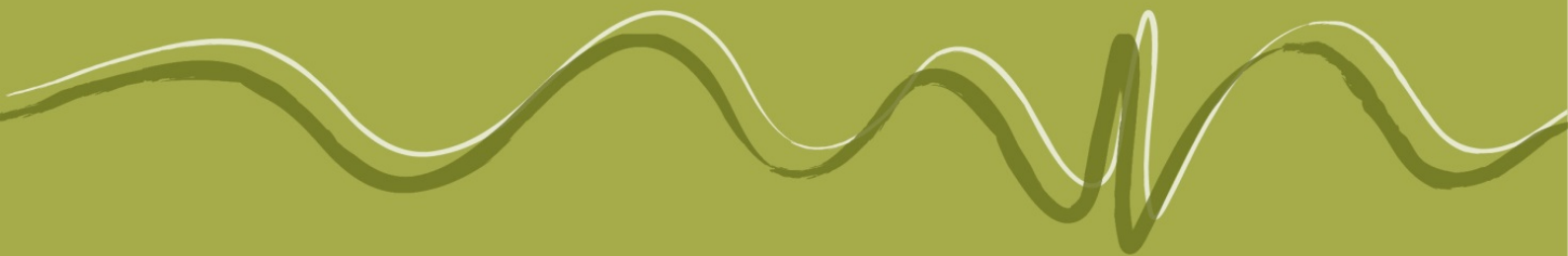


Vegetation Monitoring 2015

Salty Lagoon





GeoLINK
environmental management and design

PO Box 119
Lennox Head NSW 2478
T 02 6687 7666

PO Box 1446
Coffs Harbour NSW 2450
T 02 6651 7666

info@geolink.net.au

Prepared for: Richmond Valley Council
© GeoLINK, 2015

	Name	Signature	Date
Prepared by	TJP		25/05/2015
Reviewed by	VJS		26/05/2015

UPR	Description	Date Issued	Issued By
1731-1149	First issue	27/05/2015	TJP
1731-1156	Second issue	25/06/2015	TJP

Table of Contents

1.	Introduction	1
1.1	Background	1
1.1.1	ERMP Vegetation Monitoring	1
1.1.2	MPPC Vegetation Monitoring	2
1.1.3	Purpose of this Report	3
2.	Methodology	4
2.1	Vegetation Transects	4
2.1.1	Timing	4
2.1.2	Vegetation Habitat Zones	4
2.1.3	Selection of Indicator Species	5
2.1.4	Melaleuca Dieback/ Recolonisation Transects	6
3.	Findings and Observations	8
3.1	Vegetation Habitat Zonation	8
3.1.1	Transects 1-3	8
3.1.2	Transects 4-6	29
3.2	Melaleuca Dieback/ Recolonisation Monitoring	37
3.3	Photo Point Monitoring	44
4.	Discussion and Comparison with Previous Monitoring	45
4.1	Vegetation Habitat Zonation	45
4.1.1	Transects 1-3	45
4.1.2	Transects 4-6	47
4.1.3	Species Composition of Vegetation Habitat Zones	48
4.1.4	Species Dominance	48
4.1.5	Predicted Changes and Indicator Species	48
4.1.6	Melaleuca Dieback/ Recolonisation Monitoring	49
4.1.7	Future Monitoring	49

Illustrations

Illustration 2.1	Indicative Vegetation Sampling Sites selected for the Monitoring Program	7
Illustration 3.1	Location of Vegetation Habitat Zone Boundaries	9

Tables

Table 2.1	Modified Braun-Blanquet Cover Classes	5
Table 3.1	Extent of Vegetation Habitat Zones along Transects 1-3	8
Table 3.2	Dominant Flora by Cover Abundance (modified Braun-Blanquet Cover Classes) in Quadrats along Transects 1-3	10
Table 3.3	Vegetation Structure and Characteristics - Quadrat Data for Transects 1-3	16

<u>Table 3.4</u>	<u>Dominant Flora by Cover Abundance (modified Braun-Blanquet cover classes) in</u>	
<u>Quadrats along Transects 4-6</u>		<u>29</u>
<u>Table 3.5</u>	<u>Vegetation Structure and Characteristics - Quadrat Data for Transects 4-6</u>	<u>34</u>
<u>Table 3.6</u>	<u>Melaleuca Dieback Quadrat Data</u>	<u>38</u>

Plates

<u>Plate 4.1</u>	<u>Common Reed dominating areas of Fringing Marsh in 2015</u>	<u>46</u>
<u>Plate 4.2</u>	<u>Open-water along Transect 3 in 2015</u>	<u>46</u>
<u>Plate 4.3</u>	<u>Sea Rush dominated the same area along Transect 3 in 2011</u>	<u>46</u>
<u>Plate 4.4</u>	<u>Transect 6, quadrat A1 in 2011</u>	<u>47</u>
<u>Plate 4.5</u>	<u>Transect 6, quadrat A1 in 2015</u>	<u>47</u>

Figures

<u>Figure 3.1</u>	<u>Cover Abundance Scores for Indicator Species in Vegetation Habitat Zones of Transects</u>	
<u>1-3</u>		<u>15</u>
<u>Figure 3.2</u>	<u>Cover Abundance Scores for Indicator Species in Vegetation Habitat Zones of Transects</u>	
<u>4-6</u>		<u>33</u>

Appendices

<u>Appendix A</u>	<u>GPS Locations of Vegetation Habitat Zone Boundaries and Monitoring Quadrats</u>
<u>Appendix B</u>	<u>Cover Abundance of All Flora Species</u>
<u>Appendix C</u>	<u>Photo Point Monitoring</u>



1. Introduction

1.1 Background

GeoLINK has been engaged by Richmond Valley Council (RVC) to implement the Salty Lagoon Ecosystem Recovery Monitoring Program: Pre-Post Closure of the artificial channel (MPPC). This engagement is part of a detailed rehabilitation strategy for Salty Lagoon that has been implemented by RVC.

The rehabilitation strategy comprises three parts:

Part 1: Issues evaluation and information gap analysis;

Part 2: Rehabilitation and management options assessment; and

Part 3: Implementation strategy.

A comprehensive description of the rehabilitation strategy is provided in the Salty Lagoon Rehabilitation Plan (Hydrosphere 2011).

Prior to this current engagement, RVC implemented the Salty Lagoon Ecosystem Recovery Monitoring Program (ERMP). In brief, the ERMP aimed to monitor the ecological health of the system for a two year period, and to collect data across a range of disciplines to allow for further planning to be undertaken in accordance with the broader aims of the rehabilitation strategy. This work included a flora and vegetation mapping component and was completed in March 2010 (Hydrosphere 2010a).

The current engagement is part of the final phase of work (Part 3) which documents the implementation strategy and deals specifically with the closure of the Artificial Channel and associated actions. As part of this strategy, RVC are implementing the MPPC (Hydrosphere 2010b).

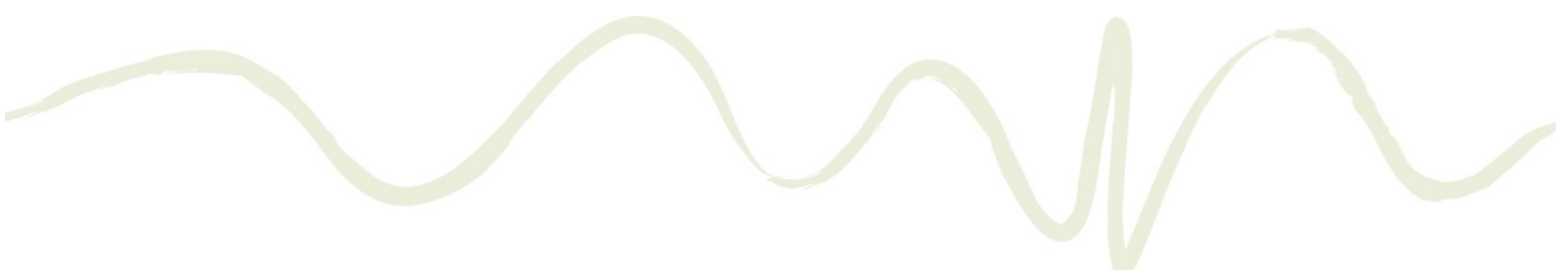
The key objectives of the MPPC are to:

1. confirm positive predicted changes in Salty Lagoon ecological and cultural values, particularly in response to the closure of the artificial channel;
2. provide adaptive management response mechanisms before and after closure to inform future stages of the rehabilitation strategy; and
3. inform long term strategies with respect to the management of effluent from the Evans Head Sewage Treatment Plan (STP).

1.1.1 ERMP Vegetation Monitoring

The aim of the flora and vegetation mapping components of the ERMP is to “*document the status of key ecosystem components as baseline data to inform planning for recovery*” (Hydrosphere 2010a). Field sampling was undertaken to allow the production of a base map and a transect and quadrat-based sampling program designed to facilitate future detection of changes to vegetation boundaries, structure and floristics was implemented. The program was particularly designed to monitor the following potential changes:

- condition of the Broad-leaved Paperbark (*Melaleuca quinquenervia*) dieback zone (referred to herein as the Melaleuca dieback zone);
- changes to the extent of Broad-leaved Cumbungi (*Typha orientalis*) and Duckweed (*Lemna* sp.) in the STP channel (drainage channel); and

- 
- changes to the vegetation on banks of the lower reaches of Salty Creek.

A comprehensive description of methods and results from the ERMP monitoring is provided in Hydrosphere (2010a).

1.1.2 MPPC Vegetation Monitoring

The MPPC was initiated in March 2011 and is due to be completed in June 2017. Vegetation monitoring is part of the Ecosystem Health and Trend Assessment of the MPPC.

The focus for the vegetation component of the MPPC monitoring is identifying and documenting the occurrence of the predicted changes in the vegetation habitat zone boundaries below 2 m AHD. The other major component is to document any re-colonisation or reduction within the Melaleuca dieback zone on the western side of the lagoon.

1.1.2.1 Predicted Changes to Vegetation Habitat Zones

Vegetation communities are anticipated to change in response to the closure of the artificial channel (this closure occurred in June 2012). A description of the potential changes is described in Hydrosphere (2010b) and in further detail in Hydrosphere (2011). The area of open water is predicted to increase. Giant Waterlilies (*Nymphaea gigantea*) were predicted to colonise the central portions of the lagoon and are also expected to occur on the fringes. Mixed sedges and rushes such as *Juncus* spp. and *Baumea* spp. are expected to dominate the western area currently occupied by Fringing Marsh. Broad-leaved Paperbark may also expand to the east.

Other predicted changes include:

- establishment of *Gahnia* spp. and Broad-leaved Cumbungi in the deeper depressions that occur on the western shore;
- drier extremities of the lagoon, where water levels will be less than 0.1 m deep are likely to remain unchanged; and
- other vegetation habitat zones that occur below 2 m AHD will also be potentially affected along the drainage channel (Sedge Swamp/ open water) and along the eastern edge of the lagoon (Fringing Marsh and Banksia Woodland).

A detailed vegetation map showing the predicted water level and vegetation habitat zones is provided in Hydrosphere (2011).

Methods that will be used to monitor changes to the location of vegetation habitat zone boundaries include recording floristic composition within each of the three main vegetation habitat zones below the 2 m AHD level, and recording and mapping the location of the current vegetation habitat zone boundaries. The three main vegetation habitat zones that potentially will be affected by the closure of the channel are located predominantly on the western side of Salty Lagoon and comprise the following:

- Fringing Marsh;
- Swamp Forest; and
- Sedge Swamp.



1.1.2.2 Re-colonisation of Broad-leaved Paperbark and a Reduction in the Area of Dieback

Historical information and evidence on site (i.e. several large tree stumps in the lagoon) indicates that Broad-leaved Paperbark once occurred further east, closer to the lagoon.

Potential re-colonisation of Broad-leaved Paperbark will be monitored using three of the four transects that were established for the ERMP to allow for comparison with ERMP data and assessment for longer term changes at these locations.

1.1.2.3 Pre-closure Baseline Vegetation Monitoring

Baseline vegetation monitoring for the MPPC at Salty Lagoon pre-closure of the artificial channel was undertaken in March-April 2011 by GeoLINK. This is referred to in this report as 'baseline vegetation monitoring'. For specific details of the methodology and findings of the baseline vegetation monitoring refer to GeoLINK (2012).

1.1.3 Purpose of this Report

The purpose of this report is to document the state of vegetation at the Salty Lagoon site in 2015 post-closure of the artificial channel, and compare these findings with the findings from the baseline vegetation monitoring undertaken in 2011.



2. Methodology

The following section details the methodology used for the 2015 vegetation monitoring. This methodology follows the methods used for the baseline vegetation monitoring and is summarised where appropriate to reduce repetition with the baseline vegetation report. More detail on methodology can be found in that report (GeoLINK 2012).

2.1 Vegetation Transects

2.1.1 Timing

Vegetation sampling was undertaken over two days on 19 March and 20 March 2015.

Water levels at the time of sampling were relatively high, as a result of significant rainfall experienced in February. As was noted at the time of the 2013 vegetation monitoring, some of the monitoring quadrats on the fringe of Salty Lagoon were covered by open water at the time of sampling and the water level was substantially higher than that in the 2011 vegetation monitoring event prior to closure of the artificial channel.

2.1.2 Vegetation Habitat Zones

The boundaries of the vegetation were evidenced in the field by the following criteria:

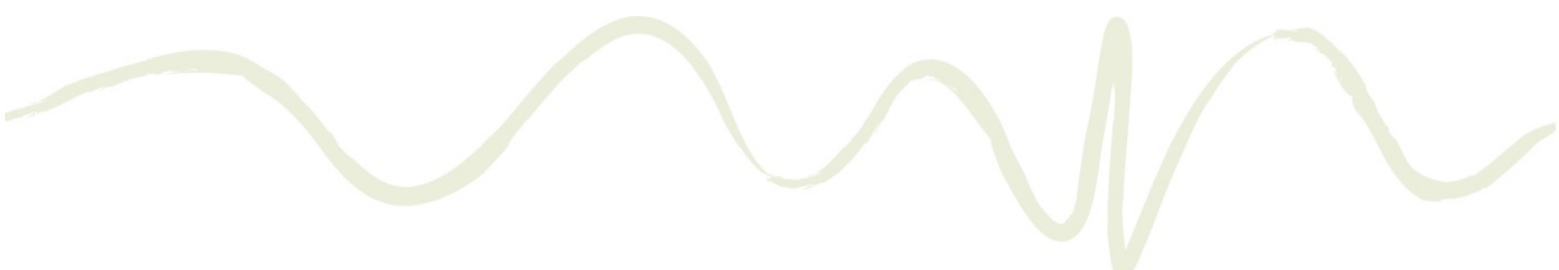
- **Sedge Swamp/ Swamp Forest:** Sedge Swamp has a clearly defined edge and generally comprises a dense thicket dominated by *Gahnia sieberiana*, which occurs in all strata including the upper stratum (generally <3 m in height). Emergent Broad-leaved Paperbark and Tea Tree can be present.
- **Swamp Forest/ Fringing Marsh:** the edge of the Swamp Forest is poorly defined due to the zone dominated by dead/ dying Broad-leaved Paperbark. The point at which the boundary was defined was where percentage foliage cover (PFC) of the Broad-leaved Paperbark greater than 3 m in height was >10%. The recorded way points should be used to accurately relocate this boundary (refer to **Appendix A** [Table A1]).

Transects in which data was collected for this monitoring are the same as those used for baseline vegetation monitoring, as outlined below.

Transects 1-3 are 400-600 m in length and each extends across the three distinct vegetation habitat zones of Fringing Marsh, Swamp Forest and Sedge Swamp. Two quadrats (10 m x 10 m) are located in each vegetation habitat zone along each transect (i.e. total of six quadrats per transect). Quadrats are orientated generally in an east-west direction and run from the open water at the eastern end through the Sedge Swamp to the heathland boundary to the west. The location of the boundary of each of the vegetation habitat zones was recorded via GPS (refer to **Appendix A** [Table A1]).

Transects 4-6 are between 20-60 m in length and each comprise two distinct vegetation habitat zones. One quadrat (10 m x 10 m) is located in each vegetation habitat zone along each of these transects (i.e. total of two quadrats per transect).

Transect 4 traverses the drainage channel (i.e. channel from the STP) and is orientated generally in a north-south direction. The two vegetation habitat zones sampled include Sedge Swamp/ open water and Swamp Forest. Transect 5 and Transect 6 are located on the eastern side of Salty Lagoon.



These transects are less than 20 m in length and are orientated generally in an east-west direction. The vegetation habitat zones sampled at both transects include Fringing Marsh and Banksia Woodland.

GPS waypoints identifying the location of vegetation quadrats along transects 1-3 are provided in **Appendix A** [Table A2]).

Data recorded for vegetation quadrats included:

- description of vegetation by stratum (height and total percentage cover) (modified Braun-Blanquet scale; refer to **Table 2.1**);
- floristic composition with cover abundance for each species;
- diameter at breast height (DBH - recorded at 1.25 m above the ground) for each stem greater than 10 cm DBH;
- description of vegetation health; and
- photos taken from the north-east corner of each quadrat.

Table 2.1 Modified Braun-Blanquet Cover Classes

<i>Class</i>	<i>Percentage Cover</i>
1	<5% sparse
2	<5% common
3	5-25%
4	26-50%
5	51-75%
6	76-100%

Trees with DBH >10 cm along Transects 1-3 are not permanently marked in the field, however to facilitate relocation of individual trees, quadrats are divided into four quarters (quadrants) and tree counts start in the north-west corner of the quadrat, moving in a clockwise direction.

2.1.3 Selection of Indicator Species

Indicator flora species were identified in the baseline vegetation monitoring on the basis that will be useful for identifying changes that may occur in vegetation habitat zones once closure of the artificial channel has occurred. These indicator species were selected based on the following methodology:

- identified in the predicted changes to the Salty Lagoon flora in Hydrosphere (2010b) (refer to **Section 1.1.2.1** of this report); and/ or
- dominant in a vegetation habitat zone, as identified in the cover abundance data collected; and
- primarily associated with a single habitat vegetation zone.

The distribution of these indicator species is expected to change over time and therefore these changes should be reflected in the cover abundance scores of the quadrat data. However, if it is apparent after a number of monitoring events that additional species should be included as indicator species it is recommended that these are included also.

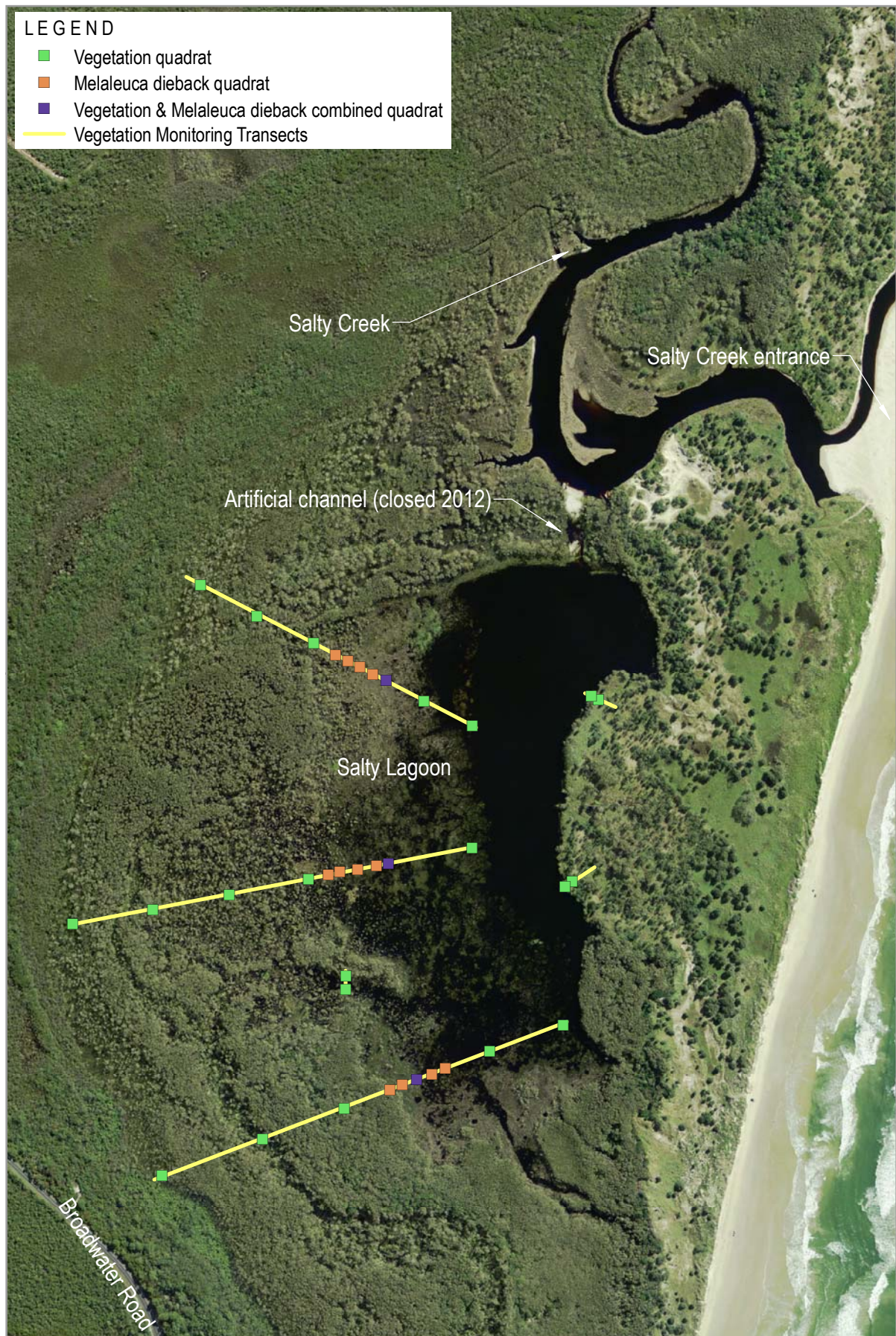


2.1.4 Melaleuca Dieback/ Recolonisation Transects

Melaleuca dieback transects and quadrats (10 m x 10 m) were established for the baseline vegetation monitoring according to the proposed methodology outlined in Hydrosphere (2010b). Three transects correspond with those previously established for the ERMP sampling (refer to Figure 2 in Hydrosphere 2010a). These transects are located along Transects 1-3 established to measure vegetation habitat zone changes (refer to **Illustration 2.1**) and quadrat locations correspond with the Fringing Marsh/ Swamp Forest boundary.

The waypoints identifying the location of each quadrat are provided in **Appendix A** (Table A3). Data recorded at Melaleuca dieback quadrats included:

- vegetation description by stratum (height and total percentage cover);
- floristic composition with cover abundance for each species (modified Braun-Blanquet scale; refer to **Table 2.1**);
- description of vegetation health (presence of necrotic spots on leaves, galls on small branches);
- photos taken from the north-east corner of each quadrat;
- number of trees with >10 cm DBH (and the DBH of each stem >10cm);
- number of small trees (i.e. height <1.5 m and DBH >5 cm);
- number of seedlings (i.e. height <0.5 m);
- condition of trees within the quadrat using the following categories:
 - unaffected/ full recovery;
 - resprouting; and
 - dead.



Indicative Vegetation Sampling Sites selected for the Monitoring Program



0 150

GeoLINK
environmental management and design

Vegetation Monitoring Report 2015 - Salty Lagoon
1731-1152

Illustration 2.1

3. Findings and Observations

3.1 Vegetation Habitat Zonation

3.1.1 Transects 1-3

3.1.1.1 Boundaries of Vegetation Habitat Zones

Transects 1-3 extend across the three distinct vegetation habitat zones of Fringing Marsh, Swamp Forest and Sedge Swamp. The location of the vegetation habitat zone boundaries along these transects is shown in **Illustration 3.1**. The relative distance occupied by the vegetation habitat zones along each transect is detailed in **Table 3.1**.

Note that due to the presence of an ecotone between the Swamp Forest and Fringing Marsh vegetation habitat zones along Transect 2, the extent of these vegetation habitat zones is provided as a range. The edges of this ecotone area are defined by:

- Western edge – Broad-leaved Paperbark total cover $\approx 10\%$.
- Eastern edge - re-shooting Broad-leaved Paperbark and the majority of dead/ alive trees end. Individuals east of here are isolated and total cover $\leq 10\%$.

Table 3.1 Extent of Vegetation Habitat Zones Along Transects 1-3

<i>Transect</i>	<i>Extent of Fringing Marsh (m)</i>	<i>Extent of Swamp Forest (m)</i>	<i>Extent of Sedge Swamp (m)</i>	<i>Total Length (m)</i>
Transect 1	45	215	42	302
Transect 2	41-135	225-320	62	517
Transect 3	43	155	178	376

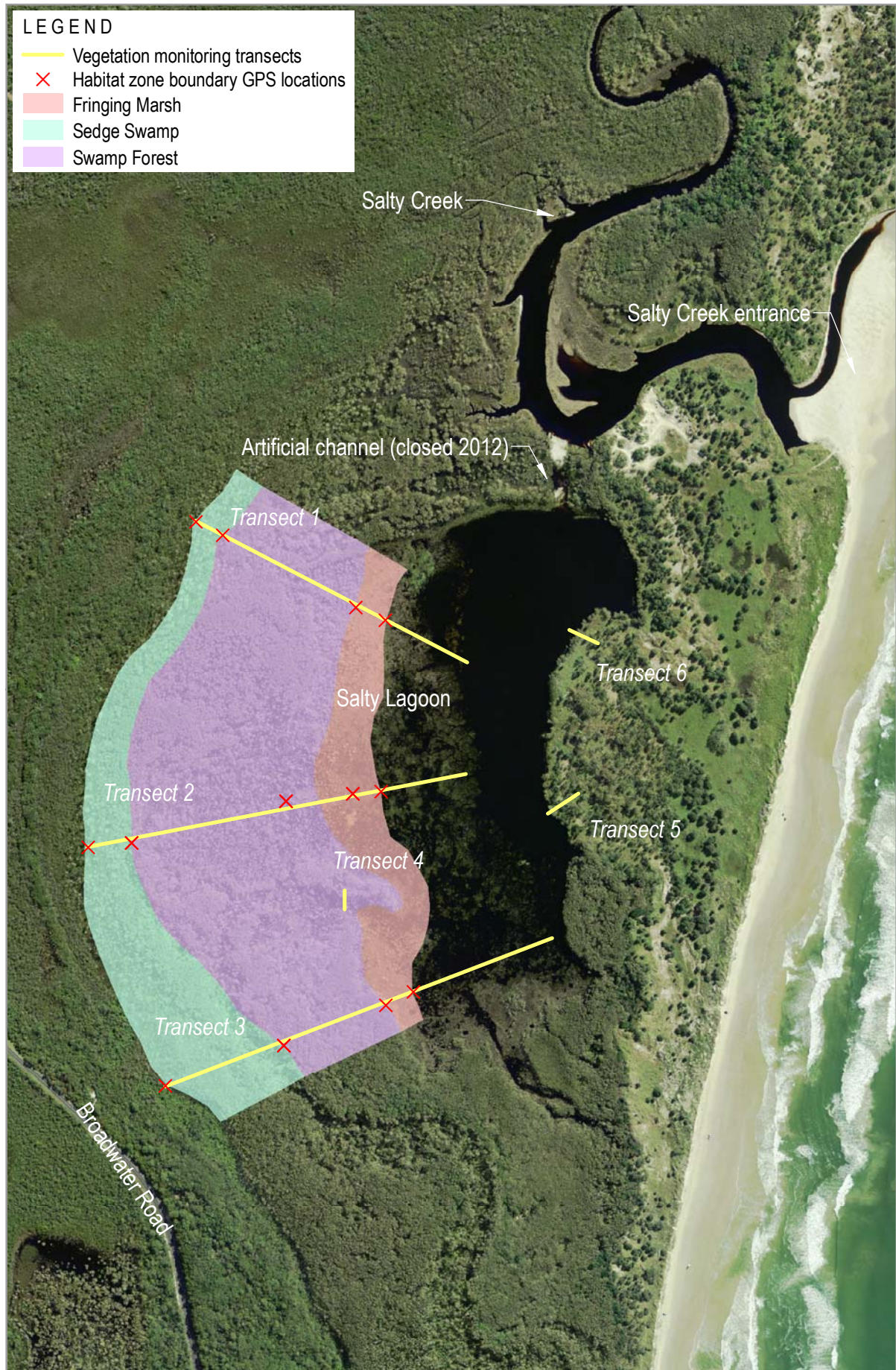
Note that since the baseline vegetation monitoring the total length occupied by the vegetation habitat zones along the transects has decreased due to a substantial amount of fringing marsh being converted to open water as water levels in the lagoon have raised since closure of the artificial channel in 2012.

3.1.1.2 Species Composition of Vegetation Habitat Zones

In total, 47 flora species (both native and exotic) were recorded from the three vegetation habitat zones. The breakdown of species by vegetation habitat zones was as follows:

- Fringing Swamp - 11 species;
- Swamp Forest – 27 species;
- Sedge Swamp – 26 species.

The dominant flora species by average cover abundance (three and above) within quadrats along Transects 1-3 is represented in **Table 3.2**.



0 150

GeoLINK
environmental management and design

Location of Vegetation Habitat Zone Boundaries

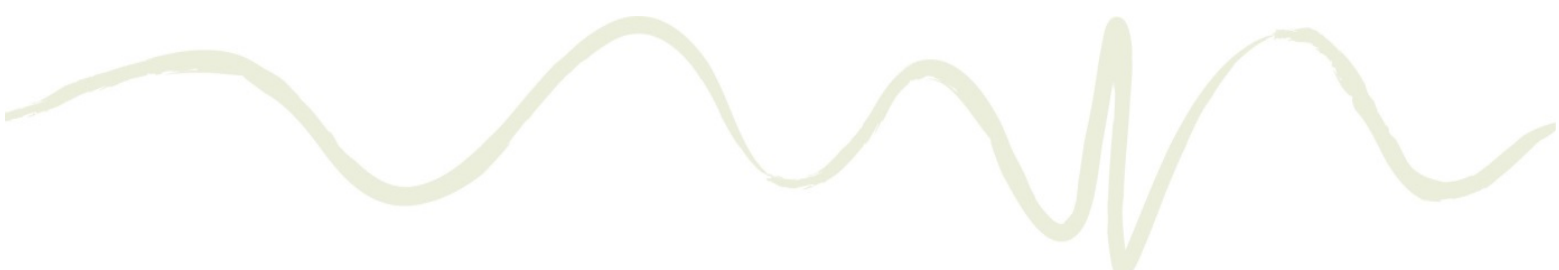
Salty Lagoon Vegetation Monitoring Report 2015
1731-1153

Illustration 3.1

Table 3.2 Dominant Flora by Cover Abundance (modified Braun-Blanquet Cover Classes) in Quadrats along Transects 1-3

	Common Name	Scientific Name	Fringing Marsh	Swamp Forest	Sedge Swamp
Transect 1	Quadrat A1				
	Grass Tree	<i>Xanthorrhoea</i> sp.			4
	Weeping Baeckea	<i>Baeckea frutescens</i>			3
	Plume Rush	<i>Baloskion tetraphyllum</i>			3
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>			4
	Quadrat A2				
	Plume Rush	<i>Baloskion tetraphyllum</i>			6
	Prickly Tea Tree	<i>Leptospermum juniperinum</i>			4
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>			4
	Quadrat B1				
	Bare Twig-rush	<i>Baumea juncea</i>		5	
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		4	
	Quadrat B2				
	Sea Rush	<i>Juncus kraussii</i> subsp. <i>australiensis</i>		3	
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		3	
	Bare Twig-rush	<i>Baumea juncea</i>		4	
	Quadrat C1				
	Sea Rush	<i>Juncus kraussii</i> subsp. <i>australiensis</i>	3		
	Saltwater Couch	<i>Paspalum vaginatum</i>	3		
	Common Reed	<i>Phragmites australis</i>	5		
	Bare Twig-rush	<i>Baumea juncea</i>	3		
	Shore Club-rush	<i>Schoenoplectus subulatus</i>	3		
	Quadrat C2				
	Azolla	<i>Azolla filiculoides</i>	3		
	Duckweed	<i>Lemna</i> sp.	3		
	Shore Club-rush	<i>Schoenoplectus subulatus</i>	3		
Transect 2	Quadrat A1				
	Weeping Baeckea	<i>Baeckea frutescens</i>			3
	Didgery Sticks	<i>Baloskion pallens</i>			3
	Zig-zag Bog-rush	<i>Schoenus brevifolius</i>			3

	Common Name	Scientific Name	Fringing Marsh	Swamp Forest	Sedge Swamp
	Swamp Twig-rush	<i>Baumea arthropphylla</i>			4
	Quadrat A2				
	Bare Twig-rush	<i>Baumea juncea</i>			5
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>			4
	Sand Couch	<i>Sporobolus virginicus</i>			3
	Quadrat B1				
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		4	
	Bare Twig-rush	<i>Baumea juncea</i>		3	
	a Tussock Grass	<i>Poa</i> sp.		3	
	Tall Sedge	<i>Carex appressa</i>		3	
	Quadrat B2				
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		4	
	Bare Twig-rush	<i>Baumea juncea</i>		3	
	Red-fruited Saw-sedge	<i>Gahnia sieberiana</i>		3	
	Azolla	<i>Azolla filiculoides</i>		3	
	Duckweed	<i>Lemna</i> sp.		3	
	Quadrat C1				
	Saltwater Couch	<i>Paspalum vaginatum</i>	3		
	Azolla	<i>Azolla filiculoides</i>	3		
	Duckweed	<i>Lemna</i> sp.	3		
	Quadrat C2				
	Shore Club-rush	<i>Schoenoplectus subulatus</i>	3		
	Common Reed	<i>Phragmites australis</i>	3		
	Azolla	<i>Azolla filiculoides</i>	3		
	Duckweed	<i>Lemna</i> sp.	3		
Transect 3	Quadrat A1				
	Swamp Twig-rush	<i>Baumea arthropphylla</i>			6
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>			3
	Bryophyte (a moss) sp.	<i>unknown</i>			3



	Common Name	Scientific Name	Fringing Marsh	Swamp Forest	Sedge Swamp
	Pouched Coral Fern	<i>Gleichenia dicarpa</i>			3
	Quadrat A2				
	Swamp Twig-rush	<i>Baumea arthropphylla</i>			6
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>			3
	Bryophyte (a moss) sp.	<i>unknown</i>			3
	Quadrat B1				
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		4	
	Tall Sedge	<i>Carex appressa</i>		4	
	Quadrat B2				
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		3	
	Spiny-headed Mat-rush	<i>Lomandra longifolia</i>		3	
	Native Violet	<i>Viola</i> sp.		3	
	Quadrat C1				
	No dominants (cover abundance >3)				
	Quadrat C2				
	No dominants (cover abundance >3)				

Note: indicator species shown in **bold** and exotic species are marked with *

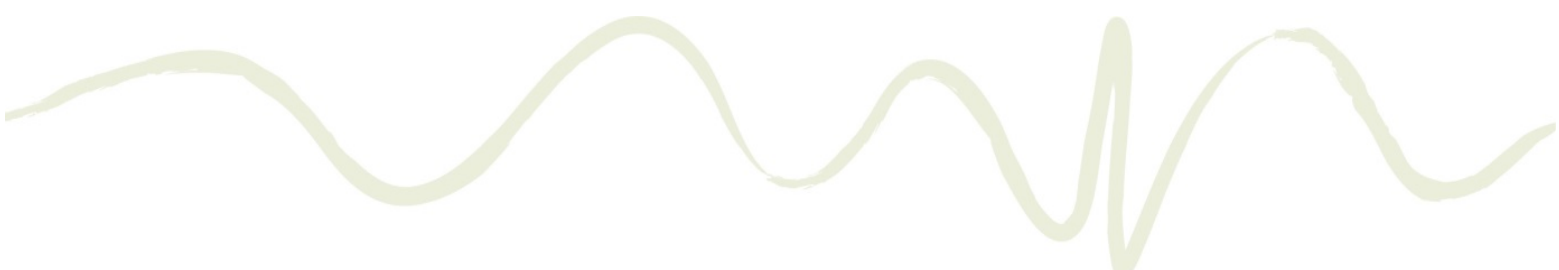
The cover abundance score for all flora species recorded within quadrats along Transects 1-3 is provided in **Appendix B** (Table B1). Ranges are given for cover abundance scores of species that occur in two quadrats of a particular vegetation habitat zone within a given transect.

3.1.1.3 Vegetation Habitat Zone Descriptions

Fringing Marsh

Dominant flora species within the Fringing Marsh quadrats (refer to **Table 3.2**) consisted of:

- Shore Club-rush (*Schoenoplectus subulatus*), Azolla (*Azolla filiculoides*) and Duckweed (*Lemna* sp.); all occurring at a moderate density in three out of six quadrats;
- Common Reed (*Phragmites australis*); occurring at a moderate to high density in two out of six quadrats;
- Saltwater Couch (*Paspalum vaginatum*); occurring at a moderate density in two out of six quadrats; and
- Sea Rush (*Juncus kraussii* subsp. *australiensis*) and Bare Twig-rush (*Baumea juncea*); both occurring at a moderate density in one out of six quadrats.



Two of the Fringing Marsh quadrats supported no dominant flora species, as these quadrats are now open water devoid of vegetation.

Swamp Forest

Dominant flora species within the Swamp Marsh quadrats (refer to **Table 3.2**) consisted of:

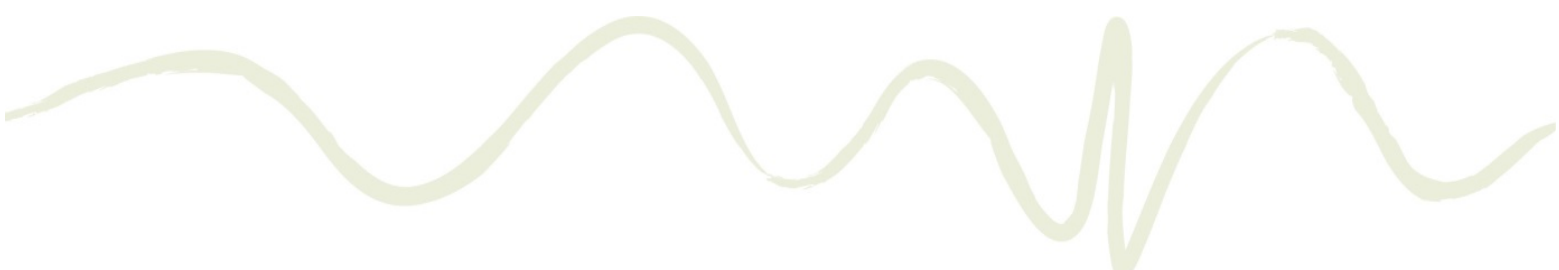
- Broad-leaved Paperbark (*Melaleuca quinquenervia*) occurring in a moderate density in all quadrats;
- Bare Twig-rush (*Baumea juncea*); occurring at a moderate to high density in four out of six quadrats.
- Tall Sedge (*Carex appressa*); occurring at a moderate density in two out of six quadrats; and
- Sea Rush (*Juncus kraussii* subsp. *kraussii*), Native Violet (*Viola* sp.), Spiny-headed Mat-rush (*Lomandra longifolia*), Azolla (*Azolla filiculoides*), Duckweed (*Lemna* sp.) and Red-fruited Saw-sedge (*Gahnia sieberiana*); all occurring at a moderate density in one out of six quadrats.

Sedge Swamp

Dominant flora species within the Sedge Swamp quadrats (refer to **Table 3.2**) consisted of:

- Broad-leaved Paperbark (*Melaleuca quinquenervia*); occurring in a moderate density in five out of six quadrats;
- Swamp Twig-Rush (*Baumea arthropphylla*); occurring in a high density in two out of six quadrats;
- Plume Rush (*Baloskion tetraphyllum*), occurring at a moderate to high density in two out of six quadrats.
- Weeping Baeckea (*Baeckea frutescens*) and Bryophyte (a moss sp.); both occurring at a moderate density in two out of six quadrats;
- Bare Twig-rush (*Baumea juncea*); occurring at a high density in one out of six quadrats; and
- Grass Tree (*Xanthorrhoea* sp.), Pouched Coral Fern (*Gleichenia dicarpa*), Sand Couch (*Sporobolus virginicus*), Zig-zag Bog-rush (*Schoenus brevifolius*) and Didgerie Sticks (*Baloskion pallens*); occurring at a moderate to high density in one out of six quadrats.

Vegetation characteristics recorded within quadrats along Transects 1-3 are detailed in **Table 3.3**. Characteristics recorded include vegetation habitat zone, vegetation structure and the species and dimensions of all trees >10 cm DBH. Broad-leaved Paperbark was by far the most common tree species recorded.



Indicator Species

Based on the expected changes to vegetation identified in Hydrosphere (2010b and 2011) and previous monitoring reports by GeoLINK (2011 and 2013), the following species were identified as indicator species for transects 1-3:

- Sea Rush (*Juncus kraussii* subsp. *australiensis*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.
- Saltwater Couch (*Paspalum vaginatum*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.
- Bare Twig-rush (*Baumea juncea*): expected to increase in the area currently occupied by Fringing Marsh.
- Broad-leaved Paperbark (*Melaleuca quinquenervia*): expected to increase in the area currently occupied by Fringing Marsh.

The average cover abundance value for each of these indicator species in the vegetation habitat zones is graphically represented in **Figure 3.1**. The results of the monitoring indicate that Plume Rush is a prominent feature of the Sedge Swamp community and Bare Twig Rush is a prominent species of the Swamp Forest. Sea Rush occurs across both the Fringing Marsh and Swamp Forest communities and Saltwater Couch is restricted to the Fringing Marsh community.

The occurrence of, and changes to, indicator species in relation to the results of previous vegetation monitoring are discussed in more detail in **Section 4**.

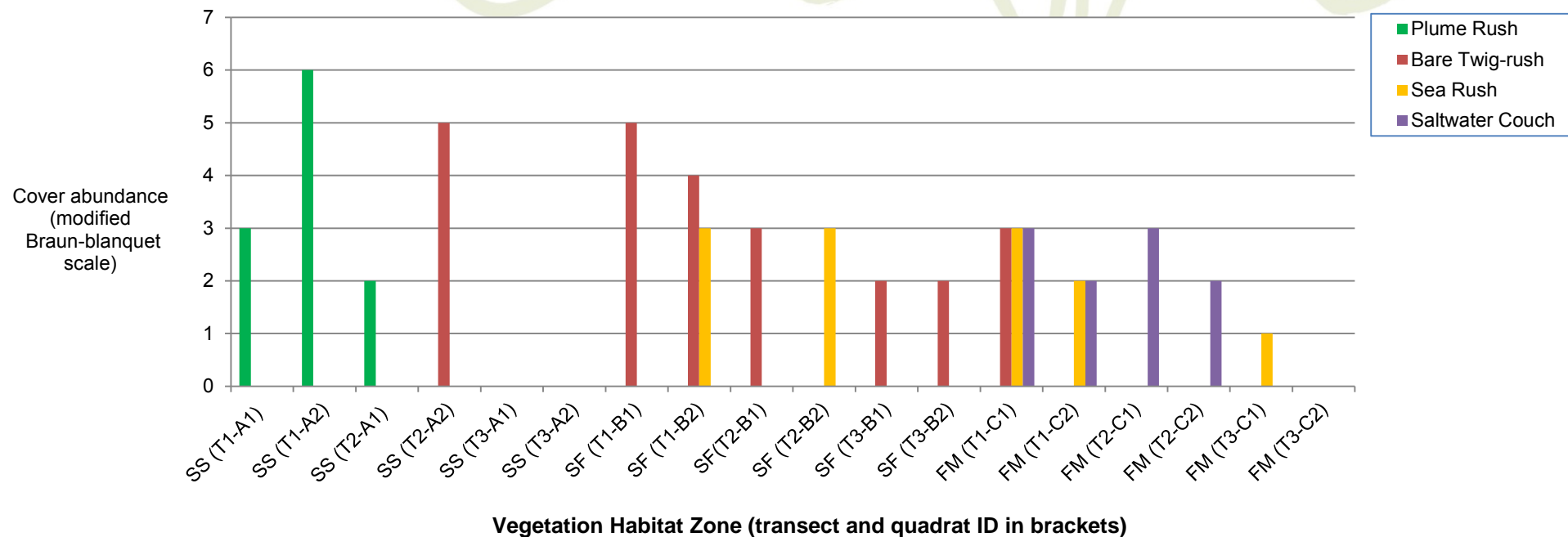


Figure 3.1 Cover Abundance Scores for Indicator Species in Vegetation Habitat Zones of Transects 1-3

Figure abbreviations – SS = Sedge Swamp, SF = Swamp Forest, FM = Fringing Marsh, T = Transect number, A, B etc. =Quadrat ID)

Table 3.3 Vegetation Structure and Characteristics - Quadrat Data for Transects 1-3

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
Transect 1	A1	Sedge Swamp	6	3	-	-	3	2	<2	6	Q2	<i>Eucalyptus robusta</i>	100/ 90	0	<i>Melaleuca quinquenervia</i> look healthy – no dead branches, galls etc. Some dead branchlets on <i>Eucalyptus robusta</i> . <i>Banksia ericifolia</i> x 2 dead within quadrat.
												<i>Eucalyptus robusta</i>	170		
												<i>Melaleuca quinquenervia</i>	200		
											Q3	<i>Melaleuca quinquenervia</i>	140	0	
												<i>Melaleuca quinquenervia</i>	200		
												<i>Melaleuca quinquenervia</i>	310		
												<i>Melaleuca quinquenervia</i>	130		
	Q4	<i>Melaleuca quinquenervia</i>	110	0											
	A2	Sedge Swamp	6	3	-	-	3	2	<1	6	Not recorded	<i>Melaleuca quinquenervia</i>	360	0	
												<i>Melaleuca quinquenervia</i>	100		
B1	Swamp Forest	8-10	3	-	-	-	-	<1.2	4	Q4	<i>Melaleuca quinquenervia</i>	220/ 150	0	Moderate number	

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
												Melaleuca quinquenervia	200	0	(approx. 7) Melaleuca quinquenervia now dead.
											Q3	Melaleuca quinquenervia	150		
											Melaleuca quinquenervia	190			
											Melaleuca quinquenervia	210			
											Melaleuca quinquenervia	140/ 170			
											Melaleuca quinquenervia	110			
											Melaleuca quinquenervia	110			
											Melaleuca quinquenervia	180			
	B2	Swamp Forest	-	-	-	-	4	3	<1.2	4	Q2	Melaleuca quinquenervia	100	0	Melaleuca quinquenervia healthy with new growth, flowering, no dieback or galls.
											Q1	Melaleuca quinquenervia	110	0	

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
	C1	Fringing Marsh	-	-	-	-	-	-	2	5	-	-	-	0	n/a - treeless vegetation/ open water
	C2	Fringing Marsh	-	-	-	-	-	-	1.5 - 2	5	-	-	-	0	n/a - treeless vegetation/ open water
Transect 2	A1	Sedge Swamp	10	3	-	-	-	-	<1.2	6	-	-	-	0	Melaleuca quinquenervia and Banksia ericifolia recorded in previous monitoring events now dead.
	A2	Sedge Swamp	10-12	3	-	-	-	-	<1.2	5	Q1	Melaleuca quinquenervia	180/ 120	0	Melaleuca quinquenervia healthy with new growth, flowering, no dieback or galls.
												Melaleuca quinquenervia	140		
											Q2	Melaleuca quinquenervia	300	0	
	Melaleuca quinquenervia	150/ 120													

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
											Q3	Melaleuca quinquenervia	250	0	
											Melaleuca quinquenervia	430			
	B1	Swamp Forest	10-12	4	-	-	-	-	1 – 1.5	5	Q1	Melaleuca quinquenervia	350	2	Canopy of Melaleuca quinquenervia appears moderately less dense than that near the lagoon edge. Despite this the vegetation is in good health, flowering and with no dead branches or galls.
												Melaleuca quinquenervia	410		
												Melaleuca quinquenervia	155/ 130		
											Q2	Melaleuca quinquenervia	215	0	
												Melaleuca quinquenervia	480		
												Melaleuca quinquenervia	100		
												Melaleuca quinquenervia	200		
												Melaleuca quinquenervia	340		

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
											Q4	Melaleuca quinquenervia	340	0	
	B2	Swamp Forest	6-8	3	-	-	-	-	<1.2	3	Q1	Melaleuca quinquenervia	150	0	Some recent death of small Melaleuca quinquenervia trees (x 6) present. Remaining trees are relatively healthy (no dead branches, evidence of dieback or galls).
											Melaleuca quinquenervia	110			
											Melaleuca quinquenervia	110			
											Melaleuca quinquenervia	110			
											Melaleuca quinquenervia	110			
											Melaleuca quinquenervia	280			
											Melaleuca quinquenervia	140/ 220			
											Q2	Melaleuca quinquenervia	120	0	
											Melaleuca quinquenervia	100			

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
												Melaleuca quinquenervia	100		
												Melaleuca quinquenervia	110		
												Melaleuca quinquenervia	130		
												Melaleuca quinquenervia	130		
												Melaleuca quinquenervia	160		
												Melaleuca quinquenervia	160		
												Melaleuca quinquenervia	170		
												Melaleuca quinquenervia	120		
												Melaleuca quinquenervia	190		
												Melaleuca quinquenervia	140/130		

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
											Q3	Melaleuca quinquenervia	270	0	
											Melaleuca quinquenervia	220/ 120			
											Q4	Melaleuca quinquenervia	140/ 120/ 130	0	
											Melaleuca quinquenervia	180			
											Melaleuca quinquenervia	140			
											Melaleuca quinquenervia	300			
											Melaleuca quinquenervia	180			
											Melaleuca quinquenervia	160			
											Melaleuca quinquenervia	130			
C1	Fringing Marsh	-	-	-	-	-	-	<1.2	3	-	-	-	0	n/a - treeless vegetation/ open water	

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
	C2	Fringing Marsh	-	-	-	-	-	-	<1.2	3	-	-	-	0	n/a - treeless vegetation/ open water
Transect 3	A1	Sedge Swamp	10-12	3	-	-	-	-	<1.2	6	Q1	Melaleuca quinquenervia	170	0	Melaleuca quinquenervia trees are relatively healthy (no dead branches, evidence of dieback or galls).
											Melaleuca quinquenervia	130/ 130			
											Melaleuca quinquenervia	180			
											Melaleuca quinquenervia	130			
											Melaleuca quinquenervia	120			
											Melaleuca quinquenervia	200			
											Melaleuca quinquenervia	220/ 220/ 120			
											Q3	Melaleuca quinquenervia	190/ 150	0	
											Melaleuca quinquenervia	110/ 110			

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
	A2	Sedge Swamp	12-15	3	-	-	-	-	<1.2	6	Q1	Melaleuca quinquenervia	210	0	Canopy of Melaleuca quinquenervia appears moderately less dense than that near the lagoon edge. Despite this the vegetation is in good health, flowering and with no dead branches or galls.
											Melaleuca quinquenervia	230			
											Melaleuca quinquenervia	120			
											Q2	Melaleuca quinquenervia	150	0	
											Melaleuca quinquenervia	180			
											Melaleuca quinquenervia	250			
											Melaleuca quinquenervia	210			
											Melaleuca quinquenervia	180			
											Melaleuca quinquenervia	200			
											Q3	Melaleuca quinquenervia	200	0	

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
												Melaleuca quinquenervia	160		
												Melaleuca quinquenervia	210		
												Melaleuca quinquenervia	290		
											Q4	Melaleuca quinquenervia	250	0	
												Melaleuca quinquenervia	140		
												Melaleuca quinquenervia	120		
												Melaleuca quinquenervia	180		
												Melaleuca quinquenervia	140		
	B1	Swamp Forest	12-15	4	-	-	-	-	1-1.5	4	Q1	Melaleuca quinquenervia	220	0	Canopy of Melaleuca quinquenervia appears moderately
												Melaleuca quinquenervia	150		

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
												Melaleuca quinquenervia	110		less dense than that near the lagoon edge. Despite this the vegetation is in good health, flowering and with no dead branches or galls.
												Melaleuca quinquenervia	170		
												Melaleuca quinquenervia	200		
												Melaleuca quinquenervia	200		
												Melaleuca quinquenervia	100		
											Q2	Melaleuca quinquenervia	270	0	
												Melaleuca quinquenervia	250		
												Melaleuca quinquenervia	240		
												Melaleuca quinquenervia	210		
												Melaleuca quinquenervia	110		

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
											Q3	Melaleuca quinquenervia	640	0	
	B2	Swamp Forest	10	3	-	-	-	-	<1.2	5	Q1	Melaleuca quinquenervia	840	0	Noticeably denser foliage on <i>Melaleuca quinquenervia</i> compared with quadrats A1 and A2. <i>Melaleuca quinquenervia</i> is in good health, flowering and with no dead branches or galls.
											Melaleuca quinquenervia	130			
											Melaleuca quinquenervia	210			
											Melaleuca quinquenervia	110			
											Melaleuca quinquenervia	190			
											Melaleuca quinquenervia	140			
											Melaleuca quinquenervia	140			
											Q3	Melaleuca quinquenervia	100		
												Melaleuca quinquenervia	140		

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics			Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Quadrant of Quadrat (Q1 = NW, Q2 = NE, Q3 = SE, Q4 = SW)	Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class					
												Melaleuca quinquenervia	150		
												Melaleuca quinquenervia	220		
												Melaleuca quinquenervia	150/ 180		
											Q4	Melaleuca quinquenervia	110	0	
												Melaleuca quinquenervia	100/ 100		
												Melaleuca quinquenervia	150		
	C1	Fringing Marsh	-	-	-	-	-	-	<1.2	3	-	-	-	0	n/a - treeless vegetation/ open water
	C2	Fringing Marsh	-	-	-	-	-	-	-	-	-	-	-	0	n/a - open water

3.1.2 Transects 4-6

3.1.2.1 Vegetation Habitat Zone Boundaries

Transects 4-6 each traverse the following two distinct vegetation habitat zones:

- Transect 4: Sedge Swamp/ open water and Swamp Forest; and
- Transect 5 and 6: Fringing Marsh and Banksia Woodland.

The location of the monitoring transects is shown in **Illustration 3.1**.

Transect 4 traverses the drainage channel (i.e. channel from the STP) and is orientated generally in a north-south direction while Transects 5 and 6 lie generally east-west and are located behind the dune system, immediately to the east of Salty Lagoon.

The vegetation habitat zone boundaries along Transects 5 and 6 were fairly well defined in the field at the time of survey. However, as the level of the lagoon has increased following the artificial channel closure, the extent of the Fringing Marsh community has decreased substantially, being replaced by open water.

3.1.2.2 Species Composition of Vegetation Habitat Zones

In total, 28 flora species (both native and exotic) were recorded from the four vegetation habitat zones. The breakdown of species by vegetation habitat zones was as follows:

Sedge Swamp/ Open Water – 13 species

Swamp Forest – 10 species

Fringing Marsh – 17 species

Banksia Woodland – 14 species

The dominant flora species by average cover abundance (three and above) within quadrats along Transects 4-6 is represented in **Table 3.4**.

Table 3.4 Dominant Flora by Cover Abundance (modified Braun-Blanquet cover classes) in Quadrats along Transects 4-6

	Common Name	Scientific Name	Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland
Transect 4	Quadrat A1					
	Shore Club-rush	<i>Schoenoplectus subulatus</i>	3			
	Sea Rush	<i>Juncus kraussii</i> subsp. <i>australiensis</i>	3			
	Saltwater Couch	<i>Paspalum vaginatum</i>	3			
	Bare Twig-rush	<i>Baumea juncea</i>	3			

	Common Name	Scientific Name	Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland
	Quadrat B1					
	Azolla	<i>Azolla filiculoides</i>		5		
	Duckweed	<i>Lemna sp.</i>		3		
	Bare Twig-rush	<i>Baumea juncea</i>		3		
	Saltwater Couch	<i>Paspalum vaginatum</i>		3		
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		3		
Transect 5	Quadrat A1					
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>			3	
	Bare Twig-rush	<i>Baumea juncea</i>			3	
	Blady Grass	<i>Imperata cylindrica</i>			3	
	Quadrat B1					
	Coast Banksia	<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>				4
	Blady Grass	<i>Imperata cylindrica</i>				4
	Snake Vine	<i>Stephania japonica</i>				3
Transect 6	Quadrat A1					
	Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>			3	
	Bare Twig-rush	<i>Baumea juncea</i>			3	
	Quadrat B1					
	Blady Grass	<i>Imperata cylindrica</i>				6
	Coast Banksia	<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>				3

Note: indicator species shown in **bold**

The cover abundance score for all flora species recorded within quadrats along Transects 4-6 is provided in **Appendix B** (Table B2).



3.1.2.3 Vegetation Habitat Zone Descriptions

Transect 4

Sedge Swamp/ Open Water

Dominant flora species within the Sedge Swamp/ Open Water quadrats (refer to **Table 3.4**) consisted of:

- Sea Rush (*Juncus kraussii* subsp. *australiensis*), Bare Twig-rush (*Baumea juncea*), Shore Club-rush (*Schoenoplectus subulatus*), and Saltwater Couch (*Paspalum vaginatum*); all occurring at a moderate density.

Swamp Forest

Dominant flora species within the Swamp Forest (refer to **Table 3.4**) consisted of:

- Azolla (*Azolla filiculoides*) occurring at a high density; and
- Duckweed (*Lemna* sp.), Bare Twig-rush (*Baumea juncea*), Saltwater Couch (*Paspalum vaginatum*), and Broad-leaved Paperbark (*Melaleuca quinquenervia*); all occurring at a moderate density.

Transects 5

Fringing Marsh

Dominant flora species within the Fringing Marsh (refer to **Table 3.4**) consisted of:

- Broad-leaved Paperbark (*Melaleuca quinquenervia*), Bare Twig-rush (*Baumea juncea*) and Blady Grass (*Imperata cylindrica*); all occurring at a moderate density.

Banksia Woodland

Dominant flora species within the Banksia Woodland (refer to **Table 3.4**) consisted of:

- Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*), Blady Grass (*Imperata cylindrica*) and Snake Vine (*Stephania japonica*); all occurring at a moderate density.

Transect 6

Fringing Marsh

Dominant flora species within the Fringing Marsh (refer to **Table 3.4**) consisted of:

- Broad-leaved Paperbark (*Melaleuca quinquenervia*) and Bare Twig-rush (*Baumea juncea*); each occurring at a moderate density.

Banksia Woodland

Dominant flora species within the Banksia Woodland (refer to **Table 3.4**) consisted of:

- Blady Grass (*Imperata cylindrica*), occurring at a high density; and

- 
- Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*), occurring at a moderate density.

3.1.2.4 Indicator Species

Based on the expected changes to vegetation identified in Hydrosphere (2010b and 2011) and previous monitoring reports by GeoLINK (2011 and 2013), the following species were identified as indicator species for transects 4-6:

- Sea Rush (*Juncus kraussii* subsp. *australiensis*) (prediction was that this species will decrease in the area currently occupied by the Gahnia sedge/ open water habitat zone along Transect 4)
- Saltwater Couch (*Paspalum vaginatum*) (prediction was that this species is expected to decrease in the area currently occupied by the Swamp Forest along Transect 4 and Fringing Marsh along Transect 5).
- Shore Club-rush (*Schoenoplectus subulatus*) (prediction was that this species is expected to decrease in the area currently occupied by Fringing Marsh vegetation habitat zone along Transects 5 and 6).
- Saw-sedge (*Gahnia* spp.) (prediction was that this species is expected to increase in the area currently occupied by Sedge Swamp/ open water in Transect 4).
- Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*) (prediction was that this species is expected to retain current density within the Banksia Woodland with expected water level changes).

Vegetation characteristics recorded within quadrats along Transects 4-6 are detailed in **Table 3.5**. Characteristics recorded include vegetation habitat zone, vegetation structure and the species and dimensions of all trees >10 cm DBH.

The average cover abundance value for each of these indicator species in the vegetation habitat zones is shown in **Figure 3.2**. Results of the monitoring indicate that Sea Rush and Saltwater Couch are prominent in the Sedge Swamp/ Open Water and Swamp Forest communities along Transect 4. Saw Sedge also occurs in the Swamp Forest community along Transect 4, while Coast Banksia is the dominant species occurring in the Banksia Woodland community along Transects 5 and 6.

The occurrence of, and changes to, indicator species in relation to previous vegetation monitoring results are discussed in **Section 4**.

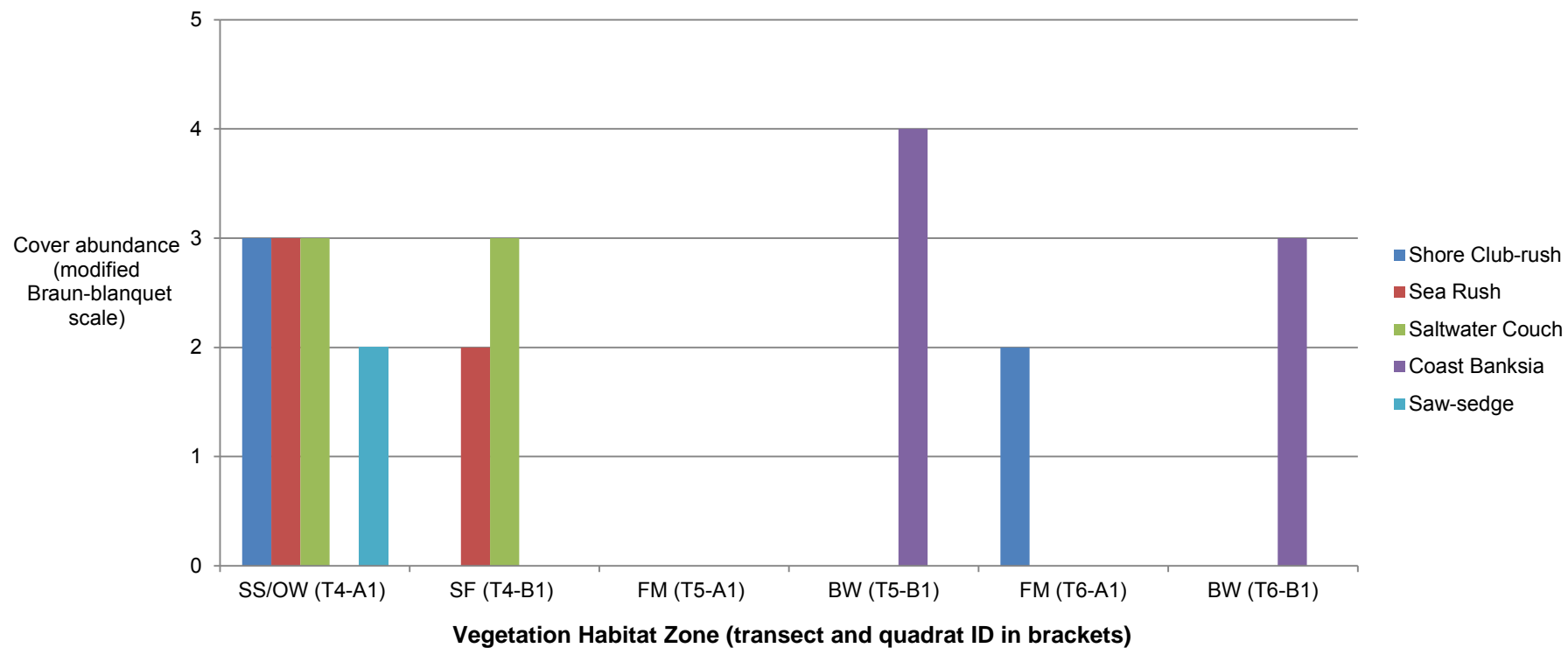


Figure 3.2 Cover Abundance Scores for Indicator Species in Vegetation Habitat Zones of Transects 4-6

Figure abbreviations – SS = Sedge Swamp, OW = Open Water, SF = Swamp Forest, FM = Fringing Marsh, BW = Banksia Woodland, T = Transects number, A, B etc. = Quadrat ID

Table 3.5 Vegetation Structure and Characteristics - Quadrat Data for Transects 4-6

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics		Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class				
Transect 4	A1	Sedge Swamp/ Open Water	-	-	-	-	-	-	<2	4	-	-	0	
	B1	Swamp Forest	8-10	3	-	-	-	-	<0.5	6	Melaleuca quinquenervia	250	0	Melaleuca quinquenervia trees are relatively healthy (no dead branches, evidence of dieback or galls).
											Melaleuca quinquenervia	410		
											Melaleuca quinquenervia	320		
											Melaleuca quinquenervia	370		
											Melaleuca quinquenervia	300/ 240		
											Melaleuca quinquenervia	205		
Transect 5	A1	Fringing Marsh	4	3	-	-	-	-	<1.2	3	Melaleuca quinquenervia	330	0	Melaleuca quinquenervia trees are relatively healthy (no dead branches, evidence of dieback or galls).
	B1	Banksia Woodland	4	4	-	-	-	-	<1.2	4	Banksia integrifolia subsp.	170	0	Banksia integrifolia trees are

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics		Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class				
											<i>integrifolia</i>			relatively healthy (no dead branches, evidence of dieback or galls).
											<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>	170		
											<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>	110		
											<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>	110		
											<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>	220/ 220		
											<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>	110/ 110		
											<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>	110		
Transect 6	A1	Fringing Marsh	4	3	-	-	-	-	<1.2	3	<i>Melaleuca quinquenervia</i>	300/ 450	0	<i>Melaleuca quinquenervia</i> trees are relatively
											<i>Melaleuca quinquenervia</i>	300/ 300		

Transect	Quadrat	Vegetation Habitat Zone	Vegetation Structure								Tree Characteristics		Saplings	Comments on Vegetation Health
			Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Tree Species	DBH of trees (mm) (/ indicates multiple trunks)		
			Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class				
											Melaleuca quinquenervia	340		healthy (no dead branches, evidence of dieback or galls).
	B1	Banksia Woodland	4	3	-	-	-	-	<1.2	6	Banksia integrifolia subsp. integrifolia	300	0	Banksia integrifolia is relatively healthy (no dead branches, evidence of dieback or galls).



3.2 Melaleuca Dieback/ Recolonisation Monitoring

Results from the Melaleuca dieback quadrats are shown in **Table 3.5**. Less than half of the quadrats contained dead Melaleuca individuals (6 out of 15), with the least dieback being recorded in the quadrats located along Transect 1. This reflects a very low general occurrence of Melaleuca (living or dead) in Melaleuca dieback quadrats along this transect. Most of the Melaleuca dieback recorded was in quadrats furthest from the edge of the lagoon, where Melaleuca dominance was also greatest.

A relatively low proportion of quadrats contained regenerating Melaleuca seedlings (4 out of 15) or saplings (5 out of 15).

Where living Melaleuca was present, in general the health appeared good, with thick foliage, flowering and no presence of necrotic spots on leaves or galls on small branches.

Table 3.6 Melaleuca Dieback Quadrat Data

Transect	Vegetation Habitat Zone	Vegetation Structure								Melaleuca Counts						Condition
		Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Trees#	Small Trees^	Seedlings*	Saplings	Dead Individuals	Tree diameter	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Sapling Count	Dead Individuals Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
Transect 1	Quadrat A															
	Fringing Marsh	-	-	-	-	-	-	1.5	6	0	2	1	0	0	-	No Broad-leaved Paperbark present
	Quadrat B															
	Fringing Marsh/ Swamp Forest	-	-	-	-	-	-	2	5	0	2	0	1	0	-	No Broad-leaved Paperbark present
	Quadrat C															
	Fringing Marsh/ Swamp Forest	2.5-3	3	-	-	-	-	2	5	0	2	0	4	0	-	Trees appear healthy with thick foliage and currently flowering
	Quadrat D															
	Fringing	4-5	4	-	-	-	-	1-1.2	4	4	14	0	1	1	150	Trees

Transect	Vegetation Habitat Zone	Vegetation Structure								Melaleuca Counts						Condition
		Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Trees#	Small Trees^	Seedlings*	Saplings	Dead Individuals	Tree diameter	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Sapling Count	Dead Individuals Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
	Marsh/ Swamp Forest														170	appear healthy with thick foliage and currently flowering
															115	
	Quadrat E															
	Fringing Marsh/ Swamp Forest	4-5	1	-	-	-	-	1-1.2	5	1	1	1	2	1	160/ 160/ 160	Trees appear healthy with thick foliage and currently flowering
	Transect 2	Quadrat A														
Fringing Marsh		-	-	-	-	-	-	1-1.5	3	0	0	0	0	0	-	No Broad-leaved Paperbark present
Quadrat B																
Fringing Marsh		-	-	-	-	-	-	1-1.5	4	0	3	0	0	1	100	No live Broad-leaved Paperbark

Transect	Vegetation Habitat Zone	Vegetation Structure								Melaleuca Counts						Condition
		Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Trees#	Small Trees^	Seedlings*	Saplings	Dead Individuals	Tree diameter	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Sapling Count	Dead Individuals Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
																present
Quadrat C																
	Fringing Marsh	-	-	-	-	-	-	1.5-2	4	0	2	0	0	0	-	No live Broad-leaved Paperbark present
Quadrat D																
	Fringing Marsh	-	-	-	-	-	-	1.2	3	1	0	6	0	2	110 110/ 150/ 150	No live Broad-leaved Paperbark present
Quadrat E																
	Fringing Marsh/ Swamp Forest	4	1	-	-	-	-	<1.2	3	8	6	5	1	8	120 110/ 100/ 100 110	Trees appear healthy with thick foliage and currently flowering

Transect	Vegetation Habitat Zone	Vegetation Structure								Melaleuca Counts						Condition
		Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Trees#	Small Trees^	Seedlings*	Saplings	Dead Individuals	Tree diameter	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Sapling Count	Dead Individuals Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
															110	
															100	
															230	
															110	
Transect 3	Quadrat A															
	Fringing Marsh	-	-	-	-	-	-	<1.2	3	0	0	0	0	0	0	No Broad-leaved Paperbark present
	Quadrat B															
	Fringing Marsh	-	-	-	-	-	-	<1.2	3	0	0	0	0	0	0	No Broad-leaved Paperbark present
	Quadrat C															
	Fringing Marsh	-	-	-	-	-	-	<1.2	6	0	0	0	0	0	0	No live Broad-leaved Paperbark present.

Transect	Vegetation Habitat Zone	Vegetation Structure								Melaleuca Counts						Condition
		Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Trees#	Small Trees^	Seedlings*	Saplings	Dead Individuals	Tree diameter	
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Sapling Count	Dead Individuals Count	DBH (mm) of trees >100 mm (/ indicates multiple trunks)	
																Dead trees <100 mm DBH are present
Quadrat D																
	Fringing Marsh	-	-	-	-	-	-	<1.2	6	0	0	0	0	0	0	No live Broad-leaved Paperbark present.
Quadrat E																
	Swamp Forest	10	4	-	-	-	-	1-1.5	5	24	0	0	0	16	110	Trees appear healthy with thick foliage and currently flowering. However, at least 4 small Melaleuca appear to have recently
															120	
															130	
															120	
															100	
															100	

Transect	Vegetation Habitat Zone	Vegetation Structure								Melaleuca Counts					Tree diameter	Condition
		Upper Stratum		Upper-mid Stratum		Mid Stratum		Lower Stratum		Trees#	Small Trees^	Seedlings*	Saplings	Dead Individuals		
		Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Height (m)	Cover Class	Trees Count	Small Trees Count	Seedling Count	Sapling Count	Dead Individuals Count		
															100	died.
															110	
															140/ 140 /120/ 100/ 110	
															130	
															130	
															110	
															120	
															100	
															100	

Trees – DBH of each stem >100 mm

^ Small trees – DBH 50-100 mm

* Seedlings – height <0.5 m



3.3 Photo Point Monitoring

Photographs taken at photo monitoring points in March 2015 are shown in **Appendix C**.



4. Discussion and Comparison with Previous Monitoring

4.1 Vegetation Habitat Zonation

4.1.1 Transects 1-3

A reduction in the extent of the Fringing Marsh community around the western edge of Salty Lagoon has continued since the artificial channel was closed in 2012. Much of the area previously occupied by this community prior to the channel closure is now open water. When compared with the extent of this community recorded in baseline monitoring the reduction in extent has been between 137 m and 216 m, with the greatest reduction in this community occurring in the southern section of Salty Lagoon along Transect 3.

Variation in the extent of Sedge Swamp and Swamp Forest since baseline monitoring has not been significant, reflecting that the primary driving factor for vegetation change to date is related to the rising water level in Salty Lagoon and associated lowering of salinity levels as the system changes to being more freshwater dominated.

4.1.1.1 Species Composition of Vegetation Habitat Zones

The overall number of flora species recorded in the three vegetation communities along Transects 1-3 has continued to decline, with only 47 species recorded in the current monitoring, compared with 55 in 2013 and 73 in 2011 prior to the closure of the artificial channel. The major factor contributing to this decrease in the number of species recorded was the closure of the artificial channel and the resulting expansion of open water covering previously exposed ground in the Fringing Marsh. Twenty-eight flora species were recorded in the Fringing Marsh in 2011 compared with a count of seven species in 2013 and 11 in the current monitoring. A relatively large proportion of the flora species occurring in the Fringing Marsh community were low-growing herbaceous species that are intolerant of submersion for an extended period.

Reduction in species diversity in Sedge Swamp and Swamp Forest has also been apparent since 2011. Despite being further from the new edge of open water in Salty Lagoon, nonetheless a substantial area of the Swamp Forest community is now regularly inundated (particularly following heavy rainfall events), and similar to the Fringing Marsh community, these inundation events may be having the overall effect of reducing flora diversity in the herbaceous understorey. However, the reason why a reduction in species diversity since 2011 has occurred in the Sedge Swamp community (which is generally not as prone to inundation) remains unclear.

4.1.1.2 Species Dominance

Since monitoring in 2011 the species dominance in the Fringing Marsh community has changed substantially, with a decline in the cover of Sea Rush (*Juncus kraussii* subsp. *australiensis*) and Saltwater Couch (*Paspalum vaginatum*) and an increase in the cover of Common Reed (*Phragmites australis*) and Shore Club-rush (*Schoenoplectus subulatus*) (refer to **Plate 4.1**).



Plate 4.1 Common Reed dominating areas of Fringing Marsh in 2015

In contrast, the dominant flora species has not substantially changed since 2011, consisting of Broad-leaved Paperbark (*Melaleuca quinquenervia*) and Bare Twig-rush (*Baumea juncea*) in the Swamp Forest community and Broad-leaved Paperbark, Plume Rush (*Baloskion tetraphyllum*) and Swamp Twig-rush (*Baumea arthropphylla*) in the Sedge Swamp community.

4.1.1.3 Predicted Changes and Indicator Species

The following predicted changes were listed in the baseline vegetation monitoring report. These are discussed in turn.

1. Sea Rush (*Juncus kraussii* subsp. *australiensis*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.

The decrease in cover of Sea Rush in both of these communities that was recorded in the 2013 monitoring has continued, with the reduction most prominent in the Fringing Marsh community (refer to **Plate 4.2** and **Plate 4.3**). This is attributable to the greater degree of inundation that has occurred in the Fringing Marsh community since channel closure.



Plate 4.2 Open-water along Transect 3 in 2015



Plate 4.3 Sea Rush dominated the same area along Transect 3 in 2011

2. Saltwater Couch (*Paspalum vaginatum*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.

A similar pattern to that seen for Sea Rush has also occurred with Saltwater Couch. There has been a decrease in cover of this species in both of these communities, with the most notable reduction occurring in the Swamp Forest community in which no Saltwater Couch was recorded in the 2015 monitoring. This absence may be a response to inundation and lower salinity levels in the Swamp

Forest community as Salty Lagoon transitions to a more freshwater-dominated system following channel closure.

3. Shore Club-rush (*Schoenoplectus subulatus*): expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest.

In the MPCC vegetation monitoring report, Shore Club-rush (*Schoenoplectus subulatus*) was identified as a potential indicator species that was expected to decrease in the area currently occupied by Fringing Marsh and Swamp Forest. This species has been recorded at a low density in the Swamp Forest community in all previous monitoring events and at a low to moderate density in the Fringing Marsh community, with no substantial decrease occurring in the area currently occupied by this species since channel closure.

4. Bare Twig-rush (*Baumea juncea*): expected to increase in the area currently occupied by Fringing Marsh.

The monitoring results indicate that Bare Twig-rush has not substantially increased in the Fringing Marsh community since 2011.

5. Broad-leaved Paperbark (*Melaleuca quinquenervia*): expected to increase in the area currently occupied by Fringing Marsh.

Broad-leaved Paperbark has not substantially extended into the Fringing Marsh as yet. The cover of this species has also remained relatively stable in and around the edge of the Swamp Forest community with neither an obvious decline in the health of Broad-leaved Paperbark occurring, nor a substantial increase in recruitment. However, this may be a reflection that the time since the closure of the artificial channel has been insufficient for changes to woody vegetation to become apparent. Future vegetation monitoring in 2017 may show that this species has extended into the Fringing Marsh over a longer time frame.

4.1.2 Transects 4-6

The major influencing factor on the extent of the vegetation communities in transects 5 and 6 was also related to increased water levels caused by the closure of the artificial channel. This is most apparent when a comparison is made between the monitoring photos for the Fringing Marsh/ Open Water quadrats in 2011 and the current monitoring event (refer to **Plate 4.4** and **Plate 4.5**).



Plate 4.4 Transect 6, quadrat A1 in 2011



Plate 4.5 Transect 6, quadrat A1 in 2015



4.1.3 Species Composition of Vegetation Habitat Zones

The overall number of species recorded in the vegetation communities along these transects was relatively not substantially changed in the period of 2011 to 2015, with 32 species recorded in 2011 and 28 species in 2015.

4.1.4 Species Dominance

Species dominance was relatively stable between monitoring events, with the exception of the Fringing Marsh community in which the dominant species have shifted from Saltwater Couch and Shore Club-rush in 2011 to Bare Twig-rush in fringing areas. This reflects the higher water levels (and associated freshwater-influence) following channel closure.

Blady Grass and Coast Banksia remain dominant species in the Banksia Woodland community.

4.1.5 Predicted Changes and Indicator Species

The following predicted changes were identified in the 2011 monitoring. These are discussed in turn.

1. Sea Rush (*Juncus kraussii* subsp. *australiensis*) (expected to decrease in the area currently occupied by the Gahnia sedge/ open water habitat zone along Transect 4).

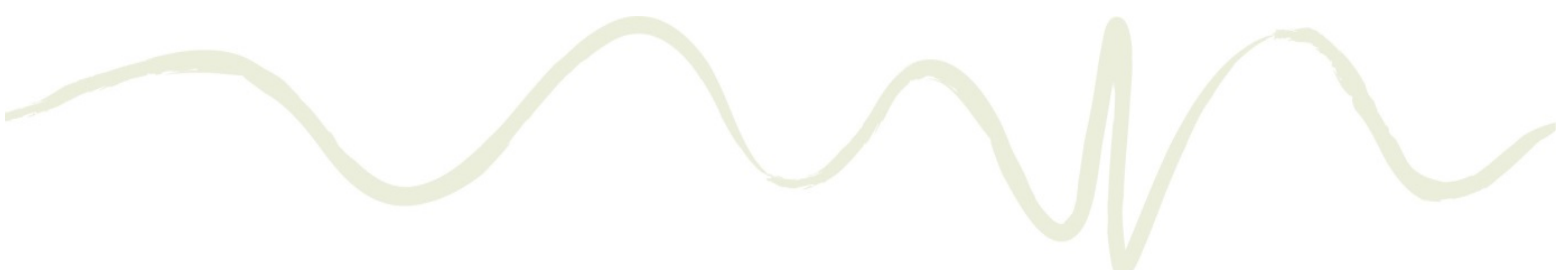
Sea Rush has shown no significant difference in cover between the 2011 monitoring and the current monitoring event. Although Sea Rush has decreased substantially overall within the Fringing Marsh community surrounding Salty Lagoon, this species still occurs at a low to moderate density in some areas, including the fringe of the drainage channel that Transect 4 crosses.

2. Saltwater Couch (*Paspalum vaginatum*) (expected to decrease in the area currently occupied by the Swamp Forest along Transect 4 and Fringing Marsh along Transect 5).

This prediction appears to have been borne out, with a lower cover being recorded in the Swamp Forest community along Transect 4 in the current monitoring and an absence from the Fringing Marsh community along Transect 5. As was discussed for Transects 1-3, this decrease in cover of Saltwater Couch is likely to be related to inundation and lower salinity levels in the Swamp Forest community as Salty Lagoon transitions to a more freshwater-dominated system following channel closure.

3. Shore Club-rush (*Schoenoplectus subulatus*) (expected to decrease in the area currently occupied by Fringing Marsh vegetation habitat zone along Transects 5 and 6).

As predicted this Shore Club-rush has decreased in cover within the Fringing Marsh community along Transect 5 and Transect 6 between 2011 and the current monitoring event. It is interesting that this species has not undergone a similar decrease in cover on the western margin of Salty Lagoon (Fringing Marsh quadrats along Transects 1-3) over the same monitoring period. This may be related to the water depth along the eastern fringe of Salty Lagoon now being relatively deep since closure of the artificial channel. On this eastern fringe there is currently a relatively distinct boundary between dry ground occupied by Banksia woodland and open water, while the transition from dryland heath communities to open water is much more gradual along the western fringe of Salty Lagoon. Consequently, the shallower water depth may be allowing Shore Club-rush to persist on the western fringe of Salty Lagoon.

- 
4. Saw-sedge (*Gahnia* spp.) expected to increase in the area currently occupied by Sedge Swamp/ open water in Transect 4).

Along Transect 4 Saw-sedge has not undergone a substantial increase in cover between the 2011 monitoring and the current monitoring event. However, opportunistic observations of this species in areas not covered by quadrats elsewhere (e.g. fringing small areas of deeper water along channels/ mini lagoons within the Swamp Forest community) seem to indicate that an increase in the prominence of this species has occurred since 2011 (however, this observation is not backed up by systematically collected quadrat data).

5. Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*) (expected to retain current density within the Banksia Woodland with expected water level changes).

As predicted, Coast Banksia has maintained a similar cover level in the Banksia Woodland between the 2011 monitoring and the current monitoring event.

4.1.6 Melaleuca Dieback/ Recolonisation Monitoring

Data recorded in the 2011 monitoring and the current monitoring is broadly consistent, with little recolonisation evident nor any further dieback occurring. The overall health of the existing Broad-leaved Paperbark was observed to be good, with thick foliage and flowering observed at the time of the current monitoring.

It is postulated that with the generally elevated water level in Salty Lagoon following closure of the artificial channel, suitable conditions for recolonisation by Broad-leaved Paperbark may now occur less frequently (assuming that for germination to occur, seeds must be able to contact with moist, bare soil). Suitable conditions for germination may now occur only during prolonged dry periods when the lagoon recedes. Such prolonged dry conditions would be expected to occur relatively infrequently, and consequently, substantial recolonisation of the lagoon edge by Broad-leaved Paperbark may only be apparent after several years or even decades have elapsed (significantly longer than the timeframe of the monitoring program which ends in 2017).

4.1.7 Future Monitoring

The results of the 2015 vegetation monitoring indicate that vegetation change has occurred around the lagoon, particularly in the Fringing Marsh community, where both the extent of this community has decreased and the dominant species have shifted in relation to inundation and changes in salinity. Some of the vegetation changes that have been observed are broadly consistent with the predictions made in Hydrosphere (2010b and 2011). Other changes may only become apparent as more time elapses since the closure of the artificial channel, such as substantial recolonisation of the western lagoon edge by Broad-leaved Paperbark.



References

GeoLINK (2012). *Vegetation Monitoring Report: Salty Lagoon – Baseline*. Report to Richmond Valley Council. GeoLINK, Lennox Head, NSW.

GeoLINK (2013). *Vegetation Monitoring Report: Salty Lagoon – May 2013*. Report to Richmond Valley Council. GeoLINK, Lennox Head, NSW.

Hydrosphere (2010a). *Salty Lagoon Ecosystem Recovery Monitoring Program (ERMP)*. A report by Hydrosphere Consulting to Richmond Valley Council. Hydrosphere Consulting, Ballina.

Hydrosphere (2010b). *Salty Lagoon Ecosystem Recovery Monitoring Program Pre-Post Closure (MPPC)*. A report by Hydrosphere Consulting to Richmond Valley Council. Hydrosphere Consulting, Ballina.

Hydrosphere (2011). *Salty Lagoon Rehabilitation Plan*. A report by Hydrosphere Consulting to Richmond Valley Council. Hydrosphere Consulting, Ballina.



Copyright and Usage

©GeoLINK, 2015

This document, including associated illustrations and drawings, was prepared for the exclusive use of Richmond Valley Council. It is not to be used for any other purpose or by any other person, corporation or organisation without the prior consent of GeoLINK. GeoLINK accepts no responsibility for any loss or damage suffered howsoever arising to any person or corporation who may use or rely on this document for a purpose other than that described above.

This document, including associated illustrations and drawings, may not be reproduced, stored, or transmitted in any form without the prior consent of GeoLINK. This includes extracts of texts or parts of illustrations and drawings.

The information provided on illustrations is for illustrative and communication purposes only. Illustrations are typically a compilation of data supplied by others and created by GeoLINK. Illustrations have been prepared in good faith, but their accuracy and completeness are not guaranteed. There may be errors or omissions in the information presented. In particular, illustrations cannot be relied upon to determine the locations of infrastructure, property boundaries, zone boundaries, etc. To locate these items accurately, advice needs to be obtained from a surveyor or other suitably-qualified professional.



Appendix A

GPS Locations of Vegetation Habitat Zone Boundaries and Monitoring Quadrats

Table A.1 Waypoints Defining the Boundaries of the Three Vegetation Habitat Zones along Transects 1-3

<i>Transect</i>	<i>Vegetation Habitat Zone</i>	<i>Easting</i>	<i>Northing</i>	<i>Comment</i>
1	Sedge Swamp (western boundary)	541564	6783212	
1	Sedge Swamp/ Swamp Forest	541601	6783226	
1	Swamp Forest/ Fringing Marsh	541791	6783090	
1	Fringing Marsh/ Open Water	541833	6783072	
2	Sedge Swamp (western boundary)	541411	6782750	
2	Sedge Swamp/ Swamp Forest	541473	6782756	
2	Ecotone between Swamp Forest and Fringing Marsh	541692- 541787	6782815- 6782826	Ecotone – location of edges is given as two figures
2	Fringing Marsh/ Open Water	541825	6782828	
3	Sedge Swamp (western boundary)	541521	6782411	
3	Sedge Swamp/ Swamp Forest	541689	6782469	
3	Swamp Forest/ Fringing Marsh	541833	6782525	
3	Fringing Marsh/ Open Water	541873	6782538	

Table A2 Location of Vegetation Habitat Zone Quadrats

<i>Transect Number</i>	<i>Quadrat Number</i>	<i>Vegetation Habitat Zone</i>	<i>Easting</i>	<i>Northing</i>
1	A1	Sedge Swamp	541564	6783237
	A2		541579	6783231
	B1	Swamp Forest	541699	6783134
	B2		541743	6783114
	C1	Fringing Marsh	541832	6783076
	C2		541885	6783044
2	A1	Sedge Swamp	541411	6782754
	A2		541453	6782756
	B1	Swamp Forest	541523	6782775
	B2		541646	6782802
	C1	Fringing Marsh	541833	6782839
	C2		541927	6782849
3	A1	Sedge Swamp	541559	6782425
	A2		541588	6782425
	B1	Swamp Forest	541697	6782464
	B2		541784	6782504
	C1	Fringing Marsh	541895	6782543
	C2		542002	6782591
4	A1	Sedge Swamp Open Water	541785	6782669
	B1	Swamp Forest	541783	6782683
5	A1	Sedge Swamp Open Water	542090	6782821
	B1	Banksia Woodland	542072	6782821
6	A1	Sedge Swamp Open Water	542109	6783073
	B1	Banksia Woodland	542118	6783068

Table A3 Location of Melaleuca Dieback Quadrats

<i>Transect Number</i>	<i>Quadrat Number</i>	<i>Vegetation Habitat Zone</i>	<i>Easting</i>	<i>Northing</i>
1	A	Fringing Marsh	541828	6783071
	B		541811	6783082
	C	Fringing Marsh/ Swamp Forest	541795	6783092
	D		541796	6783092
	E		541760	6783108
2	A	Fringing Marsh	541833	6782839
	B		541817	6782833
	C		541790	6782829
	D		541767	6782824
	E		541751	6782825
3	A	Fringing Marsh	541909	6782556
	B		541895	6782543
	C		541871	6782545
	D		541853	6782532
	E	Swamp Forest	541835	6782524



Appendix B

Cover Abundance of All Flora Species

Table B1 Cover Abundance of All Flora Species Occurring in Transects 1-3

Common Name	Scientific Name	Transect 1			Transect 2			Transect 3		
		Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
Blackwood	<i>Acacia melanoxylon</i>								1	
a Wattle	<i>Acacia</i> sp.									1
Lesser Joyweed	<i>Alternanthera denticulata</i>	2				1			2	
Midgen Berry	<i>Austromyrtus dulcis</i>			2						
Azolla	<i>Azolla filiculoides</i>	3			3	3		2		
*Groundsel Bush	<i>Bachcharis halamifolia</i>								2	
Bacopa	<i>Bacopa monnieri</i>	2			2			1	2	
Weeping Baeckea	<i>Baeckea frutescens</i>			3			3			
Didgery Sticks	<i>Baloskion pallens</i>						3			
Plume Rush	<i>Baloskion tetraphyllum</i>			3-6			2			
Swamp Twig-rush	<i>Baumea arthropphylla</i>						4			6
Bare Twig-rush	<i>Baumea juncea</i>	3	4-5			3	5		2	
Tall Sedge	<i>Carex appressa</i>					3			4	
a Laurel Dodder	<i>Cassytha</i> sp.			1			1			1

Common Name	Scientific Name	Transect 1			Transect 2			Transect 3		
		Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
a Parrot Pea	<i>Dillwynia</i> sp.						2			
Blueberry Ash	<i>Elaeocarpus reticulatis</i>			2						
Wiry Panic	<i>Entolasia stricta</i>									1
Swamp Mahogany	<i>Eucalyptus robusta</i>			2						
Red-fruited Saw-sedge	<i>Gahnia sieberiana</i>			2		3			2	2
Pouched Coral Fern	<i>Gleichenia dicarpa</i>									3
Purple Coral Pea	<i>Hardenbergia violacea</i>									1-2
Twining Guinea Flower	<i>Hibbertia scandens</i>			1					2	
Pennywort	<i>Hydrocotyle bonariensis</i>					1			2	
Blady Grass	<i>Imperata cylindrica</i> var. <i>major</i>								2	
Sea Rush	<i>Juncus kraussii</i> subsp. <i>australiensis</i>	2-3	3					1		
Duckweed	<i>Lemna</i> sp.	3			3	3		2		
Variable Sword-sedge	<i>Lepidosperma laterale</i>						1			
Grey Rush	<i>Lepironia articulata</i>					2		1		


Common Name	Scientific Name	Transect 1			Transect 2			Transect 3		
		Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
Prickly Tea Tree	<i>Leptospermum juniperinum</i>			2-4						
Olive Tea-tree	<i>Leptospermum liversidgei</i>								1	2
Spiny-headed Mat-rush	<i>Lomandra longifolia</i>								3	
Swamp Box	<i>Lophostemon suaveolens</i>								1	
Milk Vine	<i>Marsdenia rostrata</i>								2	
Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		3-4	4		4	4		3-4	3
Water Snowflake	<i>Nymphoides indica</i>	2							2	
Monkey Rope	<i>Parsonsia straminea</i>						1			
Saltwater Couch	<i>Paspalum vaginatum</i>	2-3			2-3			2		
Slender Knotweed	<i>Persicaria decipiens</i>								1	
Common Reed	<i>Phragmites australis</i>	5	2		3	2				
a Tussock Grass	<i>Poa</i> sp.					3				
Shore Club-rush	<i>Schoenoplectus subulatus</i>	3			2-3	2		1		



		Transect 1			Transect 2			Transect 3		
Common Name	Scientific Name	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp	Fringing Marsh	Swamp Forest	Sedge Swamp
Zig-zag Bog-rush	<i>Schoenus brevifolius</i>						3			
Swamp Selaginella	<i>Selaginella uliginosa</i>			2			2		2	1
Sand Couch	<i>Sporobolus virginicus</i>		1				3			
Bryophyte (a moss) sp.	<i>unknown</i>									3
Native Violet	<i>Viola</i> sp.								3	
Grass Tree	<i>Xanthorrhoea</i> sp.			2-4						

Table B.2 Cover Abundance of All Flora Species Occurring in Transects 4-6

Common Name	Scientific Name	Transect 4		Transect 5		Transect 6	
		Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland	Fringing Marsh	Banksia Woodland
Lesser Joyweed	<i>Alternanthera denticulata</i>	2	2	2		1	
Azolla	<i>Azolla filiculoides</i>	2	5				
Bacopa	<i>Bacopa monnieri</i>	2	2	2		2	
Coast Banksia	<i>Banksia integrifolia</i> subsp. <i>integrifolia</i>				4		3
Bare Twig-rush	<i>Baumea juncea</i>	3	3	3		3	2
Gotu Kola	<i>Centella asiatica</i>						1
Flax-leaf Fleabane*	<i>Conyza bonariensis</i>			2	1		2
Bitou Bush*	<i>Crysanthemoides monilifera</i>				1		
a Sedge	<i>Cyperus polystachyos</i>	2	2	1	2		
Indian Coral Tree*	<i>Erythrina x sykesii</i>			2			
Red-fruited Saw-sedge	<i>Gahnia sieberiana</i>	2					
Pennywort	<i>Hydrocotyle bonariensis</i>	2	1	2	1	2	
Blady Grass	<i>Imperata cylindrica</i>			3	4	1	6
Coastal Morning Glory*	<i>Ipomoea cairica</i>			1		1	
Sea Rush	<i>Juncus kraussii</i> subsp.	3	2				



		Transect 4		Transect 5		Transect 6	
Common Name	Scientific Name	Sedge Swamp/ Open Water	Swamp Forest	Fringing Marsh	Banksia Woodland	Fringing Marsh	Banksia Woodland
	<i>australiensis</i>						
Coral Pea	<i>Kennedia</i> sp.			1			
Duckweed	<i>Lemna</i> sp.	2	3	2		1	
Wattle Mat-rush	<i>Lomandra filiformis</i>	1					
Cockspur Thorn	<i>Maclura cochinchinensis</i>						1
Milk Vine	<i>Marsdenia rostrata</i>				2		
Broad-leaved Paperbark	<i>Melaleuca quinquenervia</i>		3	3		3	
a Basket Grass	<i>Oplismenus</i> sp.				1		
Saltwater Couch	<i>Paspalum vaginatum</i>	3	3				
Shore Club-rush	<i>Schoenoplectus subulatus</i>	3				2	
Snake Vine	<i>Stephania japonica</i>				3		1
Kangaroo Grass	<i>Themeda australis</i>				1		
Cumbungi	<i>Typha orientalis</i>	2					
Native Violet	<i>Viola hederacea</i>				2		



Appendix C

Photo Point Monitoring



Transect 1 quadrat A1



Transect 1 quadrat A2



Transect 1 quadrat B1



Transect 1 quadrat B2



Transect 1 quadrat C1



Transect 1 quadrat C2



Transect 2 quadrat A1



Transect 2 quadrat A2



Transect 2 quadrat B1



Transect 2 quadrat B2



Transect 2 quadrat C1

Not recorded

Transect 2 quadrat C2



Transect 3 quadrat A1



Transect 3 quadrat A2



Transect 3 quadrat B1



Transect 3 quadrat B2



Transect 3 quadrat C1



Transect 3 quadrat C2



Transect 4 quadrat A1



Transect 4 quadrat B1



Transect 5 quadrat A1



Transect 5 quadrat B1



Transect 6 quadrat A1



Transect 6 quadrat B1



Melaleuca Dieback Transect 1 Quadrat A



Melaleuca Dieback Transect 1 Quadrat B



Melaleuca Dieback Transect 1 Quadrat C



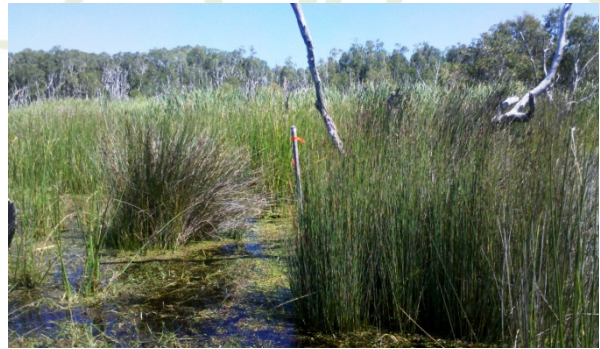
Melaleuca Dieback Transect 1 Quadrat D



Melaleuca Dieback Transect 1 Quadrat E



Melaleuca Dieback Transect 2 Quadrat A



Melaleuca Dieback Transect 2 Quadrat B



Melaleuca Dieback Transect 2 Quadrat C



Melaleuca Dieback Transect 2 Quadrat D



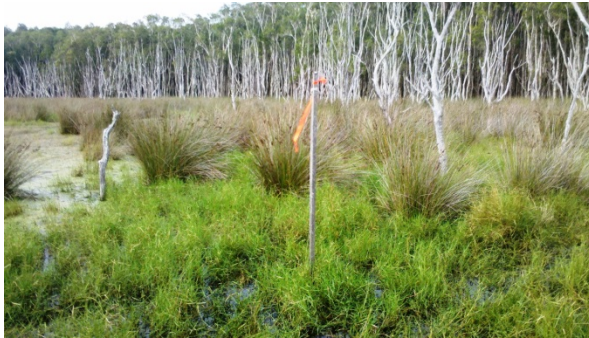
Melaleuca Dieback Transect 2 Quadrat E



Melaleuca Dieback Transect 3 Quadrat A



Melaleuca Dieback Transect 3 Quadrat B



Melaleuca Dieback Transect 3 Quadrat C



Melaleuca Dieback Transect 3 Quadrat D



Melaleuca Dieback Transect 3 Quadrat E