

Magazine Creek Wetland Management Plan

City of Port Adelaide and Enfield

12 June 2020





Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
1	Draft	GF	GF	10/2019
2	Consultation Draft	GF	GF	04/2020
3	Final	GF	GF	6/2020

Project Details

Project Name	Magazine Creek Wetland Management Plan
Client	City of Port Adelaide and Enfield
Client Project Manager	Craig Hughes
Water Technology Project Manager	Geoff Fisher
Water Technology Project Director	Geoff Fisher
Authors	Geoff Fisher, Tamar Haviv, Kerri Muller, Barrie Ormsby, John Gitsham, Alison Charles
Document Number	p19027_Magazine Creek Management Plan V3_2 200612

In collaboration with:



COPYRIGHT

Water Technology Pty Ltd has produced this document in accordance with instructions from City of Port Adelaide and Enfield for their use only. The concepts and information contained in this document are the copyright of Water Technology Pty Ltd. Use or copying of this document in whole or in part without written permission of Water Technology Pty Ltd constitutes an infringement of copyright.

Water Technology Pty Ltd does not warrant this document is definitive nor free from error and does not accept liability for any loss caused, or arising from, reliance upon the information provided herein.

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000
Fax (08) 8357 8988
ACN 093 377 283
ABN 60 093 377 283





EXECUTIVE SUMMARY

It is widely recognised that wetlands play an integral part in hydrological cycle, influencing groundwater recharge, low flows, facilitating evaporation and mitigating floods. The City of Port Adelaide and Enfield manage Magazine Creek and The Range wetlands, two stormwater treatment wetlands constructed in the mid 1990's on the samphire flats adjacent to the Port River and Barker Inlet estuary. The wetlands are now adjacent to the Adelaide International Bird Sanctuary established in October 2016 and have developed into valuable, regional habitat supporting a range of native wetland plants, small native fish, frogs and waterbirds.

Magazine Creek wetlands (15.9 ha of wetland on a 36-ha reserve) were designed to mitigate flood risk in the Torrens Road Catchment, (2322 ha) a heavily-industrialised and built-up catchment. The wetlands were constructed to treat stormwater entering from Jensen Street and Eastern Parade before it enters the Port River and provide visual amenity. However, the area where the wetlands were constructed has hypersaline groundwater lying close to the soil surface. The wetland design included a series of windmills and underground tile drains that could be operated to extract hypersaline groundwater. The aim was to lower the shallow, regional groundwater table and facilitate the creation and maintenance of a freshwater groundwater lens around the wetland. Hypersaline groundwater, extracted by the windmills whenever the wind is blowing, is discharged into the most downstream of the wetland ponds, from where it is flushed to the Port River system under higher stormwater flows. There are also a series of culverts between the ponds that were designed to contain spills or very poor-quality stormwater, if required.

A total of 16 species of native wetland plants were surveyed in summer 2018 and spring 2019. Of these approximately 10 were planted and 6 have colonised the site. Vegetation abundance and diversity was highest in the central ponds, away from the inlet and the outlet. It is likely that plant cover is limited by high turbidity of incoming stormwater and prolific algal growth near the inlet and by high salinities from the windmill discharge near the outlet. The central sections also provide more sheltered and densely vegetated habitats that in turn, attract a range of waterbirds that help bring aquatic plant seeds and propagules.

Water bird diversity and abundance was generally high with a total of 43 species observed in December 2018. The assemblage was typical for this type of freshwater-estuarine habitat, although no true saltwater (migratory) or ocean shorebird species were observed. Male frogs were heard calling in both December 2018 and September 2019. Schools of small fish were observed on both occasions in the dense submerged vegetation in the central ponds. It is assumed that they were native fish from their shape and behaviour and were most likely a species of hardyhead given the salinity profile and the connection to the ocean, noting that formal fish surveys have not been undertaken to-date.

These observations show that Magazine Creek is a functional wetland ecosystem with higher habitat values in the fresher, less turbid areas. The general habitat value and abundance of wetland species was, however, lower at Magazine Creek than at The Range wetlands (see The Range Wetland Management Plan 2019), which suggests that ecological condition at Magazine Creek can be improved.

The current eco-hydrological condition, especially the wetland plant distribution and sedimentation patterns, indicates that the wetlands are successfully intercepting and treating polluted stormwater, although treatment is likely to be limited by short-circuiting of water around plants rather than through the root zone and by poor plant cover and soil quality in the most downstream ponds that have very high salinities due to discharge of hypersaline effluent from the windmills.

Groundwater observation bores were installed in winter 2019 to test and monitor the effectiveness of the windmills. To-date there is no evidence of either a freshwater lens or a systematic lowering of the regional groundwater due to operation of the windmills. This may be due to prolonged still periods influencing local groundwater flow processes, for example, irregular pumping may reduce the effectiveness of 'saline dewatering'. Alternatively, it may be due to highly effective clay liners preventing the freshwater from discharging into the banks and/or the regional groundwater processes may be far greater drivers of



groundwater levels than the windmills and thus no changes in water or salinity levels were detected. It is clear that the windmill discharge is generating very high surface water salinities in the most downstream ponds and it is also likely that when wetland water levels are low, discharge through the outlet ponds will be restricted and the windmill discharge may recirculate back into adjoining ponds, further increasing their salinity. The high salinities are limiting plant growth and thus the capacity of the wetlands to treat the incoming stormwater. These conditions also provide poor habitat for most species (other than some waterbirds that favour saline, barren shorelines) and reduce the visual amenity of the wetland.

This draft wetland management plan will be used to engage stakeholders in the future management of Magazine Creek wetlands. There are opportunities to improve the habitat values of this site, its stormwater treatment capacity and its recreational value by changing key aspects of the site's management, without increasing the risks associated with flooding and shallow, highly saline groundwater.

This plan proposes to:

- Relocate the effluent from the windmills to further along the drain to prevent ingress of hypersaline water into the surface water of the wetlands;
- Test the effectiveness of the windmills at lowering the regional groundwater and/or generating a freshwater lens by turning them off over selected winter periods and monitoring changes in the groundwater;
- Increase habitat value, species diversity and abundance by operating the culverts to introduce a partial drying cycle into the water regime of two out of three of the inlet pathways over select summer periods and/or test active storage operations that temporarily increase water levels and thus storage capacity during flow events, whilst monitoring changes in plant diversity and abundance; and
- Plant very salt-tolerant species, such as chenopod shrubs, wattle and tea trees *Melaleuca halmaturum* (tea-tree or swamp paperbark) in strategic locations to increase shelter, shade, feeding and nesting opportunities for wetland fauna.

The expected ecological responses to implementing these actions and the monitoring and evaluation required to adaptatively manage the site are presented for discussion with managers and stakeholders.



CONTENTS

1	INTRODUCTION	1
2	SUMMARY OF PROPOSED MANAGEMENT COMMITMENTS	2
3	WETLAND OVERVIEW	6
3.1	Regional Context	8
3.2	Climate Change	8
3.2.1	Sea Level Rise and Development in the Gilman Area	8
3.2.2	Coastal Planning Information Policy	8
4	EXISTING INFRASTRUCTURE IN MAGAZINE CREEK	10
4.1	Gross Pollutant Traps (GPTs)	10
4.2	Sedimentation Basins	10
4.3	Weirs	12
4.4	Culverts	12
4.5	Windmills	12
4.6	Clay Liners	12
4.7	Overflow Bank	12
4.8	Fencing	12
4.9	Gates	13
4.10	Paths	13
4.11	Signage	13
4.12	Services and Easements	13
5	KEY ONGOING OPERATION AND MAINTENANCE ACTIVITIES FOR MAGAZINE CREEK WETLAND	15
5.1	Gross Pollutant Traps	15
5.2	Sedimentation Basins and Desilting	15
5.3	Wetland Pond Desilting	16
5.4	Weirs	17
5.5	Culverts	17
5.6	Overflow Banks	17
5.7	Fencing and Gates	17
5.8	Paths	17
5.9	Signage	18
5.10	Services	18
5.11	Windmills	18
5.12	Litter	19
5.13	Spills and Contamination Plans	19
5.13.1	Spill Response Action	19
6	EXISTING ENVIRONMENT	20
6.1	Hydrology	20
6.2	Surface Water Quality	20



6.3	Groundwater	21
6.3.1	Regional Context	21
6.3.2	Site Specific Monitoring	25
6.4	Vegetation	28
6.4.1	Emergent Plants	28
6.4.2	Submerged Plants	29
6.5	Frogs	30
6.6	Waterbirds	30
6.7	Other Opportunistic Fauna Observations	33
6.8	Key Findings - Existing Environment Review	33
7	SOCIAL/CULTURAL VALUE AND USE	34
7.1	Community Profile	34
7.2	Community use of wetland	34
7.3	Community Opinion	34
8	MANAGEMENT OPTIONS	35
8.1	Evaluation of Achievement of Original Management Objectives	35
8.2	Proposed Additional Management Objectives	36
8.3	Threats to Achievement of Site Objectives	36
8.4	Consideration of Pest Species	38
8.5	Opportunities for Improving Wetland Management	38
8.6	Proposed Revised Water Management Regime	39
8.7	Strategic Revegetation	45
9	MANAGEMENT AND MONITORING COMMITMENTS AND SCHEDULES	47
9.1	Vegetation Monitoring	47
9.1.1	Vegetation Sites and Methods	47
9.1.2	Baseline Vegetation Data	47
9.1.3	Expected Vegetation Responses to Management	50
9.1.4	Water Quality (Salinity) Monitoring	55
9.1.5	Groundwater Monitoring	55
9.2	Fauna Monitoring	55
9.2.1	Expected Wetland Fauna Responses to Management	55
9.2.2	Bird Survey	56
9.3	Further Investigations	56
9.3.1	Wetland Hydraulics	56
9.3.2	Fish Survey	57
9.3.3	Frog Census	57
9.3.4	Acid Sulfate Soils	57
9.3.5	Threatened Species	57
9.3.6	Windmills	57



10	WHS AND PUBLIC SAFETY	58
11	POTENTIAL FUNDING MECHANISMS	62
12	REFERENCES	63

APPENDICES

Appendix A Surface Water Quality Sampling Points –December 2018

Appendix B Vegetation Transects Lines

Appendix C Water Balance Model Assumptions

Appendix D Consultation Report

Appendix E Maintenance Check List Table

LIST OF FIGURES

Figure 3-1:	Surface Water Sources into Magazine Creek	7
Figure 4-1:	Flow Infrastructure Magazine Creek	11
Figure 4-2:	Easements in Magazine Creek and Range Wetland	14
Figure 6-1:	Conceptualisation of Windmill Operations (Lyons_2005)	22
Figure 6-2:	Hydrogeological Zones of the Adelaide Region (Gerges 2006)	23
Figure 6-3:	Potentiometric Surface of First (uppermost) Quaternary Aquifer (Q1) and Bedrock Aquifer (Gerges 2006)	24
Figure 6-4:	Location of the 8 Groundwater Water Piezometers in Magazine Creek	27
Figure 6-5:	Species diversity recorded at the Wicker Road/Magazine Creek Wetlands (Survey 858)	32
Figure 6-6:	Total Bird Counts recorded at the Wicker Road/Magazine Creek Wetlands (Survey 858)	32
Figure 8-1:	Predicted Water Levels and Salinities Ponds 2A and 2B	40
Figure 8-2:	Predicted Water Levels and Salinities Ponds 4A and 4B	41
Figure 8-3:	Predicted Water Levels and Salinities Pond M6	41
Figure 8-4:	Predicted Water Levels and Salinities Pond M7	42
Figure 8-5:	Inundated Areas Associated with Water Depths in Magazine Creek	43
Figure 9-1:	Magazine Creek Wetland Transects Line	48
Figure 9-2:	Expected Vegetation Response Ponds M2A & M4A	52
Figure 9-3:	Expected Vegetation Response Ponds M2B M4B & M6	53
Figure 9-4:	Expected Vegetation Response Pond M7	54

LIST OF TABLES

Table 2-1:	Magazine Creek Recommended Key Actions and Initiatives	3
Table 6-1:	Water Salinity Readings from Magazine Creek	21
Table 6-2:	Groundwater Salinity and Water Level at Monitoring Site as Measured on 25 June 2019	26
Table 6-3:	Salinity Levels at Windmills Discharge Points as Measured 4 January 2019	26
Table 6-4:	Aquatic Plant Species at Magazine Creek Showing Which Species Were Planted and When	29
Table 6-5:	Magazine Creek Wetland Bird Survey	31
Table 8-1:	List of the Threats and Probable Impacts of the Management Plan	37



Table 8-2:	Estimated Average and Maximum Salinity Levels at Minimum Water Depth in Ponds M2A & M2B as well as Ponds M4A & M4B.	44
Table 8-3:	Estimated Average and Maximum Salinity Levels at Minimum Water Depth in Ponds M6 as well as M7	44
Table 9-1:	Presence of Different Types of Aquatic Plants in Edge (Top) and Channel (Bottom) Habitats at the Nine Transects When Established at Magazine Creek in September 2019.	49
Table 10-1	Project Details	58
Table 10-2	Design Parameters	58
Table 10-3	Design Features	59
Table 10-4	Operations and Maintenance – Hazard Identification and Risk Management	59
Table 10-5	Relevant Design Guidelines / Standards / Reference Materials	61



1 INTRODUCTION

The City of Port Adelaide Enfield State of the Environment Report (2012) recognised that preserving biodiversity and stormwater management areas is a fundamental aspect of sustainable development, and a key inclusion in the Local Government Act 1999. With the current and future pressures for development within the Council, it is critical that areas of biodiversity and stormwater retention value be sustained and enhanced, and that appropriate management regimes be implemented to create resilient natural landscapes, adaptive to climate change for future generations wherever practical.

Magazine Creek and Range Wetlands located at Gillman and Dry Creek were constructed in the mid-1990s as part of a larger MFP Development Corporation project (including Barker Inlet Wetlands) to assist improving the stormwater management issues while enhancing natural landscape amenity.

The objectives in the design of the wetlands were the following:

- Intercept and treat polluted stormwater and runoff to reduce the concentrations and loads of pollutants in order to protect downstream ecosystems;
- Provide a system which supports a diverse aquatic ecosystem and will not be a source of problems including nuisance insects and odours;
- Provide a system which improves the visual amenity of the site, and provides recreational opportunities;
- Provide opportunities for the harvesting and reuse of stormwater.
- Provide a means of intercepting chemical spills or accidents within their catchments; protecting downstream systems by presenting an opportunity for isolation and clean up.

The first management plan (February 1999) written at the time of construction is due for review and updating based on lessons learnt in the first 25 years of operation. The City of Port Adelaide Enfield engaged Water Technology and associates Dr. Kerri Muller, John Gitsham and Barrie Ormsby to review the original management plan, undertake targeted investigations and prepare this updated management plan.

Two additional management objectives have been included in this management plan, as follows:

- To investigate whether operational costs can be reduced by intermittently shutting down windmills, whilst maintaining or improving aquatic habitat provision and not increasing the risk of flooding;
- To consider sea level rise impacts and how best to precondition the wetland habitats to future higher sea level.



2 SUMMARY OF PROPOSED MANAGEMENT COMMITMENTS

The wetlands were originally designed to achieve multiple outcomes, including protecting the health of downstream receiving environments whilst also providing for flood conveyance and to provide freshwater habitat and amenity in their own right.

Whilst the primary objectives of protecting downstream environments and providing flood conveyance appear to have been achieved, the ecological condition of the wetlands themselves has arguably not achieved the level of outcome, which was expected at the outset, and has required significant resources from Council.

This management plan outlines a range of initiatives that it is postulated will result in an improvement in wetland ecological condition. This will however require ongoing operation/maintenance inputs and as well as further investigations for the full potential of the system as a freshwater habitat to be realised. The main actions required can be summarised as follows:

- Ongoing maintenance and operation of existing infrastructure
- Investigations to facilitate a trial of revised operating regime, including:
 - Soil assessments to evaluate the risk of exposing acid sulfate soils during extended drying cycles.
 - Hydraulic modelling to quantify the level and scale of potential weir raising that can be achieved to maximise ecological outcomes without exacerbating upstream flooding issues.
- Field work to further clarify the ecological condition of the wetlands and potential management requirements, including:
 - Fish survey, and
 - Frog survey.
- Modifications to existing infrastructure by redirecting windmill outfall from Pond M7 to the Outlet Pond (MO).
- Additional vegetation plantings using salt tolerant and highly salt tolerant species.
- Undertaking a trial of revised operating regime to introduce an extended drying cycle for Pond M2A, M2B, M4A, M4B, M6 and M7.
- Trialling the turning off of three windmills (M1, M2 and M5) during winter to determine if windmill operations can be scaled back and costs reduced.
- Monitoring of groundwater and surface water levels and salinity.
- Undertaking bird surveys.
- Undertaking vegetation transect surveys to evaluate the effectiveness of the trial operating regime.
- Reporting the results of the trial and re-evaluating.

These measures are described in the following action tables that have been grouped as follows:

- Ongoing Infrastructure Operations
- System Improvements
- Trial operating regime
- Monitoring and Evaluation

Indicative timeframes and costs for new initiatives are also provided.



TABLE 2-1: MAGAZINE CREEK RECOMMENDED KEY ACTIONS AND INITIATIVES

Ongoing Infrastructure Operations		
Item	Action	Frequency/Timing
GPTs	Check for debris accumulation. Clean if 50% or more full. (Review frequency following observations so that cleaning and inspections frequency can be optimised).	Fortnightly plus after large flow event
Coarse Sediment Basin	Check for sediment accumulation Clean if 50% or more full. Test sediment for contamination and dispose as appropriate to contamination level.	Check in December
Fine Sediment Basin	Check for sediment accumulation Clean if 50% or more full. Test sediment for contamination and dispose as appropriate to contamination level.	Check in December
Wetland Ponds	Check for sediment accumulation Clean if 30% or more full. Test sediment for contamination and dispose as appropriate to contamination level.	Check in December
Wetland Weir Structures	Check for damage or blockages Repair or remove blockages.	Check in December
Wetland Culverts	Check for damage or blockages Repair or remove blockages.	Check in December
Wetland Overflow Banks	Check for damage or blockages Repair or remove blockages.	Check in December
Fences and Gates	Check for damage. Repair as necessary.	Check in December
Paths	Check for damage. Repair as necessary.	Check in December
Services	Report to service authority any observed irregularity.	On an event basis
Windmills	Maintain present operation and maintenance regime. Review contractor performance annually in January	Review in January



System Improvements		
Item	Action	Frequency/Timing/Cost
Ponds M2A and M2B; M3A and M3B; M4A and M4B; and M6	Revegetation program in riparian areas using salt tolerant species such as: Lignum (<i>Duma florulenta</i>), Coobah (<i>Acacia stenophylla</i>), Boobialla (<i>Myoporum insulare</i>). Tea trees (<i>Melaleuca halmatuorum</i> , <i>M. lanceolata</i>)	Late autumn Cost is flexible suggest \$20,000 budget
Pond M7	Relocate outfall from windmills M6 & M7 that currently discharge into Pond M7 to the outlet pond.	One off permanent action early in year 1. Cost: \$5,000.
Ponds M7 and M8	Revegetation program in riparian areas using high salt tolerant species such as: local Samphire and saltmarsh vegetation, Chenopods (e.g. <i>Nitraria billardiarei</i> , Nitre bush; <i>Atriplex nummularia</i> , Old man saltbush). Introduce less salt tolerant species in subsequent seasons (such as those listed for planting in pond M6).	After windmill outfall has been relocated. Cost is flexible suggest \$10,000 budget

Trial operating regime		
Item	Action	Frequency/Timing
Ponds M2A and M2B	Introduce drying cycle: Insert stop logs to - 0.3 mAHD to close Inlet structure to Pond M2A. Remove at end of drying cycle. Insert stop logs to - 0.3 mAHD to close inlet structure to Pond M2B. Remove at end of drying cycle.	Years 1, 3 and 5 of trial. Summer/autumn- timing of opening and closing varies – refer Table 8.2.
Ponds M4A and M4B	Introduce drying cycle: Insert stop logs to - 0.3 mAHD to close Inlet structure to Pond M2A. Remove at end of drying cycle. Insert stop logs to - 0.3 mAHD to close inlet structure to Pond M2B. Remove at end of drying cycle.	Years 2, 4 and 6 of trial. Summer/autumn - timing of opening and closing varies – refer Table 8.2.
Pond M6	Introduce drying cycle: Insert stop logs to - 0.3 mAHD to close Inlet structure to Pond M2A. Remove at end of drying cycle. Insert stop logs to - 0.3 mAHD to close inlet structure to Pond M2B. Remove at end of drying cycle.	Years 1, 3 and 5 of trial. Summer/autumn- timing of opening and closing varies – refer Table 8.2.
Pond M7	Introduce drying cycle: Insert stop logs to - 0.3 mAHD to close Inlet structure to Pond M2A. Remove at end of drying cycle. Insert stop logs to - 0.3 mAHD to close inlet structure to Pond M2B. Remove at end of drying cycle.	Years 2, 4 and 6 of trial. Summer/autumn - timing of opening and closing varies – refer Table 8.2.
Windmills M1, M2 and M5	Test wetland interface with hypersaline groundwater: Switch off windmills during winter for the months of May, June and July	Years 1 and 2



Monitoring and Evaluation		
Item	Action	Frequency/Timing/Cost
All Ponds	Test system hydraulics through numerical modelling using TuFlow Model to ensure wetland hydraulics are not compromised by closing off wetlands M2A or M4A. Modelling results can also be used to test holding water at higher level in selected ponds during winter period.	One off – before initiating trial drying sequence. Cost: \$10,000
All Ponds	Acid Sulfate Soil rapid assessment. To evaluate potential for adverse respond under an extended drying cycle – could limit the extent of drying achievable.	One off – before initiating trial drying sequence. Cost: \$6,000
All Ponds	Fish Survey. Determine distribution and diversity of fish species to guide ongoing management arrangements.	Year 1 to establish baseline. Repeat in 5th year in spring of trial drying sequence.to coincide with vegetation transect survey thereafter. Cost: \$8,000
All Observation Bores	Measure depth to groundwater water and groundwater salinity profile	Quarterly to June 2020 then review with aim to reduce to six monthly thereafter (spring / autumn). Cost: \$3,000 pa
Ponds M1, M2B, M3B, M4B, M5, M6, M7, M8.	Pond water level and salinity – measured at inlet structures.	Monthly during first 5 years of drying cycle trial. Review and reduce frequency as appropriate thereafter. Cost: \$ 6,000 pa
Ponds M2A, M2B, M3A, M3B, M4A, M4b, M6, M7, M8.	Bird Survey	5th year in spring of trial drying sequence.to coincide with vegetation transect survey. Cost: \$5,000
Ponds M2A, M2B, M3A, M3B, M4A, M4b, M6, M7, M8.	Vegetation transect survey and reporting	5th year in spring of trial drying sequence. Cost \$6,000



3 WETLAND OVERVIEW

The Magazine Creek wetland receives stormwater from Eastern Parade and Jenkins Street drains along with small amounts of runoff from the adjacent industrial area. Water from Magazine Creek empties into the Rosewater Drain which discharges to the Port River Barker inlet.

The wetland site covers an area of 36 ha with a water area of 15.9 ha. The catchment is low-lying and as a result the wetland had to be constructed at a low elevation, bringing levels down close to the groundwater table, creating a maximum operating permanent water level for Magazine Creek wetland of 0.6m AHD. The risk of salt entering the wetland from the surrounding groundwater is high. Consequently, windmills were incorporated into the original design to drawdown the hypersaline water table and create a freshwater “lens” around the wetland site to enhance the freshwater ecosystem. Hypersaline ground water is pumped by the windmills and discharged immediately downstream of the final weir in the wetland.

Magazine Creek wetland has one inlet (Pond MS1; Figure 3-1), which flows into Pond M1 where flow can travel along three pathways through Pond M2A, Pond M3A or Pond M4A. Pond M2A flows to Pond M2B then Pond M3B. Pond M3A flows to Pond M3B but also is connected to Pond M4A. Pond M4A flows to Pond M4B. Pond M3B flow to Pond M5. Pond M4B can flow to either Pond M5 or Pond M6. Pond M6 then flows into Pond M5. Pond M5 acts as a kind of ‘hub’ from which water can flow into Pond M7 or Pond M8. Both Pond M7 and Pond M8 flow into the outlet (Pond MO). The hypersaline effluent from windmills M1 through M5 discharges to Pond MO whereas effluent from windmills M6 and M7 discharges to Pond M7.

Magazine Creek wetland discharges from Pond MO into the Rosewater Drain, which subsequently discharges to the ocean through a one-directional flap gate in the levee surrounding the Gillman area to the Port River-Barker Inlet.

The wetland system is currently failing to drawdown after rainfall events which impacts the hydraulic capacity of the stormwater system upstream. Currently, there is limited information on the hydraulic performance of the culverts, groundwater pumps, and associated infrastructure.

Stormwater Sources Magazine Creek



FIGURE 3-1: SURFACE WATER SOURCES INTO MAGAZINE CREEK



3.1 Regional Context

Magazine Creek sits on low-lying samphire flats adjacent to the Port River and Barker Inlet estuary. Residential and industrial areas surround the Port River, whilst suburban development is occurring along the southern part of Barker Inlet. The estuary environment is diverse and includes deep channel, large areas of fringing mangroves, extensive tidal flats and seagrass beds. It is an important nursery for fish and marine invertebrates and it is possible that juvenile or small-bodied marine animals (e.g. hardyhead fish) will enter and use the Magazine Creek habitats along with other significant constructed wetland habitats in the area such as, Greenfields Wetlands and Barker Inlet Wetlands.

This estuary is part of the Adelaide International Bird Sanctuary (AIBS) - *Winaityinaityi Pangkara* – meaning ‘Country that belongs to all birds’ in Kaurna language. It is a 14.633 ha park that stretches along 60 kms of coastline from St Kilda to Port Parham and is now officially recognised as a globally significant site on the East Asian-Australasian Flyway network (NR AMLR – draft management plan 2018). The AIBS provides a safe haven for tens of thousands of migratory shorebirds that migrate each year between Australia and the northern hemisphere. Magazine Creek may also be utilised by migratory and other birds using the AIBS.

3.2 Climate Change

3.2.1 Sea Level Rise and Development in the Gilman Area

Currently Magazine Creek is being used for storing flood waters from the upstream catchment during periods of high tide. There is a flap gate structure at the outlet of Magazine Creek that prevent inflow of seawater but allows stormwater to be discharged when flood levels in the basin are at a higher level than the tide. The effects of sea level rise in the next few decades may impact the capacity and the management of the wetlands..

Previous investigation have been made to model the flows through the site during a 1 in 100 ARI , after the area has been developed and an increase in 1 m sea level The model also included changes to the wetland infrastructure in order to mitigate land development and sea level rise.

- The results of the investigation showed:
 - Land within the Gillman Development area (the intended development of the Gilman area is detailed in the Gillman Masterplan Report (Jensen Planning 2014) and 30 year Plan for Greater Adelaide) can be filled to the extent detailed in the Gillman Masterplan.
 - Two additional flap gates (at 2.4 m x 1.5 m) will need to be constructed at the Magazine Creek outlet to allow for the impact of a 1 m sea level rise and to ensure that flood levels at the upstream end of Magazine Creek Wetland are unchanged. The additional gates will reduce the impact of both the sea level rise and the Gilman development on the flood level rise in the wetland from 160 mm to only 20 mm.

Hence, the wetlands can support the increase in development from a flood conveyance perspective with relatively small investment in additional infrastructure. The impacts of sea level rise will however also have an impact on the frequency with which water is able to flow out of the wetland and the length of time it takes to drain to the design permanent pool level. Further hydrodynamic modelling (recommended later herein) is required to determine the “normal” behaviour of the wetlands under a sea level rise scenario. It is possible that the extended periods of higher water level may promote an increase in water level variability that could be of benefit to the wetland ecology, or conversely result in water logging and increased salinization.

3.2.2 Coastal Planning Information Policy

Previous studies have established that the existing 1%AEP tide level is 2.5 mAHD. Existing site levels are well below this level and the Study area is currently protected by an earth levee, which ranges in elevation (some sections lower than the 2.5 mAHD protection standard.



The current Coast Protection Board (CPB) policy for coastal development to be designed to be protected against the 1%AEP tide level, with an additional allowance for wave setup and runup effects, long term subsidence and sea level rise (300mm) with allowance made for future works to be constructed to enable protection against a further 700 mm of sea level rise.

Allowances that would satisfy this policy include:

- 400 mm for wave effects;
- 500 mm over a 50-year period for subsidence; and
- 250 mm for finish floor level above the finished site level.

Low-lying land which is now or in the future, subject to tidal or stormwater inundation should not be developed unless environmentally sound mitigation and protection works formally and securely guaranteed by Council and proponents of development.

In the future, Council will need to consider the risks to the wetlands associated with overtopping of the levee, and the additional risk of failure of the levee through elevated water levels and either appropriate maintenance, poor construction, or occurrence of a storm surge event greater than the design event.



4 EXISTING INFRASTRUCTURE IN MAGAZINE CREEK

Infrastructure is associated with the wetland which is designed to help convey flows through the system whilst ensuring that the wetland system can perform an effective treatment function. This infrastructure, its operation and function are discussed in the sections that follow.

4.1 Gross Pollutant Traps (GPTs)

GPTs are provided at the main inlet to the wetlands to protect the wetlands and downstream receiving environment from urban litter as well as excessive organic material (typically associated with urban runoff). Indeed, it has been estimated that the catchment draining to the Magazine Creek Wetland would produce approximately 360 m³ of gross pollutants in an average year based on a generation rate of 0.4 m³/ha/yr (Tonkin Consulting, 2015). These GPTs are the only trash collection facilities within the catchment. Materials that are not intercepted by the trash rack will either accumulate in the wetlands or may be transported into the downstream ponding area, and possibly into the marine environment.

The GPTs at the wetland inlet have presented a number of operational issues and their effectiveness has been questioned by Council Staff. In addition to the physical risk to fauna and the unsightly presence of litter, significant inputs of organic material into the wetlands could also lead to depletion of oxygen in the water column during decay of the material (although this is less likely to be an issue due to the size of the wetlands). It is therefore desirable that inputs of gross pollutants to the wetlands to be reduced and that the GPTs continue to be maintained.

4.2 Sedimentation Basins

A sedimentation basin is located immediately downstream of the GPTs, and immediately upstream of the GPTs is also an effective area for trapping coarse sediment.

A concrete ramp is provided to facilitate removal of collected sediment which is required when the sediment capture zone is 50% full. This is necessary to avoid resuspension of material and further transportation into the wetland system.

Flow Infrastructure Magazine Creek



FIGURE 4-1: FLOW INFRASTRUCTURE MAGAZINE CREEK



4.3 Weirs

There are 14 gabion weirs through Magazine Creek wetland that can be used to maintain water levels at -0.6 mAHD and control water levels and flow through the wetlands. The weirs incorporate a series of removable timber baffles that can be inserted to management water levels or to isolate individual ponds if required (i.e. in the event of a spill, desilting, or carp removal).

4.4 Culverts

There are a series of 13 culverts associated with regulating the weirs. In addition, there are two main sets of culverts associated with the sedimentation basin and a transfer culvert allowing the cross-transfer of water between ponds 3A and 4A.

4.5 Windmills

Magazine Creek wetland was intended to be a fresh-water system but was constructed in an area where there is hypersaline groundwater close to the surface. This required the lowering of the regional shallow water table to facilitate the creation of a freshwater lens and create an artificial freshwater system. An extensive series of seven windmills and 8400 metres of subsurface drains were installed to lower the hypersaline water table so that the freshwater wetlands could be established.

The Magazine Creek windmills discharge collected groundwater to Pond MO and Pond M7, with:

- Discharge from Windmills M1, M2, M3, M4 & M5 directed to Pond MO, where
 - Windmills M1 & M2 are combined in one discharge pile,
 - Windmill M3 has a dedicated discharge pipe, and
 - Windmills M4 & M5 are combined in one discharge pipe.
- Discharge from Windmills M6 & M7 is directed to Pond M7.

4.6 Clay Liners

Each of the main wetland ponds incorporate a clay liner. The clay liner provides two main functions:

- To reduce leakage from the wetland, thereby helping to maintain water levels and contain pollutants within the wetland; and
- Act as a barrier to saline inflows from the regional groundwater table.

4.7 Overflow Bank

An overflow bank has been incorporated into the design at the end of the western pond segmentation to reduce upstream flooding by allowing for an overflow through this section of the wetland.

4.8 Fencing

Fencing in the form of stock fencing is provided around the wetland to limit public access, particularly with regards to vehicles and illegal dumping. Excluding uncontrolled access of vehicles is important to avoid damage to sensitive wetland vegetation and disturbance of fauna. Restricting access around GPTs to limit the possibility of hazardous items (eg glass and syringes), is also important.

The fencing is not of the form required to exclude access of feral animals, such as rabbits dogs, cats and foxes.



4.9 Gates

Gates provide access for authorised persons and vehicles. There are two main access gates near the GPT and sedimentation basins with access from Whicker Road.

4.10 Paths

A network of paths allows vehicle access around the wetland for monitoring, maintenance and activities.

4.11 Signage

Signage around the wetland includes:

- Restriction of public access, located around fence lines and grates.
- Location of services passing through site, located along services lines.

4.12 Services and Easements

The following services pass through, or are adjacent to, the Magazine Creek:

- SEA Gas main

The gas pipeline (600 mm diameter steel pipe, generally 1 m below natural surface) is susceptible to damage to its corrosion resistant coating and the consequences of rupturing this pipeline are likely to be severe. The main runs along the western edge of the wetland system along Whicker Road.

- Epic Energy

There is an Epic Energy natural gas pipeline in the northern part of the site. Its alignment coincides with the existing levee bank and is contained within a 15 m wide easement on the northern perimeter of the site.

- Electricity

Transmission lines from the Torrens Island Power Station run south along Grand Trunk way and to the west of Magazine Creek Wetlands along Whicker Road.

- Brine main (Penrice Soda Products Pty Ltd)

A 300 mm diameter rising main crosses the site generally 0.5-1 m below natural earth surface, which in the past transported high-pressure brine to the LeFevre Peninsula. Its alignment travels along North Arm Road, then diagonally across the site to the Port River Expressway.



FIGURE 4-2: EASEMENTS IN MAGAZINE CREEK AND RANGE WETLAND



5 KEY ONGOING OPERATION AND MAINTENANCE ACTIVITIES FOR MAGAZINE CREEK WETLAND

5.1 Gross Pollutant Traps

The following key tasks are required for the ongoing maintenance of the GPTs.

- The GPTs should be inspected regularly - fortnightly during winter, and after large rainfall events during the summer.
- During the wetter winter months GPTs should be cleared before build-up of debris reaches half the capacity of the structure in order to maintain function.
- During dry periods, the GPTs should not be left with material in them, particularly in those traps which remain wet, to avoid anoxic conditions that can remobilise water pollutants making them more bioavailable.
- Operators should follow Councils WHS procedures and apply PPEs to protect themselves against any hazardous material including sharp objects such as glass, cans and discarded hypodermic syringes.
- Once cleared, the GPT should be inspected for any damage or deterioration and any components found to be damaged should be replaced immediately.
- For public safety, GPTs should not be accessible to the public and hence the GPT area should be securely fenced off with appropriate signage.

5.2 Sedimentation Basins and Desilting

The frequency of desilting the upstream coarse sedimentation basin and downstream fine sedimentation basin needs to be determined through monitoring. It is a balance between the cost of cleaning and disposal of material and ensuring that there is sufficient capacity for retention. It is recommended that both be cleaned before they reach 50% capacity. If the basins are allowed to fill above that level it is likely that accumulated material will be remobilised during larger storm events resulting in the material being transported further into the wetland system, and thereby smothering the wetlands with sediments and organic material.

All basins should be inspected early in the summer period and depths determined. These results should be recorded so that the long sediment accumulation rate can be determined. Based on the results of the depth assessment, the need for any desilting can be determined. Checking in early summer (November/December) will enable sufficient time for the desilting operation to be completed later in the summer period. At the end of summer, the water levels in the basin and the remainder of the wetland is likely to be low and the sedimentation ponds can be dewatered by pumping to downstream ponds in the wetland.

It is expected that the coarse sedimentation basin will generally require more frequent desilting than other areas of the wetland system.

The accumulated silt should be tested prior to removal, and dredging license may also be required. The EPA should be consulted on both matters. The analyses to be undertaken is likely to include the following potential contaminants:

- pH
- arsenic and metals (cadmium, cobalt, chromium, copper, lead, nickel and zinc)
- Organochlorine Pesticides (OCPs)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Benzene, Ethylbenzene, Toluene and Xylenes (BTEX)



- Total Petroleum Hydrocarbons (TPH) C6-C9, C10-C14, C15-C27, C28-C36 fractions

Silt removed from the wetland should be disposed of in a manner appropriate to the contaminants found in the sediment.

5.3 Wetland Pond Desilting

The main downstream ponds in the wetland will eventually also require desilting, but the frequency of this should be much lesser than the sedimentation ponds.

The original design intent was for this to be required no more frequently than every 20 to 30 years.

Any desilting operations of the wetlands are best undertaken in the drier period of the year, when water levels are at their lowest. The culvert and weir infrastructure can be used to isolate ponds so that drying and desilting and operations can be undertaken on a rotational basis, thereby ensuring that some water and habitat remains within the wetland complex to provide refuge for displaced fauna, and also so that sufficient plant stock remains to support plant and habitat re-establishment.

The desilting operation should have regard to the following:

- Stage desilting operations over a number of years so that the system disturbance across the wetland system as a whole can be kept to a minimum at any one time. This will require regular monitoring of silt accumulation so that pre-emptive desilting can be undertaken in some ponds – i.e., do not wait until many ponds need to be desilted before commencing the desilting operations.
- Consideration should be given to initiating desilting operations if the deeper pond areas within a wetland pond are 30% full of silt, or the shallower reed bed areas are causing the pond water levels in the wetland ponds to remain significantly (eg 100 mm or more) above the outlet weir level (-0.6mAHD) between storm events.
- Maintenance of the shallower reed bed areas are important for habitat and water treatment purposes. Provided these areas are covered by the correct aquatic vegetation, they should not excessively impede flow during high flow periods as the reeds will normally lay down or flex to allow flow to push through the system. Removal of reeds and sediments in these areas should therefore be undertaken using a patchwork approach over two or three years so that the excavation process does not create a linear channel through the reed bed area that effectively results in short circuiting of the reed bed in lesser flood events.
- Desilting is likely to be best done by isolating single ponds, dewatering by pumping to adjoining ponds and then excavating using an excavator. The deeper pond areas may require the use of a long reach excavator.
- Vegetation re-establishment should be cognisant of the desilting operation and access arrangements that were required so that the wetlands can still be accessed for future desilting without the need for excessive vegetation removal.
- Cleaning operations would be best carried out toward the end of summer when water levels are at their lowest. The procedure for desilting the shallow macrophyte areas between ponds should be as follows:
 - Lower the wetland water level by 600 mm as this will expose the shallow macrophyte areas.
 - Allow the shallow areas to partially dry such that the silt is able to be excavated and directly loaded onto trucks for disposal.
 - Avoid excavation of the clay liner – it plays an important role in maintaining water levels and helping to minimise the ingress of hyper-saline groundwater.



- Following removal of the silt, water levels should be allowed to return to the normal operating level as soon as possible. However, should weather conditions be unfavourable, installation of a temporary watering system may be required to maintain any liner in a moist condition until the first inflows.
- If any vegetation was removed during desilting, these areas should be kept hydrated so that replanting can occur in early autumn as soon as water levels return to normal.
- Dredging material should be removed as soon as practical after drying to minimise the impact on the terrestrial vegetation on the banks and mounds, and simply for good housekeeping.

5.4 Weirs

The following maintenance activities are recommended:

- Inspected annually for signs of damage or deterioration – e.g., erosion around any concrete structures, scour, displaced rock work, damage to gabion baskets etc.
 - The inspection would be best undertaken in late summer when water levels are low giving maximum exposure of the structure.
 - Inlet structures should continue to be maintained as these control water levels in the wetland. Deterioration in these structures will undermine wetland performance, and limit Council's capacity to undertake wetting and drying trials that are recommended as part of this management plan.
 - Ensure a correct number of baffles are available for each regulating weir so that ponds can be isolated for the purposes of initiating a drying cycle, containing a spill, or dewatering for desilting / maintenance operations.

5.5 Culverts

The following maintenance activities are recommended:

- Inspect at the start of winter and again at the start of summer for debris and sediment accumulation and remove as necessary to maintain flow conveyance capacity.
- Check annually in summer for damage or deterioration of structure as well as for any erosion or scour around the structure caused by strong flows.

5.6 Overflow Banks

The overflow banks should be inspected annually and/or after a very large flood event for signs of damage or deterioration in the structural integrity of the banks due to burrowing animals or erosion from high flows.

The reinstating of material on these structure should not exceed the original design levels in order to maintain the flood conveyance characteristics of the wetland system.

5.7 Fencing and Gates

Perimeter fencing and gates for the main wetland area should be inspected annually for deterioration and vandalism. Any damage found should be reported and repaired at the earliest convenience to ensure restricted access to wetlands.

Fencing and Gates around the GPTs should be checked each GPT cleaning operation.

5.8 Paths

Inspect annually for damage or deterioration - particularly erosion, and trim back any overgrowing vegetation that may be restricting access. Spray any weeds invading pathways.



5.9 Signage

The presence and legibility (as a result of weathering or vandalism) of signs throughout the wetland should be checked annually or more often. It is important that warning signage is maintained from a safety and legal point of view.

Maintenance of signs for services through the area are the responsibility of service managers, however, any damage noticed can be reported to those various agencies (as indicated on the signs).

5.10 Services

None of the services that cross the site are available to the site. However, Council maintenance activities associated with the wetlands need to avoid damaging services and be particularly cognisant of the two gas mains.

■ SEA Gas

The gas pipeline is susceptible to damage to its corrosion resistant coating, consequences of rupturing this pipeline are likely to be severe. If excavation or disturbance in a 20 m radius of the pipeline is required, SEA Gas should be consulted. No heavy vehicles are permitted to stand on or across the pipeline route. Wetland channel crossings of the pipeline have protection with reinforced concrete capping. Surface coverage of soil should be a minimum of 500mm, shortage in surface soil coverage should be reported.

■ Epic Energy

The gas pipeline is susceptible to damage. If excavation or disturbances near the Epic Energy pipeline is required, it is the responsibility of the excavator to report to the service manager of the wetland. Furthermore, it is also the responsibility of the excavator to expose all Gas Assets, including Gas Services pipeline, by hand. Epic Gas Asset depth may vary according to ground conditions.

5.11 Windmills

The windmills and drainage system are key features of the wetland design and their effective performance may be critical for managing wetland water quality (salinity).

The original design of the reticulation system was a 'three-pump' system at each windmill with the main lift shaft connected via a 'T-piece' to three lift pumps located in a set of caissons beneath the windmill. The intent was to drive three separate reticulation systems:

1. Groundwater discharge from the centre caisson, fed by tile drainage [150 mm perforated 'ag-pipe'];
2. Landscape irrigation (assumed from fresh pond surface water; and
3. Inter-pond transfer (assumed to allow for mixing of pond waters for fresh surface water management).

This infrastructure failed regularly, primarily when one of the three pumps failed causing an unbalanced lift and failure of the connecting 'T-piece' arrangement. The pumping design was altered soon after construction and the landscape irrigation and inter-pond transfer reticulation were abandoned. The windmills currently only reticulate groundwater from the tile drainage through to the groundwater discharge points.

Windmill operations have been outsourced to private contractors CMB Solutions. Water Technology Pty Ltd's Hydrogeologist, Scott Evans, inspected the Magazine Creek site windmills with CMB Solutions during the course of the preparation of this management plan and consider the present management regime to be a fair and reasonable approach to maintaining windmill operations.



5.12 Litter

Litter and rubbish can enter the wetlands via stormwater flows that overtop the GPTs, wind-blown litter from surrounding areas, and illegal dumping. Litter not only decreases the amenity of the area but can directly impact fauna through entanglement and suffocation.

Litter should be regularly picked up and illegal refuse dumping should be removed within 24 hrs to limit 'copycat' dumping.

5.13 Spills and Contamination Plans

There is a risk of stormwater contamination from spill, accident, or illegal dumping. While the wetlands are designed to remove pollutants from stormwater, the shock loading of a spill can cause acute effects on the wetland ecosystem. Furthermore, due to the proximity and direct discharge to the sensitive Port River Barker Inlet system, spills into the northern area of the Barker Inlet wetland poses an immediate and severe ecological threat. Potentially there is a wide range of toxic or noxious substances that could be involved in a spill incident and enter the catchment drainage system or discharge directly into the wetland. These can impact on the wetland ecosystem and water harvesting, as well as loss of amenity and recreational opportunities.

- Four types of materials are likely to occur in this area:
 - Oils spills
 - Pesticides
 - Organic waste with high biological oxygen demand (BOD)
 - Heavy metals, such as copper chrome arsenate (CCA) contained in the wood perspectives
- Impacts of Spills
 - Loss of aquatic vegetation as well as loss or adverse effects on fauna
 - Disruption to wetland treatment efficiency
 - Effects on water harvesting
 - Cost of clean-up and rehabilitation
 - Loss of amenity

5.13.1 Spill Response Action

The first action when responding to a spill should be containing the substance and limiting its entry to the public environment. If a substance should enter the wetland, a response action should immediately be determined and followed through. In summer, the ponds will be isolated due to low water levels, thus easily containing the spill in a single pond using the stop boards associated with the weir and culvert structures.

Over the winter months isolation of the wetlands will prove more difficult due to high water levels. In order to prevent the discharge of contaminants to the Barker Inlet, the flap gate and penstock gates should be closed.

Magazine Creek also has regulating weir structures with baffles which allows for isolation and or diversion of flows around contaminated pond sections. Hence, in a worst case scenario, a preferential flow path should be created through the wetlands by temporarily isolating Pond M3 and either Pond M2 or M4 (depending on the source of the spill) so that the bulk of the spill is contained, and flow can still pass through either Pond M2 or M4.



6 EXISTING ENVIRONMENT

6.1 Hydrology

Magazine Creek Wetland was designed to provide 10-day retention time for the 1 in 10 year ARI (EGIS 1999). Wetlands are intended to be permanent water bodies.

A series of stop log structures are provided between the various ponds that make up each wetland. These structures can be used to manage water levels in ponds and allow them to be isolated from each other for management purposes (eg desilting or spill response). Active management of water levels as a standard operating procedure was not intended, but the initial intent of the stop logs was for them to be at the same height throughout, with the wetland water level being controlled at the outlet structure. For the Magazine Creek wetland this is -0.6m AHD.

The initial setting of the stop logs would have created a largely static water level in the wetlands with only short term increases in water level during high flows and lower levels during periods of high evaporation losses, with no inflows. It is understood that a number of the ponds either dry out or nearly dry out during the summer.

The hydraulic performance of the wetlands in terms of flood conveyance was considered, with a design objective being set for no upstream impact for events up to the 1 in 20 year ARI flood event. The outlet weir geometry sets this design condition.

The wetland bathymetry pond-connecting structures and rocky riffles have been designed to promote mixing of water and maintain areas of permanent water (deep pools). The design intent it would appear, was to maintain areas of continuous open water with fringing vegetation, with the primary treatment processes considered at the time of design to be physical setting and filtering of water (rather than chemical uptake by plants).

Consideration was given for a modest water level operating range (150mm) to provide for potential future water harvesting, however it does not seem that there is any harvesting operation in the wetland.

Evaporation from the wetland ponds during summer, when there are no stormwater inflows, lowers water levels in the wetlands, thus increasing the salinity levels of the wetlands well above.

6.2 Surface Water Quality

Salinity is a fundamental determinant of the ecological character of wetlands whether it is surface water salinity, soil salinity or groundwater salinity (Hart et al. 1991,2003; Nielsen et al. 2003; Lester et al 2008). All organisms have salinity thresholds that determine their ability to survive, with consideration of the most sensitive phases of development (usually juvenile) being critical for population management. For example, Spotted Marsh Frogs were heard calling at Magazine Creek and their tadpoles have salinity tolerance of <6000 $\mu\text{S}/\text{cm}$ (3.3 g/L TDS; Antis 2007).

Water salinities for Magazine Creek wetlands measured in December 2018 using a TPS WP-82 at c.1 to 1.5 m out from the water's edge at c.10 depth are shown in (Table 6-1).

At the inlet to Magazine Creek wetland, surface water salinities upstream of the trash racks were approximately double that immediately downstream of the trash racks(9070 vs 4260 $\mu\text{S}/\text{cm}$) when measured in December 2018. Salinities were lowest in the middle sections of the wetlands(Ponds M2A and M2B). Groundwater pumped by the windmills had a salinity reading of (55000 $\mu\text{S}/\text{cm}$ or 30.25 g/L TDS, which is considered to be very saline).The pumped groundwater is dumped into Ponds M8 and M7, which appears to be elevating the surface water salinities in those respected ponds to 10-times that in Ponds M2A and M2B. Further away from the windmill outflow, salinities in Pond M7 dropped to around 9500 $\mu\text{S}/\text{cm}$, at which point



there were dense reed beds, fish, and water boatmen (see below). Salinities in Ponds M6 and M5B were higher than ponds M2A and M2B but lower than Ponds M8 and M7,

TABLE 6-1: WATER SALINITY READINGS FROM MAGAZINE CREEK

Location	December 2018	
Sampling Point Reference: [SP-.] refer to Appendix A for locations	E.C. (μS/cm)	ml/L TDS
Pond MS1 [upstream of Inlet Culvert]	9070	5,220
Pond MS1 [SP-M01]	4260	2,410
Pond M2A [SP-M04]	3440	1,930
Pond M2B [SP-M10]	3310	1,850
Pond M3A		
Pond M3B		
Pond M4		
Pond M5 [SP-M15]	5450	3,100
Pond M6 [SP-M18]	4980	2,810
Pond M7 [mid-section of Pond M7]	33400*	20,130
Pond M7 [SP-M19]	9560	5,520
Pond M8 [mid-section of Pond M8]	35230*	21,490

**readings taken in the nominated pond near the windmill outflow*

Note: salinities are described in units of electrical conductivity (E.C.) or concentrations (mg/L or g/L TDS). As temperature is important in salinity calculations, salinity meters have built-in temperature probes and compensation. Sodium chloride is usually the dominant salt, however other salts will also contribute to E.C. readings, especially in areas affected by seawater. The salinity meter used gave readings in E.C. in either mS/cm or μ S/cm, depending on the salinity concentration (1 mS/cm = 1000 μ S/cm). EC readings were converted to mg/L or g/L by multiplying by factor ranging from 0.52 for low EC to 0.66 for hypersaline EC.

For reference:

0 - 800 μ S/cm

800 - 2500 μ S/cm

2500 - 10,000 μ S/cm

50,000 μ S/cm (50 mS/cm; 36 g/L)

Good drinking water, suitable for all wetland biota

Suitable for all but very sensitive life stages (e.g. fish larvae)

Suitable for most adult animals, too high for juveniles (e.g. tadpoles) and some sensitive plants

Seawater

6.3 Groundwater

6.3.1 Regional Context

Hydrogeological zones of the Adelaide region are shown in Figure 6-2, with Magazine Creek Wetland located in zone 3B (Gerges 2006). Hydrogeological zone 3 is characterised as containing five to six Quaternary aquifers, underlain by three to four, almost flat-lying Tertiary aquifers (Gerges 2006). The Magazine Creek Wetland interacts directly with the Quaternary aquifers and these are the focus of the following discussion. The main lithology of the Quaternary sediments are mottled clays and silts, interbedded with layers of sands, gravel, and thin sandstones. The Quaternary aquifers are named as Q1 to Q6 in order of increasing depth (Gerges 2006). In general, the Quaternary aquifers are characterised as being thin, discontinuous, and low yielding (LWC 2017).

The Q1 (uppermost aquifer) is described as being widespread within zone 3B, located at depths of between 3 to 10m below ground level with an average thickness of 2m (Gerges 2006, LWC 2017). The average yield from the Q1 aquifer rarely exceeds 2L/s from wells mostly located along major drainage lines and structures, where the aquifer is likely to be thicker and contain a higher proportion of coarser sediments (Gerges 2006).



The remaining Quaternary (Q2 to Q5 or 6) aquifers are relatively thin with an average thickness of approximately 2m. Aquifer yields are also described as being low, ranging between <1L/s to 6L/s but with higher yields (up to 12L/s) noted at some locations.

Previous hydrogeological studies identified the St Kilda Formation as the uppermost Quaternary aquifer at Magazine Creek Wetland. The St Kilda Formation is characterised by shelly, silty, clayey sands to sandy clays as well as organic deposits (Lyons 2005, Dillon and Pavelic 1993). This is consistent with sediments encountered during the installation of monitoring wells at the study site in June 2019 (up to 6m below natural surface). The St Kilda Formation is underlain by the Glanville Formation which consists of calcareous, silty sands with abundant shells and is, in places, capped by a thin limestone layer (Lyons 2005). Within the study area the St Kilda and Glanville Formations form a layer of ~11m thickness and overlie the Hindmarsh Clay Formation.

Figure 6-3 presents the regional groundwater flow for uppermost Quaternary aquifer and indicates that regional groundwater flow in the north-western part of Adelaide is towards the Magazine Creek Wetland, which is situated within the discharge zone for a large portion of Adelaide's shallow Quaternary aquifers (Gerges 2006, Pavelic and Dillon 1993, Lyons 2005). Discharge from the upper Quaternary aquifers occurs primarily through evaporation, with a small amount of groundwater discharge to the Port River Estuary (Lyons 2005). This is consistent with Gerges (2006) who suggests that outflow from the Q1 aquifer to Gulf St Vincent is small, as the gradient at the coast is flat and the transmissivity of the aquifer is relatively low.

The water table at the site was very shallow prior to the construction of the wetlands and generally within 1m of natural surface (Lyon 2005). The water table was also found to fluctuate seasonally by 0.5m to 0.8m (Pavelic and Dillon 1993). Groundwater at the site is highly saline with salinities ranging between 60,000 $\mu\text{S}/\text{cm}$ (~equivalent to sea water) and 120,000 $\mu\text{S}/\text{cm}$ (two times the salinity of sea water) (Dillon and Pavelic 1993).

Hence the installation of the windmills to lower regional groundwater levels in the vicinity of the wetlands, refer Figure 6-1.

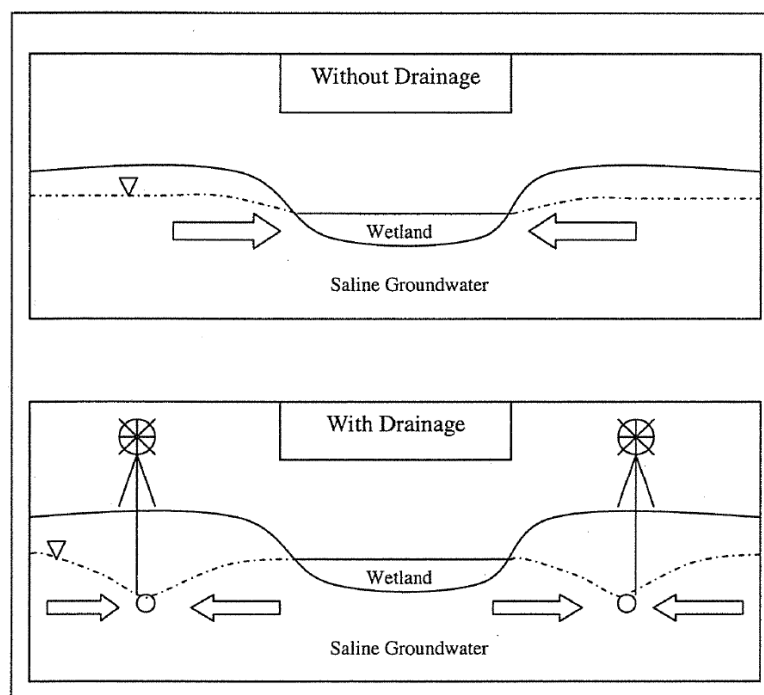


FIGURE 6-1: CONCEPTUAL ILLUSTRATION OF WINDMILL OPERATIONS (LYONS_2005)

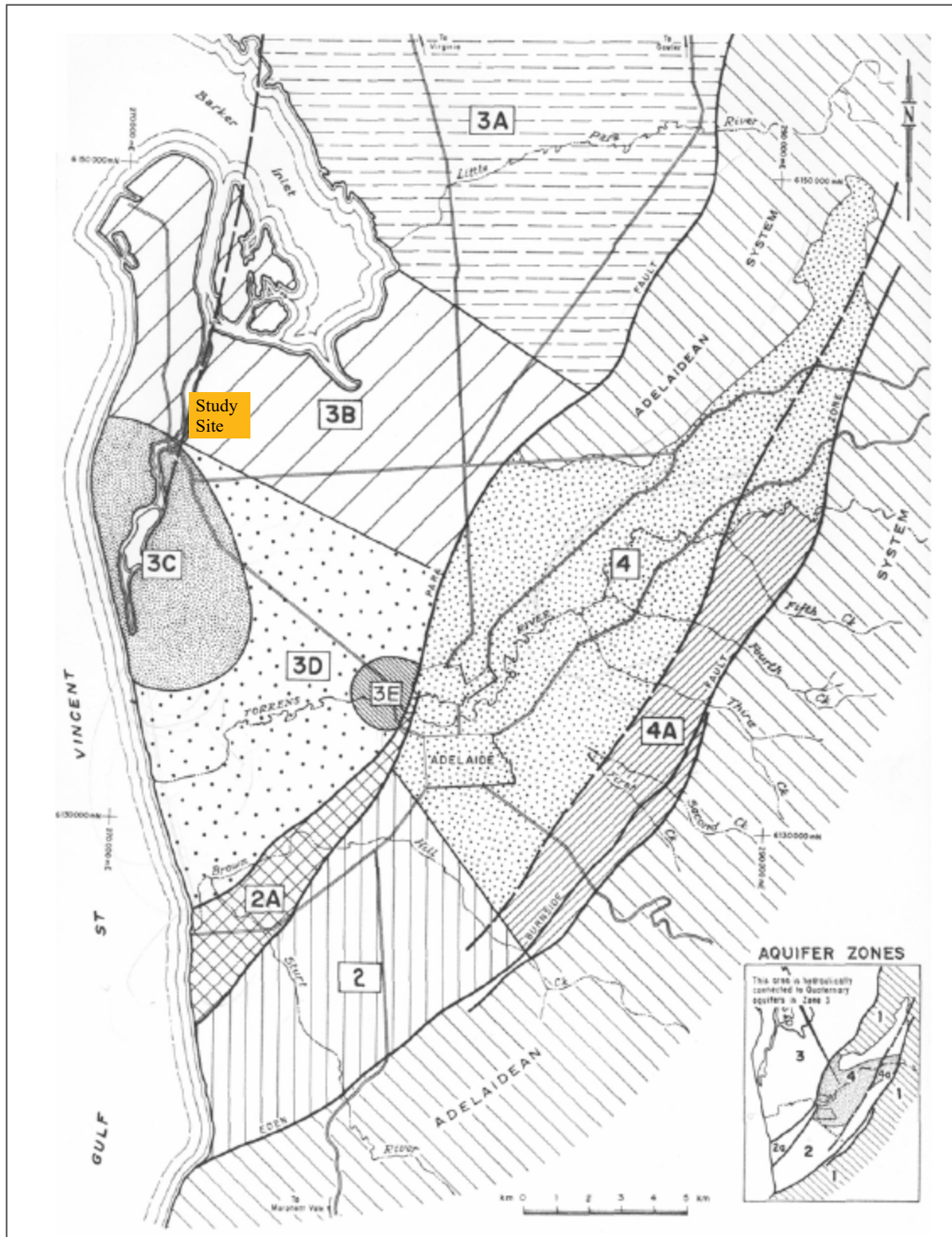


FIGURE 6-2: HYDROGEOLOGICAL ZONES OF THE ADELAIDE REGION (GERGES 2006)

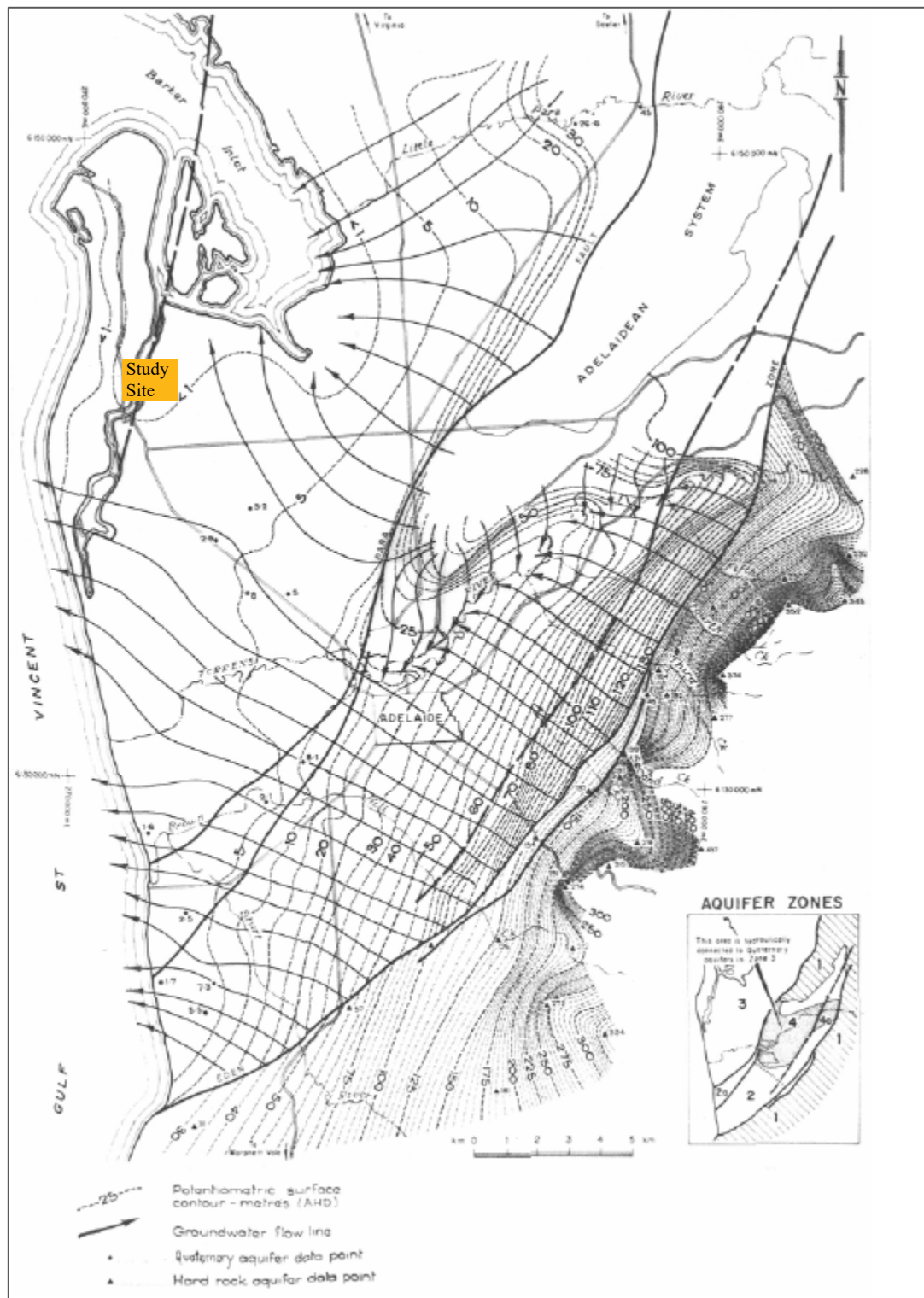


FIGURE 6-3: POTENTIOMETRIC SURFACE OF FIRST (UPPERMOST) QUATERNARY AQUIFER (Q1) AND BEDROCK AQUIFER (GERGES 2006)



6.3.2 Site Specific Monitoring

Eight monitoring wells were installed at the study site to improve the characterisation of the shallow groundwater system and its interaction with surface water features. The monitoring wells were constructed using 6" Hollow Augers and installed to a total depth of 6m below natural surface with the bottom 3m slotted screen. The location of monitoring wells is shown in Figure 6-4. Sediments encountered during drilling are consistent with descriptions of the St Kilda Formation presented in Lyon (2005) namely, shelly, silty, clayey sands and sandy clays.

Since the installation of the bores, two monitoring rounds have been undertaken with data presented in Table 6-2 and Table 6-3. The normal operating (pool) level of the wetland ponds is -0.6m AHD. Water levels in the wetlands will rise above this level (but typically by no more than 100 or 200 mm). Comparison between groundwater monitoring data and the maximum pond operating levels indicates that the water table is lower than the surface water level across the majority of the site. This can facilitate the flux of water from the ponds to the uppermost aquifer. The exception is Pond M7 where comparison between the groundwater level and pond level suggest groundwater flow towards the pond. The groundwater level at OB-M02 is also slightly above the maximum operating level, this may be related to the operation of Windmill M1.

Table 6-2 and Table 6-3 also present salinity monitoring data and confirm that groundwater is highly saline at the site. Vertical salinity profiling was also undertaken as part of monitoring to determine if the pumping and drainage system had contributed to the development of a low salinity lens around the ponds. The vertical profiles suggest that salinity is constantly high throughout the water column and no evidence of a low salinity lens was found at the newly installed monitoring wells during the two site visits. Exchange between the saline groundwater and surface water system maybe be limited by the clay lining beneath the ponds and the likely low transmissivity of the Quaternary aquifer.

The salinity data presented above is consistent with the results presented in Lyons (2005) which focused on a monitoring transect at Pond M2B. This study identified lower groundwater salinities directly beneath the ponds; ~5,000 $\mu\text{S/cm}$ at 0.6m below the pond base, ~10,000 $\mu\text{S/cm}$ 1.1m and ~25,000 $\mu\text{S/cm}$ 2.1m. However, groundwater salinities measured at bores located on the bank directly adjacent Pond M2B ranged between 60,000 $\mu\text{S/cm}$ to 95,000 $\mu\text{S/cm}$ which is consistent with recent monitoring events.

Monitoring suggests that, to date, pumping at Magazine Creek Wetland has not generated a laterally extensive freshwater lens at the site. However, pumping is likely to contribute to managing salinity in the ponds by lowering the water table across the site and limiting the inflow of saline groundwater to the pond system.

Whilst the implementation of the windmills may have lowered groundwater levels, soil salinities still appear to be high. Site inspection undertaken on 6 December 2018 indicates that there remain large areas of failed revegetation that would appear to be as a result of high salinities.

On 26 June 2019 Water Technology measured groundwater levels, in 8 locations, see Figure 6-4: Location of the 8 Groundwater Water Piezometers in Magazine Creek.



TABLE 6-2: GROUNDWATER SALINITY AND WATER LEVEL AT MONITORING SITE AS MEASURED ON 25 JUNE 2019

Piezometer Number	Salinity [EC $\mu\text{S/cm}$]	Salinity TDS mg/L	GWL(mAHD)
OB-M01	88,300	57,400	-1.01
OB-M02	64,800	42,100	1
OB-M03	90,100	58,600	-1.08
OB-M04	73,690	47,900	-0.45
OB-M05	71,780	46,700	0.39
OB-M06	76,300	49,600	0.33
OB-M07	92,800	60,300	2.4
OB-M08	82,710	53,800	2.06

TABLE 6-3: SALINITY LEVELS AT WINDMILLS DISCHARGE POINTS AS MEASURED 4 JANUARY 2019

Windmill Discharge Point	Salinity [EC $\mu\text{S/cm}$]	Salinity [TDS mg/L]	Comment
M1/M2	47,500	30,400	Outlet to Pond MO
M3	64,900	41,500	Outlet to Pond MO
M4/M5	66,900	42,700	Outlet to Pond MO
M6	60,100	38,200	Outlet to Pond M7
M7	68,900	45,000	Outlet to Pond M7

Groundwater Monitoring Bores Magazine Creek

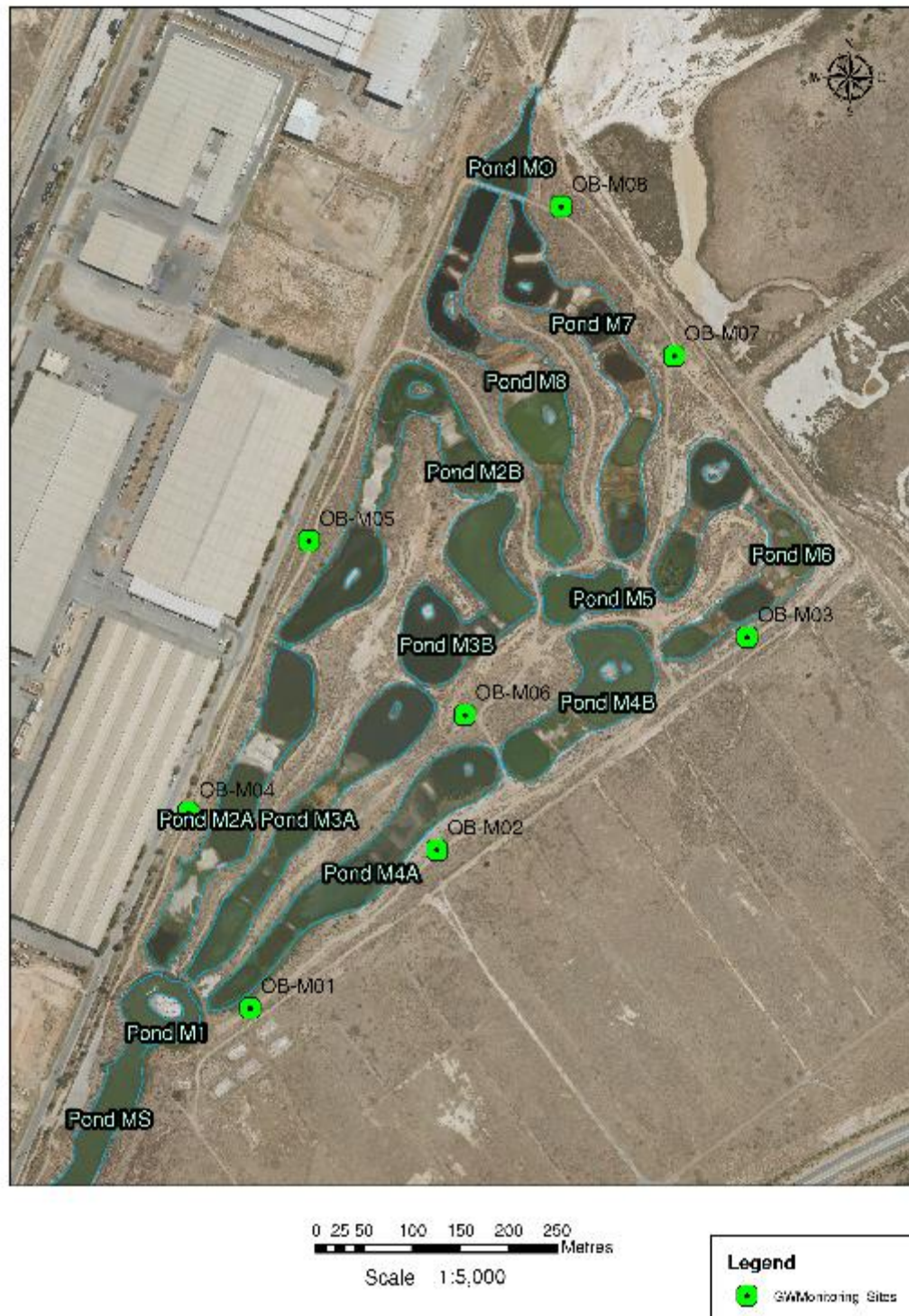


FIGURE 6-4: LOCATION OF THE 8 GROUNDWATER WATER PIEZOMETERS IN MAGAZINE CREEK



6.4 Vegetation

Wetland plants are generally characterised by their habit or function (e.g. emergent, submerged, floating), their water dependencies (e.g. permanent, fluctuating, intermittent, damp) and/or their physico-chemical tolerances (e.g. salt marsh species). This enables managers to assess the presence, abundance and condition of aquatic plants with respect to water regime and quality.

Aquatic plants provide the architecture of wetland ecosystems, food and habitat resources for wetland fauna and a range of ecosystem services (e.g. water purification) that can be exploited in constructed wetland environments for specific functions such as treating stormwater. Constructed wetlands typically have an inlet zone where coarse sediments settle and a macrophyte zone where dense stands of aquatic plants are used as a primary filtration system, intercepting and retaining pollutants and fine particles through contact between plant surfaces and the water column. To achieve this, flow through the reedbeds needs to be evenly distributed across the width of the reedbed, with minimal preferential flow paths or short-circuiting (Melbourne Water 2017).

The underlying design of Magazine Creek (and The Range) Wetlands provided for a clear, open water flow path through much of the wetland with only short sections of earth berms within ponds where flow could be spread across the full width of the reed bed, and areas around the regulator and culvert structures that connect the ponds (where flow would pass through the culverts). This is simply a reflection of the age of the design. These wetlands might be designed differently now based on increased understanding of wetland performance and design approaches developed over the last twenty years, but there is still opportunity to improve their performance within the constraints of their design.

A description of the vegetation characteristics based on our review of the available wetland construction and planting documentation as well as observations made during our site inspections on 19th October 2018, 6th December 2018 and 17th September 2019 is documented below. See Section 9 for descriptions of the monitoring sites and methods.

6.4.1 Emergent Plants

Emergent plants have been planted at Magazine Creek over the last 20 years. EGIS Consulting (1999) state that nine emergent species were planted after construction, but only eight are listed in their report (see notes in Table 6-4).

In spring 2018 and 2019, emergent plants were present along the banks of Ponds MS and M1 and their growth appeared to be limited to discrete clumps, perhaps by high water and/or soil salinities. The diversity and abundance of the emergent plants was higher around the central ponds (Ponds M2A and M2B, M3A and M3B, M4A and M4B, and M5A) and the upstream end of Pond M6 with the dominant species being *Bolboschoenus caldwellii*, *Schoenoplectus tabernaemontani* and *Juncus kraussii*.

Dense couch occurred on the banks of these ponds and there was a distinct band of dead leaves from the current water level to about 20 cm above the water line. These couch stands are a mix of native (*Distichlis distichophylla*; Emu grass) and exotic species (*Paspalum distichum*; Knotgrass or Salt couch). Regardless of provenance, couch is a very useful plant in constructed wetlands. It creates deep thatch around water's edge that provides organic matter to fuel decomposition and provide shelter for bugs, reptiles, and juvenile fish. It is also difficult to control without placing fauna and other flora at risk and thus should be retained.

Clumps of *Typha domingensis* (Bulrush) were observed in the channel along with dead stumps that may be indicative of previous plant control. *Phragmites australis* (Common reed) appeared to be restricted to Ponds M5A and M4A. Some areas of good woodland growth (e.g. *Melaleuca halmaturorum*, Tea tree and *Nitraria billardiarei*, Nitre bush) were apparent, especially along Pond M2A. Poor growth and the generally poor condition of woodland plantings in other areas was presumably due to high soil salinities (Manning 2011; Seed Consulting Services 2015) and was not reassessed.



TABLE 6-4: AQUATIC PLANT SPECIES AT MAGAZINE CREEK SHOWING WHICH SPECIES WERE PLANTED AND WHEN

Plant species	Common Name	Planting history and Field notes
<i>Bolboschoenus caldwellii</i>	Salt Club-rush	Planted 1999. Dominant emergent in 2018.
<i>Carex appressa</i>	Tussock sedge	Planted 1999.
<i>Cyperus gymnocaulus</i>	Spiny sedge	Planted 1999. Magazine Creek: 2014, 2015.
<i>Distichlis distichophylla</i>	Emu-grass	Native couch, dense cover and thatching.
<i>Eleocharis acuta</i>	Common spike rush	Planted 1999. Magazine Creek: 2014, 2015.
<i>Ficinia nodosa</i> (syn. <i>Isolepis nodosa</i>)	Knobby club rush	Planted 2015.
<i>Frankenia pauciflora</i>	Sea-heath	Planted 2015.
<i>Gahnia filum</i>	Chaffy saw sedge	Planted 2015.
<i>Juncus kraussii</i>	Sea Rush	Planted 1999. Magazine Creek: 2014, 2015.
<i>Phragmites australis</i>	Common reed	Planted 1999.
<i>Lepileana australis</i>	Sea tassels	Colonised as mixed stands of submerged plants.
<i>Ruppia megacarpa</i>	Large-fruited sea tassel	Colonised as mixed stands of submerged plants.
<i>Schoenoplectus tabernaemontani</i> (syn <i>S. validus</i>)	River club-rush	Planted Magazine Creek: 2014, 2015.
<i>Schoenoplectus pungens</i>	Sharp-leaf club rush	Planted 1999. Magazine Creek: 2014, 2015.
<i>Paspalum distichum</i> *	Knotgrass	Introduced but highly functional.
<i>Selliera radicans</i>	Tongue plant	Planted Magazine Creek 2015.
<i>Thyridia repens</i> (syn <i>Mimulus repens</i>)	Creeping Monkey-flower	Planted: unknown date.
<i>Typha domingensis</i>	Bulrush	Planted 1999.
<i>Wilsonia backhousia</i>	Narrow-leaf Wilsonia	Planted Magazine Creek 2015.

* exotic species

6.4.2 Submerged Plants

Submerged plants live in the channel and are rooted in the sediment, with the majority of their leaves and stems underwater. There is no record that these species were planted and thus it is assumed that the following species have voluntarily colonised via waterbird dispersal or through propagules entering with stormwater:

- Pond M3A – embayments contain submerged aquatic plants, predominantly and possibly only Large fruited sea tassel (*Ruppia megacarpa*).
- Pond M2B – filamentous algae present, suggesting sufficient nutrients for submerged aquatic plant growth but no evidence of submerged aquatic plants.
- Pond M6 – filamentous algae and submerged plants present (Sea tassels *Lepileana australis* and *Ruppia megacarpa*). Large quantities of gas liberated from sediments when disturbed suggests high rates of decomposition consistent with large biomass of submerged plants and algae.

6.4.2.1 Floating Plants

Lemna minor was the only floating plant observed at it was only present at the eastern end of Pond M1. The density of leaves was low, and the leaves were pale green, possibly due to high rates of herbivory, recent



dredging disturbance and/or site conditions. It is likely that it entered with stormwater and was not able to persist.

6.5 Frogs

Spotted grass frog (*Limnodynastes tasmaniensis*) calls were heard near Pond M2A. This indicates that the male frogs are attempting to mate but there is no evidence of breeding. Spotted grass frogs are very resilient, habitat generalists that will readily colonise new wet areas. They breed opportunistically and are highly dispersive. Males call at any time of year, especially after rain. Tadpoles mature rapidly (3 months) and have a salinity tolerance of < 6000 $\mu\text{S}/\text{cm}$ (Anstis 2007; Gonzalez et al 2011; DEWNR 2017). All the ponds at Magazine Creek had salinities higher than this threshold except for Ponds M2A and M7 that had salinities at this threshold, which suggests that reproduction may not be successful (Table 6-1). Seed Consulting Services (2015) also report Spotted grass frog calls in July 2011 as well as those of Common froglet (*Crinia signifera*). Common froglet are also habitat generalists that breed opportunistically, although their tadpoles have higher salinity tolerance (9360 $\mu\text{S}/\text{cm}$; Antis 2007; Gonzalez et al 2011; DEWNR 2017) than those of Spotted grass frog. Common froglet prefer abundant aquatic plant cover and their dispersal is poorly understood.

6.6 Waterbirds

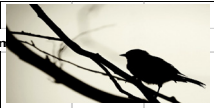
The results of the bird survey conducted by John Gitsham at Magazine Creek Wetland are summarised below and in Table 6-5.

- 43 species of birds were seen throughout the ten ponds of the wetland
- Eurasian Coots were the most dominant species (100+) in number in Pond M3, followed by Grey Teal (up to 100), so the food source (algae and a duck weed sp.) availability was obviously rich and abundant in Pond M5A for those species.
- There were approximately 30 Sharp-tailed Sandpipers (Migratory bird from Siberia) found in the shallower Ponds MS1, M2A, M8, M7 and M4A feeding on small shellfish/invertebrates of some description.
- There were 50+ Australian White Ibis around Pond M5, but they are abundant throughout the whole area due to the nearby Winfield Rubbish Dump.
- The rarest bird observed was a single Freckled Duck in amongst the many Grey Teal in Pond M3A. They are sometimes seen singularly or in small groups around inner Adelaide wetlands. This duck is very rare in Australia, with only a few thousand left across Australia and is now fully protected, even during Duck Hunting season.
- The overall habitat health for birds in this wetland was very good. The bird species seen are typical freshwater wetland and estuary birds. There were no true saltwater (migratory) or ocean shorebird species e.g. Hooded Plovers or Oystercatchers observed in any of the ponds.

Seed Consulting Services (2015) found similar numbers of birds in July 2015 (46 species) although there were some differences in species present.



TABLE 6-5: MAGAZINE CREEK WETLAND BIRD SURVEY

		birding & nature connections									
Table 4: Magazine Creek Wetland Bird Survey		John Gitsham - M: 0438 900 393 - E: john.gitsham@bigpond.com									
Location: Magazine Creek Wetland		Weather: 35c, Clear Sky, No Wind								Method:	Presence
Date: 6th Dec 2018		Time started and finished: 9.30am to 12noon									
Bird Species	Scientific Name	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5	Pond 6	Pond 7	Pond 8	Pond 9	Pond 10
Silver Gull	<i>Chroicocephalus novaehollandiae</i>										
Pied Stilt	<i>Himantopus leucocephalus</i>										
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>										
Australian Shoveller	<i>Anas rhynchotis</i>										
Grey Teal	<i>Anas gracilis</i>										
Pink-eared Duck	<i>Malcorhynchus membranaceus</i>										
Freckled Duck (Rare)	<i>Stictonetta naevosa</i>										
Hardhead Duck	<i>Aythya australis</i>										
Pacific Black Duck	<i>Anas superciliosa</i>										
Red-kneed Dotterel	<i>Erythrogonyx cinctus</i>										
Masked Lapwing	<i>Vanellus miles</i>										
Australian White Ibis	<i>Threskiornis molucca</i>										
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>										
Hoary-headed Grebe	<i>Polycephalus poliocephalus</i>										
Black-tailed Native Hen	<i>Tribonyx ventralis</i>										
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>										
Dusky Moorhen	<i>Gallinula tenebrosa</i>										
Eurasian Coot	<i>Fulica atra</i>										
Australian Pelican	<i>Pelecanus conspicillatus</i>										
Pied Cormorant	<i>Phalacrocorax varius</i>										
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>										
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>										
Black-fronted Dotterel	<i>Euseyonis melanops</i>										
Royal Spoonbill	<i>Platalea regia</i>										
Yellow-billed Spoonbill	<i>Platalea flavipes</i>										
Great Egret	<i>Ardea alba</i>										
Red-capped Plover	<i>Charadrius ruficapillus</i>										
Purple Swamphen	<i>Porphyrio porphyrio</i>										
Black Swan	<i>Cygnus atratus</i>										
Whistling Kite	<i>Haliastur sphenurus</i>										
Little Grassbird (Heard only)	<i>Megalurys gramineus</i>										
Spotted Dove *	<i>Spilopelia chinensis</i>										
White-plumed Honeyeater	<i>Ptilotula penicillata</i>										
Rock Dove *	<i>Columba livia</i>										
Willie Wagtail	<i>Rhipidura leucophrys</i>										
House Sparrow *	<i>Passer domesticus</i>										
Purple Backed Fairy Wren	<i>Malurus lamberti</i>										
Magpie Lark	<i>Grallina cyanoleuca</i>										
Common Starling *	<i>Sturnus vulgaris</i>										
Crested Pigeon	<i>Ocyphaps lophotes</i>										
Welcome Swallow	<i>Hirundo neoxena</i>										
Australian Pipit	<i>Anthus australis</i>										
42 birds species surveyed											
Introduced Species *											
Other Native Fauna Species											
Spotted Marsh Frog (Heard only)	<i>Limnodynastes tasmaniensis</i>										
Notes:											
50+ White Ibis											
1 only Rare Freckled Duck											
30+ Sharp-tailed Sandpiper											
100's Grey Teal Duck											
100's Eurasian Coot											

The City of Port Adelaide Enfield, along with Department for Environment and Water have been undertaking bird surveys in association with Birds SA in the Wicker Road / Magazine Creek wetlands area since 2012. The survey program is scheduled to continue to 2025. Results of the surveys completed to date are available to the public through the Nature Maps web site managed by DEW (Biological Survey: 858 PAE Bird Survey).

The data set is an extensive one and has the advantage of consistency in observers with Mr Christopher Evans having participated throughout most of the surveys. The observations by our project team are consistent with previous surveys, and whilst there are highly variable fluctuations in bird species diversity and total bird counts over the survey period there are no obvious trends in either over the survey period when considering total bird numbers and diversity refer diversity and abundance figures overleaf.

However, whilst it is anticipated that a detailed analysis of the data will be undertaken towards the end of the survey period, there are some interesting trends that would appear to be emerging within the data sets for individual bird species. For example, the data sets support anecdotal comments by Mr Evans that the number of Black-fronted Dotterel (*Euseyonis melanops*) and Red-kneed Dotterel (*Erythrogonyx cinctus*) along with Nankeen Night Heron (*Nycticorax caledonicus*) whereas there has been an apparent increase in the numbers of White-fronted Chat (*Epthianura albifrons*) observed since 2012.



It is difficult to be conclusive as to the reasons for these declines or increases in species, however, the proposed monitoring program as part of this management plan will assist with the collection of additional data sets that may assist with establishing causalities.

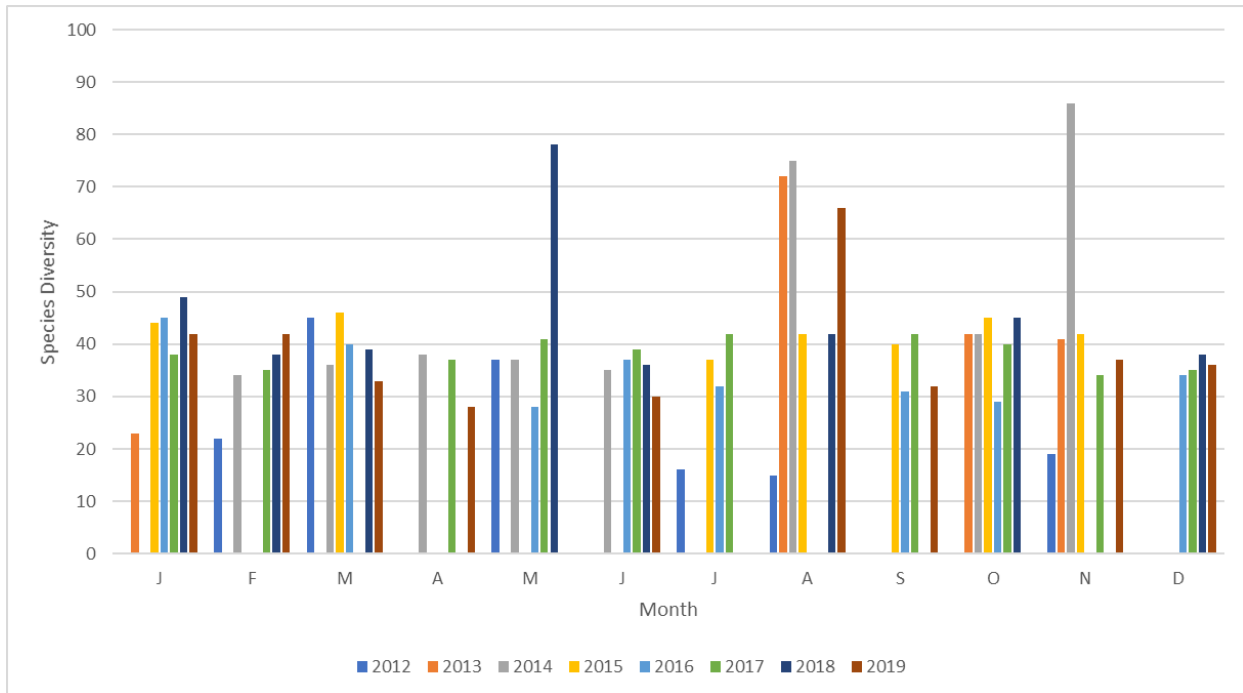


FIGURE 6-5: SPECIES DIVERSITY RECORDED AT THE WICKER ROAD/MAGAZINE CREEK WETLANDS (SURVEY 858)

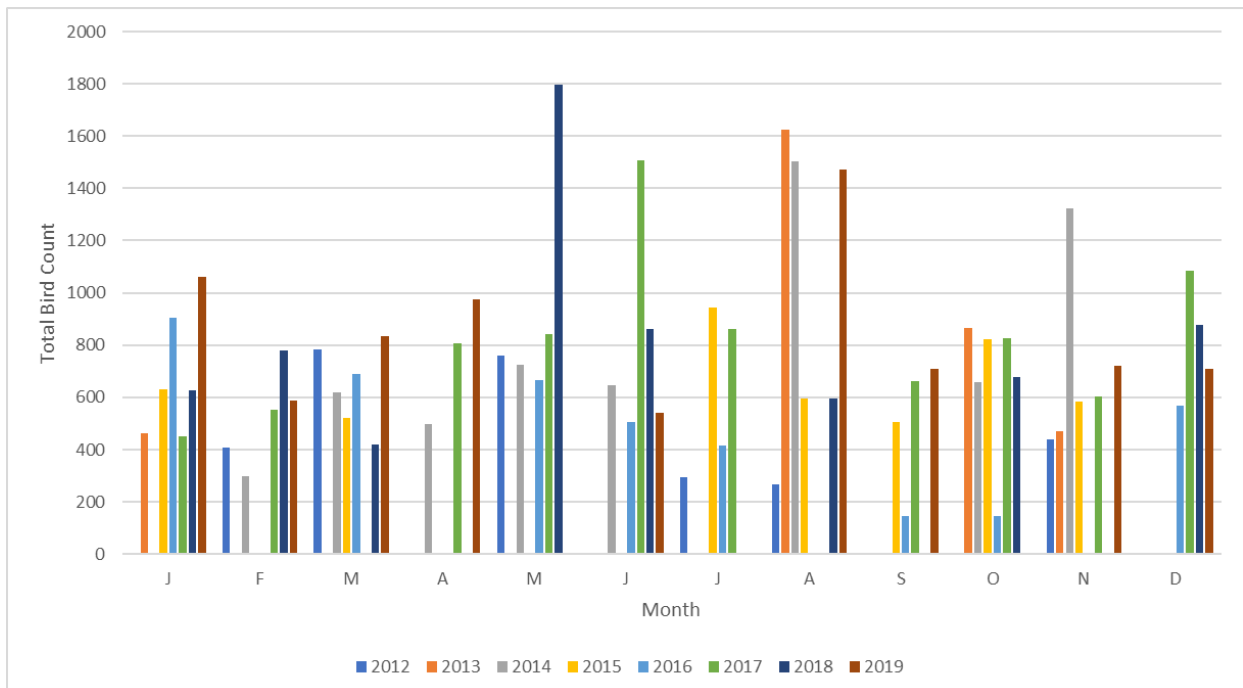


FIGURE 6-6: TOTAL BIRD COUNTS RECORDED AT THE WICKER ROAD/MAGAZINE CREEK WETLANDS (SURVEY 858)



6.7 Other Opportunistic Fauna Observations

There was little sign of life in Pond MS1 (e.g. few macroinvertebrates and no signs of bioturbation) although there were biofilms on submerged woody debris. Abundant macroinvertebrates (e.g. water boatmen) and schools of small-bodied fish were observed around the dense reed beds in Pond M3B in both spring 2018 and spring 2019, even though the sediments were easily dispersed and black. It is most likely that these fish were a species of hardyhead because of their behaviour, size, shape, tolerance of a wide range of salinities and the greater likelihood of the wetlands connecting to the ocean to allow passage of estuarine-marine species than freshwater fish entering the site with stormwater inflows.

6.8 Key Findings - Existing Environment Review

Our review of the wetland environment associated with the Magazine Creek wetlands has identified the following issues:

- Soil salinity levels have impeded terrestrial plant growth and continue to do so.
- Water quality in the wetlands are often brackish and increase towards the outlet of the wetland.
- Aquatic vegetation is of lesser diversity and abundance than expected of a healthy wetland system.
- There is an apparent lack of diversity and abundance of aquatic biota.
- The wetland system offers a low level of habitat availability for aquatic or terrestrial fauna.
- Regional groundwater beneath and adjacent the wetlands remain hyper-saline and there are no signs of a substantial freshwater lenses beneath the wetlands.
- The clay liners in the wetlands appear to be very effective.
- The wetlands have a very stable hydrologic regime with very limited variability in water levels.
- The wetlands provide an important refuge and habitat for water birds.
- Silt accumulation in the wetlands is an ongoing issue for Council.
- Ongoing operation of the windmills is required to ensure hyper-saline groundwater levels are lower than the wetland operating levels.

Refinements to the management of the wetlands are proposed and presented as management options in Section 8 within the context of revised management objectives.



7 SOCIAL/CULTURAL VALUE AND USE

7.1 Community Profile

Magazine Creek and Range Wetlands are located at approximately 17km from Adelaide's CBD in Port Adelaide, they are constructed wetlands and public access is restricted. There is a significant amount of industrial development near the wetlands, and hence public attraction and community access is limited. The wetlands are highly valued by informed community members who recognise their value in supporting bird life as well as protecting the estuarine areas of Barker Inlet from poor quality stormwater runoff.

7.2 Community use of wetland

Whilst access is limited and restricted, there are several active community groups (including Birds SA) with a keen interest to preserve and ensure the longevity of the wetland environment for migratory birds.

The general amenity provided by the wetland was appreciated by community members and all wanted to see the wetland in better condition. Specifically, the Port Adelaide Environment Residents Group seeks to enhance the environmental values of the area.

7.3 Community Opinion

The draft management plans for Magazine Creek and The Range wetlands were made available for public comment and community input through an interactive on-line community workshop meeting. The community representatives of Magazine Creek and Ranges Wetlands that were present at the meeting identified the following issues for consideration in the future management of the wetland.

- Need to maintain and improve diversity of wetland vegetation
- Recognition of the effectiveness of wetlands in improving water quality beyond salinity is required
- Protection of the values of wetlands from encroachment by industrial development
- The role this site has in contributing to addressing challenges relating to sea level rise
- Opportunities to engage community members in Citizen Science activities
- Opportunities for Blue Carbon

Implementation of the proposed management plan should assist with addressing these issues.

A full copy of the community and stakeholder workshop meetings report is provided in Appendix D



8 MANAGEMENT OPTIONS

The options for improving the ecological health whilst minimising costs and resources required to manage the Magazine Creek Wetlands are presented in this section. The options are offered within the context of the original management objectives for the wetlands as presented in the original design and management documentation.

8.1 Evaluation of Achievement of Original Management Objectives

Objective 1 – *Intercept and treat polluted stormwater and runoff to reduce the concentrations and loads of pollutants in order to protect downstream ecosystems*

Evaluation: Stormwater has been successfully intercepted and flooding controlled. It is not known whether concentrations and loads of pollutants have been reduced. It can be assumed from the vegetation and sedimentation patterns that the wetland is treating stormwater inputs, but this may be limited by short-circuiting of water around, rather than through, the plants' root zones. Only a few of the shallow 'peninsula' reedbeds in the original design of Magazine Creek contain established stands of reeds and there was evidence of short-circuiting due to plants only growing in the shallow areas and not on the 'peninsulas'. The general lack of established reedbeds and aquatic vegetation in the channels (except for water edge vegetation) is likely to be resulting in relatively poor pollutant removal efficiency.

Improvement opportunities:

- Increase variability of the water regime to achieve increased plant cover, increase detention time and improve stormwater treatment capacity
- Strategic planting of diverse reed species onto the 'peninsula' areas and areas near the inlets, if natural colonisation is slow or limited

Objective 2 - *Provide a system which supports a diverse aquatic ecosystem and will not be a source of problems including nuisance insects and odours;*

Evaluation: The littoral zone at Magazine Creek wetland was generally narrower and less diverse than at The Range Wetlands. This may reflect differences in inflows, water quality, effectiveness of management interventions and/or soil conditions between the two wetlands. Vegetation abundance and diversity was higher in areas away from the inlet and the outlet, presumably due to high surface water and/or soil salinities.

Water bird diversity and abundance was generally high. The waterbird community was typical for freshwater wetland and estuary habitat in the region, although there were no true saltwater (migratory) or ocean shorebird species. Waterbird diversity was higher at Magazine Creek than The Range presumably due to shallower water and more exposed mudflats.

Improvement opportunities:

- Increase variability of the water regime to achieve increased plant cover and diversity
- Relocate effluent from windmills to reduce salinities in ponds M7 and M8 and thus increase plant diversity and abundance over time in those ponds and in adjacent ponds that may receive saline surface water

Objective 3 - *Provide a system which improves the visual amenity of the site, and provides recreational opportunities*

Evaluation: The wetlands provides improved visual amenity to that provided by the degraded landscape on which they were established. Recreational opportunities are presented limited by restricted access being available for the public.

Improvement opportunities:



- Improved vegetation diversity and resilience would further enhance the visual amenity of the site
- Management of terrestrial soil salinity would assist with the establishment of terrestrial plantings or alternatively selection of more salt tolerant species for terrestrial plantings should result in improved plant survival and growth rates

Objective 4 - *Provide opportunities for the harvesting and reuse of stormwater.*

Evaluation: Water reuse opportunities have not been pursued to date, despite the presence of a deep tertiary aquifer that is likely to be able to support Managed Aquifer Recharge.

Improvement opportunities:

- The potential for water harvesting from the wetlands is likely to remain limited by the brackish nature of water in the wetlands making it unfavourable for most open space water uses at present

Objective 5 - *Provide a means of intercepting chemical spills or accidents within their catchments; protecting downstream systems by presenting an opportunity for isolation and clean up.*

Evaluation: The multiple cells / ponds design of the wetlands along with the provision of numerous points at which ponds can be isolated from each other provides the potential to effectively and manage a chemical spill within the upstream catchment.

Improvement opportunities:

- No improvement measures are considered necessary

8.2 Proposed Additional Management Objectives

The above management objectives would still appear to be appropriate, however, through the review of literature and data associated with the wetlands the following two additional objectives could be considered by Council.

Possible new objectives:

- *Reduce running costs without negatively impacting (or improving) on current ecological character*

Opportunity: test effects of periodically turning windmills off on salinity, groundwater and ecological character

- *Precondition the wetland ecosystems to likely changes from rising sea levels*

Opportunity: create variable estuarine-freshwater conditions to enhance colonisation of a range of more or less salt-tolerant species such that the ecological character can shift if and when sea levels rise without losing ecological function.

Improvement opportunities:

- Create variable estuarine-freshwater conditions to enhance colonisation of a range of more or less salt-tolerant species such that the ecological character can shift if and when sea levels rise without losing ecological function.

8.3 Threats to Achievement of Site Objectives

There are a number of threats that may prevent or impede site managers from achievement of the objectives for the site (Table 8-1). The levers that site managers can operate to better achieve these objectives and/or mitigate potential impacts from these threats are limited to changing operations of the windmills, actively operating the regulators between the ponds and/or strategic on-ground works (e.g. revegetation, pest control).



TABLE 8-1: LIST OF THE THREATS AND PROBABLE IMPACTS OF THE MANAGEMENT PLAN

Threat	Probable Impact	Mitigation Options	Management Considerations
Static low flow water regime	Limited aquatic plant establishment (low cover and/or diversity) Limited mud flat exposure for foraging waterbirds	Vary water levels by operating regulators to exclude stormwater inputs and draw down parts of the wetland in summer	Limit timing and period of closure of regulators to ensure risk of flooding is not increased
Sustained high salinity levels in the surface water	Limited diversity and abundance of aquatic flora and fauna	Relocate windmill effluent to prevent mixing with wetland surface water	Limit closure of regulators to keep surface water salinities below target levels
Salinization and/or Sodification of soils	Limited diversity and abundance of aquatic flora and fauna Limited stormwater treatment by soils Potential accumulation of acid-sulfate soils	Relocate windmill effluent to prevent salinization of wetland soils. Create and/or maintain freshwater discharge to soils and groundwater	Limit closure of regulators to keep surface water salinities below target levels There is no evidence that windmills have generated a freshwater lens but limiting the timing and periods of windmill shut down will limit discharge of saline groundwater
Pest Plants	Infestation of wetland banks limiting native plant cover and diversity	Control pest plants	Exotic couch grass is currently providing cover of the wetland banks and other ecosystem services so should be only be removed as part of a revegetation program
Spills /contamination	Chemical spill in catchment could cause toxicity issues for wetland ecology	Ensure Council's and EPA's response system endeavour to contain spills before they reach the wetlands, and then limit the areas of the wetlands impacted	The primary function of the wetlands is to protect the downstream estuarine and marine environments from stormwater pollution. Hence, the condition of the wetlands may need to be compromised to protect downstream environments



Threat	Probable Impact	Mitigation Options	Management Considerations
Pest Species	Predation of native wetland fauna by foxes, dogs and cats	Very difficult to control. Council may consider baiting or trapping programs for foxes and other wild, pest fauna. Increase cover for prey to avoid predation.	Domestic pets may be adversely affected by baiting or trapping programs. Also, control is likely to be costly, will need to be ongoing and unlikely to achieve eradication.
Sea Level Rise	Salinization of the soils and water due to ingress of seawater as sea level rises	Relocate hypersaline windmill effluent Encourage colonisation by estuarine species that can adapt to seawater incursions	Areas currently affected by hypersaline water are bare and could be colonised by plants that can tolerate estuarine conditions if salinities were lowered and water levels varied

8.4 Consideration of Pest Species

The control of feral animal species such as cats, dogs, foxes, and rabbits will be difficult even if Council were to initiate an ongoing baiting and trapping program across a wide area, including surrounding lands. The presence of the waste transfer station and large tracts of open-space land that are and are not under Council control will make this task difficult, and hence any such program needs to be done together with neighbouring landholders and managers. It is unlikely that eradication of pests is possible.

Pest fish species are best controlled by either completely drying out wetland areas or lowering water levels and harvesting pest fish using electro fishing and trapping techniques. Complete drying will also cause losses of native fish in the system.

Mosquitoes are best controlled through natural means by ensuring a healthy aquatic ecosystem is established and maintained which includes providing suitable habitat for native predatory species.

Pest bird species such as mallards, domestic ducks, seagulls and pigeons will be very difficult to control given the abundant sources of resources (habitat, nesting sites, water and food) in surrounding areas. Any culling program would most likely be ineffectual.

8.5 Opportunities for Improving Wetland Management

As discussed in earlier parts of this report, wetlands are areas within the landscape that are inundated with water for all, or at least part of the year. Shallow freshwater wetlands are defined to be 2 metres deep or less, Magazine Creek wetlands system meets that criteria. Such systems are typically ephemeral or at least subject to seasonal variability in water level with the system progressing through repeated seasonal wetting and drying cycles. Increasing the variability in water level in the wetlands through the year is likely to promote an increase in vegetation diversity and abundance, and thereby support increased habitat availability and in turn biodiversity.

Hence, there are opportunities for increasing the stormwater treatment capacity, plant diversity and cover and visual amenity by increasing the variability in water regime and relocating the source of hypersaline water (i.e.



the windmill discharge water). Varying the water levels will also expose mudflats for colonisation by new plants, aeration of sediments and for foraging birds.

Salinities will increase as water levels drop, however, and waterbirds also need inundated habitats for refuge from high temperatures in summer and for foraging habitat in areas that are kept inundated. It is also essential that any closures of regulators for ecological benefits do not increase the risk of flooding to unacceptably high levels.

8.6 Proposed Revised Water Management Regime

A biennial drawdown programme (Table 8-2) has been devised to evaluate responses to changes in water regime, especially salinity levels in the ponds. The drawdown periods of the ponds will be during the summer, when there is minimum runoff draining into the wetland, enabling ponds that are not being drawn down to have the capacity to hold the runoff being diverted to them. Evaporation rates are also high in summer therefore water levels should drop rapidly once the pond is shut off unless there are substantial groundwater inflows. The proposed drawdown regime has considered the flow paths of the wetlands as follows:

- Water levels can be varied by closing select regulators and channelling water along one, two or all three pathways.
 - Pathway 1: Ponds M2A & M2B
 - Pathway 2: Ponds M3A & M3B
 - Pathway 3: Ponds M4A & M4B
- Ponds 5 acts as “Hub” from which water can be directed Pond M6, M7 and/ or M8.

Water levels in the blocked ponds will decrease thus reducing the inundated areas, as detailed in Figure 8-5.

Water salinity and the availability of some water for refuge purposes remain important considerations. Accordingly, the preferred management regime described below is based on the following principles:

- For Ponds M2A & M2B as well as Ponds M4A & M4B: Not exceeding average salinities of 10,000 mg/L during drawdown, although salinity spikes in parts of the system may exceed 10,000 mg/L depending on weather conditions and stormwater inputs. This requires that regulators are only closed along one pathway in any given summer for a maximum of 3 months to achieve drying without causing unacceptable salinity spikes or drying refuge areas.
- For Ponds M6 & M7: Not exceeding average salinities of 15,000 mg/L during drawdown, although salinity spikes in parts of the system may exceed 15,000 mg/L depending on weather conditions and stormwater inputs.
- Having at least two of the three main pathways open and flowing to receive stormwater inputs at any time to avoid increased flooding risks.
- Having the whole system open and flowing from autumn to spring to encourage flushing and connectivity with the estuary, especially for small native fish that may move during these times.
- Closing regulators to induce drawdown in summer and early autumn to mimic natural wetland drying patterns.
- Varying opening and closing times from year-to-year to create variable water regimes over several years and encourage diverse mosaics of vegetated and unvegetated habitats.
- Having the capacity to refill any ponds that are being dried out, if salinity increases to unacceptable levels and/or greater stormwater interception or storage capacity is required.
- Co-ordinating opening and closing times so that operators only have to visit the site once to close regulators and once to open regulators each year.



- Undertake trials of shutting down windmills during winter when stormwater inputs are expected to be relatively high, and thus able to flush through any saline groundwater that enters the wetlands without causing unacceptable salinity spikes.

These principles culminate in the proposed operations described in Table 8-2 and Table 8-3. Under this management regime, site managers will:

- Open and close Ponds 2A, 2B and 6 together
- Open and close Ponds 4A, 4B and 7 together
- Not manipulate Ponds 3, 5 and 8

The predicted water and salinity levels for each pond under this management regime are also shown in Tables Table 8-2 and Table 8-3.

This will need to be tested; it may be better to keep Pond M7 open at all times to flush out the salts faster, until the salinity levels have dropped to less than target levels before closing regulators to create a drawdown, introducing seed or planting tube stock.

The predicted water levels and salinity responses from the proposed management regime are presented graphically in the following figures.



FIGURE 8-1: PREDICTED WATER LEVELS AND SALINITIES PONDS 2A AND 2B

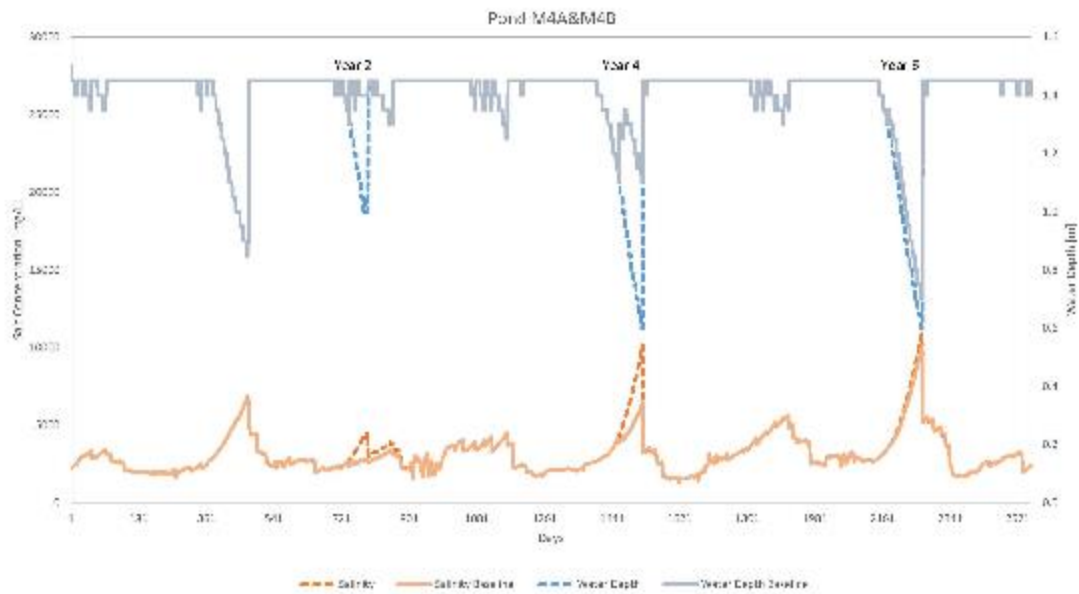


FIGURE 8-2: PREDICTED WATER LEVELS AND SALINITIES PONDS 4A AND 4B

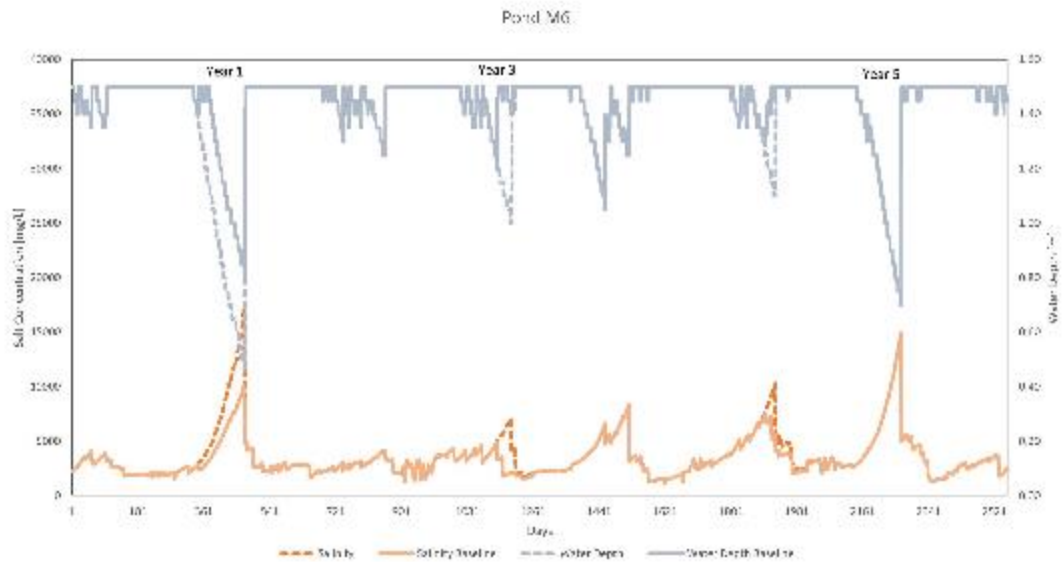


FIGURE 8-3: PREDICTED WATER LEVELS AND SALINITIES POND M6

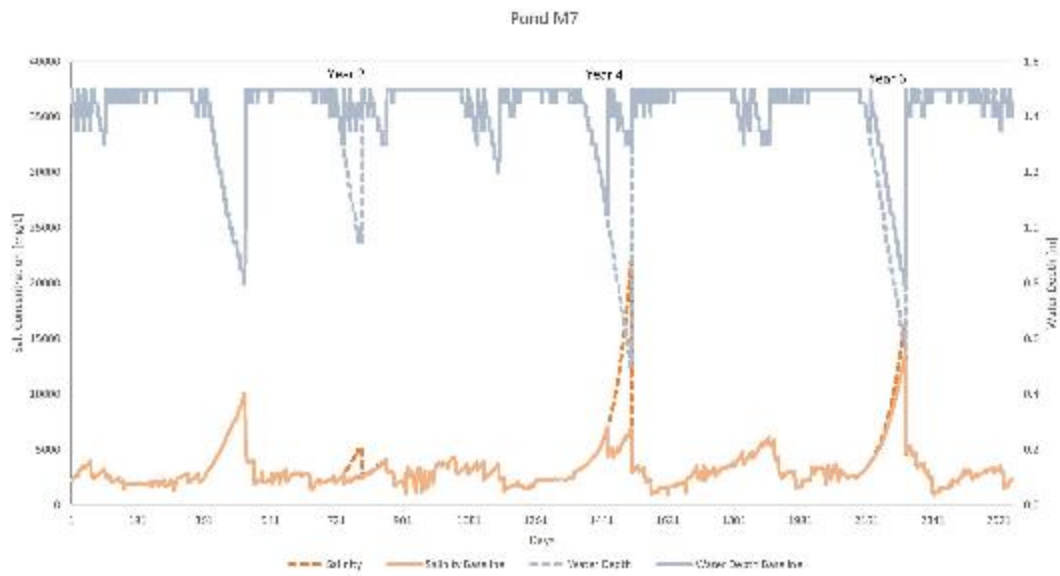


FIGURE 8-4: PREDICTED WATER LEVELS AND SALINITIES POND M7

Inundated Plan Area Magazine Creek

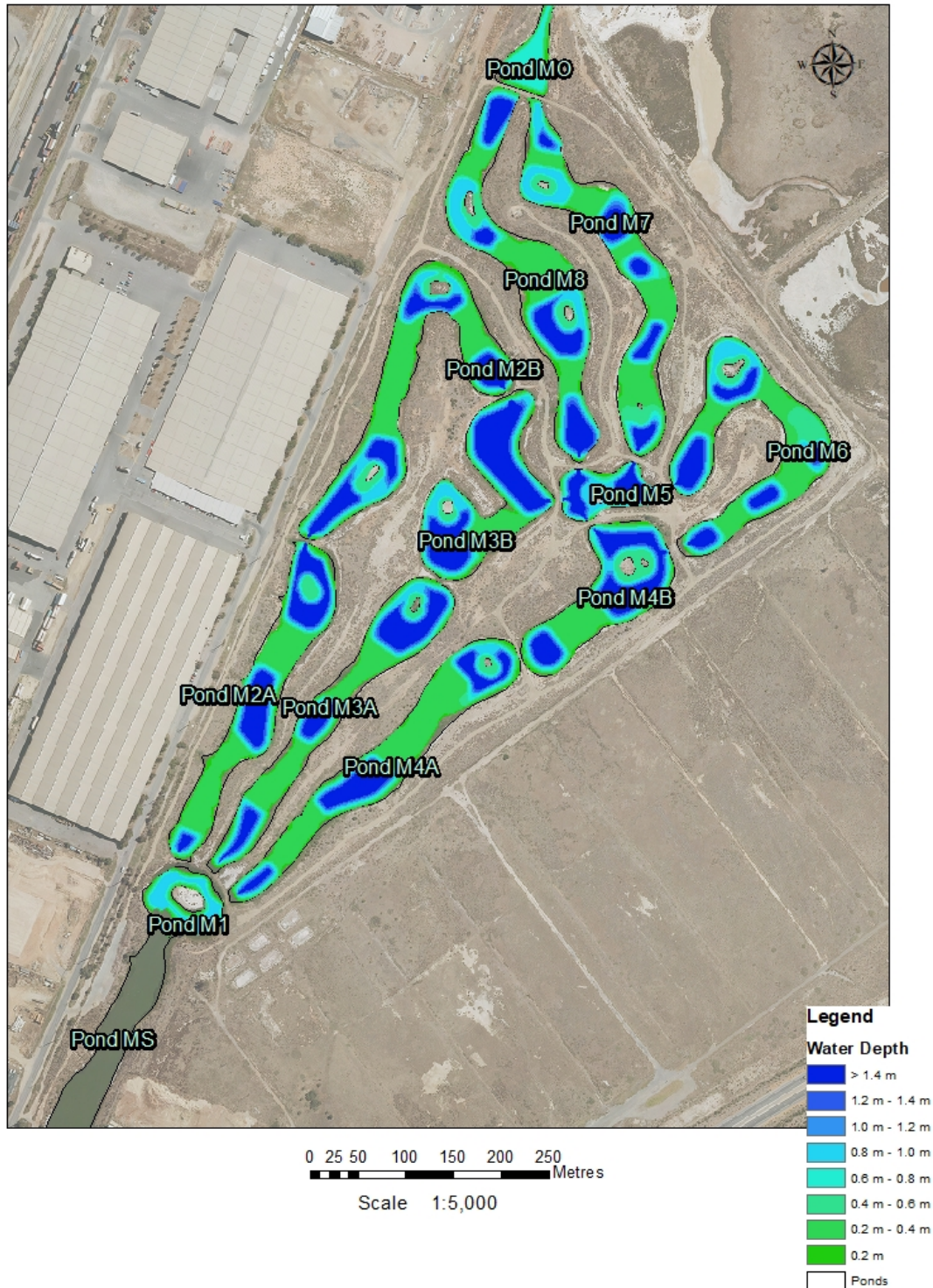


FIGURE 8-5: INUNDATED AREAS ASSOCIATED WITH WATER DEPTHS IN MAGAZINE CREEK



The inundated patterns for oscillating water levels are shown in Figure 8-5. The inundation patterns were modelled using 20 cm increments to show the inundation variation of the wetlands. At 1.5m depth, the areas coloured in green are inundated, including areas marked a lighter green and light blue. As the water depth decreases so does the inundated area. The darkest blue patches are the last to dry and will remain wet under the proposed operations.

TABLE 8-2: ESTIMATED AVERAGE AND MAXIMUM SALINITY LEVELS AT MINIMUM WATER DEPTH IN PONDS M2A & M2B AS WELL AS PONDS M4A & M4B.

Year	Ponds 2A & 2B	Ponds 4A & 4B	Minimum water depth	Average salinity at lowest depth	Max. salinity at lowest depth
1	Close December Open February		0.4 m	8000 mg/L	8300 mg/L
2		Close January Open February	0.6 m	8600 mg/L	10200 mg/L
3	Close February Open March		0.6 m	9200 mg/L	10200 mg/L
4		Close December Open February	0.4 m	8700 mg/L	10100 mg/L
5	Close January Open February		0.6 m	8200 mg/L	8900 mg/L
6		Close December Open February	0.4 m	8700 mg/L	10100 mg/L

TABLE 8-3: ESTIMATED AVERAGE AND MAXIMUM SALINITY LEVELS AT MINIMUM WATER DEPTH IN PONDS M6 AS WELL AS M7

Year	Pond 6	Pond 7	Minimum water depth	Average salinity at lowest depth	Max. salinity at lowest depth
1	Close December Open February		0.2 m	11700 mg/L	11700 mg/L
2		Close January Open February	0.6 m	10400 mg/L	14300 mg/L
3	Close February Open March		0.4 m	17300 mg/L	18500 mg/L
4		Close December Open February	0.2 m	14600 mg/L	17200 mg/L
5	Close January Open February		0.6 m	11500 mg/L	15400 mg/L
6		Close December Open February	0.2 m	14600 mg/L	17200 mg/L



8.7 Strategic Revegetation

The original intent for the terrestrial areas of Magazine Creek was to create a 'woodland' landscape. There have been low survival rates of most of the trees and shrubs however, due to high soil salinities. Along the water's edge there have been better survival rates and there are well-established tea trees and gums along parts of Magazine Creek, particularly along Ponds M1, M2A and M4A. This indicates that rainfall percolation has not been sufficient since the wetlands were constructed to flush the saline soil mounded between the wetland ponds during construction of accumulated salts, and a renewed effort in revegetation is required.

The revegetation design needs to ensure that plantings do not impact on shorebird habitat values. The maintaining of open space adjacent to water, and open space for roosting or the encouragement of natural restoration of saltmarsh which is a low lying habitat which can be utilised by shorebirds should be integrated into landscape design, maintaining distances of any overstory or tall shrub layers away from waterbody and edges and establishing conditions and undertaking treatments that will encourage saltmarsh restoration.

In this regard planting design should seek to maximise wildlife benefit and a key focus of management planning at this site identified in previous plans are waterbird habitat values. Shorebird habitats should provide a mosaic of suitable roosting and feeding habitats (Purnell et al 2017). Of consideration in restoration planning and site management is that shorebird feeding and roost sites require:

Free of dense vegetation >10cm in height.

- Open uninterrupted views.
- Large areas of shallow water (maximum surface area of shoreline).
- Close proximity to alternate feeding and roosting sites.
- Sheltered from wind.

Useful references for ensuring the revegetation program does not compromise shore bird habitat requirements can be found here:

<https://www.sopa.nsw.gov.au/Resource-Centre/WET-eBook-Workbook-for-Managing-Urban-Wetlands-in-Australia>

and

<https://www.sopa.nsw.gov.au/-/media/files/sopa/sopa/publications/wet-ebook-workbook-for-managing-urban-wetlands-in-australia/305-rehabilitation-and-management-of-saltmarsh-habitats.pdf>

It is within this context that it is recommended that some further strategic revegetation with appropriate salt-tolerant species is undertaken in the riparian areas of all the ponds to increase:

- Protection from predators and the elements for wetland flora and fauna
- Shade over the water for fish and macroinvertebrates
- Shelter on the water's edge for small wetland and terrestrial animals
- Nesting areas for waterbirds
- Food resources for insectivores, nectar-eaters and seed-eaters
- Visual amenity and bird watching opportunities

Riparian planting adjacent to areas of good couch grass or emergent reed growth is unlikely to be successful without significant augmentation, although the application of a native plant fertiliser and possibly gypsum at the time of planting is likely to improve establishment.



It is suggested that any future planting on the mounded soils uses only very salt tolerant species (e.g. chenopods, tea trees). Each plant should be planted into the side of a trench up to 150 mm or more deep and at least 1 to 1.5 m long, dug across the slope and shaped to capture and retain runoff. Mulching of the trench and immediate surrounds would be beneficial as will be the application of rock dust or other mineral fertilizers which can assist plants with establishment in saline conditions.

Lignum (*Duma florulenta*) – medium shrub, excellent habitat for many types of fauna. Additional tube stock could be planted in relatively fresh and low-lying riparian areas (or areas that flood out during higher flows) around Ponds M2A and M2B, M3A and M3B, M4A and M4B and M6. It may extend into the channel in ponds that are subject to periodic drying over time, which will decrease water velocities, increase water purification capacity and facilitate the growth of other aquatic plants. Given that only two of the three channels will be periodically dried, this should have low likelihood of increasing flooding risk, whilst having a high chance of improving habitat values. Lignum is not very salt tolerant according to the literature, but it is found in relatively dry and saline areas on the River Murray floodplain and is likely to persist once established.

Cooba (*Acacia stenophylla*) – small to medium tree, excellent habitat for birds and insects. Successfully established at Greenfields Wetlands and in areas of The Range wetlands. These populations are likely to be good seed sources for raising tube stock to plant at Magazine Creek. Tube stock could be planted in relatively fresh riparian areas around Ponds M2A and M2B, M3A and M3B, M4A and M4B and M6. Planting density and location of this salt tolerant species should be mindful of not deterring shorebirds (eg scatted planting set back from water's edge).

Boobialla (*Myoporum insulare*) – large shrub, excellent habitat for birds and insects. Common coastal riparian species. Tube stock could be planted in relatively fresh riparian areas around Ponds M2A and M2B, M3A and M3B, M4A and M4B and M6. Need to confirm local occurrences in coastal systems as a source of seeds.

Tea trees (*Melaleuca halmaturum*, *M. lanceolata*) – large shrubs to medium trees, excellent habitat for birds and insects. *M. lanceolata* is growing successful on saline mounds at Greenfields Wetlands and this population could be used as a seed source. *M. halmaturum* is the dominant tree species in many South Australian coastal and inland saline lake ecosystems. It is highly saline tolerant and can be utilised as a shade and shelter tree in the more saline areas that the above species may struggle to establish in. Tube stock could be planted around all of the ponds in strategic areas to provide shelter from prevailing winds, nesting habitats and amenity screening. Planting around Ponds M7 and M8 may need to be delayed for a few winters until the salinity levels have reduced, but over time successful establishment should be achievable.

Samphires and saltmarsh vegetation – a range of species that provide a range of habitat resources for birds, insects and fish (when flooded). These species may be harder to obtain commercially but there are many local sites of this type of habitat that could be used as seed sources to increase the diversity of the more saline Ponds M7 and M8. It is likely that the most beneficial method would be soil seedbank transplants at the water's edge to bring a variety of seeds onto the site. This should occur in spring two to three years after the windmill discharge water is relocated and the surface water salinity has reduced from current levels. Tube stock of readily available species, such as local Pig-face (*Carpobrotus* sp.) and salt-tolerant native grasses, can be used to improve visual amenity of the terrestrial areas around Ponds M7 and M8. It is expected that once these species establish in patches around Ponds M7 and M8 that they will increase in cover and distribution.

Chenopods (e.g. *Nitraria billardiarei*, Nitre bush; *Atriplex nummularia*, Old man saltbush) – medium to large shrubs, excellent habitat for birds and insects. Tube stock can be planted on the soil mounds throughout the site using the trench and mulch method described above.



9 MANAGEMENT AND MONITORING COMMITMENTS AND SCHEDULES

9.1 Vegetation Monitoring

9.1.1 Vegetation Sites and Methods

Eight vegetation survey transects were established and surveyed on 17th September 2019 by Dr. Kerri Muller (Kerri Muller NRM Pty. Ltd.) and Kate Frahn (South Australian Research and Development Institute). Sites were chosen in each of the ponds (Figure 9-1), except for the inlet pond (Pond M1) and Pond M5, at locations where the aquatic vegetation was expected to show a response to the proposed management actions.

No transects were established in Ponds MS or M1 because of the strong influence of variable but often poor stormwater quality, lack of management levers to control inflows, regular dredging disturbances and the high turbidity environment that favours algae over plants. These ponds are not expected to respond to the proposed management actions. Similarly, no transects were established in Pond M0 because of high salinity levels, low likelihood of response to management actions in the short-term and high likelihood of disturbance from works being undertaken to relocate the windmill discharge water. No transects were established in Pond M5 either because it acts as a 'hub' for this wetland, meaning that water enters and exits this pond regardless of which flow pathway is being manipulated, and thus any of vegetation changes in Pond M5 will be driven by multiple actions and other confounding factors making it less useful than the other ponds for evaluating responses to the management actions.

At each site a 15 m tape was extended along the bank at the full or static water level. A score for whether a given wetland plant was present or absent from each of fifteen adjacent 1 x 1 m cells was recorded, yielding a score out of 15 for each taxa or functional group. Another 15 cells were scored parallel to the bank at 60 cm water depth, or the middle of the channel if the water was less than 60 cm deep. This was repeated on the opposite bank to yield a total of up to 4 sets of 15 cells at each site. To ensure a high level of consistency across multiple surveyors over time, only the presence or absence of plants was recorded and not estimates of percentage cover, which tend to vary greatly between surveyors. Identification to species level was considered appropriate for species such as the emergent plants but not necessary for the samphires or submerged aquatic plant species, which only need to be recorded at the genus or functional group level in order to evaluate whether the management objectives have been achieved or not (see Section 8). Again, this will ensure a high level of consistency between observers and lends itself to surveys being undertaken by citizen scientists in the future.

It is anticipated that the transect surveys will be repeated in spring every five years at these same sites to determine whether the management actions have achieved stated objectives (Section 8) and followed the expected response (Section 9.2.1).

9.1.2 Baseline Vegetation Data

The presence and absence data for the nine transects established at Magazine Creek wetland were collated for edge and channel habitats for each pond (Table 9-1). Blank cells indicate that the given plant was not present along the transect, noting that it may have been present at other locations in that pond (e.g. dense *Scheonoplectus validus* next to but not in the transect in Pond 2A, see photos Attachment A). Light blue cells indicate sparse cover (a score of 1-6) and dark blue cells indicate abundant cover (a score of 7-15) of that species or functional group. The total number out of the nine transects at Magazine Creek that the plant was present in, is also shown in the final column. Photographs, GPS locations and the raw data for each transect is presented in Appendix B.

These baseline data show that there is a distinct difference in the plant communities on the wetland edge to those in the channel. Most transects had abundant growth of Salt club rush (*Bolboscheonus caldewellii*) and

a mix of native and exotic couch grasses, suggesting that these plants are well-adapted to the site and spreading. Pond 4A was the only transect with bare soil.

Transects Lines at Magazine Creek



FIGURE 9-1: MAGAZINE CREEK WETLAND TRANSECTS LINE



TABLE 9-1: PRESENCE OF DIFFERENT TYPES OF AQUATIC PLANTS IN EDGE (TOP) AND CHANNEL (BOTTOM) HABITATS AT THE NINE TRANSECTS WHEN ESTABLISHED AT MAGAZINE CREEK IN SEPTEMBER 2019.

Edge habitats*	M2A	M2B	M3A	M3B	M4A	M4B	M6	M7	M8	Total
Bare Soil										1
<i>Bolboschoenus caldwellii</i>										9
<i>Distichlis distichophylla</i>										3
<i>Ficinia nodosa</i>										1
<i>Gahnia filum</i>										1
<i>Juncus kraussii</i>										5
<i>Oxalis</i> spp.^										1
<i>Paspalum distichum</i> ^										8
<i>Rumex bidens</i>										2
<i>Schoenoplectus validus</i>										4
<i>Sonchus</i> sp.^										2
<i>Suaeda australis</i>										1
<i>Tecticornia</i> sp.										2
<i>Typha domingensis</i>										2
Filamentous algae										2
Open water										
<i>Lepilaena australis</i>										
<i>Ruppia megacarpa</i>										
Channel habitats	M2A	M2B	M3A	M3B	M4A	M4B	M6	M7	M8	Total
<i>Bolboschoenus caldwellii</i>										
<i>Distichlis distichophylla</i>										
<i>Ficinia nodosa</i>										
<i>Gahnia filum</i>										
<i>Juncus kraussii</i>										
<i>Oxalis</i> spp.^										
<i>Paspalum distichum</i> ^										
<i>Rumex bidens</i>										
<i>Schoenoplectus validus</i>										
<i>Sonchus</i> sp.^										
<i>Suaeda australis</i>										
<i>Tecticornia</i> sp.										
<i>Typha domingensis</i>										
Filamentous algae										4
Open water										4
<i>Lepilaena australis</i>										2
<i>Ruppia megacarpa</i>										3

*Edge habitats are at the full water level and Channel habitats are at 60cm depth or middle of channel. Abundant = dark blue (score >7 out of 15), Sparse = light blue (score 1-6 out of 15) or Absent = blank cells.

^exotic species.



Most transects had abundant growth along the water's edge with at least Salt club rush (*Bolboscheonus caldwellii*) and couch grasses, and at most six species of emergent plants at the transect at Pond M3A. The exception was the transect in Pond M4A where there was more bare soil than reeds. The two saltier transects, Ponds M7 and M8, were fringed with highly salt-tolerant samphires (*Suaeda australis* and *Tecticornia* sp.) that are typical of the samphire flats upon which the wetlands were constructed, with little or no reed growth other than Salt club rush.

Only emergent plants or terrestrial grasses and/or shrubs occurred on the water's edge and they did not extend into the deeper water in the channel. The restriction of emergent plants to the edge is likely to be due to a combination of relatively static water levels, high turbidity water and being outcompeted by filamentous algae. It was assumed that the less common emergent species (e.g. Chaffy saw sedge *Gahnia filum*) are still in clumps near where they were planted and have not successfully recruited at the site, although the planted specimens were all healthy and flowering.

Submerged aquatic plants, such as Sea tassels (*Ruppia megacarpa* and/or *Lepileana australis*) were abundant at the three 'central' transects (Ponds M2B, M3B, M4B and M6) and absent at the rest. By contrast, filamentous algae were abundant in the first ponds in sequence that did not contain submerged plants (Ponds M2A, M3A and M4A) and was smothering the submerged plants in Ponds M4B and M6. This indicates that the various limiting effects on submerged plant establishment and growth across the wetland systems from poor-quality stormwater, relatively static water levels and high turbidity were nearer to the inlet and high salinities were nearer to the outlet where the saline groundwater was discharged.

9.1.3 Expected Vegetation Responses to Management

It is expected that the diversity and abundance of aquatic plants will increase over time under the proposed management regime. The expected vegetation responses to the new water management regime, relocation of the windmill discharge water and other complimentary actions being implemented, are summarised below and in the conceptual diagrams presented in Figure 9-2 to Figure 9-4 for the different sets of transects. These diagrams show the current condition (baseline data, top), the expected vegetation responses to biannual drying (middle) and the expected vegetation community after 5-10 years of implementation (bottom).

It is expected that biannual drawdown from closing regulators on either Ponds M2A, M2B and M6 or M4A and M4B (Figure 9-2) will lead to the following changes in vegetation in Ponds M2A and M4A relative to Pond M3A (that will act as the control by not having its regulators opened and closed):

- Emergent plants will extend down the elevation gradient into the water column
- Diversity of aquatic plants will increase via colonisation of new species such as Pale knotweed (*Persicaria decipens*). Currently present at Range but not Magazine Creek.
- Further colonisation of submerged species and reduced areas of open water and filamentous algae

Ponds M2B and M4B are expected to show similar changes relative to Pond M3B (control) although submerged plants are already abundant in Ponds M3B and M4B (Figure 9-2). It is thus expected that submerged plants will colonise Pond M2B and increase in diversity and abundance at Pond M4B compared to Pond M3B. It is also expected that the greatest diversity and abundance of aquatic plants will be achieved at Ponds M2B and M4B due to their relatively high baseline condition and their central location that protects them from the poorest quality stormwater inputs and the effects of salinization near the outlet.

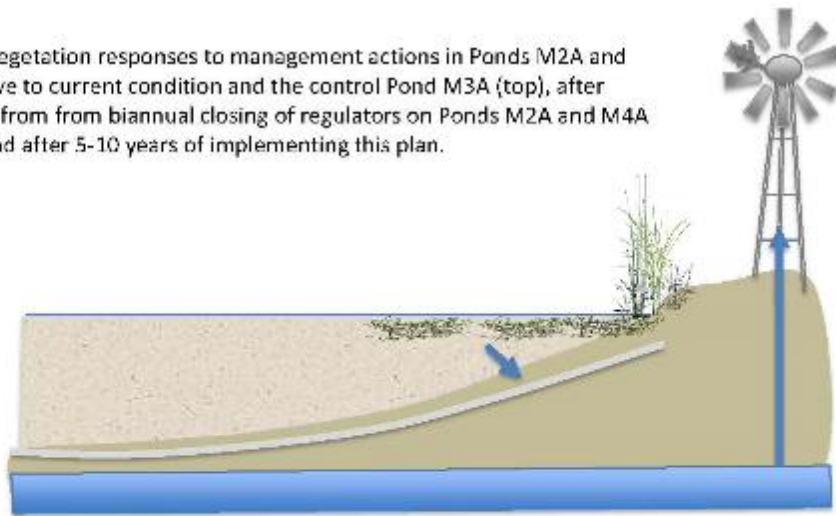
Pond M6 is grouped with Ponds M2B and M4B (Figure 9-3) because it has a relatively high diversity and abundance of aquatic plants that is more similar to these ponds than to Ponds M7 and M8, especially at the upstream end of Pond M6. Biannual drawdown from closing regulators on Pond M6 is expected to lead to increased emergent and submerged plant diversity, movement of emergent species down the elevation gradient and less filamentous algae.



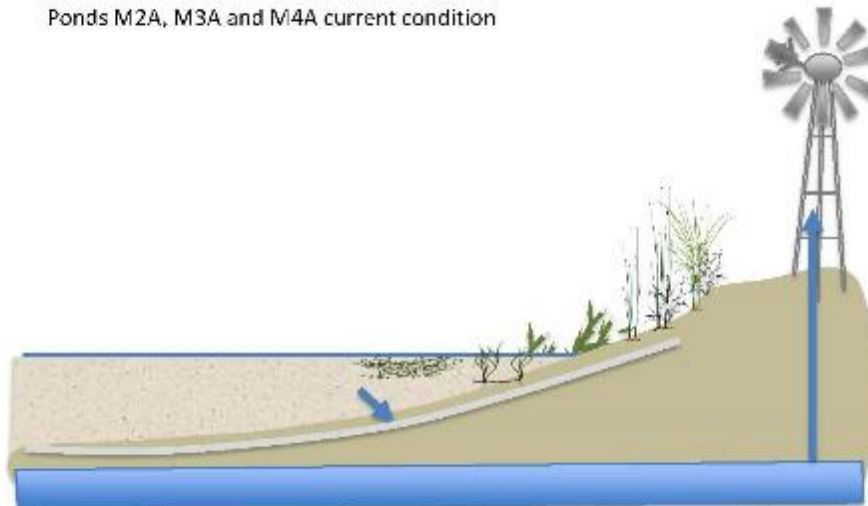
Vegetation diversity and abundance in and around both Ponds M7 and M8 (Figure 9-4) are expected to increase once the hypersaline windmill discharge has been relocated and flushing of accumulated salts occurs. It may take 5-10 years depending on the stormwater flow rates to reduce salinities in these most downstream ponds to levels similar to those seen in the central ponds. Over time it is expected that submerged plants and a greater diversity of emergent plants will colonise these ponds to compliment the suggested plantings (listed in Section 8).

Pond M7 will also experience biannual drawdown that is expected to accelerate colonisation of more diverse species and/or improve the establishment of tube stock and transplanted seed compared to the expected rate of change in Pond M8. This will need to be tested. It may be better to keep Pond M7 open at all times, to flush out the salts faster, until the salinity levels have dropped to less than target levels before closing regulators to create a drawdown, introducing seed or planting tube stock.

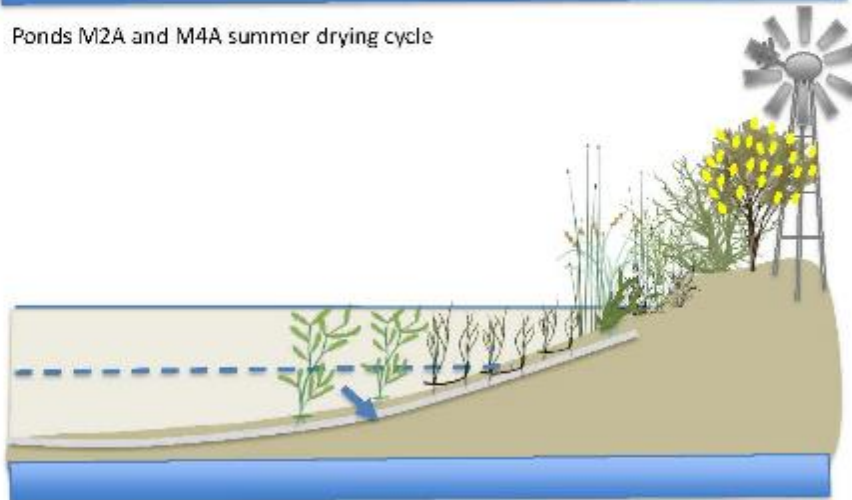
Expected vegetation responses to management actions in Ponds M2A and M4A relative to current condition and the control Pond M3A (top), after drawdown from biannual closing of regulators on Ponds M2A and M4A (middle) and after 5-10 years of implementing this plan.



Ponds M2A, M3A and M4A current condition



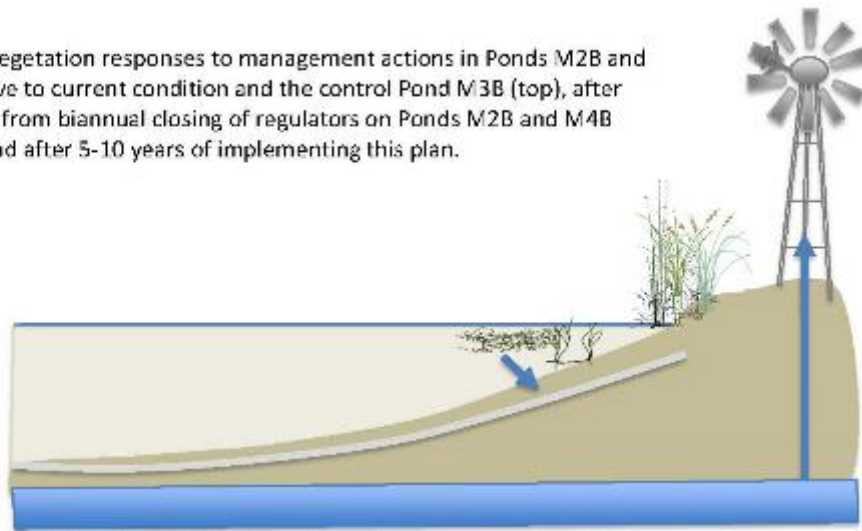
Ponds M2A and M4A summer drying cycle



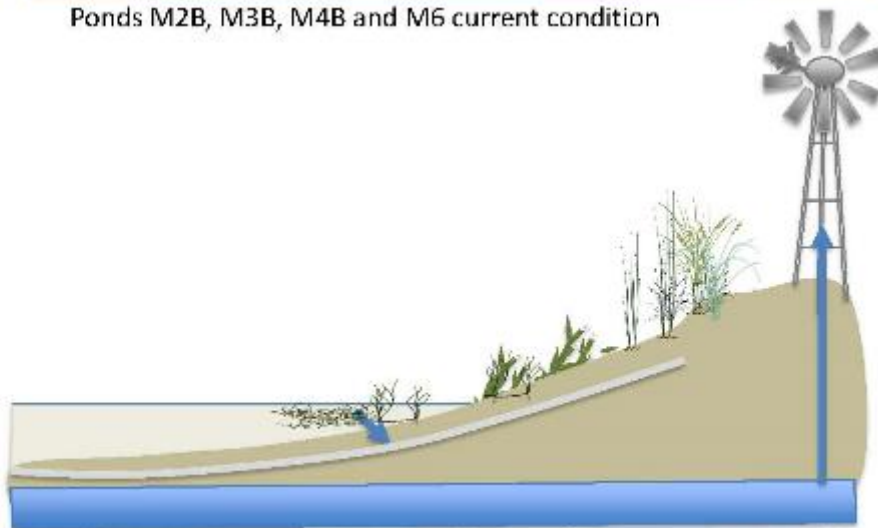
Ponds M2A and M4A after 5-10 years of manipulation + planting

FIGURE 9-2: EXPECTED VEGETATION RESPONSE PONDS M2A & M4A

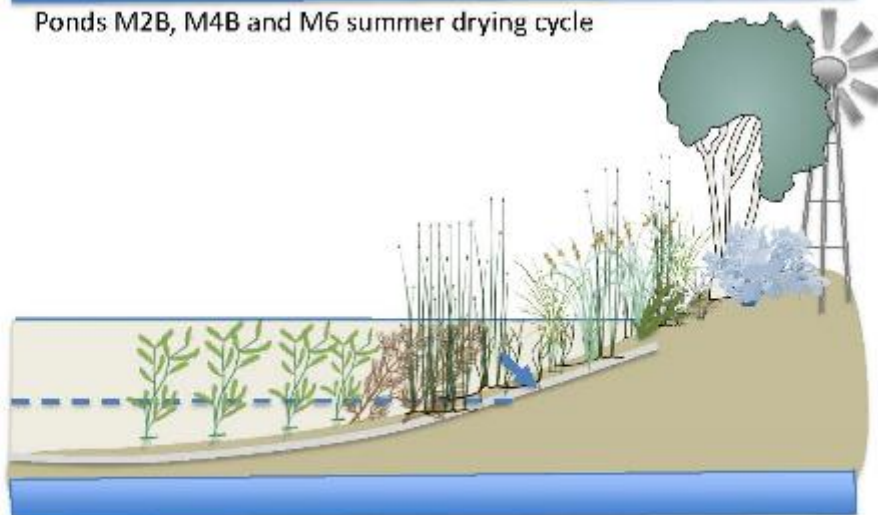
Expected vegetation responses to management actions in Ponds M2B and M4B relative to current condition and the control Pond M3B (top), after drawdown from biannual closing of regulators on Ponds M2B and M4B (middle) and after 5-10 years of implementing this plan.



Ponds M2B, M3B, M4B and M6 current condition



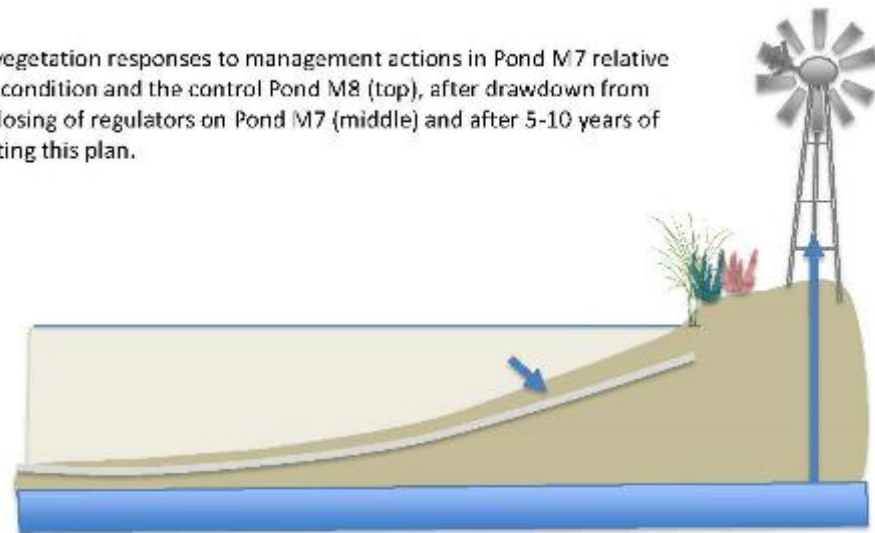
Ponds M2B, M4B and M6 summer drying cycle



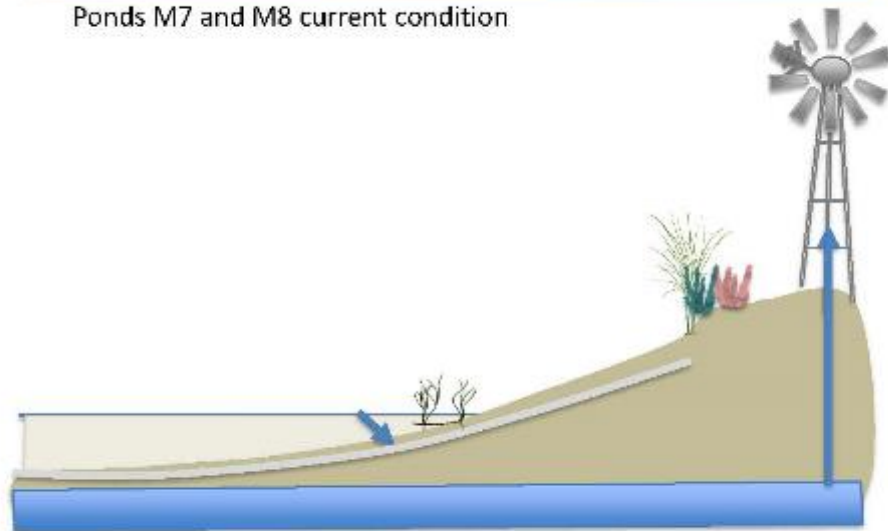
Ponds M2B, M4B and M6 after 5-10 years of manipulation

FIGURE 9-3: EXPECTED VEGETATION RESPONSE PONDS M2B M4B& M6

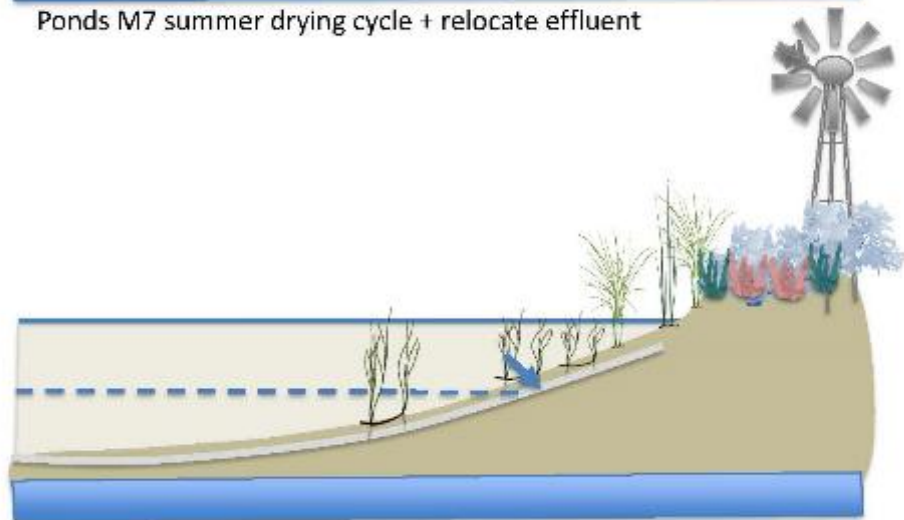
Expected vegetation responses to management actions in Pond M7 relative to current condition and the control Pond M8 (top), after drawdown from biannual closing of regulators on Pond M7 (middle) and after 5-10 years of implementing this plan.



Ponds M7 and M8 current condition



Ponds M7 summer drying cycle + relocate effluent



Ponds M7 after 5-10 years of manipulation

FIGURE 9-4: EXPECTED VEGETATION RESPONSE POND M7



9.1.4 Water Quality (Salinity) Monitoring

To date there has been no systematic and ongoing water quality measurements undertaken in the wetlands. This has limited the available data to opportunistic sampling of salinity in the ponds during periods of investigation, such as those associated with developing this monitoring plan. The salt and water balance modelling used to formulate the operating regime has been calibrated with a limited data set.

More regular, systematic monitoring of water quality and in particular salinity, is recommended. Salinity is considered the most critical parameter to be measured because it is most likely to be the limiting water quality parameter with respect to plant growth and system condition for the Magazine Creek wetlands. Salinity is also a parameter that can be readily measured in the field.

Ideally, continuous salinity recorders should be installed within the ponds to be targeted for the drying cycle trials, however it is understood that this might be cost prohibitive with an annual cost of around \$50,000. Collecting this data during the first two years of the drawdown trials for each pond would be particularly useful.

In addition, we would recommend that spot salinity recordings be taken on a monthly basis across all ponds for the first two years of the drying cycle trials. The data should then be reviewed with a view to scaling back the frequency of sampling to quarterly. This monitoring program should be continued for the first six years of the drying cycle trials so that there is a complete set of results during the period between the baseline vegetation transects and the first repeat transect assessment.

At the very minimum, the spot salinity sampling program outlined above should be undertaken within the four drying cycle ponds throughout the first five years.

This information will be invaluable for recalibrating the water and salt balance model developed for this management plan as well as for characterising the quality of inflow water and assisting in interpreting the transect results. Regular surface water monitoring will also assist in characterising the response associated with windmill operation trials and groundwater surface water interaction.

9.1.5 Groundwater Monitoring

A series of nine piezometers were installed in May 2019 as part of the development of this maintenance plan. Eight of these piezometers were installed around the Magazine Creek Wetlands, with a ninth installed at the Range Wetlands to provide a control monitoring point.

Water level and salinity measurements are being recorded on a quarterly basis at these piezometers for a twelve-month period. This monitoring frequency should ideally be continued through the full five-year initial drying cycle period, however if this cost is prohibitive the monitoring frequency should be reduced to two per year, by targeting the spring and late summer times for recordings.

Again, this information will be invaluable for interpreting the transect results. Along with regular surface water monitoring, groundwater monitoring will be required to evaluate responses associated with any windmill operation trials and characterising groundwater surface water interaction.

9.2 Fauna Monitoring

9.2.1 Expected Wetland Fauna Responses to Management

Plants provide the architecture of the various habitats across the landscape. This management plan seeks to increase the diversity and abundance of native plants from below the water line to the terrestrial areas between the wetlands. It is expected that the vegetation responses described in Section 10.1 and the proposed planting will lead to the following fauna responses. It should be noted that only annual bird surveys are included in the monitoring program. No other faunae have been nominated for monitoring due to lack of baseline data and to keep monitoring costs to a minimum.



- Increased submerged plant cover and diversity provides more habitat, food and shelter for fish, frogs, tadpoles and invertebrates. It also provides more food for herbivorous waterfowl such as black swans that were breeding at the site in spring 2019. These animals are expected to increase in number and frequency of visitation and new fauna species are expected to occupy the site over time, although the current diversity of waterbirds is already high and thus may not increase substantially. The breeding and feeding opportunities for waterbirds will, however, increase significantly.
- Increased emergent and riparian plant cover and diversity provides more habitat, food and shelter for frogs, invertebrates, fish, tadpoles and waterbirds. This is the interface between the aquatic and terrestrial habitats and thus provides habitat resources to a wide range of aquatic and terrestrial fauna. Increased density and distribution of reed beds, lignum shrublands and riparian trees will provide more nesting opportunities for a range of species, including waterbirds.
- Increased diversity and cover of saltmarsh and samphire communities provide a wider range of food resources for waterbirds, including marine and migratory species that were not recorded in December 2018.
- Introducing variable drying cycles in Ponds M2A, M2B, M4A, M4B, M6 and M7 will expose a range of vegetated and bare mudflats that will provide a wide range of habitat resources for wetland fauna, especially waterbirds, in patches over space and time.

9.2.2 Bird Survey

There is a need to monitor the density and variety of bird species and ant species that are absent but should be present or used to be present prior to on ground works. The survey techniques to be used are “Fixed Area search” using several fixed survey points around transects (Figure 9-1). These points can be reused for future survey and monitoring to see progress over time of bird population movement and species variation. One other monitoring technique will give an overall look at bird species present and provide some information on various species utilising certain key areas of the wetlands.

9.3 Further Investigations

The initial gap analysis work associated with these draft management guidelines identified a number of further investigations that would be desirable for improved management and understanding of the wetlands. The higher priority investigations that remain to be undertaken to support the ongoing management of the wetlands are summarised in the sections that follow.

9.3.1 Wetland Hydraulics

There is an existing TuFlow model that was developed on behalf of Renewal SA. The model has been used to date to model large flood flows, but it could also be used (or adapted) so that it could model the hydraulic behaviour and circulation processes within the wetlands under smaller flow events. This information would be very useful for evaluating the extent of desilting operations and for setting more precise and reliable triggers for desilting and vegetation clearing.

Desilting and vegetation clearance operations are presently required to address concerns regarding potential flooding issues, but these operations are very disruptive to the ecology of the wetland. Hence refinement of those actions should result in less disturbance and more targeted management approaches. This is also likely to result in cost savings by minimising these operations.

In addition, opportunities to hold water in some ponds at a higher level (i.e. to hold the flood peak water levels in the wetlands for longer periods) would further stimulate biological activity and be highly supported of the wetting and drying cycle processes that are promoted herein. Again, an updated TuFlow model could be used to conduct sensitivity testing of wetland hydraulics to maintain higher water levels in some ponds over longer periods of time than is currently the case.



Any potential increase would be small and intended to extend the natural range of water levels that might be experienced in the wetland for extended periods during the year. It would be no more than a 100 to 200 mm height increase that would increase the width / range of the wetting and drying cycle regime. The main over bank flow paths would not be altered nor would the final outlet weir height be modified, and the increase would only be for a selection of ponds.

The potential for this extension to the trial can be explored should results from the initial wetting and drying cycle trial recommended herein provide positive outcomes in terms of increasing species diversity and abundance.

9.3.2 Fish Survey

A fish survey of the wetlands is recommended to identify species diversity and to abundance. The presence or absence of some native and exotic species would assist in clarifying the biological value of the wetlands. At present there are no data relating to fish (or other aquatic biota for that matter) within the wetlands.

9.3.3 Frog Census

Opportunistic information on frogs has been captured during these investigations when vegetation and water quality surveys were undertaken but there has been no dedicated information collected on frogs, which are very useful biological indicators. Further information on the quality of habitat and ecological value of the wetlands could be obtained if they were to be included in the frog census survey process.

9.3.4 Acid Sulfate Soils

A rapid assessment of ASS risk (Creeper et al. 2015; MDBA 2011) is recommended to further inform management option assessments. At this stage it is uncertain if there are ASS forming in the wetland and whether they pose a risk to wetland biota and/or receiving environment.

The area generally has a high potential for ASS but there are no data from the initial design or construction process to suggest this risk has been assessed. Whilst to date no issues have been raised, it is possible that they may be triggered by a drying cycle. Hence a high level, site specific, risk assessment is recommended.

9.3.5 Threatened Species

Records of any significant, priority and threatened fauna that are observed at the wetlands should be kept. Threatened migratory birds would be a priority species that could be monitored. This will help to raise recognition of the importance of the wetlands as habitat for threatened species.

9.3.6 Windmills

Information from the proposed trial operating regime will provide further clarification of the need for their ongoing operation.

It is anticipated that the trials will indicate that windmill operation will continue to be required to avoid ingress of the highly saline groundwater that surrounds the Magazine Creek Wetland. Although the trial may suggest that a reduced pumping frequency (volume) may be considered.

Hence, whilst ongoing operation is likely it is possible that the windmills could be replaced by more cost-effective pumping systems (eg: a series of equivalent low-head pumps that are solar powered rather than wind powered). An investigation of the potential alternative pumping systems would be appropriate should the results the trial shutdown indicate that an ongoing groundwater dewatering operation is required.



10 WHS AND PUBLIC SAFETY

In accordance with the Work Health and Safety Act 2012, the aim of Safety in Design is to identify potential health and safety hazards during the design process and recommend control measures to mitigate the risks, as far as reasonably practical, to the environment and personnel.

The following sections summarise the health and safety hazards which have been considered in this management plan.

TABLE 10-1 PROJECT DETAILS

Site location	Magazine Creek Wetlands
Intended Purpose of Wetland	<ul style="list-style-type: none"> • Water treatment • Water Harvesting • Flood Detention • Amenity • Passive Recreation • Bio-diversity

TABLE 10-2 DESIGN PARAMETERS

Design Parameter	Safety Consideration
ARI	System designed to operate “normally” to 5 % AEP flood, and no exacerbate flooding in larger events.
Consequences of failure / Assets to be protected	Exposure of receiving waters to polluted stormwater. Increased incidence of flooding upstream. Exposure of personnel and public to polluted water or dangerous substances.
Inlet properties	Untreated Stormwater Drainage Inflows
Outlet properties	Low level outlet weir
Storage Water Depth	Up to 2 metres
Water Residence Time	Typically, several days or longer. In high flows may be hours.
Bank slopes	Gentle
Public Access	Restricted and controlled
Maintenance Methods and Access	GPT access by vehicles with lifting equipment and loading capabilities (eg backhoe).
Soil Contamination	Sediment inflows transported by stormwater can be contaminated.
Gross pollutants	Mostly organic matter but can contain litter and hazardous substances and objects such as syringes etc.



TABLE 10-3 DESIGN FEATURES

Design Feature	Safety Consideration
Gross Pollutant Trap	GPT designed for safe access for maintenance. PPE to be used by operators. Lifting lugs and equipment designed to avoid direct contact with debris and to facilitate cleaning. Public excluded from GPT area.
Sediment Trap	System designed for safe access for maintenance. Uncontrolled access prevented.
Inlet Control	Safe access to clean out any blockage of the inlet pipes/culverts.
Outlet Control	Safe access to clean out any blockage of the outlet weir.
Subsurface Drainage	Safe access to clean out any blockage pipe.
Public and Workforce Safety	Access to / contact with water managed through: <ul style="list-style-type: none"> Gentle slopes (typically 1 V : 8 H or flatter) Physical barriers (fencing, vegetation) Visual warnings (signage) Workforce to be vaccinated for Hepatitis A, B and C. Waders with belts and PFD to be used if entering water.
Vegetation	Vegetation selection to not include species that pose a risk to public or staff (toxic plants). Safe access for maintenance works.
Water depth (ponds and wetlands)	Range of depths provided. Public access to deeper areas prevented. Shoreline slopes gentle.
Water speed causing remobilisation of pollutants or safety hazard	Slow velocities promoted through system configuration. Regular desilting to avoid remobilisation of pollutants.
Excavation of soil including sediment removal	Chemical testing, analysis and classification of soils. Management Plan (and original design) allows for management measures for dealing with contaminated soil.

TABLE 10-4 OPERATIONS AND MAINTENANCE – HAZARD IDENTIFICATION AND RISK MANAGEMENT

Hazard	Risk(s) Identified	Control Measures
Excavation of soil.	Soil contamination	Site erosion and sediment control measures Chemical testing and analysis. Design allows for management measures for soil handling.
Traffic/ Public access	Interface with pedestrians and members of the public not familiar with site or site hazards.	Designated work area for contractor. Fencing/barriers to secure work site.
Stockpiling of material	Sediment transport Soil Contamination	Soil Erosion and Drainage Management Plan required for excavation and stockpiling soils and other materials (eg gross pollutants). Appropriate chemical testing and analysis.
Dust	Respiratory issues	Dust suppression; avoid working soils in windy weather; cover stockpiles.



Hazard	Risk(s) Identified	Control Measures
Poor water quality / polluted stormwater	Health / disease exposure to workforce or public.	Chemical testing and analysis. Exclusion of public from work areas. Workforce vaccinations Appropriate use of PPE. Design provides for equipment / machinery use to avoid contact / exposure by workforce.
Undermining of structure and rock armouring washed downstream.	Blocking of infrastructure downstream. Bypassing of structure	Ensure structures are inspected regularly and repairs carried out promptly.
Dead vegetation	Reduced treatment functionality of wetland.	Proposed species for revegetation selected by skilled professional. Regular inspections and preventative maintenance.
Debris blocking infrastructure	Hydraulic performance of structure compromised creating tail water effects causing upstream flooding	Hydraulic evaluation of wetlands to assess inbuilt resilience to partial blockages. Ensure structures are inspected regularly and blockages removed promptly.
Vegetation removal	Physical injury / cuts / infections	Monitoring system/training in place to forewarn operator. Appropriate protective equipment for operator.
Slippery slopes	Bogging of equipment Drowning	Design incorporates flat slopes and hardstand areas for heavy maintenance. Maintenance/operations plan identifies hazard and protection measures. Use of waders with belt and PFD if workforce entering water.



TABLE 10-5 RELEVANT DESIGN GUIDELINES / STANDARDS / REFERENCE MATERIALS

Document
Magazine Creek and The Range Wetlands: Maintenance Plan. (EGIS Consulting)
Barker Inlet, Magazine Creek and Range Wetlands: Management and Maintenance Plans, Spill Contingency Plans and Existing Vegetation Condition and Supplementary Planting. (Eco Management Services)
Port Adelaide Enfield Council Development Plan
SA WSUD Technical Guidelines
Australian Rainfall and Runoff
Natural Resource Management Act (SA) Environment Protection Act (SA) SA EPA Code of Practice for Construction Sites SA EPA Criteria for the classification of waste—including Industrial and Commercial Waste (Listed) and Waste Soil (EPA 889/10).
Australian Standards: <ul style="list-style-type: none"> • AS 4419 Soils for landscaping and garden use • AS1289 Method of testing soils for engineering purposes (5.1.1).



11 POTENTIAL FUNDING MECHANISMS

A review of potential funding mechanisms for stormwater management by local government was undertaken as undertaken by Jeff Tate Consulting in 2014. His report identified a range of potential funding mechanisms, the key ones being as follows:

- Local Government general revenue
- State Government general revenue;
- Recurrent grants and special purpose grants from the Australian Government;
- Use of operating surpluses (current and retained) from general government
- Australian-State-Local funding agreements;
- Special purpose funds;
- Infrastructure contributions;
- Levies/charges
 - State-wide
 - Catchment-wide
 - Council-wide;
 - Polluter-pay charges
 - Vehicle charges
 - Other fines/charges
- Revenue from stormwater sales;
- Separate rates;
- Private Public Partnerships – to facilitate private sector involvement in varying ways – direct financing.

Private sector partnerships in this instance could possibly come about through the promotion of ecotourism, however that will depend largely on ease of access and whether the wetlands can attract the rarer bird species. In any case, they would only be part of a bigger visit as part of the AIBS system of habitats for an Ecotour operator. So, in reality, there are limited funding opportunities from that source (in this instance) and the wetlands would probably be more attractive to local bird watchers and photographers.

Council can incorporate stormwater management strategies in its Infrastructure and Asset Management Plan, as well as identifying the need for a special purpose levy for water quality and biodiversity management of its stormwater infrastructure through a Stormwater Management Plan for the Range and Magazine Creek catchments. That might appear to be the most likely source of securing additional funding for ongoing management of the wetlands.

In the shorter term, it is possible that, given the exploratory nature of the proposed management regime for Magazine Creek over the next five years, Council could attract interest from the new Greening Adelaide Board or one of the local universities as the results may prove to be of value for improving the management of other urban wetland systems in Adelaide that also lie within near coastal saline environments.



12 REFERENCES

- Anstis, M. (2007). *Tadpoles of South-eastern Australia; a guide with keys*. Worldwide Fund for Nature. New Holland Publishers (Australia), Chatswood, New South Wales.
- Creeper N.L., Fitzpatrick R.W., Shand P. and R.A. Kingham (2013). The occurrence of Inland Acid Sulfate Soils in the Murray-Darling Basin, Australia, identified using a simplified incubation method. *Soil Use and Management*, 29, 130-139. doi: 10.1111/sum.12019.
- DEWNR (2017a). *Riverine Recovery Monitoring and Evaluation Program - Conceptual understanding of the ecological response to water level manipulation: 2nd Edition*. Department for Environment, Water and Natural Resources (DEWNR), Adelaide, South Australia.
- DEWNR (2017b). *Riverine Recovery Monitoring Program Monitoring and Evaluation Program: Technical Design: 2nd Edition*. Department for Environment, Water and Natural Resources Adelaide, Adelaide.
- Department of Water, Land and Biodiversity Conservation. DWLBC Report 2006/10.
- Dillon, P. and Pavelic, P. 1993, Groundwater inflow to the Jenkins Street-Eastern Parade wetland, Report: Centre for Groundwater Studies.
- Eco Management Services Pty. Ltd. (1999). Magazine Creek and Range Wetlands: Assessment of Terrestrial and Aquatic Vegetation Programmes. Prepared for Land Management Corporation. February 1999.
- Eco Management Services Pty. Ltd. (2011). *Barker Inlet, Magazine Creek and Range Wetlands: Management and Maintenance Plans, Spill Contingency Plans and Existing Vegetation Condition and Supplementary Planting*. Prepared for Port Adelaide Enfield Council. Ref: 499/11. January 2011.
- EGIS Consulting (1999). *Magazine Creek and The Range Wetlands: Maintenance Plan*. EGIS Consulting Australia, Unley, South Australia. A report for Land Management Corporation, Adelaide, South Australia. SA0106.017 REV.C. February 1999.
- Gerges, N., 2006. Overview of the hydrogeology of the Adelaide metropolitan area. South Australia.
- GHD, 2014. *Magazine Creek & The Range Wetlands*. Report 33/17403. Prepared for the City of Port Adelaide Enfield.
- Gonzalez, D., Scott, A. & Miles, M. (2011) *Assessing the vulnerability of native vertebrate fauna under climate change to inform wetland and floodplain management of the River Murray in South Australia*. Report prepared for the South Australian Murray-Darling Basin Natural Resources Management Board.
- Hart, B.T., Bailey, P., Edwards, R., Hortle, K., Kames, K., McMahon, A., Meredith, C., and Swadling, K. (1991). A review of the salt sensitivity of the Australian freshwater biota. *Hydrobiologia* 210,105-44.
- Hart, B.T., Lake, P.S., Webb, J.A., and Grace, M.R. (2003). *Ecological risk to aquatic systems from salinity increases*. Australian Journal of Botany 51, 689-702.
- Jeff Tate Consulting (2014) *Options for funding stormwater management*. Report prepared for Local Government Association of South Australia
- Land and Water Consulting, 2017. Overview of Groundwater Environment to Support MAR Viability, prepared for Southfront, Adelaide.



Lester R.E., Fairweather P.G., Heneker T.M., Higham J.S. and Muller K.L. (2011). *Specifying an environmental water requirement for the Coorong and Lakes Alexandrina and Albert: A first iteration*. Report prepared for the South Australian Department of Environment and Natural Resources, Adelaide.

Lyons, D. 2005, Surface water groundwater interactions within a constructed freshwater wetland: The effect of a wind-driven groundwater pumping scheme, Thesis, Flinders University.

Manning, P. (2011). *Barker Inlet, Magazine Creek and Range Wetlands: Management and Maintenance Plans, Spill Contingency Plans and Existing Vegetation Condition and Supplementary Planting*. Prepared by Eco Management Services Pty. Ltd. for Port Adelaide Enfield Council. Ref: 499/11. January 2011.

Melbourne Water (2017). *Wetland Design Manual. Part A2: Deemed to comply design criteria*. Melbourne Water, State Government of Victoria. July 2017.

Murray Darling Basin Authority (MDBA) (2011). *Acid Sulfate Soils in the Murray-Darling Basin*. Canberra, ACT. May 2011.

Nielsen D.L., Brock M.A., Rees G.N., and Baldwin, D.S. (2003). Effects of increasing salinity on freshwater ecosystems in Australia. *Australian Journal of Botany* 51:655-665.

Purnell, C., Peter, J., Clemens, R. 2017. *Shorebird Population Monitoring within Gulf St Vincent: July 2015 to June 2016 Annual Report*. BirdLife Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.

Seed Consulting Services (2015). *Baseline biodiversity survey: Magazine Creek Wetlands*. A report prepared for the City of Port Adelaide and Enfield, South Australia.

Tonkin Consulting, 2015. *Torrens Road Catchment Draft Stormwater Management Plan*. Prepared for City of Charles Sturt and City of Port Adelaide Enfield.



APPENDIX A SURFACE WATER QUALITY SAMPLING POINTS – DECEMBER 2018







APPENDIX B VEGETATION TRANSECTS LINES





Magazine Creek Vegetation Transect Sites and Methodology

Established 17 September 2019 by Dr. Kerri Muller (Kerri Muller NRM Pty. Ltd.) and Kate Frahn (South Australian Research and Development Institute, SARDI)

Methodology

At each site a 15 m tape was extended along the bank at the full or static water level. A score for whether a given wetland plant was present or absent from each of fifteen adjacent 1 x 1 m cells was recorded, yielding a score out of 15 for each taxa or functional group. Another 15 cells were scored parallel to the bank at 60 cm water depth, or the middle of the channel if the water was less than 60 cm deep. This was repeated on the opposite bank to yield a total of up to 4 sets of 15 cells at each site. To ensure a high level of consistency across multiple surveyors over time, only the presence or absence of plants was recorded and not estimates of percentage cover, which tend to vary greatly between surveyors. Identification to species level was considered appropriate for species such as the emergent plants but not necessary for the samphires or submerged aquatic plant species, which only need to be recorded at the genus or functional group level in order to evaluate whether the management objectives have been achieved or not (see Section 8).

It is anticipated that the transect surveys will be repeated in spring every five years at these same sites to determine whether the management actions have achieved stated objectives and followed the expected response.

Pond M0 and M1

No transects established here because of the strong influence of stormwater quality, inability to control inflows, dredging disturbance and high turbidity environment that favours algae over plants. Not expected to respond to management levers.

Pond M2A

Transect location:

Edge 1: Lat -34.8319, Long 138.5216

Edge 2: Lat -34.8322, Long 138.5221



FIGURE B-1 TRANSECT AT POND M2A SHOWING EDGE 1 (TOP LEFT), ALGAE IN THE CHANNEL (TOP RIGHT), EDGE 2 (BOTTOM LEFT) AND SCHOENOPLECTUS VALIDUS GROWING ADJACENT TO BUT NOT WITHIN THE TRANSECT



Pond M2B

Transect location:

Edge 1: Lat -34.8289, Long 138.5233



FIGURE B-2 POND M2B EDGE 1 SHOWING *BOLBOSHEONUS CALDWELLII* RESHOOTING AFTER WINTER THROUGH BROWNE-OFF COUCH. FILAMENTOUS ALGAE CAN BE SEEN ON THE WATER'S EDGE

Pond M3A

Transect location:

Edge 1: Lat -34.8323, Long 138.5223



FIGURE B-3 TRANSECT AT POND M3A SHOWING PATCHY BUT HEALTHY GROWTH OF EMERGENT PLANTS PLANTED IN 2015



FIGURE B-4 DENSE STANDS OF *PHRAGMITES AUSTRALIS* DOWNSTREAM OF THE TRANSECT (LEFT) AND *BOLBOSCHEONUS CALDWELLII* UPSTREAM OF THE TRANSECT (RIGHT) IN POND M3A



Pond M3B

Transect location:

Edge 1: Lat -34.8304, Long 138.5250

Edge 2: Lat -34.8302, Long 138.5247



FIGURE B-5 TRANSECT AT POND M3B SHOWING GREEN AND DENSE STANDS OF *BOLBOSCHEONUS CALDWELLII* AND BROWNE-OFF COUCH

Pond M4A

Transect location:

Edge 1: Lat -34.8328, Long 138.5227



FIGURE B-6 TRANSECT AT POND M4A SHOWING RESPROUTING *BOLBOSCHEONUS CALDWELLII* AND BROWNE-OFF COUCH ON EDGE 1 (LEFT) AND RELATIVELY BARE GROUND ON EDGE 2 (RIGHT)

Pond M4B

Transect location:

Edge 1: Lat -34.8314, Long 138.5260



FIGURE B-7 TRANSECT AT POND M4B SHOWING RESPROUTING *BOLBOSCHEONUS CALDWELLII* AND OTHERWISE BARE EDGES (LEFT) AND THE VIEW DOWNSTREAM



Pond M5A

No transects established in Pond M5A. It acts as the 'hub' for this site and will be affected by multiple actions and other factors making it less useful than the other ponds for evaluating the responses to the management actions.

Pond M6

Transect location:

Edge 2: Lat -34.8295, Long 138.5283



FIGURE B-8 TRANSECT AT POND M6 SHOWING RESPROUTING *BOLBOSCHEONUS CALDWELLII*. THE SWANS APPEARED TO BE NESTING AND ARE INDICATORS OF DENSE SUBMERGED AQUATIC PLANTS

Pond M7

Transect location:

Edge 1: Lat -34.8286, Long 138.5263

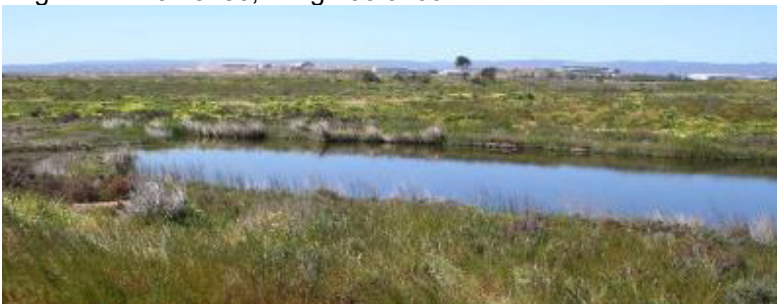


FIGURE B-9 TRANSECT AT POND M7 SHOWING RELATIVELY POOR PLANT COVER ON BOTH BANKS

Pond M8

Transect location:

Edge 1: Lat -34.8277, Long 138.5242



FIGURE B-10 TRANSECT AT POND M8 SHOWING DENSE SAMPHIRES ON BOTH BANKS



APPENDIX C

WATER BALANCE MODEL ASSUMPTIONS





Assumptions

- Inflow volumes from the catchment were modelled using MUSIC software, the input of rainfall was from data measured at the Seaton Pluvio
- The catchment area was assumed to be 900 ha, after a catchment delineation;
- The catchment was assumed to be compromised of 25 % impervious surface and 75% surface.
- The rainfall threshold in the catchment was assumed at 2 mm/day
- Direct rainfall salinity was assumed at 30mg/L
- The model was over a 7-year period between 1 January 1998 – 31 December 2004.
- It was assumed that evaporation rates changed each month, and were constant throughout the month;
- Exfiltration rates are assumed to be close to that of Clay Liners at 0.017 mm/hr;
- The ponds are completely full at the beginning of the model
- Water in the ponds is perfectly mixed
- Flow proportion into each pond were:

TABLE C-1 THE FLOW PROPORTION TO EACH POND FROM THE OVERALL FLOW

Ponds	Proportion of flow
Pond M2A&M2B	0.3
Pond M4A&M4B	0.3
M6	0.2
M7	0.7

Data Sources

- Inflow salinity level used in the model were taken from Water Connect Website, Transfer Station gauge near the Adelaide Airport , located approximately 11 km from the Wetland Inlet;
- Direct Rainfall data was taken from the Bureau of Meteorology website, Adelaide Seaton gauge, located about 5 km from the Magazine Creek wetlands Inlet;
- The volume of each pond, was calculated via the bathymetry data from the as designed lay out;
- Evaporation rates were taken from the Bureau of Meteorology Website for evaporation rates in the wetlands area;

Model Verification

The results of the MUSIC Model created to produce the catchment flow rates, from the catchment into Magazine Creek ,were measured against the results MUSIC software produced for the HEP catchment



APPENDIX D CONSULTATION REPORT



MAGAZINE CREEK & RANGES WETLANDS CONSULTATION

8 May 2020

Summary Report

This report has been compiled by
Innovative Influences



Table of Contents

Introduction	3
Engagement Methodology	3
Engagement Outcomes	4
Community Consultation	4
General Comments.....	4
What do you like about the plan?.....	4
What risks and/or opportunities haven't been addressed in the draft plan?.....	4
Agency Consultation.....	4
What do you like about the plan?.....	4
What risks and/or opportunities haven't been addressed in the draft plan?.....	5
Evaluation	5
Social characteristics of Magazine Creek & Ranges Wetlands.....	5
Community Profile.....	5
Community use of wetland	5
Community Opinion.....	5
Appendix 1: Workshop Invitation List	7
Appendix 2: Workshop Program	8
Appendix 3: Chat Box Text.....	9

Introduction

The key objective of this project is to formulate wetland management plan(s) for Magazine Creek and Ranges Wetlands which will be the new platform for managing the wetlands. Supporting this objective is engagement with stakeholders, which has involved working with Council staff, Elected Members, Birds SA and other relevant individuals, groups and stakeholders to better understand and consider their concerns and views regarding the cultural and social values of these wetlands and how they are managed.

This report provides an outline of the engagement process undertaken and collates the findings that resulted.

Engagement Methodology

Simply put stakeholder engagement allows us to share information, collect and compile input and bring people together.

Two workshops were undertaken as targeted consultation with community and agency stakeholders including members and representatives of Port Adelaide Environment Residents Group, Birds SA, Friends of Torrens Island, Estuary Care Foundation, Conservation Volunteers Australia, Birdlife Australia, Department for Environment & Water, and City of Port Adelaide Enfield.

The approach implemented recognises that effective stakeholder engagement:

- Acknowledges the desire for individuals to participate in decisions that affect them
- Facilitates understanding of both the problem or opportunity and the available options if a solution is to be found
- Improves decisions by bringing all perspectives to the table and identifying critical issues early

A detailed workshop program was developed to deliver the following outcomes.

- Inform stakeholders of the contents of the Draft Management plans, the recommended actions, and anticipated outcomes
- Provide stakeholders with an opportunity to share their opinions, concerns and recommendations on these recommended actions
- Provide stakeholders with an opportunity to identify additional risks and opportunities

The workshops were delivered on 7 May 2020 using the online platform Zoom. Zoom's features of screen sharing, chat box and polling supported the delivery of an interactive and engaging workshop. Zoom was combined with other collaborative tools such as Google Slides to ensure participant input was captured appropriately. The screen sharing facility allowed an overview presentation of the project methodology and Draft Management Plans to be delivered which provided context for the workshop activities.

A total of 15 individuals were invited to participate in the workshops. Of these 11 individuals registered to attend and on the day 8 individuals (4 community, 4 agency) actually participated in the online workshop sessions.

The workshop program led participants through a series of activities that enabled them to:

1. Seek clarification on elements of the management plans
2. Review proposed management plan actions
3. Identify new risks and opportunities for consideration
4. Provide additional comments

Engagement Outcomes

The workshop produced a significant level of discussion which was captured in the following ways.

- Text file of chat room commentary
- Google slide pack of participant comments.

These have been provided as attachments to this report. Following are the discussion points captured by participants throughout the workshop and are a direct transcript.

Community Consultation

General Comments

How do you consider its links to other areas?

Artificial ecosystem construction vs natural. Can seawater come in and out again like it used to.

Where will mangroves retreat to naturally?

Is area protected or will development push it out. Q for Craig. Industrial Zoning? New design code is out for consultation now. Mixed use zone approach for area. Current discussion about how to zone this area.

Response: coming into system when its 20 year old. Opportunities to look at landscape. Have been piping out saline water for some time. Will take comments into account. Primary objective originally was to limit impact of stormwater. Good question: What is primary objective of system?

DEW project: vegetation improvements have been made. Landscape approach to tidal movement is very important. Open up to sea, recognising need to manage pollutants.

What do you like about the plan?

Intention to improve the condition of the wetland.

Made a planned and measured approach and considered what is working at the moment.

Pleased that a considerable amount of time has been allocated to the actions. Anything that improves wetlands is a plus.

Appreciate amount of time that has gone into it.

What risks and/or opportunities haven't been addressed in the draft plan?

RISKS

Less bird visitation may result - at no time will all ponds be dry at the same time.

Values in wetlands will be overwhelmed by encroachment of industrial development.

OPPORTUNITIES

There has been a long-held interest in this area by the community. This site would be an excellent site to pursue blue carbon.

Need to recognise environmental values associated with area.

Give consideration to sea level rises and ecological values and role this site has in contributing to addressing challenges.

Agency Consultation

What do you like about the plan?

Magazine - super excited that Council are implementing these wetland plans.

Good to see exploration of what improvements could be made and testing of actions.

Very logical step through approach to managing system as a whole.

Ditto - trialling windmill will help understand effectiveness

Evidence basis of plan is a strength. Focus on where parts of system can operate without management of system. Looking for self sufficiency

What risks and/or opportunities haven't been addressed in the draft plan?

RISKS

Salinity during drying regime

Operational risks? Budget impact of getting gates back in situ. Only 2 regulators needed to be operational.

Citizen Science - ensuring scientific rigour underpinning activities

Storm water quality

Effectiveness of wetlands in improving water quality beyond salinity - N, P, solids etc

Dredging permit

Plan hasn't modelled future development or storm water flows, based on current situation

OPPORTUNITIES

Eco-tourism - bird watching

Citizen science - engaging community in surveys

Stormwater quality improvement - increasing amount of shallow areas - attractive to shorebirds - maximise recruitment opportunities

Funding opportunities - SWMA

Evaluation

The **current global health environment** and travel and social restrictions in place due to **Coronavirus (COVID-19)** shaped the nature of stakeholder engagement and techniques used. Whereas this workshop would normally be held as a face-to-face activity in a location close to the Wetlands, an alternative online approach was used.

Using the Zoom polling feature, participants were asked.

1. How well has this online format worked for you?
2. How valuable was the content presented?
3. How satisfied were you that you were able to share your views?

All participants felt the platform worked well, found the workshop either valuable, very valuable or extremely valuable and were satisfied they had been able to share their views.

Social characteristics of Magazine Creek & Ranges Wetlands

Community Profile

Magazine Creek and Range Wetlands are located at Gillman and Dry Creek (respectively) approximately 17km from Adelaide's CBD in Port Adelaide and are part of the Torrens Road Catchment. These wetlands were constructed in the mid 1990's as part of the larger Land Management Corporation project to improve stormwater management to the north western suburbs and the natural landscape amenity.

There is a significant amount of industrial development in close proximity to the wetlands.

Community use of wetland

There are several active community groups (including Birds SA) with a keen interest to preserve and ensure the longevity of the wetland environment for migratory birds. The general amenity provided by the wetland was appreciated by community members and all wanted to see the wetland in better condition. Specifically, the Port Adelaide Environment Residents Group seeks to enhance the environmental values of the area.

Community Opinion

The community of Magazine Creek and Ranges Wetlands have identified the following issues for consideration in the future management of the wetland.

- Need to maintain and improve diversity of wetland vegetation
- Effectiveness of wetlands in improving water quality beyond salinity
- Protection of the values of wetlands from encroachment by industrial development
- The role this site has in contributing to addressing challenges relating to sea level rise
- Opportunities to engage community members in Citizen Science activities
- Opportunities for Blue Carbon

Appendix 1: Workshop Invitation List

Community groups/organisations	Contact person	Email
Port Adelaide Environment Residents Group	Tony Bazelay	tonyb@sa.apana.org.au
Birds SA	Chris Evans	chrevans@gmail.com
Friends of Torrens Island	Andrew Winkler	littoral@chariot.net.au
Estuary Care Foundation	Catherine McMahon	estuarycare@internode.on.net
Conservation Volunteers Australia	Darren Kennedy	Dkennedy@cva.org.au
Birdlife Australia	Aleisa Lamanna	aleisa.lamanna@birdlife.org.au

State Government Agencies	Contact person	Email
Adelaide and Mt. Lofty Ranges NRM Board		
- Coastal unit	Tony Flaherty	Tony.Flaherty@sa.gov.au
Adelaide and Mt. Lofty Ranges NRM Board		
- Stormwater unit	Sam Phillips	sam.phillips@sa.gov.au
Department Environment Water	Katherine Ward	katharine.ward@sa.gov.au
Department Environment Water	Rachel Murchland	rachel.murchland@sa.gov.au

Local Government	Contact person	Email
City of PAE	Danny Millbank	danny.millbanks@cityofpae.sa.gov.au
City of PAE	Peter Gehling	peter.gehling@cityofpae.sa.gov.au
City of PAE	Maggie Hine	maggie.hine@cityofpae.sa.gov.au
City of PAE	Simon Trill	simon.trill@cityofpae.sa.gov.au
City of PAE	Jessica Elliott	jessica.elliott@cityofpae.sa.gov.au

Appendix 2: Workshop Program

Time	Agenda Item	NOTES
30 mins	<p>Welcome & Introductions</p> <p>Purpose of this session</p>	<p>Introduce Jeanette, Kerri, Geoff</p> <p>Slide – project title, names, acknowledgement</p> <p>Live Poll – who has used zoom? (Jeanette)</p> <p>Zoom induction (Jeanette)</p> <p>Live Poll – what are your interests in Magazine creek (Jeanette)</p> <p>Break out rooms (dependent on participant numbers) – icebreaker activity for participants to introduce themselves to each other (Jeanette)</p> <p>Slide (Kerry/Geoff)</p>
30 mins	Presentation on draft plan	Kerry & Geoff
40 mins	Collecting feedback on draft plan	<p>Break out rooms (Jeanette to facilitate)</p> <p>Participants are asked to discuss following three questions</p> <ol style="list-style-type: none"> 1. What do you like about the plan? 2. What risks and/or opportunities haven't been addressed in the draft plan? 3. How would you manage the risks you have identified? <p>Participants capture their responses on Google Slides. Report back to main group.</p>
10 mins	Next steps in plan finalisation	Kerry/Geoff
5 mins	Reflections on session	Live Poll – value of session (Jeanette)
5 mins	Thank you & Close	

Appendix 3: Chat Box Text

0:36:42	From Helen Macilwain to Jeanette Gellard(Privately)	what's the area of wetland further east that is often referred to Magazine Creek next to the old Magazine storage huts?
10:48:22	From Catherine McMahon to Jeanette Gellard(Privately)	did study see a reduction in the shorebirds using the area, as Craig suggested?
11:00:39	From Craig Hughes :	The long historic bird count collection can be accessed from SA Gov on their Statewide database. I can send the link to anyone interested. Craig
11:07:45	From Catherine McMahon to Jeanette Gellard(Privately) :	not sure I understand about what closing the regulators means
11:08:46	From Catherine McMahon to Jeanette Gellard(Privately) :	it then opens if we get a summer storm?
11:09:11	From Craig Hughes to Jeanette Gellard(Privately)	Link to Nature Maps. You need to seek fauna tool to access data.
11:09:20	From Craig Hughes to Jeanette Gellard(Privately)	https://data.environment.sa.gov.au/NatureMaps/Pages/default.aspx
11:10:03	From Jeanette Gellard :	Message from Craig: Link to Nature Maps. You need to seek fauna tool to access data. https://data.environment.sa.gov.au/NatureMaps/Pages/default.aspx
11:23:50	From Liz Millington :	Got a couple of questions.
11:31:48	From Catherine McMahon to Jeanette Gellard(Privately) :	2018 Coastal and Inundation Modelling Phase 3 Report - https://www.cityofpae.sa.gov.au/__data/assets/pdf_file/0019/541126/Item-12.3.1-Att-1-Coastal-and-Inundation-Modelling-Phase-3-Report.pdf
11:47:30	From Jeanette Gellard :	2018 Coastal and Inundation Modelling Phase 3 Report - https://www.cityofpae.sa.gov.au/__data/assets/pdf_file/0019/541126/Item-12.3.1-Att-1-Coastal-and-Inundation-Modelling-Phase-3-Report.pdf
11:53:00	From Helen Macilwain to Jeanette Gellard(Privately) :	hpmac@internode.on.net
11:53:18	From Catherine McMahon to Jeanette Gellard(Privately) :	I've got the 2 docs thanks
12:05:32	From Liz Millington :	lizmill@adam.com.au

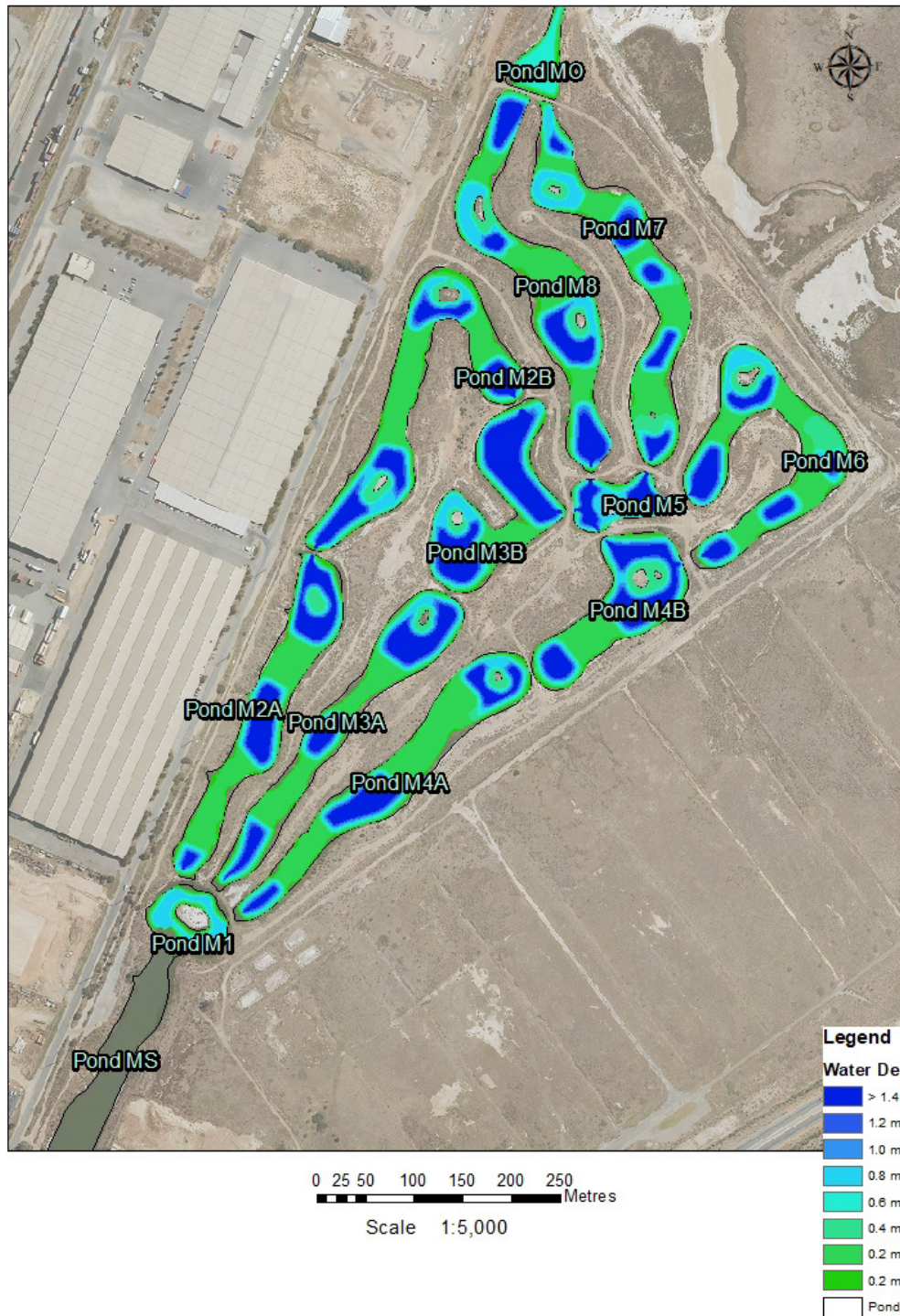


APPENDIX E MAINTENANCE CHECK LIST TABLE





POND MAP KEY





Routine Maintenance Checklist

Pond Name: _____ **: Date:** _____ **: Inspector:** _____ **: Follow-up Action Required Y/N?** _____

Item	Inspection Frequency	Section of Plan	Action	Outcome/Checked
Gross Pollutant Trap (GPT)	Fortnightly	5.1	Clean out if 50% or more full/or it has been 6 weeks before last cleanout	
GPT fencing	Fortnightly	5.7	Check fence and gates to ensure they are secure. Repair / make good as necessary.	
Sedimentation Pond (MS)	Quarterly	5.2	Clean out if average depth to sediment is less than 500 mm within the first 100 metres of the pond.	
Litter	Quarterly	5.12	Remove accumulated litter from around site	
Weeds	Quarterly	9.1	Check for invasive weeds and arrange for weed removal / spraying	
Wetland Ponds	Annually	5.3	Develop and implement staged sediment removal program of works if volume in pond is reduced by 30%	
Weirs	Annually	5.4	Check for sediment and debris accumulation around structure and desilt sediment within 10 m of weir in summer if it being obstructed by sediment. Remove any accumulated debris. Check that correct stop logs settings are in place.	
Culverts	Annually	5.5	Check for sediment and debris accumulation around structure and desilt if sediment is obstructing culvert. Remove accumulated sediment in summer from within 10m of culvert.	
Pond water Levels	Annually	5.5	Check that water levels in adjoining ponds are the same/similar. If not suspect block culvert and arrange for removal of blockage.	
Overflow banks	Annually	5.6	Check for damage and signs of scour - repair whilst ensuring design crest level are not exceeded.	
Site fencing	Annually	5.7	Check perimeter fencing and gates for the main wetland area for deterioration and vandalism. Report and repair any damage.	
Paths	Annually	5.8	Check for damage or deterioration - particularly erosion, and trim back any overgrowing vegetation that may be restricting access. Spray any weeds invading pathway.	
Signage	Annually	5.9	Check for damage and repair. Replace any lost signage.	
Windmills	Annually	5.11	Ensure maintenance contract is in place for next 12 months and review annual maintenance/operations report from contractor.	
Native Vegetation	Annually	9.1	Check plant condition and arrange for replacement plantings of dead plants.	



Melbourne

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365

Brisbane

Level 3, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144

Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000
Fax (08) 8357 8988

Perth

Ground Floor
430 Roberts Road
Subiaco WA 6008
Telephone 08 6555 0105

Geelong

PO Box 436
Geelong VIC 3220
Telephone 0458 015 664

Gippsland

154 Macleod Street
Bairnsdale VIC 3875
Telephone (03) 5152 5833

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Wimmera

PO Box 584
Stawell VIC 3380
Telephone 0438 510 240

www.watertech.com.au

info@watertech.com.au

