ULULAH LAGOONS WATERBODY MANAGEMENT PLAN

DesignFlow

Prepared for Fraser Coast Regional Council

February 2021

Document Control Sheet

Report Title:	Ululah Lagoons Waterbody Management Plan V5
Suggested Reference	Ululah Lagoons Waterbody Management Plan V5 (DesignFlow, February 2021)
Version:	FINAL
Previous versions	CONSULTATION DRAFT - 15/11/2019
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Approved By:	Shaun Leinster
Date:	26/02/2021
File Location:	S:\Projects\4409
Circulation:	Electronic Copies: Fraser Coast Regional Council
	Printed Copies: Nil

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SUMMARY

The Ululah Lagoons system is a high profile and amenity series of waterbodies located within Maryborough. The system comprises four interconnected waterbodies that receive stormwater runoff from a 228 ha catchment comprising of residential, industrial and parkland/natural land uses. The waterbodies are valued by the local community and provide a high level of recreational amenity. The waterbodies are surrounded by open parkland and are largely accessible to the public. The largest and most prominent waterbody, commonly referred to as Ululah Lagoon, is located between Anzac Park and the Maryborough Golf Club.

Priority management issues identified for the Ululah Lagoons system include:

- Public safety
- Water quality
- Aquatic vegetation
- Aquatic weeds
- Edge stability
- Waterbody residence times

As outlined in DesignFlow (2021) the risk associated with the 'business as usual' management approach may results in high reactive management costs and/or further decline in water quality due to untreated catchment inputs and associated increase in algal and floating weed issues. A proactive approach has to be adopted.

Recommended Actions: The key management actions that have been identified as part of the *Ululah Lagoons Waterbody Management Plan* (this report) include:

- Immediate actions:
  - Development of Waterbody Edge - Public Safety Risk Assessment to reduce/remove high risk waterbody edges to manage public safety risk.
  - Development of Waterbird Management Plan to assist in reducing public health risk associated with waterbird faecal contamination.
  - Development of Weed Management Plan (in particular to target Broad Leaf Pepper Tree).
- Short term actions (1-2 years):
  - Implement works to 'high risk' unsafe edges.
  - Signage and landscaping works in key locations to discourage bird feeding.
  - Implement works recommended in the Weed Management Plan (Phase 1).
  - Targeted removal of declared weeds around waterbody margins (including reoccurrences of Salvinia molesta and Hygrophila costata).
  - Terrestrial buffer planting (all systems).
- Medium term actions (3-5 years):
  - Install water level control to Ululah Lagoons main outlet.
  - Stabilise eroding edges (e.g. golf course margins).
  - Landscaping works in key locations to discourage bird feeding and loafing.
  - Other items identified in the Waterbird Management Plan.
  - Implement works recommended in the Weed Management Plan (Phase 2).
  - Wetland planting to shallow waterbody edges.
  - Management of non-declared weeds (e.g. Nymphaea mexicana).
  - Develop a catchment based stormwater management strategy.
  - Capital works to reduce weed harbouring areas in Waterbody A and B.
- Long term opportunities (5-10 years):
  - Reduce ponding within the Waterbody C channel area.
  - Removal Cyperus papyrus stands.
  - Continue to implement catchment based stormwater treatment initiatives.
- Future / Aspirational:
  - Capital works to retrofit constructed wetland and recirculation system within upper section of Ululah Lagoon.
  - Convert Ululah Lagoons to a natural wetland systems (dewater).

1 INTRODUCTION

1.1 INTRODUCTION

The Ululah Lagoons system is a series of high profile interconnected waterbodies located within Maryborough. The waterbodies are surrounded by open parkland and residential areas, and are accessible to the public. The largest and most prominent waterbody, commonly referred to as Ululah Lagoon, is located between Anzac Park and the Maryborough Golf Club (Figure 1-1).

The Ululah Lagoons system receives stormwater runoff from a 228 ha catchment comprising of residential, industrial and parkland/natural land uses. Catchment runoff flows through the series of waterbodies and is discharged to the Mary River.

Poor water quality and long water residence times within the waterbodies results in the persistent growth of aquatic weeds which require ongoing surveillance and intervention by Council.

This report presents the Ululah Lagoons Waterbody Management Plan (WMP). The Ululah Lagoons system was identified to be a 'Very High' management priority system, as part of the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021). It was therefore selected as one of the initial waterbodies to have a specific plan developed to inform its future management.

The Ululah Lagoons WMP will provide Council with a strategic path forward to manage and improve the overall condition of the waterbodies.

Figure 1-1. Ululah Lagoons view from Anzac Park.

1.2 APPROACH

The Ululah Lagoons WMP has been developed using the waterbody management framework outlined in *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical*

Report (DesignFlow, 2021). The framework involves a step-wise assessment and prioritisation approach to identify and manage FCRC waterbodies (Figure 1-2).

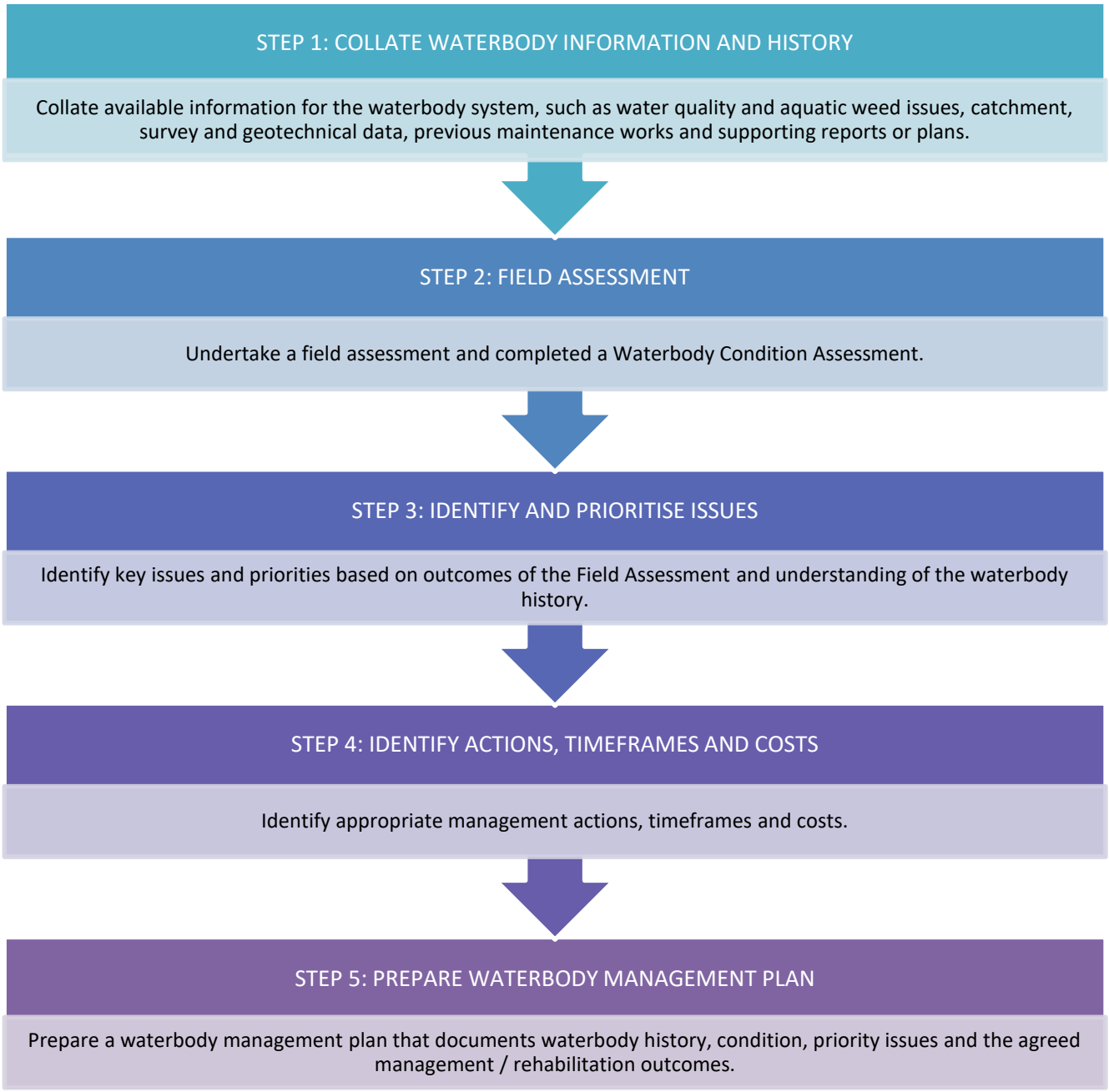


Figure 1-2. Overview of the waterbody management framework.

1.3 REPORT STRUCTURE

Sections 2-5 of this report provide details associated with each 'step' taken through the framework. Section 6 summarises the management plan for the Ululah Lagoons system based on the outcomes of these steps.

2 WATERBODY INFORMATION AND HISTORY

Waterbody information and history was collated via discussions with Council officers, correspondence and a review of existing reports.

The following information relevant to the management plan was collated:

- GIS information for the waterbody and catchment;
- Topographical survey including pipes, pits, pathways, services and vegetation; and
- Aquatic weed management approach.

2.1 BACKGROUND

Ululah Lagoons was originally a natural wetland system that was utilised by the local indigenous people. In the 19th century, European settlers to the Maryborough area constructed a large weir across the southern end of the wetland, thereby forming the large waterbody that exists today (Figure 2-1 and Figure 2-2). It is understood that the waterbody was initially used for water supply and recreational activities, however in more recent times, it has become a high profile regional waterbody, associated with passive recreation, tourism, and wetland habitat for a diverse range of native wildlife. The three smaller waterbodies upstream of the main Ululah Lagoon were not constructed until approximately 1990-1993.

The Ululah Lagoons waterbodies have a long history of water quality and aquatic weed problems. Occasional aquatic weed control and harvesting is undertaken to manage declared aquatic weeds, particularly *Salvinia molesta* and *Hygrophila costata*. *Cabomba caroliniana* is also present within the Ululah Lagoons system but is not subject to active control. Historic newspaper articles also indicate that Ululah Lagoons has experienced outbreaks of Water hyacinth, and numerous fish kills have occurred in response to poor water quality following flooding events.

The Maryborough community expects Council to provide a high level of service for the Ululah Lagoons system, with a keen desire for a high amenity waterbody associated with both Anzac Park and the Maryborough Golf Club.

Management of the waterbody to date has been largely reactive, focusing primarily on the maintenance of the waterbody edges and aquatic weed removal to preserve the amenity of the waterbodies. A large volume of accumulated sediment (approximately 1000 m^3) was also recently removed from the inlet area of Ululah Lagoon for drainage purposes.

Figure 2-1 Historical photo of Ululah Lagoons in 1916 showing dense growth of water lilies (sourced from www.pinterest.com.au).

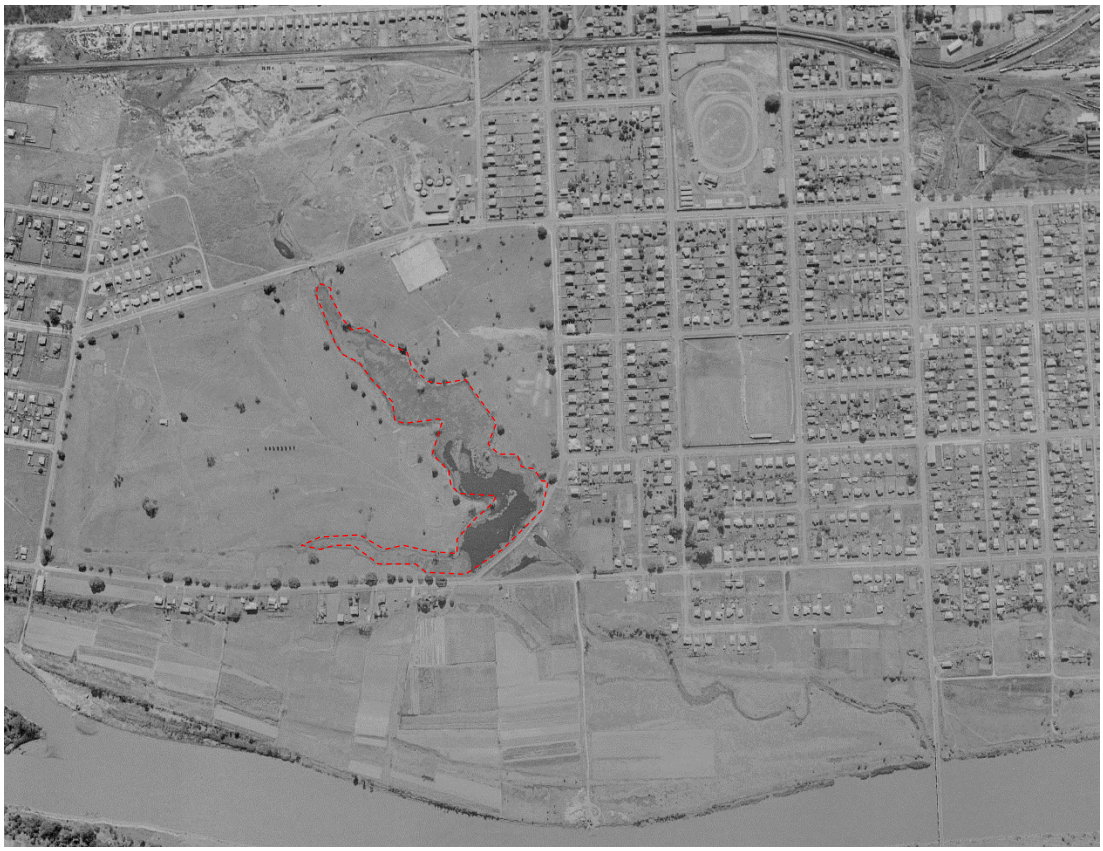


Figure 2-2. Aerial image from 1959 showing Ululah Lagoon. Waterbodies north of Alice are not yet constructed.

2.2 EXISTING CATCHMENTS

The Ululah Lagoons system comprises of four interconnected waterbodies (Figure 2-3). For the purpose of this WMP, the waterbodies have been identified as Waterbodies A to C, and Ululah Lagoon (main waterbody).

The Ululah Lagoons catchment area is approximately 228 ha and comprises of residential, parkland and industrial areas. Stormwater runoff from the surrounding sub-catchments enters the waterbody system

via stormwater inlets to Waterbodies A, C and Ululah Lagoon. Waterbody B only receives runoff from the adjacent parkland and inflows from Waterbody A. A summary of the sub-catchments areas is presented in Table 2-1.

Table 2-1 Sub-catchments draining into the Ululah Lagoons system.

Waterbody	Sub-catchments	Sub-catchment area (ha)
Waterbody A	2	73.1
Waterbody B	0	0
Waterbody C	1	91
Ululah Lagoon	4	64.5

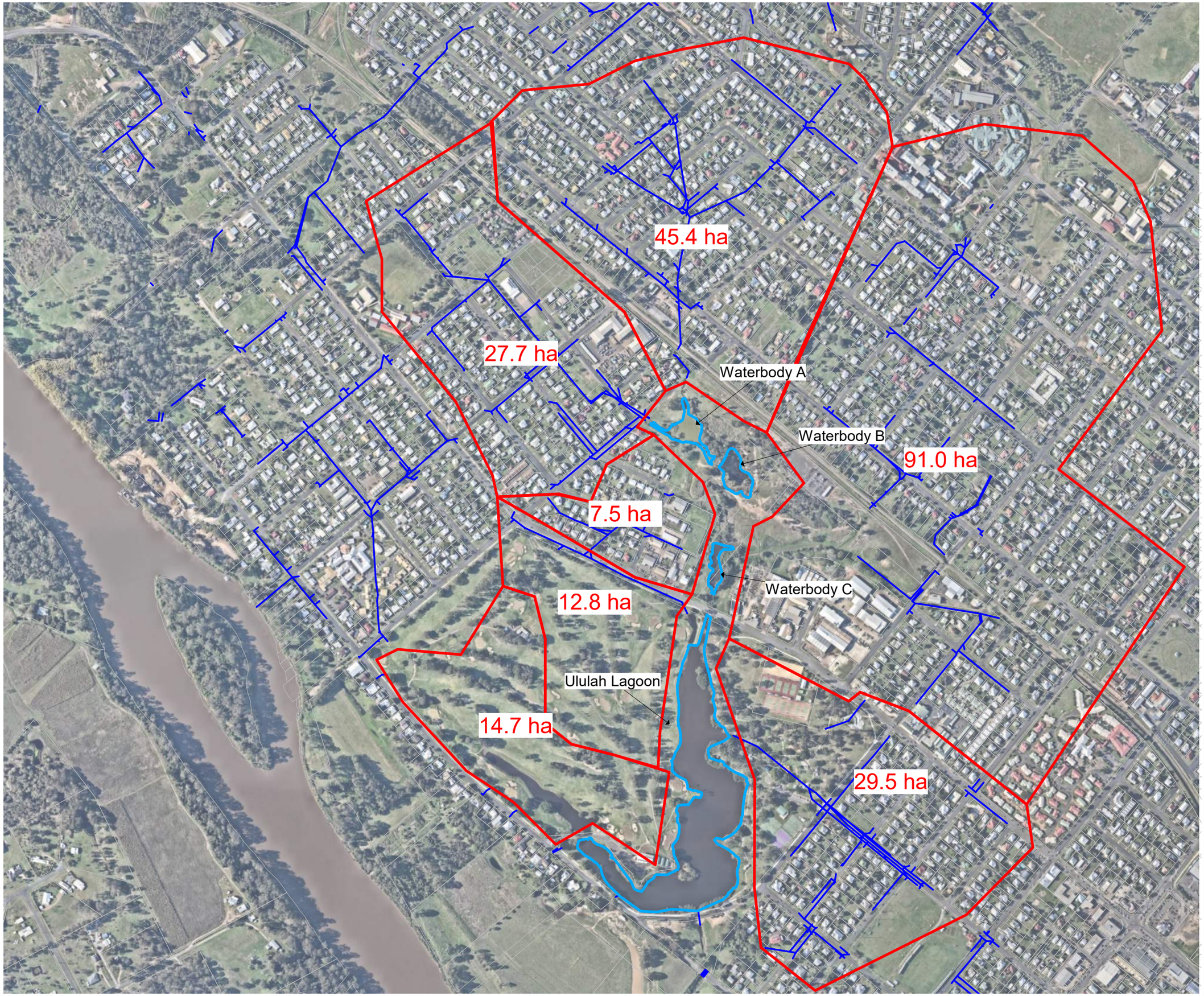
2.3 EXISTING DRAINAGE

Stormwater runoff enters Waterbody A via two inlets and flows towards Waterbody B. The connection between Waterbodies A and B is not well defined. An outlet channel runs between the two waterbodies, however the downstream end of the channel terminates in an earthen bund prior to Waterbody B. Water flowing into Waterbody A appears to backwater into an adjacent patch of Melaleuca, and it is likely that the water enters Waterbody B via informal channels within the Melaleucas (Figure 2-3). It is likely that flows from Waterbody A overtop the earthen bund and flow into Waterbody B during moderate rainfall events.

Overflows from Waterbody B are discharged into a drainage channel that meanders through EB Uhr Park and discharges into Waterbody C (Figure 2-3). Stormwater runoff from a large catchment enters Waterbody C from the east. Overflows from Waterbody C discharge over a concrete weir and enter the top of Ululah Lagoon.

Stormwater runoff enters Ululah Lagoon from sub-catchments adjacent to Alice St, Maryborough Golf Club, Anzac Park and a residential area to the east of Anzac Park. The water flows in a southerly direction through Ululah Lagoon and discharges from the waterbody via a circular (gloryhole) overflow weir. The water flows along a shallow drainage line and discharges into the Mary River.

The Ululah Lagoons system does not provide formal flood retention, however it is likely that restrictions associated with the Alice St Bridge and the Ululah Lagoons overflow function to partially retard large flood events.



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LEGEND

- Lake
- Property boundary
- Catchment boundary
- Existing stormwater pipe

0 75 150 300 m

Figure 2-1. Ululah Lagoon - System layout and sub-catchments

Ululah Lagoons Waterbody Management Plan

SCALE:	DATE:
1:7,500	19 February 2021

DesignFlow
PO Box 1250, Southport BC
7 Bauer St, Southport QLD 4215

For:
FCRC

2.4 WATERBODY BATHYMETRY

There is currently no bathymetric survey data available for the Ululah Lagoons system. Waterbodies A-C are shallow waterbodies, generally less than 1m depth. It is understood that the majority of Ululah Lagoon is shallow (generally less than 1m) grading to deeper sections (up to 5m depth) adjacent to the outlet.

Historical imagery indicates that the water levels within each of the waterbodies appears relatively stable, with minor fluctuations occurring in response to seasonal rainfall patterns. However, it is understood that the water level within Ululah Lagoons seasonally fluctuates, with the shallow submerged edges of the waterbody being exposed during extended dry periods.

2.5 INFORMAL STAKEHOLDER FEEDBACK

The following issues were identified through discussion with relevant Council officers and onsite maintenance staff having knowledge of the local system and exposure of previous community feedback and requests:

- Council is expected to provide a higher level of service for Ululah Lagoon, which is integral to both Anzac Park and the Golf Club, and a major tourist destination within the Maryborough region.
- The growth of aquatic plants, particularly the declared floating species, *Salvinia molesta*, is an ongoing management issue for Council.
- Access for Council's weed harvester is not considered to be an issue, and all waterbodies are readily accessible.
- The upper end of Ululah Lagoon is subject to sediment accumulation and has been previously dredged.
- Fish kills have occurred several times within Ululah Lagoon, generally following flooding events.
- Requests for dredging generally follow the occurrence of fish kills, and the exposure of bank edges during prolonged seasonal dry periods.
- Dredging has generally not been supported to date due to being unviable (i.e. high cost) and potentially detrimental to waterbody health, but is expected to be further informed by the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021) and this Plan.
- No water is permitted to be extracted from Ululah Lagoons for irrigation of Anzac Park or surrounding areas, including the Golf Club.
- The Golf Club maintains the waterbody edges adjacent to the golf course, however it is understood that Council controls the *Hygrophila costata* growing along the golf course edge.
- Council Officers expressed a desire to achieve a healthy and robust waterbody system through the establishment and maintenance of native aquatic and riparian vegetation.

3 FIELD ASSESSMENT

A field assessment of the Ululah Lagoons system was conducted by DesignFlow on the 3rd December 2018 and 21st May 2019. A summary of the field assessment findings and scores for each waterbody are provided in the Table 3-1 and Table 3-2. Photographs from the site inspections are provided in Figure 3-1 through Figure 3-5.

Table 3-1 Waterbodies A-C - Field condition assessment summary.

	Performance Indicator	Rating	Comments
Public Health & Safety	Risk of injury or drowning	1	• No public health & safety issues identified.
	Batter slopes	1	
	Fencing/barriers	1	
	Contaminated Water	1	
	Mosquitoes	1	
	Overall condition score	**1**	
	Overall condition rating	**Good**	
Hydraulic Function	Inlet condition	2	• Waterbody A inlet channels backwatered. • Waterbody A overtops bund into Waterbody B. • Weir below Waterbody C is damaged and leaking. • Long residence times in all three waterbodies during the dry season. • Waterbody B is shallow and filled via overflows from Waterbody A. • Water level in Waterbody C lower than overflow weir due to leakage. • Notable sediment accumulation present in Waterbody C.
	Outlet condition	3	
	Other structures	-	
	Flushing/Residence Time	4	
	Water Levels	2	
	Stability of batters and bunds	1	
	Sediment accumulation	3	
	Overall condition score	**2.5**	
	Overall condition rating	**Poor**	
Water Quality	Odours	1	• Water in Waterbody A and C turbid due to suspended solids.
	Algae/Cyanobacteria	1	
	Turbidity	3	
	Litter/debris	1	
	Overall condition score	**1.5**	
	Overall condition rating	**Adequate**	
Aquatic habitat	Aquatic vegetation - emergent	3	• Isolated patches of emergent waterplants present along the margins of the waterbodies. • No native submerged waterplants present in the waterbodies. • No native floating waterplants present. • Declared weed *Cabomba caroliniana* (submerged waterplant) present within Waterbodies A and B. • Declared weed *Salvinia molesta* (floating waterplant) present within all waterbodies. • Margins of waterbodies with notable cover of introduced grass species (Guinea grass),
	Aquatic vegetation - submerged	4	
	Aquatic vegetation - floating	1	
	Aquatic weeds - declared	4	
	Aquatic weeds – non-declared	3	
	Aquatic fauna and pests	1	
	Filamentous algae	**1**	
	Overall condition score	2.4	
	Overall condition rating	**Adequate**	
Terrestrial habitat	Edge vegetation condition	2	• Edges of waterbodies generally with dense vegetation cover comprising a mix of native and introduced species. • Declared Broad-leaved Pepper trees present in several locations. • Waterbody edges dominated by introduced grasses (i.e. Para and Guinea grass) in several locations. • Other weeds present include Cockspur Coral tree.
	Terrestrial weeds – declared	1	
	Terrestrial weeds – non-declared	2	
	Overall condition score	**1.7**	
	Overall condition rating	**Adequate**	
Maintenance Access	Access to waterbody reserve	1	• Access to water surface in Waterbodies A and B via batters (i.e. no formal ramp). • Limited access to water surface in Waterbody C.
	Access to waterbody margin	2	
	Access to water surface	3	
	Overall condition score	**2**	
	Overall condition rating	**Adequate**	

Overall condition rating based on: Good <1.5, Adequate 1.5-2.5, Poor 2.5-3.5, Very Poor >3.5.

Table 3-2 Ululah Lagoons - Field condition assessment summary.

	Performance Indicator	Rating	Comments
Public Health & Safety	Risk of injury or drowning Batter slopes Fencing/barriers Contaminated Water Mosquitoes **Overall condition score** **Overall condition rating**	3 2 3 3 1 **2.4** **Adequate**	• Steep edges present adjacent to deep water areas. • Steep batter slopes present including partially submerged concrete revetment which has collapsed at one end. • Rail fencing present on embankment near the waterbody outlet. • Fencing or passive barriers required adjacent to high risk areas. • High algal biomass present in waterbody. • Presence of large waterbird population likely to be contributing faecal matter to the waterbody.
Hydraulic Function	Inlet condition Outlet condition Other structures Flushing/Residence Time Water Levels Stability of batters and bunds Sediment accumulation **Overall condition score** **Overall condition rating**	3 2 - 3 1 3 2 **2.3** **Adequate**	• Inlet channel to waterbody below the Alice St bridge appears to be an eroded channel. • Waterway above the Alice St bridge incised up to weir below Waterway C. • Submerged culverts under Alice St may be partially blocked with sediment. • Waterbody outlet (glory hole weir) is leaking through the walls. Minor damage to weir crest. • Waterbody residence times likely to be very high. • Several backwater areas present including enclosed lagoons near waterbody inlet, waterbody edges and around Papyrus 'islands'. • Minor erosion present around the waterbody edges, particularly along Golf Course edges. • Accumulated sediment likely to be present throughout the waterbody.
Water Quality	Odours Algae/Cyanobacteria Turbidity Litter/debris **Overall condition score** **Overall condition rating**	1 3 3 1 **2** **Adequate**	• Visible algal biomass present within the water column. • Water column notably turbid due to combination of algal biomass and suspended solids.
Aquatic habitat	Aquatic vegetation - emergent Aquatic vegetation - submerged Aquatic vegetation - floating Aquatic weeds - declared Aquatic weeds – non-declared Aquatic fauna and pests Filamentous algae **Overall condition score** **Overall condition rating**	4 4 1 2 2 3 1 **2** **Adequate**	• No native emergent or submerged water plants present within the waterbody. • Lemna sp. observed floating on the surface of the enclosed lagoons near waterbody inlet. • Declared water plant species – *Salvinia molesta* and *Hygrophila costata* present within the waterbody. *Cabomba caroliniana* also likely to be present but not observed due to high turbidity. • Large stands of Cyperus papyrus present adjacent to Anzac Park. • Large permanent waterbird population present including: Ibis, Egrets, Cormorants, Darters, Spoonbills, native and introduced Ducks and Coots.
Terrestrial habitat	Edge vegetation condition Terrestrial weeds – declared Terrestrial weeds – non-declared **Overall condition score** **Overall condition rating**	3 3 2 **2.7** **Poor**	• Riparian vegetation cover generally very poor around the waterbody margins. • Batters dominated by grasses and weed species. • Large trees with dense canopy present in some areas. • Broad-leaved Pepper trees present around the waterbody margins. • Other notable weed species present include Cockspur Coral tree. •
Maintenance Access	Access to waterbody reserve Access to waterbody margin Access to water surface **Overall condition score** **Overall condition rating**	1 2 2 **1.7** **Adequate**	• The majority of the Ululah Lagoons can be accessed via Anzac Park and Maryborough Golf Club. • No formal access to the water surface present. Harvester access possible from most margins of the waterbody.

Overall condition rating based on: Good <1.5, Adequate 1.5-2.5, Poor 2.5-3.5, Very Poor >3.5.

Figure 3-1 Waterbody A – a) Main waterbody, and b) Channel connecting Waterbodies A and B.

Figure 3-2 Waterbody B – a) Main waterbody, and b) Overflow weir and outlet channel.

Figure 3-3 Waterbody C – a) Overflow weir, and b) Shallow waterbody upstream from the overflow weir.

Figure 3-4 Ululah Lagoons – a) Inlet channel below Alice St, and b) Enclosed lagoons within the golf course adjacent to waterbody inlet.

Figure 3-5 Ululah Lagoons – a) Main waterbody, and b) Buffer zone along edge adjacent to Anzac Park.

4 ISSUES IDENTIFICATION AND PRIORITISATION

Following the condition assessment, the range of waterbody management issues were identified and prioritised.

Priority issues (high–medium) identified for the Ululah Lagoons system include:

- Public safety
- Water quality
- Aquatic vegetation
- Aquatic weeds
- Waterbody edge stability
- Waterbody residence times

4.1 IDENTIFY ISSUES

The following sub-sections provide a summary of the management issues associated the Ululah Lagoons system.

4.1.1 Public safety (Batter slopes)

The majority of the batter slopes throughout the Ululah Lagoons system are generally less than 1V:3H, and in most cases, the presence of shallow water adjacent to the waterbody edge renders the edges relatively safe as there is low drowning risk.

Sections of the batter slopes along the eastern side of Ululah Lagoons (adjacent to Anzac Park) are extremely steep, do not have a vegetated buffer zone and are considered to be a potential public safety risk. In most areas, shallow water along the waterbody edge renders the risk low, however there are a number of sections where the steep batters transition into deeper water and the potential risk is higher.

Some edges within Ululah Lagoon, comprise of sharp drop offs into deep water, and represent an increased risk of drowning should someone accidentally enter the water. This includes the upper section of Ululah Lagoons on either side Alice St where the waterbody is channelised.

Areas of Ululah Lagoons that have batter slopes steeper than 1:3 are considered a potential safety risk due to:

- The high risk of unintentional water entry
- Exiting the water can be difficult due to the batter slope
- The presence of drop offs/vertical edges at the base of the batter slope makes exiting more difficult
- The presence of deep water and steep batter slope increases drowning risk substantially

The edges in south-east corner of Ululah Lagoon comprise of concrete revetments which slope from the mown grassed edge into the water to approximately 0.4-0.5 m depth (Figure 4-1). In several locations, the concrete revetment has collapsed resulting in a steeper entry into the water (1:1-1:2 in some locations). Where this has occurred, the revetment slope and presence of deep water would make exiting the waterbody difficult.

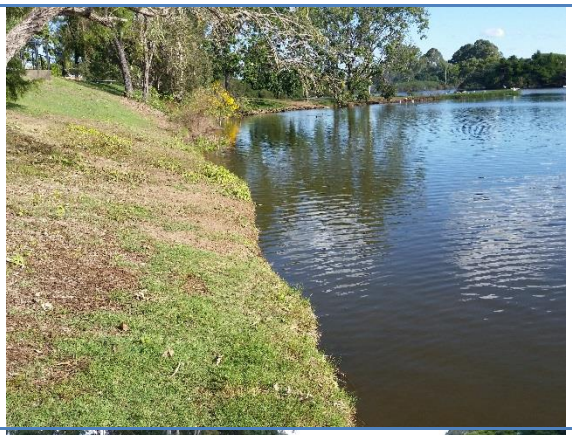
Figure 4-1 Concrete revetment in the SE corner of Ululah Lagoon: a) Main section, and b) Collapsed section towards the northern end.

The edges of Ululah Lagoon adjacent to the golf course varies from gentle grassed slopes to sharp-vertical drop-offs. The majority of the golf course edges have been stabilised with rock beaching and a submerged bench is present in most areas.

The deepest section of Ululah Lagoon is located adjacent to the overflow weir at the southern end of the waterbody. The batter slopes in this section of the waterbody are generally steeper than 1:4 slope, however the presence of dense buffer vegetation on the batters effectively prevents unintentional water access.

A summary of the common batter slope/waterbody edge profiles and associated safety risks are presented in Table 4-1. Unsafe edges are mapped for Ululah Lagoon in Figure 4-13 (yellow edges).

Table 4-1 Waterbody edge profiles within Ululah Lagoon.

Edge Type	Comments/notes	Photo
Gentle batter +/- sharp drop off into shallow water	Generally >1:3 batter slope, mown grassed edge +/- sharp drop off into shallow (<0.3m) water. Moderate risk but shallow depth of water means exiting is fine. Safe	
Gentle batter +/- sharp drop off into deep water	Generally >1:3 batter slope, mown grassed edge +/- sharp drop off into deep (>0.3m) water. High risk as deep depth of water means exiting may be difficult. Potentially Hazardous	
Steep batter +/- sharp drop off shallow water	Generally <1:3 batter slope, +/- sharp drop off into shallow (<0.3m) depth water. Moderate risk but steep batter slope may make it very difficult to exit the water (and easy to fall back in). High drowning risk Potentially Hazardous	
Steep batter +/- sharp drop off deep water	Generally <1:3 batter slope, +/- sharp drop off into deep (>0.3m) water. High risk as steep batter slope and deep depth of water means exiting is extremely difficult (and easy to fall back in). High drowning risk Hazardous	

4.1.2 Waterbody edge stability

The majority of the waterbody edges/lower batters have good vegetation cover and are stable. The edges of Waterbodies A-C are well vegetated with a mix of groundcovers (i.e. grasses), shrubs and trees, and a minimum 1.5-2 m vegetated buffer zone is generally present in public accessible areas.

The majority of the publicly accessible edges in Ululah Lagoons (adjacent to Anzac Park), comprise of either mown grass or a vegetated buffer. In most locations, wave action or waterbird activity has resulted in minor scour and the development of shallow vertical edges (Figure 4-2). These edges are relatively stable but are susceptible to further instability due the presence of the bare soils along the exposed edges.

The waterbody edges adjacent to the golf course are grassed and vary in slope from a gentle batter slope to the water's edge to steep vertical drop-offs. The presence of rock protection below the water surface in most cases renders the edges reasonably safe. There are several sections where localised erosion of the waterbody edge has occurred resulting in slumping and the creation of vertical edges Figure 4-3.

Figure 4-2 Minor scour present below grassed edges creating shallow vertical edge.

Figure 4-3 Localised edge erosion occurring adjacent to the golf course near the inlet to Ululah Lagoon.

4.1.3 Water quality

No water quality data is readily available for Ululah Lagoons so the following section is based upon observations made during the site inspections and discussions with Council staff.

Nutrients:

It is likely that high nutrient concentrations are present within each of the waterbodies based on the growth of floating waterplants (i.e. Salvinia) and the visible algal biomass within Ululah Lagoon.

Catchment runoff is likely to comprise the primary source of nutrient loads into the Ululah Lagoons system. Both surface runoff and shallow groundwater discharge from the golf course is also likely to contribute significant nutrient loads into Ululah Lagoons. Inputs of faecal matter associated with the large waterbird population in Ululah Lagoons is also likely to contribute to the overall nutrient load.

Algal biomass:

Planktonic algal biomass was visible in Ululah Lagoons during the 2018 and 2019 waterbody condition assessments. The presence of algal biomass indicates that there are high nutrient concentrations present throughout the waterbody.

Algal growth within urban waterbodies is stimulated by nutrients, water temperature and light. Healthy, robust, shallow waterbodies generally have high submerged and emergent waterplant cover. Waterplants, and in particular submerged species, aggressively compete with algae for nutrient resources, such as phosphorus, and help to maintain low turbidity in shallow waterbody systems. Waterbodies with high waterplant cover are generally able to withstand moderate increases in nutrient levels and turbidity, however, a threshold exists whereby the submerged waterplants are unable to access sufficient light resources to survive the plant population crashes. This may be due to excessive turbidity (i.e. via stormwater runoff) or the growth of floating waterplants (i.e. Azolla or Salvinia). The loss of submerged plants is rapid and catastrophic, and results in a transition from a clear water waterplant dominated state to either an algal or floating waterplant state. This is referred to as the 'alternative states model' and is a scientific model often used to interpret and understand shallow waterbody function (Figure 4-4).

Catchment inputs:

The Ululah Lagoons' 228 ha contributing catchment includes low density residential and some industrial land uses. Stormwater runoff from these land uses areas will deliver pollutants into the waterbodies in the form of nutrients, sediments and other contaminants (i.e. associated with roads etc). These catchment inputs over time result in the accumulation of pollutants and deterioration of waterbody health.

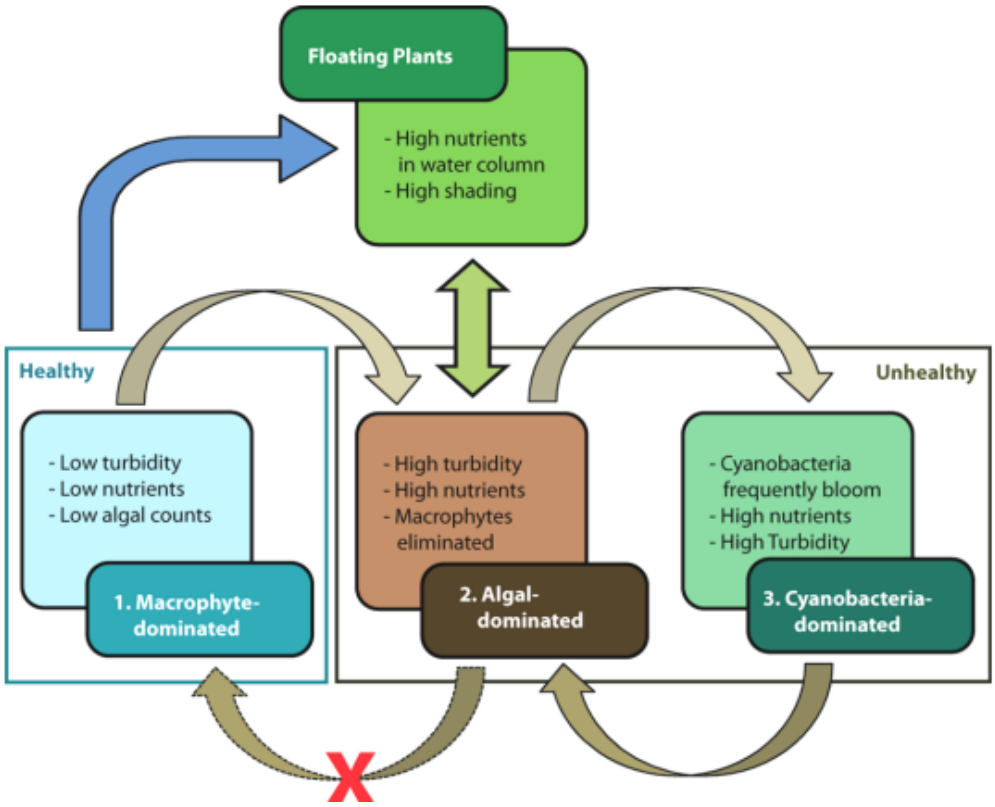


Figure 4-4 Alternative states model used to interpret shallow waterbody function.

4.1.4 Waterbirds (Faecal contamination)

Ululah Lagoon is home to a diverse assemblage of waterbirds including: Ibis, Egrets, Cormorants, Darters, Spoonbills, Black Swans, Pelicans, native and introduced Ducks, Purple Swamp Hens and Coots.

A potential public health risk is associated with contact with waterbird faecal matter present within the water and edges of Ululah Lagoon, particularly adjacent to the roosting/rookery areas and bird feeding areas.

Areas within the Anzac Park where waterbirds congregate (i.e. public feeding areas) are likely to represent a higher health risk, as there is generally higher deposition of bird faeces in these areas.

Observations during the site inspections indicated that the waterbirds are being regularly fed throughout the day within the park (Figure 4-5). Public feeding of the waterbirds in Anzac Park is currently promoted by Council as indicated by the roadside signs located within Alice St (Figure 4-6).

Ibis and Egret rookeries are present within Anzac Park and the island adjacent to the Golf Clubhouse (Figure 4-7). The presence of the rookeries is related to tree habitat located adjacent to or overhanging the water.

The size of the waterbird population in Ululah Lagoon appears to reflect the feeding regime occurring within Anzac Park, and not necessarily the quantity and quality of habitat and food resources present within the waterbody. The regular supply of food sustains higher numbers of birds than would naturally be present within the waterbody system, and is potentially impacting waterbody health via bird faeces and organic material (e.g. egg shells, feathers, food scraps etc.) entering the system.

The presence of the large waterbird population within Ululah Lagoon potentially impacts upon:

- **Water quality** – Bird faeces entering the waterbody is likely to contribute a significant nutrient load and promote the growth of algae and floating water plants.
- **Public safety** – The large volume of bird faeces present represents a potential public health risk from direct exposure to excreta or indirect exposure to waters contaminated by faeces or associated algal blooms.
- **Public amenity** – Many of the grassed around the waterbodies are used by the birds for loafing and are generally covered by excreta resulting in smell and reduced amenity.

Figure 4-5 Bird feeding within Anzac Park, particularly around public seating areas, represent a potential public health risk.

Figure 4-6 Information sign on Alice St promoting the feeding of waterbirds within Anzac Park.

Figure 4-7 Ibis rookery present on the island adjacent to the Golf Clubhouse.

4.1.5 Aquatic plant management

Declared weeds - A number of declared aquatic weeds were observed during the waterbody condition audit including: *Salvinia molesta*, *Cabomba caroliana* and *Hygrophila costata*. A declared terrestrial species, Broad-leaved Pepper tree, was also observed growing throughout the Ululah Lagoons system. Discussion with Council staff and a review of historical aerial imagery indicates that growth of Salvinia regularly occurs within all of the waterbodies, and is an ongoing management issue (Figure 4-8).

Figure 4-8 Historical aerial imagery indicating Salvinia blooms present within Ululah Lagoons in: a) 2010, and b) 2019.

Salvinia is mechanically removed from Waterbody A using Council's aquatic weed harvester, however Salvinia growth in Waterbodies B and C is sprayed with herbicide due to the shallow water depths present. Salvinia is also sprayed in Ululah Lagoons due to issues operating the Council harvester in shallow depths near the waterbody inlet. A floating boom is also placed across the centre of Ululah Lagoons to isolate the floating plants to one end of the waterbody.

It is likely that the growth of Salvinia with the Ululah Lagoons waterbodies is stimulated by both nutrients and water temperature. Backwater areas present throughout the waterbodies harbour Salvinia in between growth events, thereby providing an ongoing source of vegetative material. Backwater areas present include:

- Melaleuca swamp between Waterbodies A and B
- Waterbody C
- Inlet channel areas to Ululah Lagoons (upstream and downstream of Alice St)
- Enclosed lagoons in the golf course (adjacent to the Ululah Lagoons inlet area)
- Areas associated with the *C. papyrus* stands within Ululah Lagoon
- Backwater/inlet areas within Ululah Lagoon

It is understood that Hygrophila growth around the margins of Ululah Lagoons is chemically controlled. There is currently no active control of Cabomba or Broad-leaved Pepper tree being implemented within the Ululah Lagoons system.

4.1.6 Aquatic vegetation

Waterplant communities within the Ululah Lagoons system comprise of isolated patches of emergent waterplants along the waterbody edges (mainly *Phragmites australis* and Typha sp.), and widespread cover of submerged waterplant, *Cabomba caroliniana* (declared weed), within Waterbodies A and B. No submerged waterplants were observed in Waterbody C or Ululah Lagoon, although it highly likely that Cabomba is also growing in both. No native emergent waterplant species were observed in Ululah Lagoon, although there are several large patches of *Cyperus papyrus* (introduced) present adjacent to Anzac Park, and widespread growth of *Hygrophila costata* (declared weed) along the golf course waterbody edge.

The presence of dense waterplant communities, particularly submerged waterplants, provides competition for bio-available nutrients and assists with the removal of suspended solids. It can be seen in the conceptual model outlined in Figure 4-4 that the absence of waterplants leads to a turbid waterbody dominated by either floating waterplants or algae. In the case of Ululah Lagoon, the waterbody has transitioned to a state dominated by floating waterplants (i.e. Salvinia) and algae, where the presence of turbid water and deep submerged edges prevents waterplants from re-establishing within the waterbody.

Emergent waterplants are also important as the biofilms growing on the plant stems and the plants themselves aggressively compete for nutrients within the water column. Emergent water plants are also important for stabilising the waterbody edges, preventing erosion and the introduction of suspended solids to the waterbodies.

The distribution of emergent waterplants throughout the Ululah Lagoons system is extremely patchy. The reasons for sparse emergent waterplant cover are not clear but may be due to:

- waterbird grazing
- active erosion
- root disturbance by fish
- lack of waterplant recruitment
- steep to vertical batters
- deep water at the waterbody edges
- herbicide overspray (when treating Salvinia outbreaks)

Figure 4-9 Examples of emergent waterplants growing on the edges of Ululah Lagoons system: a) Typha sp. (foreground) *Phragmites australis* (background), and b) *Cyperus papyrus*.

4.1.7 Hydraulic retention times and mixing

The Ululah Lagoons system is characterised by high residence times and areas with poor flushing. The waterbody residence times are dependent upon seasonal rainfall patterns. Residence times are shorter during the wet season when stormwater inflows flush the waterbodies, and longer during the dry season due to the lack of inflows.

Long residence times during the dry season combined with areas of the waterbodies with moderate depth (i.e. >2m) is likely to facilitate the development of stratified conditions. Stratification of the water column is important to understand as it can lead to the development of an anoxic hypolimnion (bottom layer of water) and the subsequent release of nutrients from the waterbody sediments. The release of nutrients due to stratification is often associated with the development of algal biomass and the excessive growth of aquatic weeds (Figure 4-4).

Long residence times combined with warmer water temperatures, such as the start and end of the dry season, can also stimulate the breakdown of organic material within the base of the waterbodies, resulting in similar conditions to stratification. This can also lead to the release of nutrients into the water column. The presence of stratified conditions followed by mixing of the waterbody can also lead to fish kills due to low oxygen concentrations within the water column.

Backwater areas within the waterbodies often have longer residence times as they are poorly flushed. Backwater areas often appear stagnant and are associated with the accumulation and decomposition of organic material. Poorly flushed areas combined with nutrient release from the sediments often results in ideal conditions for incubating algae and floating water weeds. This clearly occurs within the Ululah Lagoons system, particularly in Waterbodies A and B, where stagnant backwater areas provide ideal conditions for Salvinia incubation and growth. Several backwater areas are also present in Ululah Lagoons where Salvinia growth can occur. This includes the enclosed lagoons within the golf course adjacent to the waterbody inlet, inlet channel areas upstream and downstream of Alice St, and areas associated with the large stands of Papyrus within Ululah Lagoons (Figure 4-11).

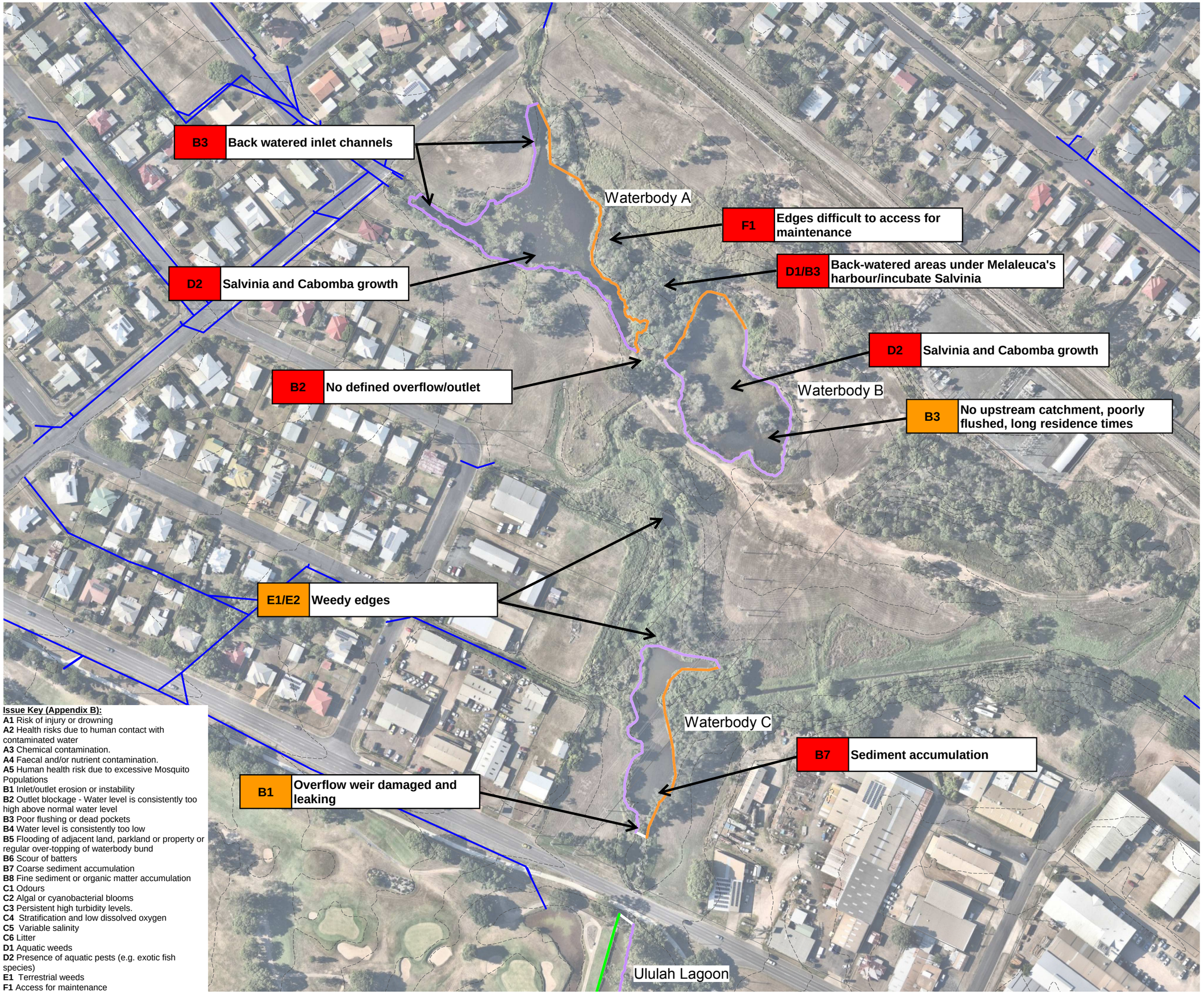
Figure 4-10 Backwater areas present within: a) Waterbody A, and b) Waterbody B

Figure 4-11 Backwater areas present within Ululah Lagoon: a) Enclosed lagoons within the golf course, and b) Areas within and adjacent to the Papyrus stands (act as incubators for algae and floating waterplants).

4.2 PRIORITISE ISSUES

The waterbody management issues identified above have been mapped and prioritised for each waterbody (refer Figure 4-12 and Figure 4-13). Issues have been prioritised based on the rating system developed in the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021). Each waterbody issue has been prioritised as either:

- High – Issue is currently management risk to Council, health and safety or environment that requires addressing.
- Medium - Issue is a minor management risk to Council, health and safety or environment but has the potential to become a High priority in future if not managed.
- Low – Not currently a management risk to Council and unlikely to become issue in near future.



Issue Key (Appendix B):

A1 Risk of injury or drowning
A2 Health risks due to human contact with contaminated water
A3 Chemical contamination.
A4 Faecal and/or nutrient contamination.
A5 Human health risk due to excessive Mosquito Populations
B1 Inlet/outlet erosion or instability
B2 Outlet blockage - Water level is consistently too high above normal water level
B3 Poor flushing or dead pockets
B4 Water level is consistently too low
B5 Flooding of adjacent land, parkland or property or regular over-topping of waterbody bund
B6 Scour of batters
B7 Coarse sediment accumulation
B8 Fine sediment or organic matter accumulation
C1 Odours
C2 Algal or cyanobacterial blooms
C3 Persistent high turbidity levels.
C4 Stratification and low dissolved oxygen
C5 Variable salinity
C6 Litter
D1 Aquatic weeds
D2 Presence of aquatic pests (e.g. exotic fish species)
E1 Terrestrial weeds
F1 Access for maintenance

DesignFlow

LEGEND

- Property boundary
- Existing stormwater pipe
- 1m contours
- Grassed edge, steep batter, sharp drop-off
- Grassed edge, mown
- Vegetated buffer (unmown)
- Overhanging vegetation (native & introduced)
- Edge dominated by over hanging Broadleaf Pepper Tree
- High priority issue
- Medium priority issue

0 20 40 80 m

Figure 4-12.
Waterbody A to C issues plan

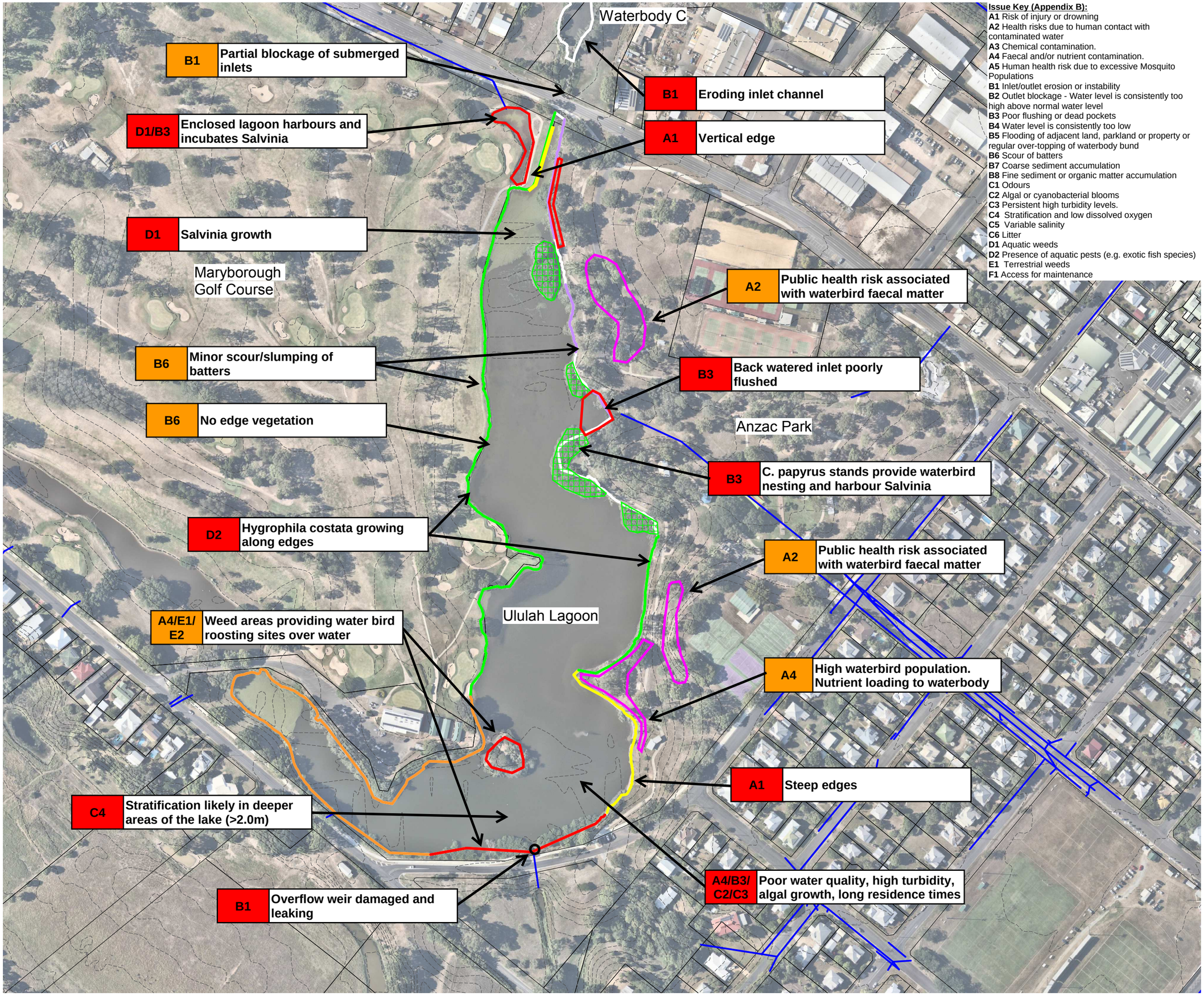
Ululah Lagoon Waterbody Management Plan

SCALE: 1:2,000

DATE: 18 February 2021

DesignFlow
PO Box 1250, Southport BC
7 Bauer St, Southport QLD 4215

For:
FCRC



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B5 Flooding of adjacent land, parkland or property or regular over-topping of waterbody bund
B6 Scour of batters
B7 Coarse sediment accumulation
B8 Fine sediment or organic matter accumulation
C1 Odours
C2 Algal or cyanobacterial blooms
C3 Persistent high turbidity levels.
C4 Stratification and low dissolved oxygen
C5 Variable salinity
C6 Litter
D1 Aquatic weeds
D2 Presence of aquatic pests (e.g. exotic fish species)
E1 Terrestrial weeds
F1 Access for maintenance

DesignFlow

LEGEND

- Property boundary
- Existing stormwater pipe
- 1m contours
- Grassed edge, steep batter, sharp drop-off
- Grassed edge, mown
- Vegetated buffer (unmown)
- Overhanging vegetation (native & introduced)
- Edge dominated by over hanging Broadleaf Pepper Tree
- *High use bird feeding or roosting area*
- *Cyperus papyrus* stand
- High priority issue
- Medium priority issue

0 30 60 120 m

Figure 4-13.
Ululah Lagoon Issues Plan

Ululah Lagoon Waterbody Management Plan

SCALE: 1:3,000

DATE: 18 February 2021

DesignFlow
PO Box 1250, Southport BC
7 Bauer St, Southport QLD 4215

For:
FCRC

5 IDENTIFY MANAGEMENT ACTIONS

5.1 IDENTIFYING MANAGEMENT ACTIONS

The following section provides discussion of the range of management actions proposed to address the identified issues in **Section 4**.

5.1.1 Public safety (Batter slopes)

Undertake detailed batter safety risk assessment: A detailed batter safety risk assessment should be conducted to review safety around waterbodies to both the public and for Council workers. The field condition assessment identified some areas around Ululah Lagoons where steep batters lead directly into deep water, and where a potential drowning risk is present. A detailed audit is required to investigate all of the waterbody edges, including the Golf Club, to assess high risk locations where intervention is required to manage public safety risk and minimise the risk of persons falling into the waterbodies.

It is expected that an outcome of the safety risk assessment will be a staged plan for rectifying high risk waterbody edges. Actions may include:

- Establishing vegetated buffers (e.g. in key locations to create physical barriers to open water)
- Fencing high risk areas (e.g. where vegetation buffers are not practical)
- Re-profiling and stabilising batter slopes

5.1.2 Waterbody edge stability

Assess and Stabilise waterbody Edges: Scoured batters and edges, particularly vertical edges, need to be assessed to determine whether they are stable or require rectification. The management of unstable edges will involve:

- Stabilising and re-enforcing eroded areas with rock protection and benching.
- Replacing topsoil and re-establishing vegetation cover.

Establish vegetated buffers: A minimum 1.5m vegetated buffer strip should be established around the margins of the waterbodies. This will involve:

- Establishing grassed buffer strips in mowed areas, or
- Dense groundcover or shrub buffers, or
- On unstable edge/batters or areas with poor or no batter vegetation cover:
    - Removing terrestrial weeds
    - Re-establishing native vegetation cover (including the use of Bacopa monnieri and Leersia hexandra stabilise the waterbody edge/batter interface)

5.1.3 Water quality

The following actions should be considered to improve the water quality within the Ululah Lagoons system.

Catchment Management and Stormwater treatment: Develop and implement a catchment based stormwater quality treatment strategy to reduce nutrient and sediment loads discharged to the Ululah Lagoons system. The majority of stormwater runoff entering the waterbodies is untreated, and therefore the waterbodies are continuously subject to nutrient and suspended solids inputs.

Reduce Sediment Loads entering Ululah Lagoon: Provide dedicated sediment capture and removal location upstream of Ululah Lagoon. This can be achieved by creating a dedicated sediment removal area within Waterbody C via:

- Repair leaking overflow weir to maintain permanent water level.
- Remove accumulated sediments to provide formal sediment storage volume.
- Construct formal maintenance access ramp to enable future sediment removal.
- Re-vegetate the batters with riparian groundcovers.

Nutrient Management: Potential actions to reduce nutrient loads within the waterbodies:

- Improving stormwater runoff quality before entering the waterbodies (see above)
- Establishing native waterplants throughout Ululah Lagoons system. Refer to Section 5.1.6.
- Reduce nuisance waterbird populations. Refer to Section 5.1.4.
- Converting a section of Ululah Lagoons into a water quality treatment wetland combined with a waterbody recirculation system. Refer to Section 5.1.8.

General Waterbody Condition Monitoring: To assist in gauging the general condition of the waterbodies over time it is suggested that a regular condition assessments are undertaken for the Ululah Lagoons system. A suggested monitoring frequency is bi-annually (or in response to a specific issue) using the Field Condition Assessment Form in Appendix A. Ideally this would involve an assessment late-spring and late-summer where waterbody condition may be in decline and management responses may be required.

Decline in performance indicators from visual inspections, or other triggers may prompt water quality testing, where warranted, for example in response to a fish kill (refer Appendix C for discussion of triggers for monitoring).

5.1.4 Waterbird management (Faecal contamination)

Development of a bird management plan: Management of the waterbird population within Ululah Lagoons is crucial to managing public health risks and the long term health of the waterbody. It is recommended that a Bird Management Plan be developed to detail how the resident bird population will be managed. The management plan should focus upon reducing the overall waterbird population numbers through restricted waterbird feeding and managing the potential human health risk associated with faecal contamination of publicly accessible areas.

The following recommendations for managing the waterbird population at Ululah Lagoons are proposed. These actions aim to: a) reduce the overall waterbird population numbers, and b) promote waterbird diversity within the Ululah Lagoons system.

- Remove or modify the signage present on Alice St which promotes waterbird feeding areas within Anzac Park.
- Install signage in the primary bird feeding areas to discourage feeding. An example of signage that could be erected in these areas is illustrated in Figure 5-1.
- Implementing phased removal of Broad-leaved Pepper trees from the margins of the Ululah Lagoons system (and island) will effectively reduce waterbird nesting habitat. Where practical, Broad-leaved Pepper trees should be replaced with native tree species with low nesting habitat potential such as Melaleucas and Eucalypts.

- Establish vegetated barriers to prevent the waterbirds from accessing the main feeding areas within Anzac Park and to limit roosting and loafing areas within Anzac Park.
- Creating a diversity of habitat within and around Ululah Lagoons to promote waterbird diversity (rather than large numbers of a limited number of species). This could be achieved by:
    - Lowering the permanent water level to create shallow areas for foraging.
    - Establishing native waterplants and riparian species along the edges of the waterbody.
    - Installing permanent habitat structures such as large dead trees in selected areas of the waterbody.
    - Installing nesting boxes/platforms.

Figure 5-1 Example of direct-education message approach.

5.1.5 Aquatic weed management

The following declared aquatic weeds were observed during the waterbody condition assessment:

- *Salvinia molesta* (A, B, C and Ululah Lagoon)
- *Cabomba caroliniana* (A, B and Ululah Lagoon)
- *Hygrophila costata* (Ululah Lagoon)

Salvinia molesta

The growth of Salvinia represents a management issue that requires ongoing Council funding and resources. It is recommended that a long term strategy is developed to control Salvinia growth within the Ululah Lagoons system. The strategy should adopt a multi-faceted approach to controlling Salvinia growth including:

- Removal of Salvinia harbouring habitat (i.e. shallow backwater areas);
- Reduction in the nutrient concentrations within the waterbodies; and
- Continuation of chemical and physical control (as per current program).

The following rectification actions are proposed to manage Salvinia growth within the respective waterbodies:

Waterbody A:

- Lower the permanent water level between 100-200mm to reduce backwatering within the flooded Melaleuca areas (adjacent to the waterbody). This will remove Salvinia harbour habitat (areas where the Salvinia cannot be accessed by current Council control methods and where Salvinia incubates prior to major growth events).
- Remove the small islands within Waterbody A to enable the Council weed harvester to access all areas of the waterbody.
- Construct a weir across the head of the Waterbody A outlet channel. This will set the normal water level within Waterbody A.
- Where required, infill, re-profile and revegetate Waterbody A edges to prevent water entry to potential backwater areas (Melaleucas). This will enable any Salvinia growth that occurs within Waterbody A to be accessed by Council's weed harvester/contractors.
- Construct a channel between the Waterbody A outlet channel and the waterway downstream of Waterbody B. This will ensure that the outlet channel from Waterbody A is free-draining (as opposed to ponding) and that the adjacent backwater areas (Melaleuca areas) are drained. The outlet channel will need to be stabilised with rock protection and re-vegetated.

Waterbody B:

- Decommission the waterbody by lowering the level of the existing overflow to the downstream waterway.
- Infill and re-profile edges and any low points within the basin to ensure that the former waterbody is free-draining to the downstream waterway.
- Re-vegetate the basin with native vegetation commensurate with the adjacent vegetation (i.e. groundcovers, shrubs and trees).

Waterbody C:

- Option 1 – convert waterbody to channel
    - Lower water level by removing the overflow weir. This will drain and transition the waterbody into a waterway (channel), effectively removing Salvinia habitat.
    - Retain the concrete apron below the overflow weir and stabilise the downstream channel (e.g. with rock protection). The inlet channel to Ululah Lagoons upstream of Alice St appears to be incised due to an erosion head which has migrated to the base of the Waterbody C overflow weir. Retention of the concrete apron will help to prevent further movement of the erosion head.
    - Infill and re-profile edges to provide maximum 1:4 batter slope.
    - Re-vegetate the channel edges and batters with emergent waterplants and riparian groundcovers.
- Option 2 – retain existing waterbody (informal sediment basin)
    - No change in Salvinia habitat but benefits to suspended solids concentrations within Ululah Lagoons (refer to Section 5.1.3)

Ululah Lagoon:

- Remove Cyperus papyrus 'islands' from waterbody to remove backwater areas where Salvinia is harboured and incubates between growth periods.

- Install floating boom within the inlet channel downstream of Alice St to prevent Salvinia entering the Ululah Lagoon, or from being blown into the inlet channel (from the waterbody) where the plants can be harboured.
- Install a flap-gate on the downstream end of the culvert connecting the enclosed lagoons in the golf course and Ululah Lagoon. This will prevent Salvinia from entering the lagoons when the water level in Ululah Lagoons is low.
- Infill inlet (backwater area) adjacent to Anzac Park.

Cabomba caroliniana

It is noted that it will be extremely difficult to fully eradicate Cabomba from the Ululah Lagoons system. The following actions are recommended:

- Short term actions:
    - Focus Cabomba eradication efforts on Waterbody A to reduce spread to the downstream waterbodies.
    - Where feasible, continue to control Cabomba populations using selective manual removal (i.e. Council weed harvester).
    - Decommission Waterbody B. This will permanently remove the Cabomba population growing within the existing waterbody and prevent further spread to Waterbodies C and Ululah Lagoon.
- Long term actions:
    - Draw down water levels in Waterbody A and Ululah Lagoons during the dry season to expose Cabomba foliage.
    - Spray the exposed Cabomba foliage with systemic herbicides (i.e. glyphosate) and mechanically remove any remaining plants.
    - Re-establish native submerged waterplants within the waterbodies as a replacement for the Cabomba.
    - Trial chemical control using Carfentrazone, (the only registered herbicide for the control of Cabomba, refer www.biosecurity.qld.gov.au for further information).

Hygrophila costata

The complete removal of Hygrophila from Ululah Lagoons is desirable, particularly if a strategy to re-establish native emergent waterplants around the edges of the waterbody is adopted. Develop a targeted chemical control program to permanently remove Hygrophila from Ululah Lagoon. There are numerous populations of Hygrophila present around the waterbody and a coordinated approach with the Golf Club will be required for the program to be successful.

5.1.6 Aquatic vegetation

It is recommended that emergent and submerged waterplants are re-established throughout the Ululah Lagoons system to manage nutrient concentrations and turbidity. This will be achieved by:

- Lowering the permanent water level within Waterbody A and Ululah Lagoons by 150-200mm. This will be achieved by modifying the outlet levels for each of the waterbodies. Lowering the water level will expose the waterbody edges and enable waterplants to be re-established around the margins of the waterbodies.
- Planting emergent waterplants along the exposed edges to a depth of 0.25m. It is recommended that larger format tubestock (i.e. 600cm^3) are planted as the:
    - Plant foliage extends well above the water and enables the seedlings to cope with minor water level fluctuations (i.e. minor floods)

- Larger format tubestock grow more vigorously and quickly establish
- Larger root biomass enables the plants to be embedded into the sediments, thereby preventing waterbirds from plucking the seedlings from the sediments
- Well-developed root biomass enables the seedlings to withstand waterbird grazing
- Lower planting density 1-2 plants per m^2 means that the overall planting cost is comparable to using conventional tubestock ($200cm^3$ tubes).

- Planting submerged waterplants (e.g. *Ceratophyllum demersum, Vallisneria australis*) along the waterbody edges. The re-establishment of submerged waterplants within turbid waterbodies is extremely difficult due to limited light penetration to the base of the waterbody. The presence of a large waterbird population will also make re-establishing submerged waterplants a challenge, as some species graze on submerged waterplants. Ideally, submerged waterplants need to be established across the base of the waterbodies to establish sufficient aquatic waterplant coverage to manage nutrients and reduce algal growth. Ideally, submerged waterplants grow in less than 2m water depth. Average depths across the Ululah Lagoons system are generally less than 2m, and aerial imagery clearly shows that submerged macrophytes (most likely *Cabomba caroliniana*) were previously growing within the waterbodies. It is recommended that submerged plants be established along the shallow edges (0.25 - 0.6m water depth) so that the plants can access sufficient light to survive. If successful, the submerged plants will migrate into the deeper zones of the waterbodies, but this may take a long time, and other measures to manage waterbody nutrients and turbidity will be required to achieve this outcome. The growth of native waterplants throughout the waterbodies may also help to displace *Cabomba caroliniana* in some locations.

5.1.7 Hydraulic retention times and mixing

Water level control (recommended)

It is recommended to introduce a water level control outlet to the Ululah Lagoon overflow outlet. This will enable Council to manage water levels as/if required. Lowering the water levels permanently (by 150mm or more) would provide a number of benefits including:

- Improving turnover by reducing the overall waterbody volume and therefore decrease waterbody residence times and minimise the opportunity for stratification to occur and the potential to release nutrients into the water column.
- Decreasing the waterbody water level would also expose the shallow edges and enable emergent waterplants to be established around Ululah Lagoon.
- Edge safety will improve for some steep batters by reducing water depths adjacent to the waterline (particularly where this can be combined with additional edge planting).

5.1.8 Long Term Opportunities

Waterbody recirculation system

A long term option for managing water quality within Ululah Lagoon is to convert a section of the existing waterbody into a treatment wetland. The treatment wetland would function to remove suspended solids and nutrients from stormwater inflows. A waterbody recirculation system would circulate water from one end of Ululah Lagoons to the treatment wetland between rainfall periods. The water would pass through the wetland where the water quality would be improved before being discharged back into Ululah Lagoon. Recirculation of water from Ululah Lagoon through the treatment wetland would also effectively lower the waterbody residence time, thereby reducing the risk of algal growth within the waterbody.

Revert Ululah Lagoon back to a natural wetland

Decommission Ululah Lagoon by removing the overflow weir, draining the waterbody and reverting Ululah Lagoon to a natural wetland system (pre-European conditions). This would provide a range of benefits including: reduced waterbody maintenance through the removal of open water zones; significant environmental and ecological benefits through restoration of native riparian habitat; increase in nature based recreation space. The loss of open water area would also have negative impacts including: significant loss of open water areas that are highly valued by the community; and, significant capital cost related to completing the conversion.

5.1.9 Excluded actions

A number of management actions were considered through the assessment process but ultimately excluded as unviable for either social, environmental or economic reasons. A summary of these are provided in Table 5-1.

Table 5-1 Excluded management actions.

Proposed action	Potential benefits	Reason action excluded
Dredging sediments and /or increasing depths	• Creates more open water zones.	• Significant construction cost associated with dewatering and earthworks. • Increased waterbody volume results in longer hydraulic residence times (which reduces flushing rates). • Deepening waterbody increases likelihood of stratification (and associated fish kills). • Loss of aquatic habitat and fauna. • Environmental impacts with disposed sediments. • Physical disturbance of bed sediments and associated impacts on water quality and potential increased algal growth during works. • Difficult to establish wetland plants which play an important role in maintaining water quality.
Convert part of Waterbody C into a formal sediment pond	• Creates a dedicated sediment capture zone prior to flows entering Ululah Lagoon • Limit sediment accumulation d/s Alice St	• Impact on existing vegetation upstream of Alice Street • High capital cost

5.1.10 Discussion of Dredging / Deepening

One of the re-occurring feedback suggestions arising from community and stakeholder engagement (refer 2.5) was to ‘dredge’ or ‘deepen’ the waterbodies. These suggested actions were based on a number of perceived benefits associated with dredging, including improving water quality, reducing fish kills and reducing aquatic weeds. Removing organic matter and nutrient loads may improve water quality in the short term, but ultimately the same issues will re-occur unless catchment inputs can be treated prior to entering the system.

The process of dredging/deepening would result in a number of negative impacts including significant disturbance and impacts on water quality (re-suspension of sediments and fine particulate), potential to expose acid sulfate soils and groundwater and associated impacts fauna within the system. There would also be a significant financial cost associated with dredging / deepening on a large scale.

There are also a range of potential negative impacts in the long term associated with dredging or deepening waterbodies, including increased hydraulic residence times (i.e. reduced flushing) and risk of stratification (refer 4.1.7). Deeper water can also make it more difficult to establish wetland plants (required for a healthy waterbody).

5.2 MANAGEMENT PRIORITY

Each management action discussed above has been prioritised as either High, Medium or Low priority based on the following considerations:

- The scale of the risk to Council and ongoing cost to Council if proactive management is not implemented.
- The community desires for the waterbody.
- The environmental/conservation values of the waterbody and surrounds.
- The ability to manage a number of risks through a single actions (e.g. converting a waterbody to a wetland will improve water quality, aquatic weeds and hydraulic issues).

Appendix B presents a recommended schedule of works with broad implementation times for all High and Medium priority actions. The timeframes established are suggestions only and based on immediate, short (1-2 years), medium (3-5 years) and long (5-10 years) term implementation periods. Future or aspirational actions are subject to further consideration and may only be feasible based on the success of earlier actions. The order is subject to review based on Council priorities and available budgets.

It is recommended that management works associated with public safety and health issues are implemented as priority issues. We note that some management actions could be implemented over several years (such as the re-establishment of waterplants throughout the waterbodies) and other actions may be contingent on the successful implementation of previous management works (e.g. management of the local waterbird population prior to planting to improve plant survival).

5.3 COMMUNITY CONSULTATION

A community consultation process was undertaken to inform the development of the Ululah Lagoons Management Plan. The aim of the consultation program was to ensure that community feedback on the draft actions (as shown in Figure 5-2) were incorporated in the final WMP (as documented in Section 6). The community consultation process presented the potential management actions for Ululah Lagoons to the community in a range of formats including:

- A letter drop to all residents within 1km of the Ululah Lagoons
- An online survey
- A drop-in session and walking tour of the waterbody with Council and DesignFlow personnel.

Figure 5-2. Summary of potential actions from the community consultation process.

Key findings of the community consultation process included:

- Respondents were typically regular visitors and lived within walking distance of the waterbody.
- There were a range of concerns but the key issues related to fish kills and nuisance water bird populations.
- Respondents generally supportive of the draft plan and potential management approaches
- Actions with HIGH community support:
    - Re-vegetate backwater and weedy areas with native species
    - Educate on and discourage water bird feeding
    - Infill backwater areas and plant shallow areas with emergent water plants to improve water quality Improve drainage structures (overflows, weirs)
    - Remove declared and targeted weed species
    - Establish 1.5-3m vegetated buffer to water edge to improve safety and reduce water quality impacts from birds and runoff
    - Re-profile bank edges and revegetate with native submerged and emergent water plants
    - Stabilise eroded areas (rock or other)
    - Modify unsafe steep edges to make them safer (fencing or landscaping).
- Actions with MODERATE community support:

    - Reducing water levels in Ululah Lagoon
- Actions with LOW community support included:
    - Removal of small islands in Waterbody A

The feedback obtained from the community consultation process has been incorporated into the Management Plan (refer Section 6).

6 MANAGEMENT PLAN

This section outlines the Ululah Lagoons Waterbody Management Plan. The plan is presented in three sections:

- Section 6.1 provides an overview of the Ululah Lagoons system.
- Section 6.2 details all the waterbody issues identified and provides a range of recommended management actions.

Further detail of the proposed actions, including high level costs, timeframes, delivery mode and scope of works are provided in Appendix B - Ululah Lagoons Actions Table.

6.1 WATERBODY CHARACTERISTICS, ISSUES AND CONSTRAINTS

A summary of the key characteristics, issues and constraints associated with the Ululah Lagoons system is provided in Table 6-1.

Table 6-1 Key characteristics of the Ululah Lagoons system.

Name:	**Ululah Lagoons system**
Description:	The Ululah Lagoons system is a very high profile and amenity series of waterbodies located within Maryborough. The system comprises four interconnected waterbodies. The Ululah Lagoons system receives untreated stormwater runoff from a 228 ha catchment comprising of residential, industrial and parkland/natural land uses. The waterbodies are valued by the local community and provide a high level of amenity. The waterbodies are surrounded by open parkland and are largely accessible to the public. The largest and most prominent waterbody, commonly referred to as Ululah Lagoon, is located between Anzac Park and the Maryborough Golf Club. Ululah Lagoons was originally a natural wetland and was highly valued resource utilised by the local indigenous people. In the 19th century, settlers to area constructed a large weir across the end of the wetland, thereby forming the large waterbody that exists today. It is understood that the waterbody was used for water supply and recreation. The waterbodies have a history of water quality and aquatic weed problems. Regular aquatic weed control and harvesting is undertaken to manage aquatic weeds, particularly *Salvinia molesta and Hygrophila costata. Cabomba caroliniana* is also present within the Ululah Lagoons system. The batter slopes along the margins of the waterbodies vary from shallow slopes to vertical drop offs in some areas. The waterbody edges are variously covered with groundcovers (grasses, sedges, rushes and herbs), shrubs and trees. The waterbody edges are generally stable however areas of localised erosion exist along some of steeper batter areas. Steep batters with drops into open water also present safety concerns in numerous locations.
Waterbody Priority:	**High – Waterbodies A, B & C;** **Very High – Ululah Lagoon**
Management Goal:	Maintain and enhance public safety, long term water quality and aesthetic values through: • Improving public safety • Re-establishing native aquatic vegetation • Managing aquatic weeds • Minimising maintenance (and allowing easier maintenance) • Improving hydraulic function, particularly by increasing flushing rates and/or removing dead water pockets • Improving waterbody water quality by: ○ reducing bird numbers and feeding

	○ re-establishing aquatic vegetation around the waterbody margins		
Council ID:	STDS00057A & STDS00057B	**Surface Area:**	16,385 m^2
Catchment:	Ululah Lagoon		
Function / Purpose	Ululah Lagoons system provides high visual and passive recreational amenity to the local residents and visitors, and provides habitat to a high number of native waterbird species.		
Issues / Values	**Public safety** • Steep batters and edges present along some of the waterbodies present very high safety risk **Water quality** • No treatment of stormwater entering the waterbodies. • Poor water quality conditions resulting in algal and aquatic weed growth. • Large waterbird population associated with potential faecal contamination and likely to contribute a significant nutrient load to the waterbody system. **Aquatic vegetation/weeds** • Lack of native emergent and submerged aquatic waterplants throughout the waterbodies, particularly along the margins. • Aquatic weeds which require ongoing management (e.g. *Salvinia molesta, Hygrophila costata* and *Cabomba caroliana*) **Edge stability** • Some edges have vertical drop-offs to the water. • Localised erosion is undermining the stability of some edges. **Hydraulic function** • Excessively long water residence times which can lead to nutrient release from the sediments. • Poorly flushed backwater areas present		
Constraints	• Each of the waterbodies are online to untreated catchment inflows and are subject to frequent flood flows. • Ululah Lagoons is surrounded by both public open space (Anzac Park – Council land) and the Maryborough Golf Club. Potential works within the waterbody may impact on waterbody users.		
Conservation designations	None identified – it is noted that Ululah Lagoons is home to a diverse suite of native waterbirds.		
Existing management and rectification	Council currently maintains the Ululah Lagoons system to a moderate standard. The waterbody edges are maintained in accordance with Council's *Urban Lakeside Vegetation Management* policy, which involves mowing and removal of high priority weeds (e.g. Singapore Daisy) and retention of an edge buffer zone. Removal of aquatic weeds occurs on an 'ad hoc' basis, generally in response to aquatic weed growth outbreaks in accordance with Council's *Aquatic Plant Management Policy*. Management of aquatic weeds is undertaken by Council maintenance staff using equipment (e.g. mechanical weed harvester, vehicles and spray kits, mowing equipment etc). Management of western margins of Ululah Lagoons is undertaken by the Maryborough Golf Club.		
Supporting information	• GIS information for the waterbodies and catchment • Aquatic weed maintenance Schedules • Council Management Policies		

6.2 WATERBODY ISSUES AND MANAGEMENT ACTIONS

A summary of the waterbody issues and management actions for the Ululah Lagoons system is provided in Table 6-2. The table identifies the primary and supporting Council departments that are proposed to be responsible for managing each management issue. Figures 6-1 and 6-2 show the location of potential management actions across each of the waterbodies.

Table 6-2 Issues and management actions for Ululah Lagoons system.

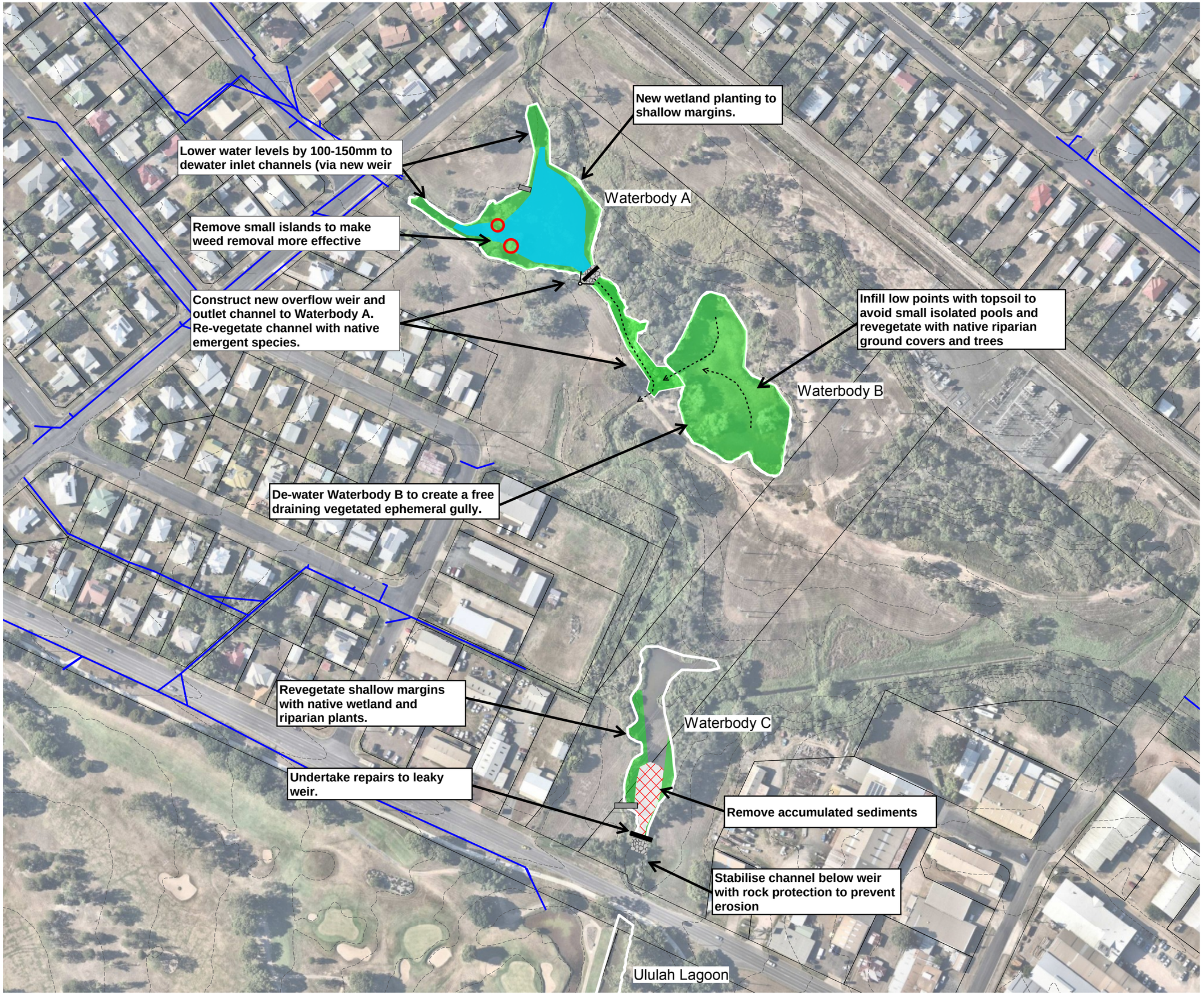
Management Issue (refer Appendix C)	Issue	Description of issue	Condition Rating	Management Priority (H,M,L)	Potential Management Actions	Likely rating following management	Responsible Departments	
							Primary	Supporting
A1	Risk of injury of drowning	Batter slopes vary around the waterbodies. Some edges in Ululah Lagoons have a heightened risk of drowning associated with steep batter slopes/edges adjacent to deep water (>0.5m) areas.	Poor	High	A batter safety risk assessment should be conducted to review public safety around Ululah Lagoon. Initiate management of high risk waterbody edges. This may include: • Establishing vegetated buffers • Fencing high risk areas • Re-profiling and stabilising batter slopes. Refer B6	Adequate	E&NAM	LPS
A2	Health risks due to human contact with contaminated water	A potential health risk exists associated with human contact with waterbird faecal matter present within Ululah Lagoon, and edges of the lagoons adjacent to the waterbird rookeries or feeding areas.	Poor	Medium	Reduce waterbird numbers to more sustainable levels and discourage bird feeding, via: • Develop and implement a bird management plan to inform the management of bird populations to sustainable levels. • Provide public education and signage to discourage bird feeding and health risks associated with bird faeces • Removal of Broad-leaved Pepper trees overhanging water • Removal of rookery habitat (e.g. Broad-leaved Pepper trees overhanging water) and Cyperus papyrus stands from within Ululah Lagoon. Replace with native vegetation (to discourage overhanging water roosting sites). Refer D2.	Adequate	-	-
A3	Chemical contamination	No chemical contamination observed in waterbody system.	Good	Low	No Action Required	Low	-	-
A4	Faecal and/or nutrient contamination	Nutrient levels in the waterbody system are elevated as illustrated by the visible presence of algal biomass and floating aquatic weeds in the water column. The primary sources of nutrients within the system includes: untreated stormwater runoff, runoff and leaching from the golf course, water bird population and organic sediments. The high number of birds present within Ululah Lagoon, particularly near the feeding areas, means that the waterbody may be subject to high faecal contamination. Given the high interaction between the local residents and the waterbody/Anzac Park, the faecal contamination represents a health risk.	Poor	Medium	The following initiatives should be implemented to mitigate the health risks associated with waterbody water: • Reduce unsustainable bird population. Refer A2 • Establish waterplants throughout the waterbody system. Refer C2.	Adequate	E&NAM	LPS
B1	Inlet/Outlet erosion or instability	Erosion of inlet channel to Ululah Lagoons observed, upstream and downstream of Alice St. Outlet weir below Waterbody C is damaged and not functioning as intended. Ululah Lagoons overflow weir is leaking.	Poor	Medium	• Stabilise and re-inforce eroded channel below the Waterbody C overflow weir using rock protection. • Repair Waterbody C overflow weir.	Good	D&CP	C&CIS
B2	Outlet blockage – water level is consistently too high above normal water level.	There is no dedicated outlet from Waterbody A into Waterbody B or the downstream channel resulting in backwatering of the inlet channels and culverts under Neptune St. The increased water level is causing backwatering of the adjacent vegetation and providing conditions for Salvinia to harbour and incubate.	Poor	Medium	Lowering the water level in Waterbody A will ensure that the inlet channels are not backwatered and remove potential harbouring areas for Salvinia. Lower the water level in Waterbody A by: • Connecting the outlet channel from Waterbody A directly to the waterway below Waterbody B. This will involve constructing a new channel. • Installing a weir between the main waterbody and the outlet channel to Waterbody B. This will set the water level in Waterbody A, ensure that the outlet channel is free draining and remove backwater areas between Waterbodies A and B. • Modifying the edges of Waterbody A to ensure that all outflows exit via the overflow weir and not through the adjacent vegetation. This may involve partial infilling of backwater areas.	Good	D&CP	C&CIS

Management Issue (refer Appendix C)	Issue	Description of issue	Condition Rating	Management Priority (H,M,L)	Potential Management Actions	Likely rating following management	Responsible Departments	
							Primary	Supporting
B3	Poor flushing or dead pockets	Dead pockets/backwater areas are within Waterbodies A, B and C, and Ululah Lagoon. Backwater areas that are poorly flushed provide ideal conditions for Salvinia harbour and growth. Waterbody residence times within Ululah Lagoons are expected to be high during the dry season when catchment inflows are low.	Poor	High	Remove dead pockets/backwater areas by: • Waterbody A - Lower water level and connect outflow channel to downstream waterway. Refer to B2. • Waterbody B - Decommission waterbody by lowering the level of the outlet (waterbody outlet comprises of earthen/rock channel). - Infill edges and re-profile waterbody to ensure that the basin is free draining to the downstream waterway • Waterbody C - Option 1 (recommended) – remove overflow weir to lower water level and convert waterbody to a waterway (channel). This may involve minor works to re-profile and re-vegetate the channel edges with emergent waterplants and riparian groundcovers. The channel below the overflow weir would also need to be stabilised to prevent erosion of the upstream channel. - Option 2 – convert waterbody to a formal sediment basin. Excluded option refer to Table 5-1 . • Ululah Lagoons - Remove Cyperus papyrus stands from waterbody to remove backwater areas where Salvinia is harboured between growth periods. Refer to D2. - Install flap-gate on the downstream end of the culvert connecting the enclosed lagoons in the Golf Club and Ululah Lagoon. This will prevent Salvinia from entering the lagoons when the water level in Ululah Lagoons is low. - Infill inlet (backwater area) adjacent to Anzac Park. - Decrease waterbody residence times by reducing the waterbody volume. This could be achieved by installing a water level control to allow water levels to be lowered. If water levels were to be 100-150 mm lower would enable emergent waterplants to be established along the waterbody edges. Refer to D1.	Adequate	D&CP	C&CIS
B4	Water level is consistently low	Water levels in the Ululah Lagoons system appear to be stable due to the presence of catchment baseflows for most of the year. Reduction in water levels expected following extended dry periods.	Good	Low	No Action Required	Good	-	-
B5	Flooding of adjacent land, parkland or property or regular overtopping of waterbody bund	Flooding of EB Uhr Park between Waterbody A and Alice St occurs during large rainfall events (extent and frequency unknown).	Adequate	Low	The construction of earthen bunds adjacent to Waterbody A may help to retain minor flood events within the waterway (as opposed to flowing across EB Uhr Park). A flood modelling study would confirm the flood levels and frequency, and help to evaluate whether the benefit gained by constructing the flood bunds. It is not clear whether the submerged culverts under the Alice St bridge are required to convey flows during flooding events, or are redundant infrastructure left following upgrade works to the Alice St bridge (installation of larger box culverts above the submerged culverts). The presence of the culverts results in the section of Ululah Lagoons upstream of Alice St being effectively isolated from the main waterbody. Removal of the culverts may improve the flow capacity of the Alice St culverts and assist with alleviating upstream flooding issues.	Adequate	-	-
B6	Scour of batters	Scour of the batters/edges was observed in Ululah Lagoons in the following locations: - Shallow edges adjacent to Anzac Park - Golf Club edges – vertical slumping including adjacent to the Ululah Lagoons inlet channel area downstream of Alice St.	Poor	Medium	Investigate scoured batter areas to assess whether they are stable or require rectification. Rectify scoured batter/edge areas by: • Lowering the waterbody water level. Refer to D1. • Stabilising the waterbody edges by establishing emergent waterplants and riparian groundcovers. Refer to D1. • Stabilising the vertical edges to inlet channel and some areas adjacent to the Golf Club using rock and protection.	Adequate	D&CP	C&CIS

Management Issue (refer Appendix C)	Issue	Description of issue	Condition Rating	Management Priority (H,M,L)	Potential Management Actions	Likely rating following management	Responsible Departments	
							Primary	Supporting
B7	Coarse sediment accumulation	Sediment accumulation in Waterbody C which appears to functioning as a sediment pond. Potential blockage of the submerged inlet culverts to Ululah Lagoons underneath Alice St.	Adequate	Low	Course sediment deposition may be managed by: • Option 1 – constructing sediment ponds at all major stormwater inflow points to the Ululah Lagoons system (i.e. two above Waterbody A and one above Waterbody C, or • Option 2 - Converting Waterbody C into a large sediment basin. Refer to B3. Excluded option refer to Table 5-1 . It is noted that removal of accumulated sediments from the inlet areas of Ululah Lagoons has been previously undertaken by Council. It would appear that the submerged culverts underneath the Alice St bridge may be partially blocked with sediment. Consider decommissioning the submerged culverts as they appear to be redundant infrastructure and susceptible to sediment accumulation. Refer to B5.	Good	-	-
B8	Fine sediment or organic matter accumulation	No fine sediment or organic matter accumulation observed in Ululah Lagoons system. Note: Sediment testing was not conducted as part of the waterbody condition assessment.	Good	Low	No Action Required	Good	-	-
C1	Odour	No odours were detected during the waterbody condition assessment.	Good	Low	No Action Required	Good	-	-
C2	Algal or cyanobacterial blooms	Planktonic algal biomass is visible in Ululah Lagoon. Algal growth within the waterbody is stimulated by: • nutrients • water temperature • light The presence of algal biomass in the water column indicates that there are high nutrient concentrations present within the waterbody system.	Poor	Medium	Algal growth within the waterbody system should be managed by reducing nutrient concentrations within the water column. This can be achieved by: • Establishing emergent and submerged waterplants throughout the Ululah Lagoons system (recommended). Waterplants compete with algae for nutrient resources and help to maintain water quality. Refer to D1.	Adequate	-	-
C3	Persistent high turbidity levels.	Turbidity levels vary throughout the Ululah Lagoons system depending on algal and suspended solids concentrations. High turbidity was observed in Waterbodies A and C which appeared to be associated with high suspended solids concentrations. It is uncertain whether the turbidity within these waterbodies is persistent given that Waterbody A has high submerged waterplant cover (albeit *Cabomba caroliniana*). It is possible that turbidity within Waterbody C is associated with inflows from an adjacent catchment which bypass Waterbodies A and B. Elevated turbidity in Ululah Lagoons was due to algal biomass and suspended solids concentrations.	Poor	Medium	Waterbody turbidity should be managed by • Managing stormwater runoff quality. Refer A2 • Reducing waterbird numbers. Refer A2 • Establishing waterplants throughout the waterbody system. Refer C2	Adequate	-	-
C4	Stratification and low dissolved oxygen	The presence of long residence times during the year is likely to facilitate the development of stratification in parts of Ululah Lagoon. Stratification of the water column can lead to the development of an anoxic hypolimnion (bottom layer of water) and the subsequent release of nutrients from the sediments into the water column. Whilst there is no data to verify that stratification occurs within Ululah Lagoon, it is highly likely to occur given the long waterbody residence times and the waterbody depth near the outlet (up to 4.5m). It is generally thought that the presence of the fountain at the southern end of Ululah Lagoons functions to aerate and mix the waterbody.	Poor	Medium	Reduce the risk of stratification in Ululah Lagoons by: - Short term option – Install a waterbody mixing system (e.g. aeration system). Note: The use of convection type mixers such as SolarBee units have proven to be ineffective in large shallow waterbodies, • Long term options – - Modify the waterbody bathymetry to reduce the average waterbody depth (max. 2m) and encourage wind forced mixing, or - Install a waterbody recirculation system. This would involve recirculating water from one end of the waterbody to the other end. A recirculation system would also include constructing a treatment wetland to remove nutrients and suspended solids from the recirculated water.	Poor	D&CP	C&CIS
C5	Variable salinity	Ululah Lagoons system is freshwater.	Good	Low	No Action Required	Good	-	-
C6	Litter	No litter issues were observed during the waterbody condition assessment.	Good	Low	No Action Required.	Good	-	-

Management Issue (refer Appendix C)	Issue	Description of issue	Condition Rating	Management Priority (H,M,L)	Potential Management Actions	Likely rating following management	Responsible Departments	
							Primary	Supporting
D1	Aquatic vegetation	Aquatic plant communities throughout the waterbody system comprise of isolated emergent waterplants along the waterbody edges, and submerged waterplant cover within Waterbodies A and B (comprising declared aquatic weed *Cabomba caroliniana*). It is also likely that Cabomba is also growing within Ululah Lagoons but the species was not observed during site inspections. Floating waterplants (declared weed *Salvinia molesta*) were also present in Waterbodies A, B, C and Ululah Lagoon. Refer to D2. A native floating waterplant, Lemna sp., was observed growing in Ululah Lagoon. It also understood that Azolla sp. also grows extensively within the waterbodies. The presence of dense waterplant populations, particularly submerged waterplants, provides competition for bio-available nutrients. Shallow waterbodies with high submerged waterplant cover are generally characterised by low turbidity due to low algal biomass. The presence of waterplants also assists with the removal of suspended solids. Emergent waterplants are also important as the biofilms growing on the plant stems, and the plants themselves aggressively compete for nutrients within the water column. Emergent water plants are also important for stabilising the waterbody edges, preventing erosion and the introduction of suspended solids to the waterbodies.	Poor	High	Re-establish emergent and submerged waterplants within Waterbodies A and C, and Ululah Lagoons to manage nutrient concentrations and turbidity: • Reduce the water level within the waterbodies (A, B and Ululah Lagoon) by 100-150mm to expose the waterbody edges. Refer to B3. • Plant native emergent waterplants along the waterbody edges (depth range NWL to -0.25m). It is recommended that 600cm^3 tubestock are used as the plants foliage extends well above the water, the large root biomass enables the plants to be embedded into the sediments (thereby preventing waterbirds from plucking the seedlings from the sediments). The well-developed root biomass also enables the seedlings to withstand repeated waterbird grazing. Recommended planting density minimum 2 plants per m^2. • Plant native submerged waterplants (Ceratophyllum demersum, Vallisneria australis) along the waterbody edges (depth range -0.25m to -0.6m). Recommended 600cm^3 tubestock at 1 plant per m^2. The re-establishment of submerged waterplants within turbid waterbodies is extremely difficult due to limited light penetration to the base of the waterbody. Ideally, submerged waterplants should be planted across the base of the waterbody to establish sufficient aquatic waterplant coverage to manage waterbody nutrients and reduce algal growth.	Adequate	D&CP	CEP
D2	Aquatic weeds	The following declared aquatic weeds were observed during the waterbody condition assessment: - *Salvinia molesta* (A, B, C and Ululah Lagoon) - *Cabomba caroliniana* (A, B and Ululah Lagoon) - *Hygrophila costata* (Ululah Lagoon) It is understood that Council actively controls the growth of *Salvinia molesta*, *Hygrophila costata* but not *Cabomba caroliniana* in the Ululah Lagoons system.	Poor	High	Long term removal of *Salvinia molesta* from the Ululah Lagoons system will require the following actions: • Reducing nutrient concentrations within the waterbodies - Establishing emergent and submerged waterplants. Refer to D1. - Implementing stormwater treatment measures within the catchments. Refer to A4. - Reducing waterbody residence times (managing stratification). Refer to B3. • Removing Salvinia harbouring sites such as the large Cyperus papyrus islands and backwater areas. • Reducing the water level in Waterbody A. Refer to B2. • Decommissioning Waterbody B. Refer to B2 • Isolating the enclosed lagoons within the Golf Club from Ululah Lagoon. Refer to B2. Decommissioning Waterbody B will effectively remove both *Salvinia molesta* and *Cabomba caroliniana* from this waterbody.	Adequate	**C&CIS**	**BPW**
D3	Presence of exotic fish species	No exotic fish species observed	Good	Low	No Action Required	Good	-	-
E1	Batter/edge vegetation	Batter vegetation composition and cover varies throughout the Ululah Lagoons system. Generally, the edges of Waterbodies A, B and C are well vegetated with a mix of native and introduced species. The vegetated edge around the margins of Ululah Lagoons varies from weedy/mown turf/bare edges to dense native vegetation. Council maintained batters (adjacent to Anzac Park) generally have a minimum 1.5-2m buffer along the waterbody edge (in accordance with Council's *Management of Urban Lakeside Vegetation* management policy). In contrast, the batters adjacent to the Golf Club are generally mown to the water edge.	Poor	Low	Rectify batter/edge vegetation cover adjacent to Anzac Park in accordance with the following tasks: • Remove terrestrial weeds and replace with native species, particularly adjacent to unsafe edges. • Re-establish vegetation on unstable/bare earth batters. • Where mown turf is present, leave minimum 1.5 m buffer zone, particularly in areas where waterbirds exit and enter the waterbody.	Adequate	**LPS**	**E&NAM**
E2	Terrestrial weeds	Class 3 declared weeds observed within the waterbody riparian zones include: • Broad-leaved Pepper Tree – all waterbodies	Poor	Medium	Phased removal of Broad-leaved Pepper trees from all of the Ululah Lagoons system is recommended. Broad-leaved Pepper trees provide ideal roosting and	Adequate	**LPS**	**E&NAM**

Management Issue (refer Appendix C)	Issue	Description of issue	Condition Rating	Management Priority (H,M,L)	Potential Management Actions	Likely rating following management	Responsible Departments	
							Primary	Supporting
		The lower batters of Ululah Lagoons adjacent to Anzac Park are characterised by high weed cover comprising introduced grasses and broad leaved species.			nesting habitat for Ibis and compete with native species for space within the riparian zones. • Cut and paint stems with herbicide (e.g. glyphosate 360 mg/L or similar) • Replant with native shrub and tree species that are less favoured as Ibis nesting habitat. • Re-establish batter groundcover vegetation. Refer to E1 Edges adjacent to Anzac Park: • Undertake staged weed removal along waterbody edges focusing upon areas with unsafe edges/batters. • Revegetate cleared areas with a mix of indigenous species to enhance habitat quality and visual amenity. Refer to E1			
F1	Access for maintenance	No formal maintenance access for weed harvester equipment. It is noted that the waterbodies can be readily accessed (via the batters) by Council's mechanical harvester at multiple locations within each waterbody.	Adequate	Low	No Action Required	Good	-	-



DesignFlow

LEGEND

- Waterbody
- Property boundary
- Existing stormwater pipe
- 1m contours
- New wetland planting
- Retained open water
- New access ramp

0 20 40 80 m

Figure 6-1.
Waterbody A to C Management and Rectification Plan

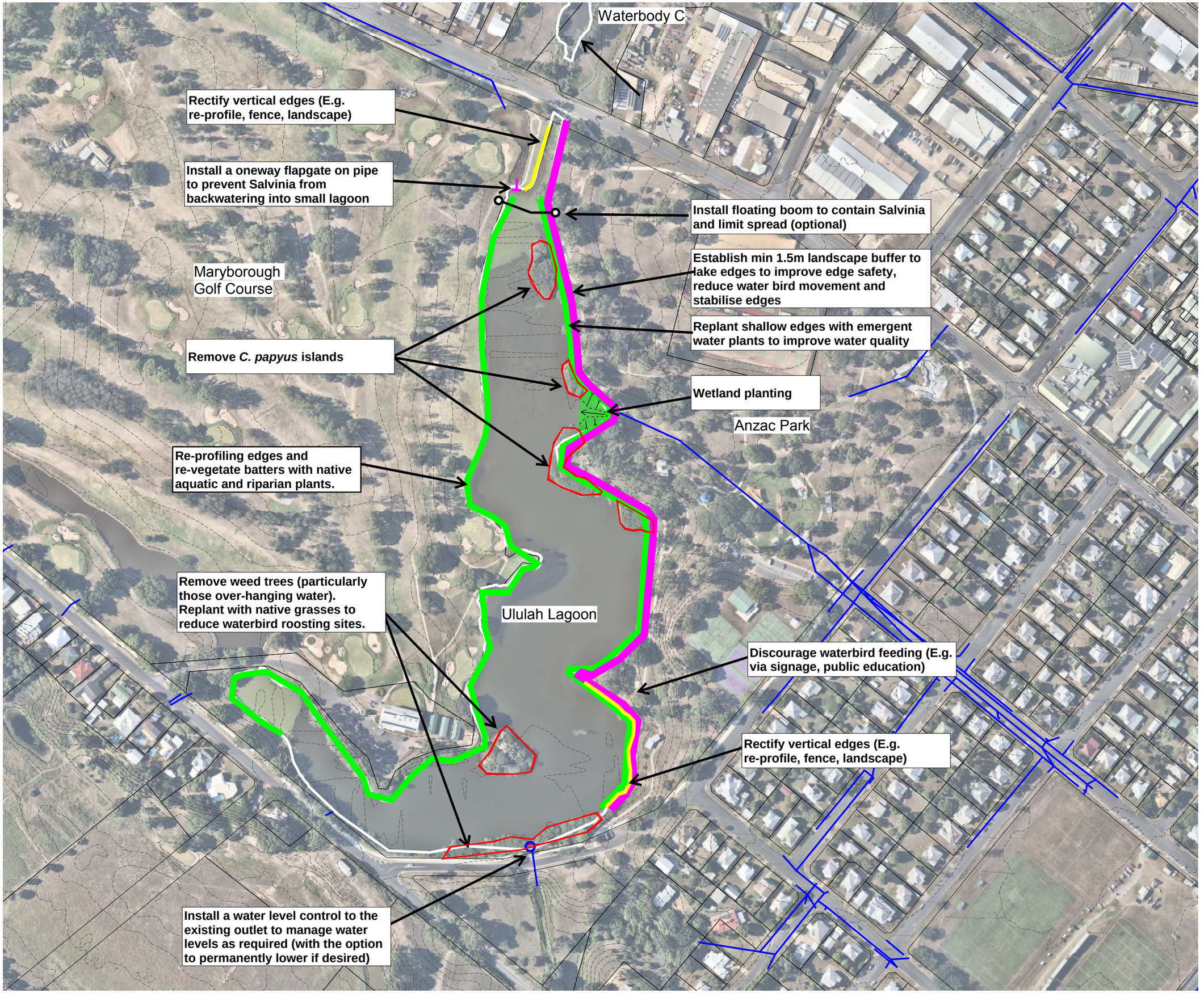
Ululah Lagoons Waterbody Management Plan

SCALE: 1:2,000

DATE: 21 February 2021

DesignFlow
PO Box 1250, Southport BC
7 Bauer St, Southport QLD 4215

For:
FCRC



DesignFlow

LEGEND

- Property boundary
- Proposed floating boom
- Existing stormwater pipe
- 1m contours
- *Cyperus papyrus*
- Terrestrial buffer
- Emergent water plants

0 30 60 120 m

Figure 6-2.
Ululah Lagoon Management Actions

Ululah Lagoons Waterbody Management Plan

SCALE: 1:3,000

DATE: 23 February 2021`

DesignFlow
PO Box 1250, Southport BC
7 Bauer St, Southport QLD 4215

For:
FCRC

7 REFERENCES

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DesignFlow (2021) *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report*.

FCRC (2017) *Fraser Coast Regional Council Biosecurity Surveillance Program for Prohibited and Restricted matter 2017 – 2021.*

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FCRC (2017) *Aquatic Plant Management Policy.*

FCRC (2017) *Management of Urban Lakeside Vegetation Policy.*

APPENDIX A. WATERBODY FIELD CONDITION ASSESSMENT FORM

Asset Name:	Asset ID:	Location:	Date:

Condition Scoring: 1 = Good (PI exceeded), 2 = Adequate (PI met), 3 = Poor (PI not met), 4 = Very Poor (PI failed)

Cate-gory	Item	Component	Performance indicator (PI)	Condition Score	Comment
Public Health & Safety	1.1	Risk of injury or drowning	Open space areas adjacent to water minimise risk of drowning		
	1.2	Batter slopes	Slope ideally 1:6 or flatter adjacent to open water zones. Batter slope above and below water level is no steeper than 1 in 4.		
	1.3	Fencing/ barriers	Fencing / barriers present in unsafe areas (walls greater than 1m high anywhere or walls/steep batters of any height into permanent water). Appropriate fencing or vegetation barriers in place where batter slope is steep or adjacent to deep water		
	1.4	Contaminated Water	No obvious contamination of water. E.g. due to chemical contamination, faecal matter (e.g. large bird population, sewer leaks etc.)		
	1.5	Mosquitoes	Low mosquito populations, no isolated depressions creating mosquito habitat, no larvae observed.		
Hydraulic Condition	2.1	Inlet Condition - e.g. pipes, channels	No blockage, erosion or structural damage		
	2.2	Outlet Condition - Including bund, pipes, pits, grates, outlet weirs, scour protection	No blockage or damage. No erosion, scour tunnelling or structural damage. The waterbody bund is not overtopped regularly		
	2.3	Other structures	No erosion and damage to other structures, e.g. pits, pipes, ramps and walls.		
	2.4	Flushing/ Residence Time	The system is well flushed with no dead pockets/backwatered areas		
	2.5	Water levels	Water level close to normal operating level.		
	2.6	Stability of Batters and bunds	Minor and localised erosion only. No scour or exposed earth on batters.		
	2.7	Sedimentation accumulation	No visible coarse sediment accumulation within waterbody.		
Water Quality	3.1	Odours	No odours detected		
	3.2	Algae / Cyano-bacteria	No obvious sign of planktonic algae in water column or floating scums.		
	3.3	Turbidity	Water column clear and visibility >1m. Turbidity ranges between 1-20 NTU		
	3.4	Litter/ Debris	No grass clippings. No floating litter. Bins are provided and are adequately maintained and routinely empty.		
Aquatic habitat	4.1	Aquatic vegetation - emergent	Native emergent macrophytes present around the shallow margins (<0.35m depth) of the waterbody. Plants healthy and free from disease (includes native water lilies).		
	4.2	Aquatic vegetation - submerged	Native submerged macrophytes present (0.35-1.5 m depth). Includes all submerged genera (Ceratophyllum, Potamogeton, Myriophyllum)		
	4.3	Aquatic vegetation – free-floating	Less than 5% of the waterbody surface covered by native floating macrophytes (i.e. Azolla, Water lilies).		
	4.4	Aquatic weeds – declared	Declared weeds controlled.		
	4.5	Aquatic weeds – non-declared	Less than 20% of the waterbody surface area covered in non-declared weeds		
	4.6	Aquatic fauna pests	No damage by pests (e.g. Tilapia digging). No pests present (e.g. no Tilapia observed, no large bird populations)		
	4.7	Filamentous algae	Less than 10% of the water surface covered with filamentous algae.		
Terrestrial Habitat	5.1	Edge vegetation condition	A minimum vegetation width of 1.5m along the lower waterbody batter. Greater than 90% vegetation cover. Plants healthy and free from disease.		
	5.2	Terrestrial weeds - declared	Declared weeds controlled.		
	5.3	Terrestrial weeds – non-declared	Less than 10% of the batters covered in non-declared weeds		
Access for Maintenance	6.1	Access to waterbody reserve	Formal access provided into the waterbody reserve.		
	6.2	Access to waterbodies margin	Adequate access to waterbody edge provided for weed management		
	6.3	Access to water surface	An appropriate access is available for harvesting aquatic weeds (weed harvester or boat)		

APPENDIX B. ULULAH LAGOONS ACTIONS TABLE

Action Category	Proposed Action	Timeframe	Indicative Budget period (planning purposes only)	Cost Level	Indicative Cost estimate	Indicative Scope of Works	Indicative Lead Department	Indicative Delivery Mode	Pros	Cons	Comments
WATERBODY EDGE - PUBLIC SAFETY RISK ASSESSMENT (AND DESIGN)	Development of Waterbody Edge - Public Safety Risk Assessment + Design	Immediate	2021 - 2022	Low	$15k-$30k + Design Cost	Inspect waterbody margins to map and rate risk areas that may present risk of falling or drowning as a result of steep batters into open water. Assessment should take a risk management approach where 'consequence' and 'likelihood' are rated for each bank profile. Where risks are rated as 'high' then cost effective 'risk control measures' should be recommended and the residual risks rated. This could range from temporary or permanent physical barriers, landscaping, re-profiling, signage or combination of above works. Scope to include actions to manage eroding edges and dispersive soil management (e.g. golf course margins).	Infrastructure Planning	External consultants (Risk assessment Inspector, Landscape Architect + Environment or Geotechnical Engineer) to resolve design responses.	Identifies approach to managing public safety risk.	Cost to complete Requires actioning of recommended works to manage FCRC liability.	Action applicable across all FCRC waterbodies. Implement works to address identified high risk locations as a priority.
	Implement works to 'high risk' unsafe edges (Ululah Lagoon only)	Short	2022 - 2023	Medium	$50k-100k	Subject to outcomes of the 'Waterbody Edge Risk Assessment and Design' action. Focus on is on managing high use areas, such as edges that interface with ANZAC Park (excludes golf course edge - see below).	Capital Delivery	Design Team for detailed design; External Contractors for construction.	Improved public safety associated with accessible waterbody edges.	Cost to complete.	Combine action with other edge planting works (e.g. planting bird loafing areas and terrestrial buffers).
WATERBIRD MANAGEMENT	Development of Waterbird Management Plan	Immediate	2021 - 2022	Low	$25k-35k	Focus of waterbird management plan would be to characterise nuisance water bird species and locations were they are congregating (particularly in areas over water) and developing appropriate management responses to reduce numbers to more sustainable numbers (e.g. reducing bird feeding via signage and community education, limit loafing via landscaping, removing roosting sites associated with Broad leave pepper trees). Plan should inform associated actions including removal of BLP trees, public signage, etc. Scope could also consider actions to reduce bird faecal matter on park infrastructure (e.g. relocate pathways or trim branches in key locations, remove Camphor laurels).	Open Space & Environment	Specialist ecological consultants	Provides transparent approach to inform future decisions around waterbird management. Allows for reductions in: bird population, public health risk, odours, nutrient loads and algal/cyanobacterial growth. Improvements to: waterbird health, water quality, batter/edge stability and increased amenity.	Minor loss of resident experience (waterbird feeding).	Action applicable across all FCRC waterbodies.
	Signage to discourage bird feeding	Short	2022 - 2023	Low	$10k	Development of educational signage to discourage bird feeding an inform visitors of the various bird species that utilise the parkland.	Open Space & Environment	External contractors for design and manufacturing. Internal resources for installation.	Improved community education of waterbirds	Visual amenity impacts	Potential for signage to be informative (rather than prescriptive). Could be completed in partnership with bird watchers / community groups. Signage should be generic and suitable to use across all systems
	Landscaping works in key locations to discourage bird feeding and loafing	Short	2022 - 2023	Low	$30k	Design and installed landscaping to bare margins associated with bird feeding (e.g. grass peninsular area in Ululah Lagoon).	Open Space & Environment	External landscape architect	Improve landscape outcome in areas impacted by birds in high use area.	Cost to complete. Reduced open grass areas near water.	Combine action with other edge planting works (e.g. edge safety and terrestrial buffers).
	Other items identified in the BMP	Medium	2023 - 2025	Low	$20k-50k	TBA - e.g. actions to support lowing bird numbers such as breeding restrictions, modifications to park infrastructure to avoid bird droppings).	Open Space & Environment	TBA	*TBA*	*TBA*	*TBA*

Action Category	Proposed Action	Timeframe	Indicative Budget period (planning purposes only)	Cost Level	Indicative Cost estimate	Indicative Scope of Works	Indicative Lead Department	Indicative Delivery Mode	Pros	Cons	Comments
TERRESTRIAL WEEDS	Development of Weed Management Plan (e.g. Broad Leaf Pepper Tree)	Immediate	2021 - 2022	Low	$15k	Development of strategy/plan to remove terrestrial weeds (in particular Broad Leaf Pepper (BLP) trees and Camphor laurel) including replacement planting to align with the waterbird management objectives. Follow-up maintenance to limit re-occurrence.	Open Space & Environment	External ecological consultants	Provides transparent approach to inform future decisions around weed management informed by the outcomes of the Waterbird Management Plan	Concerns about loss of tress or bird habitat from community.	Action applicable across all FCRC waterbodies. FCRC may be able to review and adapt existing policies to support this action.
	Implement works recommended in the Weed Management Plan (Phase 1)	Short	2022 - 2023	Low	$50k	Implement removal of terrestrial weeds in accordance with the Weed Management Plan. Priority initially to remove Ibis rookery habitat areas associated with Broad-leaved Pepper trees overhanding water) and replace with more appropriate native vegetation (e.g. groundcovers and shrubs).	Open Space & Environment	Design Team for detailed design; External Contractors for construction.	Reductions in: bird population, public health risk, odours, nutrient loads and algal/cyanobacterial growth. Improvements to: waterbird health, water quality, batter/edge stability and increased amenity.	Concerns about loss of tress ofr bird habitat from community.	Ongoing monitoring and removal of new BLP trees will be required
	Implement works recommended in the Weed Management Plan (Phase 2)	Medium	2023 - 2025	Medium	$150k	Implement removal of BLP in accordance with the plan. Priority initially to remove Ibis rookery habitat Waterbodies D & E (i.e. associated with Broad-leaved Pepper trees overhanding water) and replace with more appropriate native vegetation (e.g. groundcovers and shrubs).	Open Space & Environment	Design Team for detailed design; External Contractors for construction.	Reductions in: bird population, public health risk, odours, nutrient loads and algal/cyanobacterial growth. Improvements to: waterbird health, water quality, batter/edge stability and increased amenity.	Concerns about loss of tress ofr bird habitat from community.	Ongoing monitoring and removal of new BLP trees will be required
	Terrestrial buffer planting (all systems)	Short	2022 - 2025	Medium	$70k-$100k	Works involve planting waterbody margins to reduce areas to create native vegetation buffers to waterbody margins. Existing weedy 'no mow buffers' to be infill planted with natives. Existing mown edges to be planted with native species (min 1.5m wide).	Open Space & Environment	Design Team for detailed design; External Contractors for installation.	Stabilise edges, limit bird egress locations, improve water quality, improve edge safety	Potential for loss of views to adjacent residents.	Combine action with other edge planting works (e.g. edge safety and terrestrial buffers).
WATERBODY PLANTING	Wetland planting to shallow edges	Medium	2023 - 2025	Medium	$150k	Works involve planting shallow waterbody margins with native emergent water plants.	Open Space & Environment	Design Team for detailed design; External Contractors for construction.	Stabilise edges, limit bird egress locations, improve water quality, provide aquatic habitat	Cost to complete. Poor water clarity and steep drop-offs will limit planting success.	These works may also be required as part of edge stabilisation or removal of BLP actions
AQUATIC WEEDS	Water level control - Ululah Lagoons	Medium	2023 - 2025	Low	$30k	As part of the proposed repair/restoration works to the existing overflow outlet provide water level control function to the system.	Capital Delivery	Design Team for detailed design; External Contractors for construction.	Enables water levels to be lowered to establish water plants around the shallow margins or permanently lower water levels to help expand vegetated buffer.	Reduced open water area. May expose sediments that smell (until vegetated)	Costs would be reduced if combined with proposed weir rectification works.
	Management of declared weeds	Short	Ongoing	Low	$20k	Monitor for and remove as required declared weeds occurring within all waterbodies.	Biosecurity	Internal works team to action	Required under Biosecurity Act.		Ongoing monitoring and maintenance but none present in the system currently
	Capital works to reduce weed harbouring areas in Waterbody A and B.	Medium	2023 - 2025	High	$350k-$500k	Capital works to undertake actions to reduce the size of waterbody A and Waterbody which involves installation of new outlet weir in Waterbody A, lowering water levels and dewatering as much as possible Waterbody B.	Capital Delivery	Design Team for detailed design; External Contractors for construction.	Less area for Salvinia and Cabomba to harbour and spread into the main Ululah Lagoon. Smaller Waterbody A will be better flushed and reduce backwatering into stormwater drainage network. Improvement in water quality.	Lowering the water level may make some waterbody edges difficult to maintain (steeper dry drop off).	These works may be part of a single capital works package as per the functional design plans. Requires detailed design and tender specification package to confirm scope and costs.
	Reduce ponding within the Waterbody C channel area	Long	2025 - 2030	Low	<$50k	Remove overflow weir to lower the water level upstream (weir is leaking). Re-profile edges of the channel (including removing any accumulated silt in base when dewatered) and revegetate with appropriate native riparian species. Establish emergent waterplants and riparian species along margins.	Capital Delivery	Design Team for detailed design; External Contractors for construction.	Reduced waterbody size and partly converting the existing waterbody back to natural channel. Slight reduction in weed harbouring areas.	Access to modify edges is difficult due to existing vegetation.	Water levels within Waterbody C will be dictated by water levels in Ululah Lagoon (rather than the leaky weir).

Action Category	Proposed Action	Timeframe	Indicative Budget period (planning purposes only)	Cost Level	Indicative Cost estimate	Indicative Scope of Works	Indicative Lead Department	Indicative Delivery Mode	Pros	Cons	Comments
	Removal Cyperus papyrus	Long	2025 - 2030	Low	$15k	Removal of large stands of the introduced aquatic plan C. papyrus from Ululah Lagoon.	Open Space & Environment	Internal works team to action	Removes weed species. Improves views from Anzac Park to open water zones. Reduce habitat for pest species.	Reduced habitat for native bird species	Works lower priority and would be completed once other edge management actions are completed. Works to be stages to ensure some stands retained for native bird species (e.g. away from high public use areas.
CATCHMENT MANAGEMENT	Develop a catchment based stormwater management plan	Medium	2023 - 2025	Low	$15k p.a.	Long term strategy to Improve stormwater runoff quality.	Infrastructure Planning	External stormwater consultant	Improved stormwater runoff quality. Reduced sediment and nutrient load being discharged to the system. Improved water quality.	Retrofitting stormwater treatment infrastructure into developed catchments can be difficult and expensive.	Works contingent on improved water quality and clarity.
	Continue to implement catchment based stormwater treatment initiatives	Long	2025 - 2030	High	>$500k	Subject to outcomes of updated Catchment Management Strategies.	Infrastructure Planning	Design Team for detailed design; External Contractors for construction.			Works contingent on improved water quality and clarity.
GOLF COURSE MANAGEMENT ACTIONS	Stabilise eroding edges (Golf Course)	Medium	2023 - 2025	Medium - High	$100k-$500k	Implement actions to manage eroding edges identified as part of the edge assessment action. Works will need to be itemised and prioritised based on return on investment approach due to the extent of waterbody edges that could potentially require works.	Infrastructure Planning	Co-ordinated between Golf Course / Council	Stabilises edges.	Some actively eroding edges may cost significant amount to address to avoid impacts to private land holders (but may not currently create a safety risk).	Dispersive soils are a re-occurring issue across a number of FCRC waterbodies. Such soil types are prone to slaking and erosion resulting in vertical and undercut edges. Particularly evident when water levels are lower during dry periods.
WATERBODY MIXING / TURN-OVER	Capital works to retrofit constructed wetland and recirculation system within upper section of Ululah Lagoon	Future / Aspirational	2025 - 2030	High	>$500k	Retrofit of a constructed wetland (within upper section of Ululah Lagoon or potentially upstream such as Waterbody A) and install waterbody recirculation system. The location of a wetland would ideally be located in the upper section of Ululah Lagoon (downstream of Alice Street) where water depths are thought to be shallower. Creation of suitable depths to support emergent wetland would likely require a infilling and/or lowered water levels. Recirculation of water through the wetland section would assist in reducing stagnant water at depth and generally improve water quality.	Infrastructure Planning	External stormwater/civil consultant for detailed design; External Contractors for construction.	Reduced waterbody residence times. Increased mixing of the water column. Reduced stratification and release of nutrients from the sediments. Improved water quality (reduced nutrients and algal/cyanobacterial growth).	Loss of open waterbody area due to construction of treatment wetland. Expensive to design and construct. Maintenance costs associated with the recirculation system and treatment wetland.	Contingent on implementing short and medium term actions. Recirculation system could be added at a later stage to reduce costs.
	Convert Ululah Lagoons to a natural wetland systems (dewater)	Future / Aspirational	2025 - 2030	High	>$500k	Capital works to modify the glory hole outlet to dewater the Ululah Lagoon open water areas and convert to a natural wetland system (potentially with smaller retained open water zones).	Infrastructure Planning	External stormwater consultant	Creation of natural wetland habitat and increased open space recreational areas.	Significant loss of open water areas that are highly valued by the community. Significant capital cost related to completing the conversion	Contingent on community consultation process.

APPENDIX C. WMS FRAMEWORK: ISSUES AND MANAGEMENT TABLE

The following table is an extract from the *Fraser Coast Waterbody Management Strategy: Waterbody Management Framework Technical Report* (DesignFlow, 2021).

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
A. Public Health and Safety					
A1 **Risk of injury or drowning**	Potential safety issues (i.e. drowning) may be due to: • Steep batters • Lack of access control • Lack of perimeter vegetation	Discuss with asset owner to identify and document any issues. Undertake desk-top review and initial site inspection.	If risk is deemed unacceptable the following actions should be considered: • Install temporary protection (temporary fencing) to exclude public entry; and/or • Erect signage to highlight risk to public and that a response is being identified.	Proactive management actions will depend on the scale, type and degree of risk. Actions may include: • Planting waterbody batters with dense vegetation to restrict access. • Installing access control using barriers such as permanent fencing where risk of access is high. • Modifying the waterbody edge to provide safe batters above and below the water level (a maximum slope of 1:4 is recommended as a minimum). • Reducing the depth of the waterbody, particularly around the edges. • Where the waterbody is located near high children use area (i.e. children's playground), consider moving the use to another part of the parkland. Refer to *Rectifying WSUD Assets* – Appendix B (Water by Design) for additional guidance.	Water by Design (2011) *Rectifying WSUD Assets.*
A2 **Health risks due to human contact with contaminated water**	Potential health risks may exist where public have direct access to water contaminated with chemicals, faecal matter or cyanobacteria Certain types of cyanobacteria (blue–green algae) can release toxins that affect the liver or nervous system when they die, which can be a major public health issue. In addition, all Cyanobacteria contain toxins within their cell walls that can cause skin irritations and allergic responses in human skin tissue from direct contact with the cells.	Discuss waterbody contamination history with asset owner, engineering and environmental health departments to identify and document any issues. Undertake desk-top review and site inspection. Detailed investigations will depend on the nature of the contamination. Refer to issue A-3 for chemical contamination, A-4 for faecal contamination and C-2 for algal and cyanobacterial blooms	Where contamination is reported, the relevant state government department (environmental health) should be notified and monitoring/management completed in accordance with DERM (2009), ANZECC (2018) and NH&MRC (2008). Management actions will be guided by monitoring outcomes but may include: • Installation of temporary protection (temporary fencing) to exclude public entry; • Erecting signage to highlight risk to public and that a response is being identified. • Community consultation • clean-up/treatment or adaptive management as required For ongoing management actions refer to issue A-3 for chemical contamination, A-4 for faecal contamination and C-2 for algal and cyanobacterial blooms	Refer to issue A-3 for chemical contamination, A-4 for faecal contamination and C-2 for algal and cyanobacterial blooms	DSDIP (2017) *State Planning Policy.* ANZECC (2018) *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2018 edition.* NH&MRC (2008) *Guidelines for managing risk in recreational waters.* DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)* DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)* Chorus and Bartram (1999). *Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management.*

[1] Actions that can be completed immediately, rapidly or cost effectively in response to the issue. The focus of management actions is investigation and easily implemented responses. May require ongoing management/investigations.

[2] Actions that require planning, design and budgeting to implement. Generally involves responses/actions which are more onerous and take time to consider.

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
A3 **Chemical contamination.**	The presence of chemical contamination may be indicated by: • Obvious discoloration of the waterbody water (i.e., orange, red, grey). • Chemical residues floating on the surface of the waterbody (e.g. oily scums). • Fish kills	Discuss with asset owner, engineering and environmental health departments to identify and document any historical issues. Undertake desk-top review of potential contamination sources (e.g. proximity to ERAs) and site inspection.	Suspected contamination by toxic chemicals should be reported immediately to DERM. If toxic chemicals are found at levels which exceed the relevant WQOs (DERM 2010a, DERM 2010b) an adaptive management program should be implemented in accordance with the risk assessment framework set out in NH&MRC (2008). Management actions may include: • Installation of temporary protection (temporary fencing) to exclude public entry; • Erecting signage to highlight risk to public and that a response is being identified. • Community consultation • treatment or adaptive management as required	Clean-up of spills should be conducted with advice from DERM and an appropriate specialist as required, in accordance with the NH&MRC (2008) risk assessment framework. Management actions will be resolved as part of the waterbody investigations. Potential management responses to may include : • Installation of stormwater treatment systems in the upstream catchment to remove pollutants prior to entering the waterbody. • Resetting the waterbody system as a wetland.	NH&MRC (2008) *Guidelines for managing risk in recreational waters.* DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)* DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)*
A4 **Faecal and/or nutrient contamination.**	Contamination of the waterbody by faecal bacteria and nutrients may be due to: • Large bird populations on or adjacent to the waterbody. • Untreated sewage entering waterbody via stormwater inflows. • Leakage of septic systems into ground, surface or stormwater. • Diffuse runoff from surrounding land uses, particularly areas with high concentrations of domestic animals (e.g. dogs, cats, cattle, sheep, pigs, poultry etc.). • Internal (nutrient) loading from the sediments) The presence of faecal contamination is often difficult to detect, however may be indicated by: • Obvious discolouration of the waterbody water (e.g. grey, blue-grey). • Unusual foaming on the surface of the waterbody, especially at inflow sites • Unusual water odours (e.g. effluent).	Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues. Undertake desk-top review and initial site inspection. Depending on the outcomes of the risk assessment, the asset owner may wish to undertake additional site surveys and /or Implement a water quality monitoring program in accordance with NH&MRC (2008).	If faecal contamination is found at levels which exceed the relevant WQOs (DERM 2010a, DERM 2010b) an adaptive management program should be implemented in accordance with the risk assessment framework set out in NH&MRC (2008). Management actions may include: • Installation of temporary protection (temporary fencing) to exclude public entry; • Erecting signage to highlight risk to public and that a response is being identified. • Community consultation • Routine inspections and maintenance of existing dog waste bins • treatment or adaptive management as required	If the risk is deemed unacceptable, management actions may include:: • Removing or culling waterfowl from the waterbody system. • Treating contamination sources from the catchment, including illegal sewer connections to drainage system, STP overflows, stormwater etc. • Treatment or containment of drainage from intensive agriculture / industry • Signage and public education programs. • Installation of dog/domestic animal waste bins	NH&MRC (2008) *Guidelines for managing risk in recreational waters.* DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)* DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)*

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
A5 **Human health risk due to excessive Mosquito Populations**	The presence of large mosquito populations represents both a potential human health risk (as mosquitoes are vectors for many pathogens including protozoa, nematodes and viruses) and a nuisance to local residents.	Discuss safety with asset owner and environmental health stakeholders to identify and document any issues. Undertake site inspection to check for evidence of mosquito breeding sites around the margins of the waterbody and also in any isolated shallow pools in the near vicinity. Check for evidence of litter which may support mosquito breeding. Record whether or not: • The mosquito problem is associated with the waterbody (or the surrounding ecosystems). • Simple management actions can be implemented to reduce populations. • A mosquito control plan should be prepared and management actions implemented. Where a mosquito control plan is required then an audit of the mosquito species and population density both within the waterbody and adjacent habitats is required.	Simple management actions may include: • Implementing a regular litter removal program • Regular Spraying with larvicides (seek advice from environmental health experts within Council if the use of chemical control agents are deemed necessary.)	Where further management is required, a mosquito control plan should be prepared in accordance with the *Mosquito Management Code of Practice for Queensland* (Local Government Association of Queensland Inc. 2002). Rectification options may include: • Draining isolated pockets of pooled water. • Filling in uneven areas where stagnant water accumulates • Increasing depth in open water areas to >60cm to limit mosquito breeding • Improving waterbody circulation and flushing • Introducing mosquito predators (native fish).	Local Government Association of Queensland (2002) *Mosquito Management Code of Practice.* Diseases Control Services, Communicable Diseases Unit, Queensland Health (2002) *Guidelines to minimise mosquito and midge biting problems in new development areas.* Water by Design (2011) *Rectifying WSUD Assets.* Water by Design (2011) *Maintaining WSUD Assets.*
B. Hydraulic condition					
B1 **Inlet/outlet erosion or instability**	Instability or erosion of inlet or outlet structures may be hazardous due to structural failure of hydraulic controls, blockages, creation of deep pools/unsafe batters, etc. Instability of the inlet/outlet may result from: • High discharges due to storm inflows. • Lateral surface flows entering the waterbody via drainage lines. • Localised high velocities (e.g. shape of waterbody, around inlet). • Failure of aging infrastructure	Inlet/outlet scour/instability issues with inlets and outlets with asset owners to identify and document any issues. Complete a site inspection to check for evidence of failure of hydraulic controls at inlets/outlets and assess the scale of the problem and reason for erosion/instability. Following the investigation tasks listed above a decision needs to be made regarding the following whether the issues require management or not. This decision will be dictated by the amount of erosion/instability, risk of further failure and the public safety risk (**A1**). Where management is required, in most cases this will not require detailed assessment but rather will involve design of a replacement structure / scour protection measures.	Where erosion/instability exists and has stabilized or is not considered a risk to Council, then no management action required. Monitor the issue zones via regular visual inspection.	Management of significant erosion/instability will be dictated by the investigations and may require specialist input from a soil scientist and /or stormwater engineer. Management responses may include: • Re-enforcing the eroded areas with rock protection. • Directing inflows to rock-lined channels that feed down the batters to the waterbody. • Replacing topsoil in scoured zones and re-establishing the vegetation. • Modifying hydraulic control structures (i.e. inlet and outlet pipes and weirs). If the soil is problematic, seek advice from the soil laboratory for management options to meet the specifications. In some cases, in-situ management may be possible. However, if not, remove and replace the soil.	
B2 **Outlet blockage - Water level is consistently too high above normal water level**	Persistent high water levels (minor flood conditions) within the waterbody causing issues adjacent to waterbody (e.g. death of vegetation, waterlogging of parkland area, tidal backwatering etc.).	Discuss elevated water levels issue with asset owner and engineering services to identify and document any issues. • Complete site inspection following rainfall and during dry conditions to assess elevated water levels and identify potential causes: This will include checking for blockage of the outlet pipe or weir. • Incorrect design or construction of the outlet pipe or weir. • Blockage or siltation of downstream drainage system causing backwatering up the pipe. • Increased catchment inflows due to changes in catchment land use or drainage. Where the risk of elevated water levels is high or very high and the solution is not straight forward then further technical assessment may be required. Seek advice from an engineer if the outlet is regularly blocked or undersized. Review catchment land use to determine if there has been a significant increase in catchment imperviousness. Catchment modelling may be required to determine waterbody inflows. Assess the capacity of the waterbody outlet to cope with increased flows. Installation of a water level gauge may assist with technical assessment.	Management options for elevated water level may include: • Undertaking regular inspection and maintenance of waterbody outlet. • Cleanout of downstream waterways to ensure free drainage of waterbody • Erecting signs to inform the community about the water level issue in the waterbody.	If the risk is deemed unacceptable, management actions may include: • Decrease future risk of blockage (i.e. submerged outlets, inclined grates, large conveyance opening to allow for accumulation of litter) • Provide increased capacity (i.e. new pit or pipes). • Provide easy inspection and maintenance access (4.8) • Allow adaptive management of the waterbody water levels (e.g. install valve or stage outlet to allow water levels to be lowered or raised easily).	Healthy Waterways (2010) *WSUD Technical Design Guidelines.*

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
B3 **Poor flushing or dead pockets**	Poor flushing or dead pockets are demonstrated by patches of still, stagnant water, sometimes accompanied by an odour and / or algal growth. This is caused locally by areas of open water that are rarely flushed (isolated 'dead pockets') or more broadly waterbodies that have relatively small or infrequent inflows.	Discuss coarse poor flushing and dead pockets with asset owner and engineering services to identify and document any issues. Complete site inspection around the full perimeter of the waterbody to identify potential to dead pockets indicated by: • Small backwaters which do not receive flowing water. • Poor water quality and algae	Where poor flushing exists but it is not leading to poor water quality, then no management action required. Monitor the poorly flushed zones via regular visual inspection.	Where poor flushing is resulting in poor water quality outcomes (i.e. algae blooms), then management should occur. Options include: • Recirculation • Removal of islands • Retrofitting of inlets/outlets to maximize flushing • Redirecting flows through the waterbody to ensure flow pass through dead pockets. • Re-shaping base of the waterbody to remove or fill in dead pockets. • Converting dead pockets to wetland zones.	
B4 **Water level is consistently too low**	The waterbody water level drops following rainfall to expose the bed of the waterbody system.	Discuss low water levels with asset owner and engineering services to identify and document any issues. Complete site inspection following rainfall and during dry conditions to assess elevated water levels and identify potential causes. This will include checking for: • Incorrect outlet structure. • Leaking outlet structure. • The waterbody catchment is small (i.e. not enough inflow to sustain water level) • The base or bund of the waterbody is not properly sealed. • Depth of waterbody has reduced due to siltation. • Inflows are bypassing the waterbody. Where the risk of low water levels is high or very high and the solution is not straight forward then further technical assessment may be required. Seek advice from an waterbody specialist (internal or external to Council) to confirm the reason for the water level reduction: • Obtain design information for the waterbody in particular catchment area, inflow points, earthworks/bathymetry and outlet structure. • Obtain certification and construction information for the waterbody. • Where required collect survey data to confirm the design levels are achieved. • Review the catchment area to ensure the catchment is suitably large enough to sustain water in the waterbody (i.e. waterbodies which are greater than 5% of the catchment in the Fraser Coast region may experience significant water level variation). • Review the depth of the system to confirm whether siltation has occurred (may require survey). • Complete boreholes in the base of the waterbody to confirm the presence of a clay liner (or otherwise).	Management options for low water levels may include: • Erecting signs to inform the community about the water level issue in the waterbody.	If the risk is deemed unacceptable, management actions may include: • Installing a new outlet structure. • Fixing any leaks in the outlet structure. • For a waterbody with a small catchment, reduce the size of the waterbody or decommission. • Diverting more catchment into the waterbody. • Use proprietary product which flocculates fine sediment to the base of the waterbody to create a thick impermeable liner. Apply following a number of rainfall events where suspended solids are elevated to maximize sediment capture on base. • Draining and sealing the base or bund of the waterbody properly • Converting a waterbody which has a 'leaky' base to an ephemeral wetland. Where the waterbody has been constructed recently and certified by geotechnical engineer or civil engineer, consider taking action for compensation to cover costs of management works.	
B5 **Flooding of adjacent land, parkland or property or regular overtopping of waterbody bund**	Drainage into or out of the waterbody has the potential to flood adjacent land, park or property due to poor hydraulic controls (i.e. uncontrolled flow out of waterbody).	Discuss flooding issues with asset owner and engineering services to identify and document any issues. Complete site inspection following rainfall to assess flow behaviour through the waterbody system with a focus on inflows and outflows from the waterbody and any recorded flood prone areas. Further assessment may be required if risk is identified as high. This may include undertaking a detailed desktop catchment investigation (areas, land use incl. changes, flood/stormwater management reports, flow calculations and/or modelling, complaints register)	Management actions may include:: • Undertaking regular inspection and maintenance of waterbody outlet. • Regular cleanout of downstream waterways to ensure free drainage of waterbody.	If the risk is deemed unacceptable, management actions may include: • Modifying outlet structures to control flooding (i.e. lower water levels, increase capacity, staged outlet) • Installing or increasing the size of the high flow weir outlet from the waterbody. • Increasing the capacity of downstream waterways • Stabilising flood inflow and outflow locations. • Diverting upstream catchment into or around waterbody.	Department of Natural Resources and Water (2016) *Queensland Urban Drainage Manual Fourth Edition.*

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
B6 **Scour of batters**	Scoured batters may be hazardous due to the instability of the waterbody edges and presence of under-cut edges. Scour of the batters may result from: • High discharges due to storm inflows. • Lateral surface flows entering the waterbody via drainage lines. • Localised high velocities (e.g. shape of waterbody, around inlet). • Lapping of water against exposed turf edges. • Use of inappropriate soils around the edge of the waterbody (dispersive soils and the associated tunnel erosion).	Discuss scour of waterbody batters with asset owner and environmental health stakeholders to identify and document any issues. Complete a site inspection to check for evidence of scour around the margins of the waterbody and assess the scale of the problem and reason for scour. Following the investigation tasks listed above a decision needs to be made regarding the following whether the scour issues require management or not. This decision will be dictated by the amount of scour, risk of further scour and the public safety risk (1.1). Where management is required, in most cases this will not require detailed assessment but rather will involve design of a new waterbody batter which stable.	Where scour exists and has stabilized or is not considered a risk to Council, then no management action required. Monitor the scour zones via regular visual inspection.	Management of significant scour will be dictated by the investigations and may require specialist input from a soil scientist and /or stormwater engineer. Management responses may include: • Re-enforcing the eroded areas with rock protection and benching. • Directing inflows to rock-lined channels that feed down the batters to the waterbody. • Replacing topsoil in scoured zones and re-establishing the vegetation. • Modifying hydraulic control structures (i.e. inlet and outlet pipes and weirs). If the soil is problematic, seek advice from the soil laboratory for management options to meet the specifications. In some cases, in-situ management may be possible. However, if not, remove and replace the soil.	
B7 **Coarse sediment accumulation**	Coarse sediment is the largest component of urban stormwater pollutants in term of quantity. Therefore, coarse sediment deposition in the inlet zones to waterbodies will eventually be an issue for management. Excessive sediment accumulation within the waterbody may result in the blockage of preferred flow path and the development of multiple flow paths. The growth of emergent macrophyte vegetation upon silted areas may also influence the hydraulic behaviour of a waterbody system	Discuss coarse sediment accumulation with asset owner and engineering services to identify and document any issues. Complete site inspection to each of the inflow points into the waterbody to assess coarse sediment accumulation: • Visible sediment accumulation above or below the normal water level. Sediment accumulation is often most evident near the waterbody inlet zone/s. • Growth of emergent macrophytes within the waterbody. • Collection of sediment cores using a simple grab sampler/corer. Where coarse sediment has accumulated the cause should be identified e.g.: • Untreated catchment runoff • Catchment land use or activities • Failure of WSUD systems (GPTs or sediment basins) within the catchment to adequately capture coarse sediments • Erosion of upstream waterways.	Management actions for coarse sediment manage can be undertaken provided access to the inlet zone is possible and include: • Desilting the inlet area with machinery or dredges • Desilting sediment basins of GPTs located upstream of the waterbody.	If the risk is deemed unacceptable and cannot be treated by management actions alone, management actions may include: • De-watering the waterbody and mechanically removing the sediments. • Managing the coarse sediment at its source (e.g. stabilizing upstream waterway). • Installing GPT or sediment basins at the inflow point to the waterbody • Creating maintenance access to the inflow zones or sediment capture systems. • Creating dewatering areas Note: An analysis of the sediment quality should be undertaken prior to removing sediments in order to determine the contamination level.	
B8 **Fine sediment or organic matter accumulation**	Fine or organic sediment accumulation on the bed of the waterbody system has a significant influence on waterbody function. Fine or organic sediment carries a large quantity of particulate nutrients. At the bed of the waterbody the sediment becomes anaerobic and these nutrients may be released in soluble form into the waterbody water column. Therefore, the fine organic sediment that accumulates on the base of waterbody can become a limitless source of nutrients to support algae blooms and weed growth.	It can be generally assumed that most waterbodies will have fine sediment accumulation. The question is how much accumulation. Discuss fine sediment accumulation with asset owner and engineering services to identify and document any issues. Complete site inspection to the waterbody to assess fine sediment accumulation. This will require collection of sediment cores using a simple grab sampler/corer and visual inspection. Sample testing may be considered but in most cases the accumulation of fine sediment will be obvious. The sediment assessment should be combined with water quality profiling for dissolved oxygen and redox to assess the state of the sediment (i.e. anoxic). Where fine sediment has accumulated the cause should be identified e.g.: • Untreated catchment runoff • Catchment land use or activities • Failure of WSUD systems within the catchment to adequately fine coarse sediments • Erosion of upstream waterways.	Where fine sediment accumulation is minor (say < 5cm) and the waterbody water quality is in relatively good condition, monitor waterbody water quality and health. No need to remove sediment.	Where fine sediment accumulation is significant (say > 5cm), anoxic and is the likely cause of poor water quality in the waterbody the management is required. Management options include: • Converting the waterbody to a wetland (if shallow enough) • Filling in the waterbody • Dewatering the waterbody, allowing to dry out and removing sediment. • Dredging or desilting the waterbody in wet conditions. • Sealing the fine sediments under a layer of flocculated layer of sediment (i.e. flocculent added to waterbody)	

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
C. Water Quality					
C1 **Odours**	Odours that detract from public open space or are a nuisance for local residents. There are a number of reasons why odours may develop in waterbody systems (also refer to Issues A2 - A4 and C2 - C5 in this table).	Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues. Undertake desk-top review and initial site inspection. Site inspections should be undertaken during early morning or low wind conditions to confirm presence of odour. Check the waterbody for possible sources of odour. This will include checking for: • Decomposing organic matter • Evidence of algal blooms (e.g. surface scums). • Anoxic sediments (surface bubbling, sulphur-based odours when the sediment is disturbed). • Chemical residues upon the water surface • Large populations of water birds • Chemical spillage (via the stormwater drainage system). • Cross-connections from the sewerage system, or cross-contamination from septic systems in rural areas. As indicated by the possible causes above, the presence of odour is almost always associated with other waterbody management issues. In most cases the presence of odour will be temporary and not a significant issue.	Where the odour issue is believed to be temporary or low-medium risk then no action is required. Where odour is believed to be permanent and high to very high risk then management will be required. In the interim the odour issues could be managed by: • Notifying residents of the issue • Erecting signage notifying people of the issue.	If the risk is deemed unacceptable, management actions may include: • Installation of mixers or aerators into the waterbody to increase dissolved oxygen levels (C7 and B3) • Removing organic matter and fine sediment (B8) • Removal or treatment of chemical contamination (A3) • Managing bird populations (A4) • Identifying and sealing sewerage cross connection (A4) • Rectifying the source of algal blooms (C2)	
C2 **Algal or cyanobacterial blooms**	Algal and / or Cyanobacterial blooms are indicators of poor water quality and aquatic health within a waterbody system. While most species of algae (e.g. green algae, flagellates and diatoms) are not dangerous to humans or animals, some may reduce aesthetic values through changes in water colour, odours and surface scums. The presence of persistent cyanobacterial / algal biomass may be due to a range of factors, including: • Untreated stormwater inflows. • Nutrient released from the sediments. • Excessive waterbody residence times • High internal carbon (organic) loading (i.e. resulting from decay of aquatic weeds such as Salvinia). • Low submerged or emergent macrophyte cover. • Excessive waterbird population. • Rapid variations in salinity	Discuss algal and cyanobacterial issues with asset owner, engineering and environmental health departments to identify and document any historical issues. Undertake desk-top review and site inspection. Further assessment is only required if persistent blooms are recorded and if the asset owner considers it necessary to obtain a more detailed understanding of waterbody processes to inform rectification. This may include: Monitoring for the following parameters:: • Chlorophyll-a, total phosphorous, soluble phosphorous, total nitrogen and nitrate-N. • Temperature, redox, salinity and DO depth profiles at a number of locations • Cyanobacterial identification and counts • Cyanobacterial toxin concentrations (i.e. where counts exceed the Red Alert level).	If cyanobacteria / algal risks are deemed unacceptable, a specialist should be consulted to develop a monitoring program and implement an adaptive management framework in accordance with DERM (2009), ANZECC (2018) and NH&MRC (2008). Management actions will be guided by monitoring outcomes but may include: • Installation of temporary protection (temporary fencing) to exclude public entry; • Erecting signage to highlight risk to public and that a response is being identified. • Community consultation • Treatment or adaptive management as required Immediate actions are not generally required for managing harmless algal blooms. However, long term management actions may be necessary to improve aesthetic values and aquatic habitat condition (refer to management actions).	The management actions will be resolved as part of the waterbody investigations. Potential management responses • the waterbody system as a wetland. • Installing recirculation systems for waterbody waters (wetland, sand filter, UV) to deplete algal biomass and nutrient loading within the waterbody. If cyanobacterial toxin concentrations exceed the primary contact recreation WQOs Powdered activated carbon (PAC) dosing may be required (note that specialist advice should be sought before this action is undertaken).	DERM (2009) *Queensland Water Quality Guidelines.* ANZECC (2018) *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2018 edition.* NH&MRC (2008) *Guidelines for managing risk in recreational waters.* DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)* DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)* Chorus and Bartram (1999). *Toxic cyanobacteria in water: A guide to their public health consequences, monitoring and management.*

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
C3 **Persistent high turbidity levels.**	Excessive turbidity, total suspended solids (TSS) or total dissolved solids (TDS) can smother aquatic habitats and reduce sunlight infiltration, which may provide conditions favourable to increased algal production and invasive species (e.g. carp, tilapia etc) that are more tolerant to a range of water quality conditions.	Discuss with asset owner and engineering department to identify and document any current or historical issues. Undertake desk-top review and site inspection. Record turbidity levels in-situ using a water quality probe. Further monitoring during both wet and dry weather may be required if potential sediment sources are identified. If turbidity levels within the waterbody consistently exceed the relevant WQOs (1-20 NTU), for the protection of moderately disturbed freshwaters) in DERM 2010a or b, then further investigation may be required to determine the source/s of the high turbidity (e.g. development sites, stormwater inflows, sediment re-suspension etc) and to consider other catchment management solutions.	Treatment of persistent high turbidity levels will not normally require any ongoing management actions – refer to rectification	Management actions will be dictated by the field investigations and whether or not the risk is identified by the asset owner as acceptable. Management actions may include: • Establish and maintain healthy submerged and emergent macrophytes within the waterbody. • Establish and maintain healthy riparian vegetation on waterbody margins. • Repair areas of bank erosion (e.g. lining with geofabric) and revegetating using endemic species • Stormwater treatment within the upstream catchment. (e.g. providing additional sediment capture upstream of waterbody such as sediment basins). • Managing runoff from construction sites in accordance with State Planning Policy for Healthy Waters (DERM 2010c) and IECA Australasia (2008). • Replacing topsoil used within the waterbody (refer AS4419 2003). • Repairing areas of the waterbody where the clay liner has been exposed.	DERM (2010a) *Environmental Protection (Water) Policy 2009 Burrum, Gregory, Isis, Cherwell and Elliott Rivers environmental values and water quality objectives Basin No. 137 (July 2010)* DERM (2010b) *Environmental Protection (Water) Policy 2009 - Mary River environmental values and water quality objectives. Basin No. 138, including all tributaries of the Mary River (July 2010)* AS4419 (2003). *Soils for landscaping and garden use* DSDIP (2017) *State Planning Policy.* IECA Australasia (2008). *Best Practice Erosion and Sediment Control. November 2008.*
C4 **Stratification and low dissolved oxygen**	Water column stratification may be present due to a range of factors, including: • Excessive water depth (>2.5 m) – although stratification can occur in highly eutrophic waterbodies less than 1m deep. • High surface water temperatures. • Elevated salinity in freshwater waterbody systems. • Fresh water inflows to saline waterbodies. • Elevated organic carbon, nutrient and sediment loading. • Long detention times or lack of wind mixing. • Low or absent cover of submerged or emergent aquatic macrophytes. • Unsuitable waterbody configuration / orientation • The presence of inappropriate or multiple flow paths One of the major concerns associated with stratification is dissolved oxygen depletion. This may result in the release of dissolved (bioavailable) nutrients from the waterbody sediment which encourages algae and floating weed growth. Low dissolved oxygen concentrations are also a major cause of fish kills and sediment odour problems.	Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues. Undertake desk-top review and initial site inspection. The asset owner may wish to undertake additional monitoring to determine the spatial extent and duration of stratification. This will involve regularly monitoring electrical conductivity, water temperature dissolved oxygen and Redox potential through the full water column at several locations throughout the waterbody system. (Note: as dissolved oxygen concentrations vary considerably throughout the day due to the processes of respiration and photosynthesis it is recommended that monitoring is undertaken at different times during the day.)	Persistent stratification will not normally require any ongoing management actions – refer to rectification	If the risk of persistent stratification is deemed unacceptable, management actions may include: • Installation of mixing systems (including aerators and water pumps). • Modification of waterbody bathymetry to increase hydraulic efficiency and wind forced mixing (e.g. infilling backwaters, moving inlet/outlet structures, targeting planting, removal of clumped vegetation to promote longer flow paths, removal of islands, dredging etc). • Installation of waterbody re-circulation systems to improve internal waterbody mixing. • Establishment and maintenance of healthy submerged and emergent macrophytes within the waterbody to facilitate nutrient uptake, reduce turbidity levels and reduce sediment oxygen consumption. • Establishment and management of healthy riparian vegetation on waterbody margins to improve shading and reduce sources of diffuse runoff. • Removal and / or treatment (e.g. Phoslock®) of the waterbody sediments (refer to 'Siltation' in this table). • Installation of stormwater treatment systems in the upstream catchment to remove pollutants before they enter the waterbody.	

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
C5 **Variable salinity**	Brackish waterbodies and waterbodies which experience large variations in salinity should be avoided. For freshwater and saline waterbody systems, large fluctuations in salinity levels may provide conditions that are unfavourable for submerged macrophytes and favour undesirable vegetation (riparian or aquatic) and algae (particularly blue-green algae). Increased salinity within freshwater waterbodies may be due to: • Tidal intrusion of saline water into waterbody. • Ingress of saline groundwater to the waterbody. • Contamination from upstream land uses (e.g. industrial, agricultural etc.) via stormwater inflows or diffuse runoff For saline waterbodies (tidally flushed), decreased salinity may be due to: • Stormwater inflows or diffuse runoff to the waterbody. • Ingress of freshwater groundwater to the waterbody. • Often the inflow of freshwater into saline waterbodies is accompanied by increased nutrient loads.	Discuss with asset owner and engineering department to identify and document any current or historical issues. Undertake desk-top review and initial site inspection. Refer to Appendix G of the *Queensland Water Quality Guidelines* (DERM 2009) to determine acceptable variations in salinity. The asset owner may wish to undertake additional site surveys and /or Implement a monitoring program including monitoring electrical conductivity both after rain and during long dry periods to observe changes in salinity. For freshwater waterbodies, electrical conductivity levels of >1500 µS/cm pose an immediate risk to aquatic plants. For saline waterbodies, the risk of cyanobacterial blooms increases where electrical conductivity is <10 000 µS/cm. Refer to DesignFlow 2010 for guidance on additional investigations to determine the source of the saline / freshwater intrusion.	Variable salinity will not normally require any ongoing management actions – refer to rectification	If the risk of variable salinity levels is deemed unacceptable, management actions may include: <u>Freshwater waterbodies</u> If observations during large tide events and salinity monitoring confirm tidal backwatering into the waterbody, consider: • Raising the water level within the waterbody so that saline water cannot enter through the waterbody outlet. This will require modifying the configuration of the outlet structure. • Installing a flap gate on the outlet pipe to the downstream saline environment. • Raising bund levels to prevent tidal backwatering If saline groundwater intrusion is evident within the waterbody and impacts on vegetation health are obvious, it may be necessary to replace or repair the waterbody liner. Alternative options include • Trenching along the waterbody batter and placing a clay or bentonite barrier across the groundwater intrusion site. • Replanting the waterbody with saline or brackish tolerant plant species. (Note: there is an increased risk of mosquitoes in saline / brackish waters which will need to be monitored). Refer to mosquitoes in this table. If other catchment sources are suspected, contact DERM to investigate potential sources of contamination. <u>Saline (tidal) waterbodies</u> If observations during rainfall events and salinity monitoring confirm freshwater inflows and lack of tidal flushing is occurring, consider: • Diverting stormwater flows around waterbody • Converting to a freshwater waterbody • Increasing tidal flushing or removing any blockages • Groundwater management as per above	DERM (2009). *Queensland Water Quality Guidelines: Appendix G: Salinity guidelines (expressed in conductivity units) for Queensland freshwaters.* ANZECC (2018) *The Australian and New Zealand Guidelines for Fresh and Marine Water Quality – 2018 edition.* DesignFlow (2010). *Townsville Constructed Lakes Guideline.*
C6 **Litter**	The presence of excessive amounts of litter reduces the amenity of the waterbody and can increase public health risk by harbouring mosquitoes.	Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues. Undertake desk-top review and initial site inspection. Check for possible sources of litter. This will include checking for: • Catchment runoff from commercial or industrial zones • Failure of a gross pollutant traps • Direct dumping of litter in adjacent parkland areas • Overflowing or un-managed bins	Where risk is medium then litter removal should occur on a scheduled or reactive basis. If gross pollutant traps or trash racks exists then commence maintenance on this system as required.	If the risk is deemed unacceptable management actions may include: • Retrofitting the upstream drainage system with litter controls, e.g. a gross pollutant trap or a trash rack • Incorporating a trash rack with easy access to the inlet zone of the waterbody • Providing litter disposal bins in the adjacent public open space • Creating access to the zones in the waterbody where litter tends to accumulate for litter collection. This will typically be at the downwind of the waterbody along the line of prevailing winds. • Undertaking an education campaign within the catchment on litter and its impact on downstream ecosystems.	

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
D. Aquatic Habitat					
D1 **Aquatic weeds**	The persistence of aquatic weeds within the waterbody may be due to: • Uncontrolled weed infestations in the upstream catchment. • Excess sediment accumulation within waterbody. • High nutrient concentrations present within the waterbody • Vegetation failure allowing weeds to colonise. • Accidental or illegal introduction (e.g. ornamental pond or aquarium species, such as Salvinia) • Presence of vectors, e.g. birds. • Lack of maintenance.	Discuss aquatic weed issues with asset owner, engineering and environmental health departments to identify and document any issues. Complete a site inspection to determine presence of / proportion, species etc. Seek advice from a weed specialist for long term weed removal or control strategies. This will require: • Confirming the weed species present • Identifying the cause/s of the weed infestation • Considering the biological characteristics of the weed species • Determining long term weed management options	The control of declared weeds is mandated under the *Biosecurity Act 2014*. Therefore, these weeds must be dealt with as part of the regular maintenance schedule. Refer to *Maintaining WSUD Assets* for general advice about managing weeds. Management actions may include • Regular harvesting using aquatic weed harvester • Chemical control (Note: Seek advice from weed specialist if chemical control is being considered. The potential impacts of chemical herbicides on the waterbody ecosystem should be considered. • Biological control agents, such as the Salvinia weevil (*Cyrtobagous salviniae*) and water hyacinth weevil (*Necochetina eichorniae*) (Note: specialist advice should be sought *from the CSIRO divisio*n of entomology).	If the risk is deemed unacceptable and the aquatic weed infestation cannot be controlled by management alone, management actions include: • Completely removing the weed species using control methods listed in *Maintaining WSUD Assets*. • Draining and drying out the waterbody in order to desiccate the weed species. Obtain specialist advice about the required drying out period. • Preventing the future ingress of weeds by planting the edges of the waterbody with plant species that provide dense cover and shade. • Establishment and maintenance of healthy submerged and emergent macrophytes within the waterbody. • Establishment and management of healthy riparian vegetation on waterbody margins to improve shading and reduce sources of diffuse runoff. Generally a combination of the above actions is required to manage and / or eradicate infestations.	*Biosecurity Act 2014*. Water by Design (2011) *Maintaining WSUD Assets.* Refer to Biosecurity Queensland: DPI website (http://www.dpi.qld.gov.au), including: • *Guideline for the management of Salvinia* • *Guideline for the management of water lettuce* • *Guideline for the management of water hyacinth* Refer to weeds of national significance (WONS) http://www.weeds.gov.au/weeds/lists/wons.html FCRC (2017) *Fraser Coast Regional Council Biosecurity Surveillance Program for Prohibited and Restricted matter 2017 - 2021*
D2 **Presence of aquatic pests (e.g. exotic fish species)**	Exotic fish species (e.g. European carp, tilapia, mosquitofish, goldfish etc.) are generally able to tolerate a wide range of water quality and environmental conditions, and so have a competitive advantage over native fish species. Exotic fish can also contribute to the further deterioration of water quality through sediment re-suspension (bottom feeders), habitat destruction/fragmentation and increased internal loading of nutrients.	Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues. Undertake desk-top review and initial site inspection. The asset owner may wish to undertake a fish survey to determine the proportion of native and exotic fish species, biomass and size distribution present. (Note: The capture, removal or destruction of fish is governed by strict ethical considerations and should only be undertaken by qualified staff, in accordance NH&MRC (2004) and with relevant permits obtained from the Queensland Department of Primary Industries and Fisheries).	The presence of exotic fish species will not normally require any ongoing management actions – refer to rectification	If the risk is deemed unacceptable management actions to reduce/eliminate the invasion of exotic fish species may include: • Trapping and removal of pest species in accordance with NH&MRC (2004). • Improving aquatic habitat conditions to encourage recruitment and breeding of native species. This may include the establishment and maintenance of healthy submerged and emergent macrophytes, installation of artificial habitat structures, introducing large woody debris (LWD/re-snagging) etc. • Establishing and maintaining healthy riparian vegetation. • Implementing a native fish stocking program. • Improving hydraulic connectivity of on-river waterbodies (where possible) by modifying/replacing existing inlet/outlet structures to provide for suitable upstream passage of native fish and other aquatic organisms. • Improving water quality conditions.	Refer to DAF Website: https://www.daf.qld.gov.au/business-priorities/fisheries/habitats FCRC (2017) *Fraser Coast Regional Council Biosecurity Surveillance Program for Prohibited and Restricted matter 2017 - 2021*
E. Terrestrial Habitat					
E1 **Terrestrial weeds**	The persistence of terrestrial along waterbody edges or adjacent to the waterbody may be due to: • Uncontrolled weed infestations in the upstream catchment. • Discontinuous or fragmented perimeter vegetation • Vegetation failure allowing weeds to colonise. • Accidental or illegal introduction • Presence of vectors, e.g. birds. • Lack of maintenance. • Contaminated fill and mulch (on batters)	Discuss terrestrial weed issues with asset owner, engineering and environmental health departments to identify and document any issues. Complete a site inspection to determine presence of / proportion, species etc. Seek advice from a weed specialist for long term weed removal or control strategies. This will require: • Confirming the weed species present • Identifying the cause/s of the weed infestation • Considering the biological characteristics of the weed species • Determining long term weed management options	The control of declared weeds is mandated under the *Biosecurity Act 2014*. These weeds must be dealt with as part of the regular maintenance schedule. Refer to *Maintaining WSUD Assets* for general advice about managing weeds. Management actions include: • Chemical control (Note: Seek advice from weed specialist if chemical control is being considered. The potential impacts of chemical herbicides on the waterbody ecosystem should be considered). • Regular inspection and application of clean mulch around waterbody perimeters	If the risk is deemed unacceptable and the aquatic weed infestation cannot be controlled by management alone, management actions include: • Completely removing the weed species using control methods listed in *Maintaining WSUD Assets*. • Establishment and management of healthy riparian vegetation on waterbody margins Generally a combination of the above actions is required to manage and / or eradicate infestations	*Biosecurity Act 2014.* Water by Design (2011) *Maintaining WSUD Assets.* Refer to weeds of national significance (WONS) http://www.weeds.gov.au/weeds/lists/wons.html FCRC (2017) *Fraser Coast Regional Council Biosecurity Surveillance Program for Prohibited and Restricted matter 2017 - 2021*

Issue	Description	Investigations / monitoring	Minor or Immediate Response Management Actions[1]	Proactive Management Actions[2]	Relevant policy, legislation and supporting information
F. Maintenance					
F1 **Access for maintenance**	Poor access for maintenance of hydraulic structures, removal of sediment from inlet areas and pump infrastructure can result in deterioration of the system Ideally maintenance access should be following locations: • Stormwater inflows to waterbody for sediment desilting. • Edge of waterbody for weed harvesting or to launch boat. • Hydraulic controls • Around the broad perimeter of the waterbody of riparian weed management.	Discuss maintenance access allowance with asset owner, maintenance and engineering services to identify and document any issues. Complete site inspection to identify existing maintenance allowance and obvious access problems.	Provided the maintenance access is constructed from suitable materials (i.e. gravel, concrete or reinforced vegetation), then maintenance will be minimal and based on inspections. Maintenance may involve weeding and filling of wheel ruts.	Where maintenance access is deficient installation of access will be required. The nature of access for different maintenance activities should be discussed with the asset owner. Management actions may include: • Provision of maintenance access for vehicles, boats and weed harvesters (e.g. ramps for sediment removal, tracks for access to structures etc) • Provision of work areas for sediment drying, maintenance of hydraulic structures and erosion/scour • Installation of access tracks • Provision of Sediment drying area/s	*Maintaining WSUD Assets* (Water by Design, 2012)