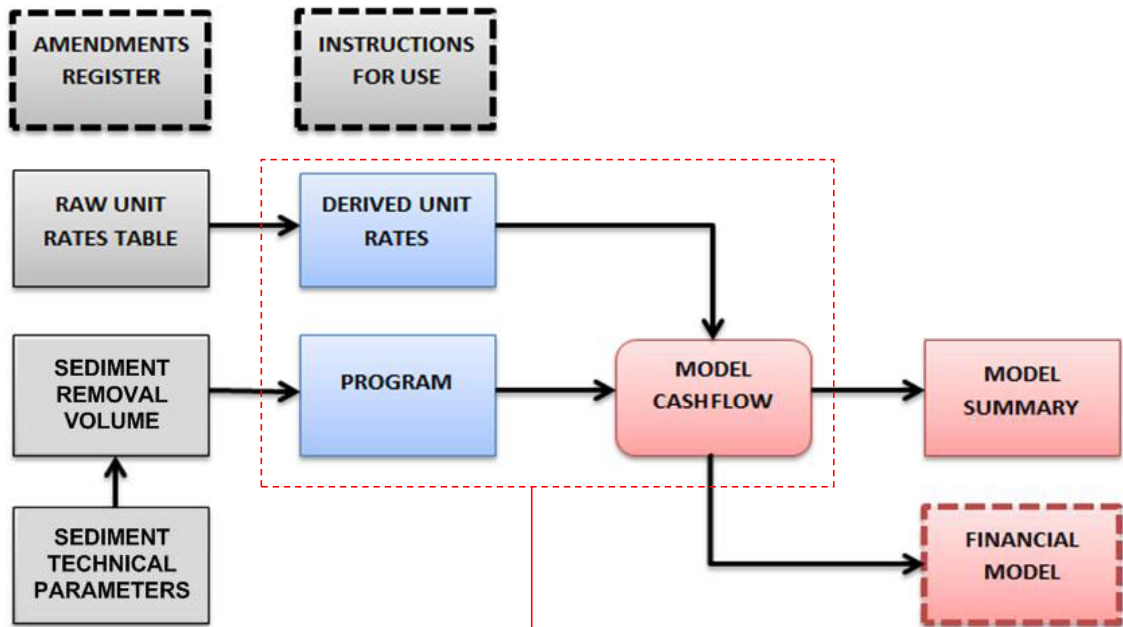
DATE	REV No.	BY	DETAILS
	A 0	KBR KBR	

SOVEREIGN WATERS MAINTENANCE MODEL

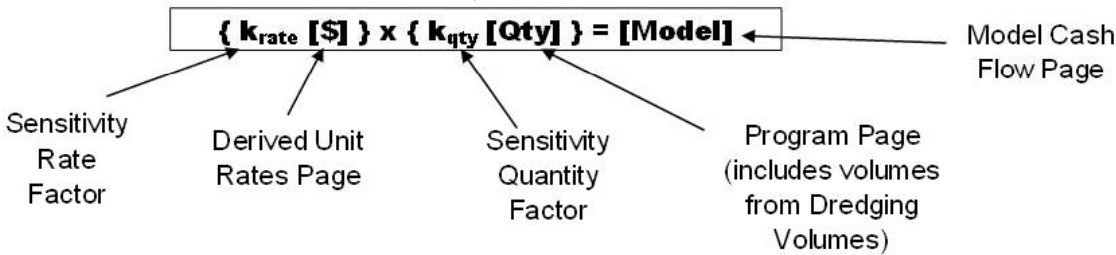
Guidelines on the Use of this Model

Note: Worksheet is ordered such that data flows from RIGHT to LEFT. This results in the SUMMARY data being on tabs to the LEFT and INPUT data on tabs to the RIGHT

Worksheet Data Flow



Governing Equation



Assumptions

General Assumptions

The Lake Management Plan identified several recommendations which would improve the system. These have been identified and discussed. However, costing of these items has not been performed and the costs are not included in the maintenance model. These are:

- ☐ Re-installation of the trash rack
- ☐ Construction of a weir between the macrophyte wetland and lake to avoid scouring of the bund in between the wetland and lake walls
- ☐ Wetland re-habilitation, including excavation of a high flow bypass channel

Maintenance frequencies have been estimated based on best practice, experience or where available published guidelines. It is expected that monitoring and inspection throughout will identify the requirement to conduct maintenance. Therefore, the costs developed herewithin are accurate based on proposed maintenance requirements and reviews by council will be performed to develop more accurate maintenance frequencies based on inspection findings.

Due to the small scale of sediment removal the costs for sediment removal design and approvals for conducting sediment removal and for disposal at landfill or large quantities has not been included.

A routine maintenance fee has been included for repairs to the lake wall, as a one off item at the end of the ten year maintenance model.

Sediment Technical Parameters

Key assumptions used in the development of these parameters include:

- ☐ density of solids = 2.6 t/m³
- ☐ density of water = 1.025 t/m³
- ☐ moisture content assumed at key stages in the spoil life cycle.
 - o pond wet – M.C. = 130 %
 - o pond crust – M.C. = 20%
 - o Heaped Dry – M.C. = 10%
- ☐ bulking factor = 1.2
- ☐ dry density of spoil = 1.6 t/m³
- ☐ bulk density of insitu sediment = 1.350 t/m³
- ☐ bulk density of spoil within cutter section dredge = 1.135 t/m³.

Sediment Removal Volumes

Rev A data has been input from the sedimentation study presented in the Sovereign Waters Estate Management Plan Draft Report (KBR, 2012).

This plan covers the period 2013 to 2023.

The plan produced in the referenced report is based upon a number of important assumptions, most notably the siltation rates within the wetlands and lake. It is critical that the siltation be assessed using surveys to ensure that the actual siltation rates are comparable to those assumed in the dredging plan. If the siltation rates are found to vary appreciably from those assumed for the proposed schedule (whether higher or lower) then an update of the schedule will be necessary.

Allowance can be made for the possibility of increased or reduced siltation. This is implemented via an increase or reduction in dredging volumes across all years (using the increased/reduced siltation check box in the dredging volumes worksheet), or in individual years by altering the dredge volumes sensitivity

Raw Unit Rates

Key assumptions with regards to the spoil disposal system include:

- **Sediment to be disposed of has been assumed to be uncontaminated fill**
- The user selects their 'confidence percentage' preference; however as default it is set to 50% - that is there is a 50% probability that the costs will be exceeded.
- Costs for RCC administration have been sourced from the 'Aquatic Paradise Transactions Ledger' provided by RCC are indicative of future costs for comparable items.

Program

Some key events have been assumed and inserted into the model. These include:

- Wetland re-structure and rehabilitation in 2015
- The only cost of wetland re-structure and rehabilitation included is excavation; other costs are too difficult to determine at this stage.
- Repair of signage within the next ten years.
- Minor lake wall repair in the next ten years.
- Humes tide flap replacement at end of design life; in approximately 2025 - rough cost to replace these is estimated at \$140,000
- Review of maintenance model – commencing in 2012 and again in 2015, then every 5 years thereafter.
- Each sediment removal operation has 2 surveys - pre and post dredging/excavation
- Sediment sampling and analysis is undertaken prior to grab dredging to assess spoils suitability to dispose at landfill.
- Wet disposal (>20% moisture content) of the spoil at landfill as uncontaminated waste.

Assumptions for this section are to be entered by RCC

Derived Unit Rates

No Assumptions made

Model Cash Flow / Model Summary

No Assumptions made

Finance Model

Assumptions for this section are to be written by RCC as it is developed

SOVEREIGN WATERS MAINTENANCE MODEL

FINANCE MODEL

To be completed by RCC

SOVEREIGN WATERS MAINTENANCE MODEL

MODEL SUMMARY

Budget No.	Component No.	ITEM / DESCRIPTION	1	2	3	4	5	6	7	8	9	10	11
			2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
		1. LOCAL POLLUTANT CONTROLS											
		1.1 Trash Racks	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00
		1.2 Gross Pollutant Traps (GPTs)	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63	\$ 12,647.63
		TOTAL	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63
		2. WETLAND (INLET ZONE)											
		2.1 General Maintenance	\$ 2,131.00	\$ 2,131.00	\$ 2,131.00	\$ 2,131.00	\$ 2,131.00	\$ 2,421.25	\$ 2,131.00	\$ 2,131.00	\$ 2,131.00	\$ 2,131.00	\$ 2,421.25
		2.2 Sediment removal	\$ -	\$ -	\$ 31,594.38	\$ -	\$ -	\$ -	\$ -	\$ 9,594.38	\$ -	\$ -	\$ -
		2.3 Spoil Disposal	\$ -	\$ -	\$ 65,101.55	\$ -	\$ -	\$ -	\$ -	\$ 11,409.55	\$ -	\$ -	\$ -
		2.4 Monitoring	\$ -	\$ -	\$ 1,911.00	\$ -	\$ -	\$ -	\$ -	\$ 1,911.00	\$ -	\$ -	\$ -
		TOTAL	\$ 2,131.00	\$ 2,131.00	\$ 100,737.93	\$ 2,131.00	\$ 2,131.00	\$ 2,421.25	\$ 2,131.00	\$ 25,045.93	\$ 2,131.00	\$ 2,131.00	\$ 2,421.25
		3. WETLAND (MACROPHYTE ZONE)											
		3.1 General Maintenance	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00	\$ 5,167.00
		3.2 Sediment removal	\$ -	\$ -	\$ 23,619.38	\$ -	\$ -	\$ -	\$ -	\$ 23,619.38	\$ -	\$ -	\$ -
		3.3 Spoil Disposal	\$ -	\$ -	\$ 32,215.20	\$ -	\$ -	\$ -	\$ -	\$ 32,215.20	\$ -	\$ -	\$ -
		3.4 Monitoring	\$ 252.00	\$ 252.00	\$ 2,163.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 2,163.00	\$ 252.00	\$ 252.00	\$ 252.00
		TOTAL	\$ 5,419.00	\$ 5,419.00	\$ 63,164.58	\$ 5,419.00	\$ 5,419.00	\$ 5,419.00	\$ 5,419.00	\$ 63,164.58	\$ 5,419.00	\$ 5,419.00	\$ 5,419.00
		4. LAKE											
		4.1 General Maintenance	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 4,074.25	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 4,074.25
		4.2 Monitoring	\$ -	\$ -	\$ -	\$ -	\$ 7,456.88	\$ -	\$ -	\$ -	\$ -	\$ 7,456.88	\$ -
		TOTAL	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 10,079.88	\$ 4,074.25	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 10,079.88	\$ 4,074.25
		5. TIDAL EXCHANGE SYSTEM											
		5.1 General Maintenance	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50
		TOTAL	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50
		6. LAKE PERIMETER WALL											
		6.4 General Maintenance	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ 22,000.00
		TOTAL	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ 22,000.00
		7. ENVIRONMENTAL MONITORING	\$ 16,148.65	\$ 33,152.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65
		TOTAL	\$ 16,148.65	\$ 33,152.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65
		8. MAINTENANCE MODEL REVIEW & ADMINISTRATION	\$ 10,750.00	\$ 10,750.00	\$ 31,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 31,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00
		TOTAL	\$ 10,750.00	\$ 10,750.00	\$ 31,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 31,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00
		GRAND TOTAL	\$ 51,847.78	\$ 68,851.78	\$ 232,135.28	\$ 52,351.78	\$ 59,808.65	\$ 56,524.28	\$ 52,351.78	\$ 154,012.28	\$ 54,782.78	\$ 59,808.65	\$ 76,093.28
		ACCUMULATIVE TOTAL	\$ 51,847.78	\$ 120,699.55	\$ 352,834.83	\$ 405,186.60	\$ 464,995.25	\$ 521,519.53	\$ 573,871.30	\$ 727,883.58	\$ 782,666.35	\$ 842,475.00	\$ 918,568.28
		RUNNING AVERAGE FROM 2013	\$ 51,847.78	\$ 60,349.78	\$ 117,611.61	\$ 101,296.65	\$ 92,999.05	\$ 86,919.92	\$ 81,981.61	\$ 90,985.45	\$ 86,962.93	\$ 84,247.50	\$ 83,506.21

Instructions for Model Summary Worksheet
DO NOT MODIFY CELL CONTENTS DIRECTLY
MODIFY RAW UNIT RATES AND PROGRAM SHEETS TO UPDATE DATA.

TO SIMULATE EFFECTS OF COST VARIATION, USE SENSITIVITY FACTORS ON DERIVED UNIT RATES AND DREDGING VOLUMES PAGES (FOR RATES AND QUANTITIES RESPECTIVELY)

SOVEREIGN WATERS MAINTENANCE MODEL

MAINTENANCE MODEL CASH FLOW

ITEM / DESCRIPTION	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1. LOCAL POLLUTANT CONTROLS											
1.1 Trash Racks											
Litter & debris removal	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00
1.2 Gross Pollutant Traps (GPTs)											
Inspection	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50	\$ 892.50
Servicing (Full removal of materials)	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13	\$ 11,755.13
TOTAL	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63	\$ 13,722.63
2. WETLAND (INLET ZONE)											
2.1 General Maintenance											
Litter collection	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00
Algae / undesired weed removal	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00	\$ 1,056.00
Signage maintenance	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 290.25	\$ -	\$ -	\$ -	\$ -	\$ 290.25
2.2 Sediment removal											
Survey	\$ -	\$ -	\$ 3,819.38	\$ -	\$ -	\$ -	\$ -	\$ 3,819.38	\$ -	\$ -	\$ -
Mob/Demob - Excavator	\$ -	\$ -	\$ 1,100.00	\$ -	\$ -	\$ -	\$ -	\$ 1,100.00	\$ -	\$ -	\$ -
Excavating	\$ -	\$ -	\$ 26,675.00	\$ -	\$ -	\$ -	\$ -	\$ 4,675.00	\$ -	\$ -	\$ -
Dredging Design, Approvals & Monitoring	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
2.3 Spoil Disposal											
Wet Spoil Disposal - Directly to landfill (>20% MC)	\$ -	\$ -	\$ 65,101.55	\$ -	\$ -	\$ -	\$ -	\$ 11,409.55	\$ -	\$ -	\$ -
2.4 Monitoring											
Inlet zone bed surface survey	\$ -	\$ -	\$ 1,911.00	\$ -	\$ -	\$ -	\$ -	\$ 1,911.00	\$ -	\$ -	\$ -
TOTAL	\$ 2,131.00	\$ 2,131.00	\$ 100,737.93	\$ 2,131.00	\$ 2,131.00	\$ 2,421.25	\$ 2,131.00	\$ 25,045.93	\$ 2,131.00	\$ 2,131.00	\$ 2,421.25
3. WETLAND (MACROPHYTE ZONE)											
3.1 General Maintenance											
Litter collection	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00	\$ 1,075.00
Aquatic vegetation removal	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00	\$ 1,584.00
Algae / undesired weed removal	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00	\$ 2,112.00
Clear and rehabilitate wetland outlet structure to lake - free from macrophyte growth and litter	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00	\$ 396.00
3.2 Sediment removal											
Survey	\$ -	\$ -	\$ 3,819.38	\$ -	\$ -	\$ -	\$ -	\$ 3,819.38	\$ -	\$ -	\$ -
Mob/Demob - Excavator	\$ -	\$ -	\$ 1,100.00	\$ -	\$ -	\$ -	\$ -	\$ 1,100.00	\$ -	\$ -	\$ -
Excavating	\$ -	\$ -	\$ 13,200.00	\$ -	\$ -	\$ -	\$ -	\$ 13,200.00	\$ -	\$ -	\$ -
Dredging Design, Approvals & Monitoring	\$ -	\$ -	\$ 5,500.00	\$ -	\$ -	\$ -	\$ -	\$ 5,500.00	\$ -	\$ -	\$ -
3.3 Spoil Disposal											
Wet Spoil Disposal - From Spoil Facility to landfill (>20% MC)	\$ -	\$ -	\$ 32,215.20	\$ -	\$ -	\$ -	\$ -	\$ 32,215.20	\$ -	\$ -	\$ -
3.4 Monitoring											
Vegetation performance	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00	\$ 252.00
Macrophyte zone bed surface survey	\$ -	\$ -	\$ 1,911.00	\$ -	\$ -	\$ -	\$ -	\$ 1,911.00	\$ -	\$ -	\$ -
TOTAL	\$ 5,419.00	\$ 5,419.00	\$ 63,164.58	\$ 5,419.00	\$ 5,419.00	\$ 5,419.00	\$ 5,419.00	\$ 63,164.58	\$ 5,419.00	\$ 5,419.00	\$ 5,419.00
4. LAKE											
4.1 General Maintenance											
Litter collection	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00	\$ 2,107.00
Access ramps - remove slip hazards and marine fouling	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00	\$ 516.00
Signage maintenance	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 1,451.25	\$ -	\$ -	\$ -	\$ -	\$ 1,451.25
4.2 Monitoring											
Lake bed surface survey	\$ -	\$ -	\$ -	\$ -	\$ 7,456.88	\$ -	\$ -	\$ -	\$ -	\$ 7,456.88	\$ -
TOTAL	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 10,079.88	\$ 4,074.25	\$ 2,623.00	\$ 2,623.00	\$ 2,623.00	\$ 10,079.88	\$ 4,074.25
5. TIDAL EXCHANGE SYSTEM											
5.1 General Maintenance											
Litter collection	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50
TOTAL	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50	\$ 1,053.50
6. LAKE PERIMETER WALL											
6.4 General Maintenance											
Complete wall inspection	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -
Wall repair	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ 22,000.00
TOTAL	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ -	\$ 2,431.00	\$ -	\$ 22,000.00
7. ENVIRONMENTAL MONITORING											
Water level gauge/ruler installation	\$ -	\$ 16,500.00	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -	\$ -
Water level	\$ -	\$ 504.00	\$ 504.00	\$ 504.00	\$ 504.00	\$ 504.00	\$ 504.00	\$ 504.00	\$ 504.00	\$ 504.00	\$ 504.00
Water quality	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04	\$ 12,724.04
Event based Microbial testing of recreational water (as per Appendices C)	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61	\$ 3,424.61
TOTAL	\$ 16,148.65	\$ 33,152.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65	\$ 16,652.65
8. MAINTENANCE MODEL REVIEW & ADMINISTRATION											
Review of Maintenance Model (ALL ITEMS)	\$ -	\$ -	\$ 21,000.00	\$ -	\$ -	\$ -	\$ -	\$ 21,000.00	\$ -	\$ -	\$ -
RCC Administration	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00
TOTAL	\$ 10,750.00	\$ 10,750.00	\$ 31,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00	\$ 31,750.00	\$ 10,750.00	\$ 10,750.00	\$ 10,750.00
Grand Total	\$ 51,847.78	\$ 68,851.78	\$ 232,135.28	\$ 52,351.78	\$ 59,808.65	\$ 56,524.28	\$ 52,351.78	\$ 154,012.28	\$ 54,782.78	\$ 59,808.65	\$ 76,093.28
Cumulative Total	\$ 51,847.78	\$ 120,699.55	\$ 352,834.83	\$ 405,186.60	\$ 464,995.25	\$ 521,519.53	\$ 573,871.30	\$ 727,883.58	\$ 782,666.35	\$ 842,475.00	\$ 918,568.28
Running Average from 2013	\$ 51,847.78	\$ 60,349.78	\$ 117,611.61	\$ 101,296.65	\$ 92,999.05	\$ 86,919.92	\$ 81,981.61	\$ 90,985.45	\$ 86,962.93	\$ 84,247.50	\$ 83,506.21

Instructions for Model Cash Flow Worksheet
DO NOT MODIFY CELL CONTENTS DIRECTLY
MODIFY UNIT RATES AND PROGRAM SHEETS TO UPDATE DATA.
TO SIMULATE EFFECTS OF COST VARIATION, USE SENSITIVITY FACTORS
ON DERIVED UNIT RATES AND DREDGING VOLUMES PAGES
(FOR RATES AND QUANTITIES RESPECTIVELY)

SOVEREIGN WATERS MAINTENANCE MODEL

MAINTENANCE MODEL DERIVED UNIT RATES

ITEM / DESCRIPTION	Units	RATE	SENSITIVITY: RATE FACTOR	COMMENT
1. LOCAL POLLUTANT CONTROLS				
1.1 Trash Racks				
Litter & debris removal	\$	\$ 268.75	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
1.2 Gross Pollutant Traps (GPTs)				
Inspection	\$	\$ 44.63	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Servicing (full removal of all materials)	\$	\$ 2,351.03	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
2. WETLAND (INLET ZONE)				
2.1 General Maintenance				
Litter collection	\$	\$ 268.75	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Algae / undesired weed removal	\$	\$ 528.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Signage maintenance	\$/sign	\$ 290.25	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
2.2 Sediment removal				
Survey	\$	\$ 7,638.75	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Mob/Demob - Excavator	\$	\$ 2,200.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Excavating	\$/m³	\$ 11.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Dredging Design, Approvals & Monitoring	\$	\$ 5,500.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
2.3 Spoil Disposal				
Wet Spoil Disposal - Directly to landfill (>20% MC)	\$/m³	\$ 26.85	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
2.4 Monitoring				
Inlet zone bed surface survey	\$	\$ 3,822.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
3. WETLAND (MACROPHYTE ZONE)				
3.1 General Maintenance				
Litter collection	\$	\$ 268.75	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Aquatic vegetation removal	\$	\$ 792.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Algae / undesired weed removal	\$	\$ 528.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Clear and rehabilitate wetland outlet structure to lake - free from macrophyte growth and litter	\$	\$ 396.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
3.2 Sediment removal				
Survey	\$	\$ 7,638.75	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Mob/Demob - Excavator	\$	\$ 2,200.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Excavating	\$/m³	\$ 11.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Dredging Design, Approvals & Monitoring	\$	\$ 5,500.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
3.3 Spoil Disposal				
Wet Spoil Disposal - From Spoil Facility to landfill (>20% MC)	\$/m³	\$ 26.85	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
3.4 Monitoring				
Vegetation performance	\$	\$ 126.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Macrophyte zone bed surface survey	\$	\$ 3,822.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
4. LAKE				
4.1 General Maintenance				
Litter collection	\$	\$ 526.75	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Access ramps - remove slip hazards and fouling	\$	\$ 258.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Signage maintenance	\$	\$ 1,451.25	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
4.4 Monitoring				
Lake bed surface survey	\$	\$ 7,456.88	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
5. TIDAL EXCHANGE SYSTEM				
5.1 General Maintenance				
Litter collection	\$	\$ 526.75	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
6. LAKE PERIMETER WALL				
6.4 General Maintenance				
Complete wall inspection	\$	\$ 2,431.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Wall repair	\$	\$ 22,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
7. HYDRAULIC & ENVIRONMENTAL MONITORING				
Water level gauge/ruler installation	\$/Unit	\$ 5,500.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Water level	\$/event	\$ 126.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Water quality	\$/event	\$ 3,181.01	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
Event based Microbial testing of recreational water (as per Appendices C)	\$/event	\$ 3,424.61	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
8. MAINTENANCE MODEL REVIEW & ADMINISTRATION				
Review of Maintenance Model (ALL ITEMS)	\$	\$ 21,000.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]
RCC Administration (ALL ITEMS)	\$	\$ 10,750.00	1	Derived Rate = Sensitivity Rate Factor * [Raw Unit Rate * (1 + Adopted Confidence Percentage)]

ITEM / DESCRIPTION	Units	RATE	REF NO.	COMMENT
Dry Spoil Disposal - Drying at disposal pond site then Haul to Landfil				Assuming drying necessary to be trucked to Landfill site
Treat	\$/m³	\$ 5.25		Dry and Lime
Spoil Trenching, Loading, and Haul to Landfill Sit	\$/m³	\$ 60.90		
Dispose at Landfill Site	\$/m³	\$ 6.50		Derived unit rate shown below
	\$/m³	\$ 72.65	miii	
Wet Spoil Disposal - Haul straight to Landfil				Excess material to be taken to land fill while wet.
Treat	\$/m³	\$ 5.35		
Haul to Landfill Site	\$/m³	\$ 15.00		
Dispose at Landfill Site	\$/m³	\$ 6.50		Derived unit rate shown below
	\$/m³	\$ 26.85	miv	

CALCULATED UNIT RATES - CONVERSION FOR \$/T TO \$/M³

ITEM / DESCRIPTION	Units	RATE	REF NO.	COMMENT
Dispose at Landfill (20% MC)	\$/m³	\$ 6.50	36	Quote from trial disposal(2011) * density
Wet Disposal	\$/m³	\$ 159.08	37	Quote from MBRC - Moreton Bay Waste (2011) * density

SOVEREIGN WATERS MAINTENANCE MODEL

MAINTENANCE MODEL PROGRAM (QUANTITIES TIME SERIES)

ITEM / DESCRIPTION	Units	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
1. LOCAL POLLUTANT CONTROLS												
1.1 Trash Racks Litter & debris removal	No.	4	4	4	4	4	4	4	4	4	4	4
1.2 Gross Pollutant Traps (GPTs) Inspection Servicing (full removal of all materials)	No. No.	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5	20 5
2. WETLAND (INLET ZONE)												
2.1 General Maintenance Litter collection Algae / undesired weed removal Signage maintenance	No. No. No.	4 2	4 2	4 2	4 2	4 2	4 2 1	4 2	4 2	4 2	4 2	4 2 1
2.2 Sediment removal Survey Mob/Demob - Excavator Excavating Dredging Design, Approvals & Monitoring	No. No. m³ No.	-	-	0.5 0.5 2,425	-	-	-	-	0.5 0.5 425	-	-	-
2.3 Spoil Disposal Wet Spoil Disposal - Directly to landfill (>20% MC)	m³	-	-	2,425	-	-	-	-	425	-	-	-
2.4 Monitoring Inlet zone bed surface survey	No.			0.5					0.5			
3. WETLAND (MACROPHYTE ZONE)												
3.1 General Maintenance Litter collection Aquatic vegetation removal Algae / undesired weed removal Clear and rehabilitate wetland outlet structure to lake - free from macrophyte growth and litter	No. No. No.	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1	4 2 4 1
3.2 Sediment removal Survey Mob/Demob - Excavator Excavating Dredging Design, Approvals & Monitoring	No. No. m³ No.	-	-	0.5 0.5 1,200 1	-	-	-	-	0.5 0.5 1,200 1	-	-	-
3.3 Spoil Disposal Wet Spoil Disposal - From Spoil Facility to landfill (>20% MC)	m³	-	-	1,200	-	-	-	-	1,200	-	-	-
3.4 Monitoring Vegetation performance Macrophyte zone bed surface survey	No. No.	2	2	2 0.5	2	2	2	2	2 0.5	2	2	2
4. LAKE												
4.1 General Maintenance Litter collection Access ramps - remove slip hazards and fouling Signage maintenance	No. No. No.	4 2	4 2	4 2	4 2	4 2	4 2 1	4 2	4 2	4 2	4 2	4 2 1
4.4 Monitoring Lake bed surface survey	No.					1					1	
5. TIDAL EXCHANGE SYSTEM												
5.1 General Maintenance Litter collection	No.	2	2	2	2	2	2	2	2	2	2	2
6. LAKE PERIMETER WALL												
6.4 General Maintenance Complete wall inspection Wall repair	No. No.			1			1			1		1
7. HYDRAULIC & ENVIRONMENTAL MONITORING												
Water level gauge/ruler installation Water level Water quality Event based Microbial testing of recreational water (as per Appendices C)	No. No. No. No.		3 4 4 1		4 4 4 1	4 4 4 1	4 4 4 1	4 4 4 1	4 4 4 1	4 4 4 1	4 4 4 1	4 4 4 1
8. MAINTENANCE MODEL REVIEW & ADMINISTRATION												
Review of Maintenance Model (ALL ITEMS) RCC Administration (ALL ITEMS)	No. No.	1	1	1	1	1	1	1	1	1	1	1

Instructions for Model Sensitivity Worksheet
MODIFY DIMENSIONLESS EVENTS BY INSERTING THE NUMBER OF EVENTS FOR THAT YEAR.
DO NOT MODIFY CELLS IN THIS SPREADSHEET WHICH APPEAR IN BROWN, AS THEY ARE LINKED TO DREDGING VOLUMES WORKSHEET. MODIFY BLUE CELLS.

THIS WORKSHEET IS THEN MULTIPLIED BY THE COSTS WORKSHEET TO PRODUCE COSTS FOR EACH ITEM
IN EVENT THAT COSTS ITEMS ARE SHARED BETWEEN 'WETLAND (BOTH)' & 'LAKE' SECTIONS,
PLACE A FRACTION IN EACH CELL FOR DISTRIBUTION OF COSTS (TO SUM TO 1)

RAW UNIT RATES TABLE

SOVEREIGN WATERS MAINTENANCE MODEL

RAW UNIT RATES TABLE

ITEM	UNIT	RATE	CONFIDENCE LEVEL	ORIGIN / REFERENCE / DATE / COMMENT
<u>Maintenance - Inlet Zone</u>				
Litter collection	\$	250.00	3	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 2 hours + (RedWaste commercial & industrial disposal cost/tonne * estimated weight(kg) of litter)
Algae / undesired weed removal	\$	480.00	4	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 4 hours
Signage maintenance	\$/sign	270.00	3	Estimate from australiasigns.com.au based on a 200mm * 500mm Aluminium sign with moderate artwork, GST&delivery
<u>Maintenance - Macrophyte Zone</u>				
Litter collection	\$	250.00	3	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 2 hours + (RedWaste commercial & industrial disposal cost/tonne * estimated weight(kg) of litter)
Aquatic vegetation removal	\$	720.00	4	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 6 hours
Algae / undesired weed removal	\$	480.00	4	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 4 hours
Clear and rehabilitate wetland outlet structure to lake - free from macrophyte growth and litter	\$	360.00	4	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 3 hours
Signage maintenance	\$/sign	270.00	3	Estimate from australiasigns.com.au based on a 200mm * 500mm Aluminium sign with moderate artwork, GST&delivery
<u>Maintenance - Lake</u>				
Litter collection	\$	490.00	3	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 4 hours + (RedWaste commercial & industrial disposal cost/tonne * estimated weight(kg) of litter)
Replace all tidal exchange flap valves	\$	90,600.00	5	Cost for gate(s) + cartage + scuba diver(s) labour to replace submerged valves + labour for replacement of valves which are not submerged * 50% for additional fees and equipment
Replace wetland outlet structure gates	\$	50,280.00	5	Cost for gate(s) + cartage + labour for replacement of flood gates + cost of installation
Access ramp maintenance	\$	240.00	3	2012 actual expenditure based on a fortnightly cycle. Cost is inspection of 2x ramps. Cost is for inspection and clean only. - Quotes supplied by Steve Turfrey
Signage maintenance	\$	1,350.00	3	Estimate from australiasigns.com.au based on 5 * 200mm * 500mm Aluminium sign with moderate artwork, GST&delivery
Lake wall repair	\$	20,000.00	5	
<u>Maintenance - Pollutant Controls</u>				
Litter collection - trash racks	\$/event	250.00	3	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons * 2 hours + (RedWaste commercial & industrial disposal cost/tonne * estimated weight(kg) of litter)
GPT inspections	\$/asset	42.50	2	2012 actual expenditure based on a 4monthly cycle. Cost is per asset to be inspected. Cost is for inspection only. - Quotes supplied by Steve Turfrey
GPT servicing (full removal of materials)	\$/asset	2,187.00	3	2012 actual expenditure based on average expenditure on assets in a yearly cycle. Cost is per asset to be cleaned. Cost is for full clean. - Quotes supplied by Steve Turfrey
<u>Sediment Removal - Excavation</u>				
Survey	\$	7,275.00	2	Based on KBR Sovereign Waters variation #1 - sediment sampling of lake - and factored by 1.5 (if for variation in cost of other/specialist contractors are used)
Mob/demob excavator	\$	2,000.00	5	based on: (Tender - PoB (2007) + BCI increase - factored by 2 due to locality) factored down due to location and size of plant
Sediment removal	\$/m³	10.00	4	[(Excavator (\$/hr) / volume moveable (m³/hr)) + (Rawlinsons 2012 Ed.30, p.692: Labourer group 1: 2 persons * 8 hours)]
Sediment Removal Design, Approvals & Monitoring	\$	5,000.00	5	KBR Estimate -based upon previous Newport work - largely dependant upon Monitoring component - factored to half due to small scale of sediment removal
<u>Spoil Treatment</u>				
Lime treatment (ASS)	\$/m³	5.00	4	KBR Estimate - *assumes agricultural lime is spread onto spoil pond surface and sufficient mixing occurs during crust scraping & disposal process
<u>Spoil Disposal</u>				
Dry spoil disposal (crust scraping, loading and haul to landfill)	\$/m³	35.00	3	KBR Calculation (2012) including Crust Scraping (for drying) Loading and Transport to Dakabin
Wet spoil disposal (loading & haul to landfill)	\$/m³	15.00	5	BEJ009 - Unit Cost Estimate 2 - doc #: TD-MN-CAL-0002 (sullage tanker transport, using tanker pump)
Spoil facility construction & preparation	\$/m³	58.00	5	BEJ009 - Unit Cost Estimate 2 - doc #: TD-MN-CAL-0002 - {COST/VOLUME}
<u>Direct Disposal Costs</u>				
Dry Disposal at landfill	\$/tonne	4.00	0	RWBU Fee for uncontaminated Clean fill / soil (2011)
Wet Disposal	\$/tonne	97.00	1	Quote from MBRC - Moreton Bay Waste (2011)
<u>Monitoring</u>				
Water Level	\$/event	120.00	2	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons x 1 hours
Water level gauge/ruler	\$/unit	5,000.00	5	Estimate based on a simple 'ruler' gauge. Cost of a surveyor and installation
Water quality	\$/event	3,134.00	0	RCC provided cost estimate + Labour (Rawlinsons 2012 Ed.30, p.692: Labourer group 1: 2 persons * 4 hours)
Event based Microbial testing of recreational water (as per Appendices C)	\$/event	3,374.00	0	Estimate based of RCC cost estimate + Labour (Rawlinsons 2012 Ed.30, p.692: Labourer group 1: 2 persons * 4 hours)
Wetland vegetation check	\$/event	120.00	2	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 1 persons x 2 hours
Wetland bed surface surveys	\$/event	3,640.00	2	Based on KBR variation 1 - sediment sampling of lake - halved and factored by 1.5 (if for variation in cost of other/specialist contractors are used)
Lake bed surface survey	\$/event	7,275.00	1	Based on KBR variation 1 - sediment sampling of lake - and factored by 1.5 (if for variation in cost of other/specialist contractors are used)
Lake perimeter wall visual monitoring	\$/event	2,210.00	4	(Rawlinsons 2012 Ed.30, p.692: Labourer group 1) 2 persons x 8 hours + boat hire + equipment
<u>Administration</u>				
Review of Maintenance Model	\$/annum	20,000.00	2	KBR Estimate
RCC Management, Administration& Staff Costs*	\$/annum	10,000.00	3	Aquatic Paradise Ledger - by RCC

SOVEREIGN WATERS MAINTENANCE MODEL

ANNUAL TOTAL SEDIMENT REMOVAL VOLUMES

Proposed Sediment Removals Schedule Based on Calculated Siltation Rates

ITEM / DESCRIPTION	Units	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
SENSITIVITY: QUANTITIES FACTOR		1	1	1	1	1	1	1	1	1	1	1	1
SEDIMENT REMOVAL VOLUMES TOTAL (INSITU)	(m³)	-	-	-	3,625	-	-	-	-	1,625	-	-	-
SEDIMENT REMOVAL METHOD & CORRESPONDING VOLUMES													
EXCAVATION	(m³)	-	-	-	3,625	-	-	-	-	1,625	-	-	-
SEDIMENT REMOVAL VOLUMES PROPORTION WETLAND INLET ZONE	%	0%	0%	0%	67%	0%	0%	0%	0%	26%	0%	0%	0%
SEDIMENT REMOVAL VOLUMES PROPORTION WETLAND MACROPHYTE ZONE		0%	0%	0%	33%	0%	0%	0%	0%	74%	0%	0%	0%
INCREASE OR REDUCTION IN SEDIMENT REMOVAL VOLUMES													
☐ INCREASED/REDUCED SILTATION - factored by: 25%	(m³)				-	-	-	-	-	-	-	-	-
FACTORED SEDIMENT REMOVAL VOLUMES (INSITU)													
Total volumes of sediment removal	(m³)	-	-	-	3,625	-	-	-	-	1,625	-	-	-
Wetland volume of sediment removal	(m³)	-	-	-	3,625	-	-	-	-	1,625	-	-	-
DISPOSAL													
WET SPOIL DISPOSAL - FROM DEWATERING FACILITY TO LANDFILL (>20%MC)													
Total Volumes % wet dispos 100%	(m³)	-	-	-	3,625	-	-	-	-	1,625	-	-	-
Inlet Zone		-	-	-	2,425	-	-	-	-	425	-	-	-
Macrophyte Zone		-	-	-	1,200	-	-	-	-	1,200	-	-	-

SEDIMENT REMOVAL VOLUMES INPUT

		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Total	% of Total
Total Volumes	(m³)	-	-	-	3,625					1,625				5,250	100%
INLET ZONE SEDIMENT REMOVAL	(m³)				425					425				850	16%
INLET ZONE RE-STRUCTURE	(m³)				2,000									2,000	38%
MACROPHYTE ZONE SEDIMENT REMOVAL	(m³)				1,200					1,200				2,400	46%

Instructions for Sediment Removal Details Workpage

SEDIMENT VOLUMES INPUT TABLE IS BASED ON SEDIMENT REMOVAL SCHEDULE - VALUES CAN ALSO BE MANUALLY MANIPULATED (CELLS SHOWN IN BOLD BLUE FONT AND GREEN SHADING)

MANUAL MANIPULATION IS ONLY ADVISABLE IF THE USER HAS A KNOWLEDGE OF THE SEDIMENT REMOVAL SCHEDULE AND SEDIMENT REMOVAL AND DISPOSAL CONSTRAINTS

THE SPOIL VOLUMES FOR EACH DISPOSAL METHOD ARE TRACKED THROUGH AND FACTORED BY THE SEDIMENT REMOVAL TECHNICAL PARAMETERS

SPOIL VOLUMES DIRECTLY INFORMS THE PROGRAM SHEET, AND THEREFORE AFFECTS COSTS

SOVEREIGN WATERS MAINTENANCE MODEL

SEDIMENT VOLUMES - TECHNICAL PARAMETERS TABLE

Volume Conversion Factors - Dredge Spoil			
Spoil Location	From Insitu to the following:	M.C. %	% Air Volume
Insitu	1.00	152	0.00
C/S Dredge	2.95	525	0.00
Pond wet	0.89	130	0.00
Pond Crust on Batter	0.36	20	7.24
Pond Crust in Truck - Bulked	0.44	10	22.85

Assuming:

Bulking Factor	1.2
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Density of Spoil (t/m ³)	1.6
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Instructions for Technical Parameters Worksheet

DO NOT MODIFY CELL CONTENTS WITHOUT NEW GEOTECHNICAL DATA

BULKING FACTOR APPLIED FOR TRUCKING VOLUMES

SUPPORTING GEOTECHNICAL CALCULATIONS

$$\rho_{\text{solids}} = 2.600 \text{ t/m}^3$$
$$\rho_{\text{water}} = 1.025 \text{ t/m}^3$$

Location	Total V(m ³)	ρ _{bulk} (t/m ³)	Solids (t/m ³)	Water (t/m ³)	% Solids Mass	% Solids Vol	% Water Vol	% Air Vol	M.C. (%)	Total Mass (t)	Solids Mass (t)
Insitu	1,000	1.350	0.537	0.813	39.74	20.63	79.37	0.00	152	1,350	537
C/S Dredge	2,955	1.135	0.182	0.953	16.00	6.98	93.02	0.00	525	3,353	537
Pond wet	887	1.391	0.605	0.786	43.48	23.27	76.73	0.00	130	1,234	537
Spadeable	363	1.919	1.476	0.443	76.92	56.79	43.21	0.00	30	697	537
Pond Crust	335	1.920	1.600	0.320	83.33	61.54	31.22	7.24	20	644	537
Heaped Dry	335	1.760	1.600	0.160	90.91	61.54	15.61	22.85	10	590	537

Note : Bold and italic is the assumed or known value

Appendix C

**SOVEREIGN WATERS ESTATE
MICROBIAL TESTING OF
RECREATIONAL WATERS
REGIONAL MANAGEMENT
RESPONSE FLOWCHART**



Microbial Testing of Recreational Waters

Regional Management Response Flowchart: FINAL DRAFT V2

Adapted for use by Redland City Council (April 2013)

