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Estimation of Water Requirements of Wetlands in the South East of South Australia

Department of Water, Land and Biodiversity Conservation

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ECOLOGICAL ASSOCIATES DG003-D

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1.1 Introduction

Ecological Associates was engaged by the Department of Water, Land and Biodiversity Conservation (DWLBC) to estimate the water requirements of priority wetlands in the South East of South Australia. Estimation of such water requirements will contribute to surface water management in the South East.

The work has been undertaken as part of a National Water Initiative project to develop a flow management strategy for the South East of South Australia. Estimates of the environmental water requirements of high value wetlands in the region will provide target storage volumes for hydrologic modelling of the rainfall and runoff processes and inform management decisions regarding the ecologically optimal use of available flows.

The preparation of this report included two workshops, at which key concepts and information were discussed and refined. The workshops were attended by staff from DWLBC, the Department for Environment and Heritage (DEH) and the South East Water Conservation and Drainage Board (SEWCDB) who are experts in the fields of wetland ecology, hydrology and hydrogeology. The workshop attendees were:

- Ben Taylor, Wetland Ecologist, Ecological Associates;
- Geoff Wood, Hydrologist, DWLBC;
- Mark de Jong, Senior Environmental Officer, SEWCDB;
- Claire Harding, Hydrogeologist, DWLBC;
- Craig Billows, Wetland Inventory Ecologist, DEH;
- Paul Masters, Business Analyst, DWLBC;
- Scott Slater, Wetland Ecologist, DEH;
- Randall Johnson, Regional Ecologist, DEH;
- Lachlan Farrington, Wetland Management Advisor, DEH;
- Steve Clarke, Wetland Restoration Ecologist, DEH; and
- Melissa Herpich, Wetland Program Manager, DEH.

1.2 Scope of Work

The key tasks to be completed for this project were to:

- prepare a revised list of priority wetlands in the South East, i.e. high and very high conservation value wetlands that are ‘manageable’;
- review the existing Wetland Vegetation Component (WVC) models (de Jong and Harding 2007) and revise where appropriate;
- prepare new WVC models for wetland vegetation types not defined by de Jong and Harding (2007) but present at priority wetlands;

- assign relevant WVCs to all priority wetlands using the South Australian Wetland Inventory Database (SAWID) and other appropriate sources; and
- recommend an approach to defining the water regime and salinity requirements of priority wetlands based upon the WVCs present.

2.1 List of Priority Wetlands

For the purposes of this project, priority wetlands in the South East region were defined as those of high and very high conservation value that are manageable.

'Manageable' wetlands were defined as those integrated with the drainage network and/or a natural watercourse where flows and levels can be augmented or reduced by the operation of regulators and control structures either at the wetland or elsewhere within the larger hydrologic network. Unmanageable wetlands are those that exist outside the influence of the drainage network or natural watercourses of the South East and are therefore not able to be hydrologically manipulated by management of surface flows.

High and very high conservation value wetlands were defined using the 'ecological significance score' embedded within SAWID. The SAWID approach to quantifying ecological significance is described by Harding (2007). A list of all 123 'high' and 'very high' wetlands in the South East based on the SAWID classification wetlands was provided by DWLBC and formed the basis of the project.

On October 31 2008 a workshop was held in Mt Gambier to review the list of priority wetlands and assign WVCs. At this workshop it was determined that several important wetlands had been omitted from the priority list and that several low value wetlands had been incorrectly included. It was therefore deemed necessary to review and revise the list of priority wetlands.

An alternative to the SAWID approach to the quantification of ecological significance is provided by the Lower South East Wetland Inventory (LSEWI) (Taylor 2006). The list of priority wetlands for the project was revised to include all high and very high conservation value wetlands according to the LSEWI approach in addition to those included using the SAWID approach.

2.2 WVC Model Revision and Development

A Wetland Vegetation Component (WVC) is a wetland vegetation type, defined according to its floristic composition (species present) and structure. A WVC model is a description of the floristic composition and structure of a WVC, it's water requirements, salinity requirements and role as habitat for fauna.

The 14 WVC models of de Jong and Harding (2007) describe water regime and salinity requirements mainly in the form of a range of tolerable limits. For example, duration of inundation of "up to 6 months" is recommended for one WVC. For the purposes of the current project it was deemed necessary to revise the WVC models of de Jong and Harding (2007) to provide more specific 'target' values and 'tolerance ranges' for water regime and salinity.

Target values for water regime and salinity parameters represent the recommended long-term average required to maintain optimal ecological condition.

Tolerance ranges for water regime and salinity parameters represent the extreme values that can be tolerated without leading to ecological change (loss of condition or a shift towards a different WVC) provided the long-term average approximates the target values.

The water regime and salinity parameters defined for each WVC were:

- **Target Hydrology** – describes the recommended depth, duration and frequency of inundation for each WVC required to maintain optimal condition. For all 20 WVCs the target hydrology includes a recommendation for annual depth and duration of inundation. For 7 of the 20 WVCs an additional recommendation for every third year is made (see Section 3.2).
- **Maximum Depth Tolerance** – describes the maximum depth that a given WVC can tolerate during a single inundation event without causing ecological change. At depths greater than the maximum depth tolerance, a single inundation event may lead to ecological change.
- **Dry Phase Required** – indicates whether or not the WVC requires regular (typically annual) complete drying to maintain optimal condition.
- **Maximum Continuous Inundation** – indicates the duration of continuous inundation (of a depth less than the maximum depth tolerance) that can be tolerated by the WVC without causing ecological change.
- **Maximum Continuous Dry Phase** - indicates the duration of a continuous dry phase that can be tolerated by the WVC without causing ecological change.
- **Surface Water Salinity Target** – the surface water salinity (expressed in electrical conductivity units) that the WVC should be exposed to during peak inundation to maintain optimal condition. Note that for a given wetland, salinity is typically minimal when depth is maximal (peak inundation) and increases via evapoconcentration as depth decreases. Target values for salinity refer to the salinity at peak inundation. Note also that the surface water salinity target does not represent the recommended salinity of surface water to be provided to a wetland from the drainage network or elsewhere. Determination of the target salinity of surface water to be directed into a wetland is beyond the scope of this report but could potentially involve calculations that make use of the salinity targets for WVCs.
- **Surface Water Salinity Tolerance Range** – the surface water salinity range that the WVC can tolerate during peak inundation without causing ecological change. At salintities outside the tolerance range, a single inundation event may lead to ecological change.

The fourteen WVCs described by de Jong and Harding (2007) were reviewed and target values and tolerance ranges assigned. For some WVCs target values and tolerance ranges were already implied and revision involved simply making such information explicit. For other WVCs further review of available literature was required to define target values and tolerance ranges. The resultant revised WVC models are summarised in Table 1 and are numbered with the prefix 1. Supporting information is presented in Appendix B.

Six new WVCs present at priority wetlands were identified and models prepared using the existing WVC models as a guide. These new WVC models are summarised in Table 1 and are numbered with the prefix 2. Supporting information is presented in Appendix B.

Two new WVCs were identified but not developed into models because the number of priority sites at which they were present was small and they were not deemed critical to defining the water regime or salinity requirements of those sites. These undeveloped WVC models are presented in Appendix B and are numbered with the prefix 3. They may be worthy of development in the future.

The models developed for all WVCs are based on the best available information. Sources of information include the personal observations of wetland ecologists (mainly Ben Taylor, Marcus Cooling, Claire Harding and Mark de Jong), SAWID, various reports and published, peer reviewed papers. Scope remains to improve the WVC models as better information becomes available. They should be interpreted as preliminary hydrological prescriptions subject to refinement as part of an adaptive management process. For wetlands with more site-specific information regarding the recommended water regime and salinity, this should be used in preference to the hydrological prescriptions provided by the models.

2.3 Assignment of WVCs to Wetlands

The WVCs present at priority wetlands were determined based on a review of available wetland vegetation information from a variety of sources including:

- SAWID;
- DEH regional vegetation mapping;
- the personal observations of key experts including Ben Taylor, Claire Harding, Mark de Jong and Jason Nicol and local landholders including John Mullins;
- Bachmann, M. R. (2002). Silky Tea-tree and Cutting Grass Wetland Rehabilitation Project 1999-2002. (Nature Conservation Society of South Australia: Adelaide);
- Stewart, H. J., Hudspith, T. J., Graham, K. L., Milne, S. J. and Carpenter, G. A. (2001). A Biological Survey of Lake Hawdon South, South Australia. (Department for Environment and Heritage: Adelaide, South Australia);
- Nicol, J. M. (2006). Baseline Vegetation Survey of Lake Bonney SE, Admella Flats and Bucks Lake. Final Technical Report to the South Australian Department for Environment and Heritage. SARDI Publication Number RD06/0475. (South Australian Research and Development Institute (Aquatic Sciences): Adelaide, South Australia);
- Lake George Management Committee (2006). Lake George Management Plan. (Department for Environment and Heritage: Adelaide, South Australia);
- Ecological Associates (in prep). Integrated Monitoring Program for the Bool and Hacks Lagoons Ramsar Site - Draft Monitoring Methodology. (Department for Environment and Heritage: Mt Gambier, South Australia);
- Ecological Associates (2008). Stage 2 Draft Report - Vegetation Monitoring Program Design and Implementation, Lake Hawdon South. (Department for Environment and Heritage: Mt Gambier, South Australia); and
- Ecological Associates (2008). Final Report - Floristic Mapping of the Piccaninnie Ponds Conservation Park and Pick Swamp. (Department for Environment and Heritage: Mt Gambier, South Australia).

In most cases the available information was in a format different to that of the WVC models and interpretation was required to assign the appropriate WVC.

For some wetlands there was inadequate information available to assign WVCs. These have been identified (Appendix A) and are a high priority for future assessment (wetland inventory).

3.1 Priority Wetlands

The number of priority wetlands identified was 112. All of these wetlands are manageable and have a high or very high conservation value according to either SAWID or the LSEWI. A list of the priority wetlands and the WVCs they contain is provided in Appendix A.

3.2 Summary of Revised and New WVC Models

The 14 existing WVC models were revised, 6 new WVC models were developed and 2 WVCs were identified but not developed into models. A summary of the water regime and salinity targets and tolerance ranges of all revised and new models is provided in Table 1. Revised models are numbered with the prefix 1 (e.g. model 1.14) while new models have the prefix 2 (e.g. model 2.15). Detailed descriptions of the revised and new WVC models are provided in Appendix B.

The target hydrology for all WVC models includes a target duration of inundation at several depths (Table 1). For all WVC models, the target hydrology that should be provided annually is indicated. Note however that for several WVC models a target hydrology that should be provided 1 year in 3, and is different from that which should be provided annually, is also indicated (WVC models 1.1, 1.3, 1.4, 1.5, 1.8, 1.9, 1.11 and 2.16). Most of these WVCs are those that occur high on the elevation gradient and are subject to only shallow inundation or waterlogging annually. The deeper inundation recommended for these WVCs 1 year in 3 is required to suppress the invasion of terrestrial species and thus help maintain their condition. A greater depth of inundation 1 year in 3 has also been recommended to incorporate natural variability of these wetland systems, with the hydrology recommended 1 year in 3 intended to mimic wet years.

Table 1. Summary of water regime and salinity targets and tolerance ranges for revised and new WVCs.

WVC Model	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)	
	Target Hydrology			Tolerance Range				Target	Tolerance Range
		Duration (months)		Max. Depth Tolerance (m)	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase		
	Depth (m)	Annual	1 year in 3						
1.1 *Eucalyptus camaldulensis* woodland	dry waterlogged 0.1	12 n/a n/a	10 1 1	> 2.0	yes	48 months	36 months	< 5000	
1.2 Seasonal brackish aquatic bed	dry waterlogged 0.2 0.4 0.6	4 2 2 2 2		2	no	several years	2 years	3000 to 16600	
1.3 *Melaleuca brevifolia* low shrubland	dry waterlogged 0.2	10 2 n/a	8 2 2	0.5	yes	6 months	2 years	< 4000	0 to 6500
1.4 *Melaleuca halmaturorum* tall shrubland	dry waterlogged 0.2	10 2 n/a	8 2 2	0.5	yes	24 months	4 years	6000	5000 to 30000
1.5 *Leptospermum continentale* shrubland	dry waterlogged 0.2	10 2 n/a	8 2 2	0.5	yes	6 months	2 years	< 3000	
1.6 *Leptospermum lanigerum* shrubland	dry waterlogged 0.1	4 4 4		0.3	no	indefinite (waterlogged)	8 months	< 3000	0 to 10000
1.7 *Callistemon rugulosus* Shrubland	dry waterlogged	6 6		0.2	yes	9 months	?	< 2000	
1.8 *Gahnia filum* tussock sedgeland	dry waterlogged 0.2 0.4	8 2 2 n/a	6 2 2 2	0.5	yes	9 months	several years	8000	3000 to 16600

WVC Model	Hydrology							Surface Water Salinity (µS.cm^{-1})	
	Target Hydrology			Tolerance Range				Target	Tolerance Range
	Depth (m)	Duration (months) Annual	Duration (months) 1 year in 3	Max. Depth Tolerance (m)	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase		
1.9 *Gahnia trifida* tussock sedgeland	dry waterlogged 0.2 0.4	8 2 2 n/a	6 2 2 2	0.5	yes	indefinite (waterlogged)	several years	< 5000	
1.10 Drier Emergent Macrophytes Mixed Sedgeland	dry waterlogged 0.3	8 2 2		0.5	yes	12 months	4 years	< 6500	
1.11 Seasonal freshwater emergent sedgeland	dry waterlogged 0.2 0.4 0.6	6 2 2 2 n/a	4 2 2 2 2	1	no	indefinite (waterlogged)	4 years	< 5000	0 to 15000
1.12 Samphire low herbland	dry waterlogged 0.3	8 2 2		0.5	yes	indefinite (waterlogged)	5 years	< 60000	
1.13 Semi-permanent deep/open water	dry deeply inundated	0 12		no upper limit	no	indefinite	several years	< 10000	
1.14 Hypersaline Wetlands	dry 1.5 approx.	0 12		2.5	no	indefinite	several years	> 58300	
2.15 Seasonal saline low aquatic bed	dry waterlogged 0.2 0.4	6 2 2 2		0.8	yes	9 months	3 years	16600 to 58300	
2.16 *Melaleuca squarrosa* mid shrubland	dry waterlogged 0.2 0.4	8 2 2 n/a	6 2 2 2	0.3	yes	12 months	2 years	< 5000	

WVC Model	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)	
	Target Hydrology			Tolerance Range				Target	Tolerance Range
	Depth (m)	Duration (months) Annual	Duration (months) 1 year in 3	Max. Depth Tolerance (m)	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase		
2.17 *Typha* sp., *Phragmites australis* grassland	dry waterlogged 0.2 0.5	6 2 2 2		2	no	indefinite	4 years	< 8000	
2.18 Karstic spring pool with deeply submerged aquatics	dry deeply inundated	0 12		no upper limit	no	indefinite	intolerant of drying	< 3000	
2.19 Permanent coastal lake	dry 3.5 approx.	0 12		4.5	no	indefinite	intolerant of drying	30000	2500 to 75000
2.20 Seasonal freshwater aquatic bed	dry waterlogged 0.2 0.4 0.7	3 3 2 2 2		2	no	indefinite	4 years	< 3000	0 to 15000

4.1 Use of WVCs to Estimate Required Wetland Hydrology

Overview of Approach

An approach is needed to define an appropriate water regime for an individual wetland in the absence of detailed knowledge of the spatial distribution of WVCs within it. Ideally, the spatial distribution of WVCs within all priority manageable wetlands would be mapped. It would then be a relatively simple task to determine the water level required (in absolute terms, i.e. mAHD) to meet the water requirements of the WVCs present using the regional digital elevation model (DEM). However, with a few exceptions, WVCs have not been mapped within the wetlands of the South East. Mapping has been generally limited to wetland extent, i.e. the outer boundaries of entire wetlands.

Within a single wetland basin, different WVCs typically occur as distinct zones related to the elevation of their position in the landscape. The WVCs most tolerant of inundation occur at the lowest elevations while those most tolerant of exposure occur at the highest elevations. Tolerance to inundation is indicated by the target hydrology for a WVC. The greater the maximum annual depth in the target hydrology of a WVC the lower it occurs on the elevation gradient. For a given wetland, the WVC with the greatest maximum annual depth can be assumed to occupy the lowest elevations.

The proposed approach for determining the appropriate water regime for a wetland consists of several stages. First, the WVCs present are identified. Second, the "Key WVC" is identified.

The Key WVC for a wetland is the WVC present that has the greatest target maximum annual depth and is a useful determinant of wetland hydrology.

The target hydrology of the Key WVC for a wetland is then adopted as the recommended *annual* hydrology for the wetland as a whole. Table 2 provides a ranking of all WVCs according their target maximum annual depth for the purpose of identifying the Key WVC for a wetland. Note that several WVCs (those ranked 10) are not useful in this regard because their target maximum annual depth cannot be confidently defined.

Table 2. Ranking of WVCs according to target maximum annual depth.

Priority Rank	WVC Model	Maximum Annual Depth (m)
1	2.20 Seasonal freshwater aquatic bed	0.7
2	1.2 Seasonal brackish aquatic bed	0.6
3	2.17 *Typha* sp., *Phragmites australis* grassland	0.5
4	2.15 Seasonal saline low aquatic bed	0.4
5	1.11 Seasonal freshwater emergent sedgeland	0.4
6	1.12 Samphire low herbland	0.3
	1.10 Drier Emergent Macrophytes (*Baumea juncea*/*Leptocarpus* spp./*Lepidosperma* spp.) Mixed Sedgeland	0.3
7	1.9 *Gahnia trifida* tussock sedgeland	0.2
	1.8 *Gahnia filum* tussock sedgeland	0.2
	2.16 *Melaleuca squarrosa* mid shrubland	0.2

Priority Rank	WVC Model	Maximum Annual Depth (m)
8	1.4 *Melaleuca halmaturorum* tall shrubland	waterlogged
	1.5 *Leptospermum continentale* shrubland	waterlogged
	1.3 *Melaleuca brevifolia* low shrubland	waterlogged
	1.7 *Callistemon rugulosus* Shrubland (under *Eucalyptus leucoxylon* Woodland)	waterlogged
9	1.1 *Eucalyptus camaldulensis* woodland	dry
10*	1.6 *Leptospermum lanigerum* shrubland	0.1
	2.18 Karstic spring pool with deeply submerged aquatics	deeply inundated
	2.19 Permanent coastal lake	3.5 (approx.)
	1.13 Semi-permanent Deep / Open Water	deeply inundated
	1.14 Hypersaline Wetlands	1.5

*WVCs 1.6, 2.18, 2.19, 1.13 and 1.14 are not useful determinants of required wetland hydrology – see text.

In the next step any requirement for a different target hydrology 1 year in 3 is ascertained. If the Key WVC has target hydrology 1 year in 3 that differs from it's annual target hydrology, the Key WVCs target hydrology 1 year in 3 is adopted for the wetland. If, however, the Key WVC has only an annual target hydrology, the other WVCs present must be examined. If any of the other WVCs present have a 1 in 3 year target hydrology, then a different target 1 year in 3 must be assigned to the wetland. The wetland's target hydrology 1 year in 3 is determined by adding 0.2 m to the target maximum annual depth for a duration of 2 months and subtracting 2 months from the duration of minimum depth (e.g. "dry"). Alternatively, if all of the other WVCs present have only an annual target hydrology, the target hydrology for the wetland has only an annual component, with no requirement for a different target hydrology 1 year in 3.

The above process for estimating the target hydrology of an individual wetland using the WVC models can be summarised as a decision tree (Figure 1).

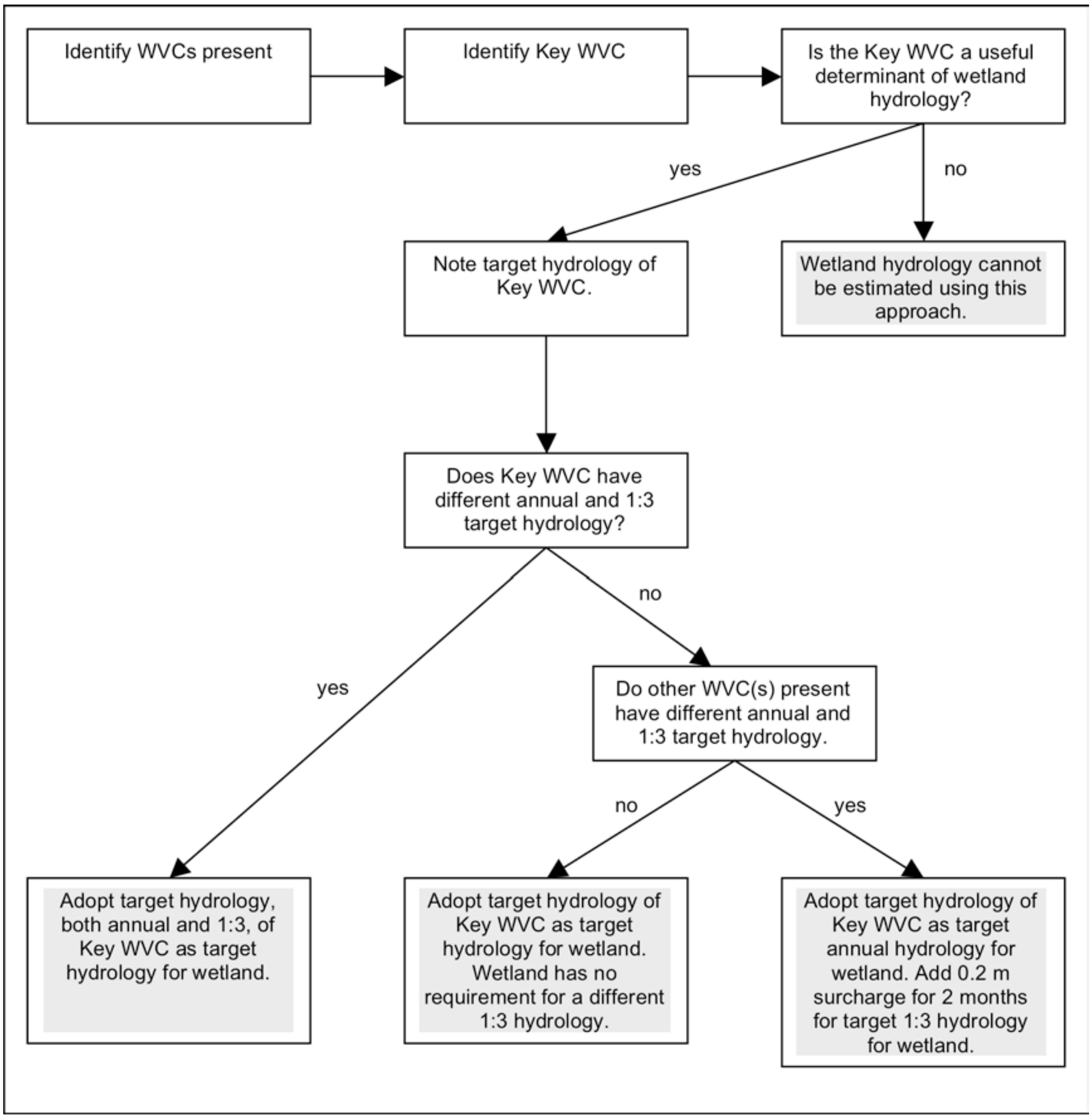

Figure 1. Decision tree for the use of WVC models to estimate wetland hydrology.

Example Wetland: Lake Hawdon North

The following is an example of the process, using Lake Hawdon North as an example wetland.

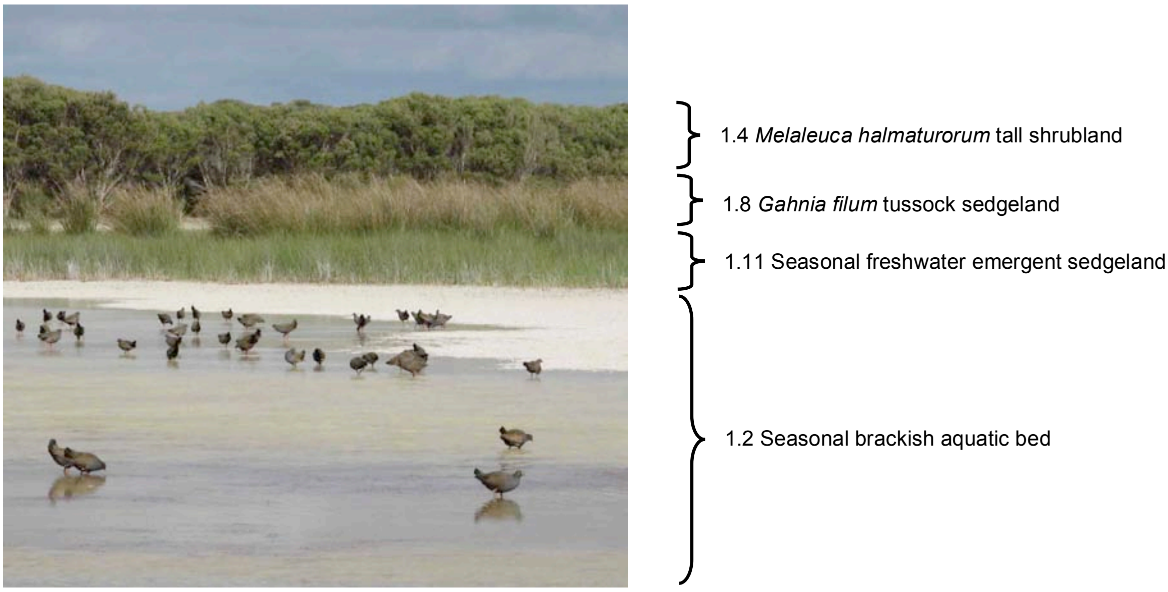

Figure 2. An area of Lake Hawdon North showing the arrangement of WVCs present.

Lake Hawdon North (S0109028) features four modelled WVCs: 1.2, 1.4, 1.8 and 1.11. The arrangement of these WVCs across the elevation gradient in order from lowest to highest is 1.2, 1.11, 1.8 and 1.4 (Figure 2). Using the approach described above WVC 1.2, being the highest ranking WVC according to it's target maximum annual depth (Table 2), is the Key WVC for the wetland. The target annual hydrology of WVC 1.2 is adopted as the target annual hydrology for the wetland. Thus the target annual hydrology for Lake Hawdon North is:

Depth (m)	Duration (months)
dry	4
waterlogged	2
0.2	2
0.4	2
0.6	2

The reference point at which these depths are measured is the deepest part of the wetland. The assumption implicit in this approach is that provision of the target annual hydrology for WVC 1.2 also provides the target annual hydrologies for WVCs 1.11, 1.8 and 1.4. Thus, it is assumed that:

- when WVC 1.2 is dry all other WVCs are dry;
- when WVC 1.2 is waterlogged all other WVCs are dry;
- when WVC 1.2 is inundated to 0.2 m WVC 1.11 is waterlogged and all other WVCs are dry;
- when WVC 1.2 is inundated to 0.4 m WVC 1.11 is inundated to 0.2 m, WVC 1.8 is waterlogged and WVC 1.4 is dry; and

- when WVC 1.2 is inundated to 0.6 m WVC 1.11 is inundated to 0.4, WVC 1.8 is inundated to 0.2 m and WVC 1.4 is waterlogged.

In other words, it is assumed that the elevations occupied by each of the above WVCs occur in 0.2 m increments up the elevation gradient.

Next, the requirement for a different target hydrology 1 year in 3 is ascertained. Because Lake Hawdon North features WVCs with a different target hydrology 1 year in 3 (WVCs 1.8 and 1.4), an additional 0.2 m of surface water is required for 2 months 1 year in 3. Thus, the overall target hydrograph for Lake Hawdon North is:

	Duration (months)	
Depth (m)	Annual	1 year in 3
dry	4	2
waterlogged	2	2
0.2	2	2
0.4	2	2
0.6	2	2
0.8	n/a	2

Note that the addition of the 0.2 m surcharge 1 year in leads to a greater depth and duration of inundation for all WVCs present, not just those that require it. Thus, target values for 13 of the 20 modelled WVCs are exceeded by 0.2 m for 2 months 1 year in 3. This is not considered likely to have any undesirable ecological consequences. Indeed, such variation mimics the natural variation provided by high rainfall years and thus is likely to be ecologically beneficial for all WVCs.

WVCs Not Useful as Determinants of Wetland Hydrology

As indicated in Table 2, several WVCs are not useful as determinants of wetland hydrology. WVCs 1.6 and 2.18 are associated with surface expressions of groundwater (springs and soaks) and their water requirements are typically provided by groundwater. The manipulation of surface water is not generally required to provide the target water regime for these WVCs. At sites featuring these WVCs, other WVCs present should be used to determine the water regime requirements of the wetland. However, at sites where WVCs 1.6 and/or 2.18 are the only WVCs present, the water requirements of these WVCs should be used.

WVCs 2.19, 1.13 and 1.14 do not have specific or reliable targets for maximum depth. For wetlands featuring these WVCs the water requirements of the peripheral, more elevated WVCs should be used as determinants of wetland water regime. The key difference in this situation is that the reference point at which the depths are measured is the elevation occupied by the peripheral WVC with the highest priority ranking (Table 2). An example is provided below.

Lake George features WVCs 1.4, 1.12, 1.6, 2.15 and 2.19. Of these, the WVC with the highest ranking as a determinant of annual wetland hydrology is WVC 2.15. The target annual hydrology for WVC 2.15 is therefore adopted as the target annual hydrology for Lake George, i.e.:

Depth (m)	Duration (months)
dry	6
waterlogged	2
0.2	2
0.4	2

However, the elevation used as the reference point for depth is not the lowest elevation in the wetland but the elevation occupied by WVC 2.15, i.e. the shoreline of the permanently inundated area of the wetland. By selecting this WVC and reference point it is implicit that the hydrological requirements of the lower lying WVC will also be met.

4.2 Use of WVCs to Estimate Required Wetland Salinity

Using the target values for surface water salinity, the complete set of revised and new WVCs ranked according to priority as determinants of wetland surface water salinity is shown in Table 3. The highest ranking WVCs have the lowest salinity tolerance. For a wetland with more than one WVC, the salinity of the highest ranking WVC should be used as the determinant of the required salinity of the wetland.

Table 3. Ranking of WVCs as indicators of wetland salinity.

Priority Rank as Determinant of Wetland Salinity	WVC Model	Target Salinity (μS.cm^{-1})
1	1.7 *Callistemon rugulosus* Shrubland (under *Eucalyptus leucoxylon* Woodland)	< 2000
2	1.5 *Leptospermum continentale* shrubland	< 3000
	1.6 *Leptospermum lanigerum* shrubland	< 3000
	2.18 Karstic spring pool with deeply submerged aquatics	< 3000
	2.20 Seasonal freshwater aquatic bed	< 3000
3	1.3 *Melaleuca brevifolia* low shrubland	< 4000
4	1.1 *Eucalyptus camaldulensis* woodland	< 5000
	1.9 *Gahnia trifida* tussock sedgeland	< 5000
	1.11 Seasonal freshwater emergent sedgeland	< 5000
	2.16 *Melaleuca squarrosa* mid shrubland	< 5000
5	1.4 *Melaleuca halmaturorum* tall shrubland	6000
6	1.10 Drier Emergent Macrophytes (*Baumea juncea*/*Leptocarpus* spp./*Lepidosperma* spp.) Mixed Sedgeland	< 6500
7	2.17 *Typha* sp., *Phragmites australis* grassland	< 8000
8	1.8 *Gahnia filum* tussock sedgeland	8000

Priority Rank as Determinant of Wetland Salinity	WVC Model	Target Salinity ($\mu S.cm^{-1}$)
9	1.13 Semi-permanent Deep / Open Water	< 10000
10	1.2 Seasonal brackish aquatic bed	3000 to 16600
11	2.19 Permanent coastal lake	30000
12	2.15 Seasonal saline low aquatic bed	16600 to 58300
13	1.12 Samphire low herbland	very broad range (< 60000)
14	1.14 Hypersaline Wetlands	> 58300

Using Lake Hawdon North as an example, the recommended wetland surface water salinity at peak inundation is < 5000 $\mu S.cm^{-1}$, which is the target for WVC 1.11. Note that as water levels drop and evapoconcentration occurs, surface water salinity is likely to exceed 5000 $\mu S.cm^{-1}$, as indicated by the presence of WVC 1.2 (target salinity 3000 to 16600 $\mu S.cm^{-1}$) at the lowest elevations. As previously stated, the target salinity for a WVC is the salinity during peak inundation, which is when salinity is typically at its lowest.

4.3 Estimation of Required Hydrology and Salinity for Priority Wetlands

Using the approach outlined in Sections 4.1 and 4.2 the required hydrology and salinity for all priority wetlands has been estimated (Table 4).

Table 4. Estimation of required hydrology and surface water salinity for priority wetlands. Note wetlands highlighted yellow require further survey to ascertain all WVCs present, therefore required hydrology and salinity is uncertain at such sites.

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)								
				Depth (m)	Annual	1 year in 3	Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
S0100020	MESSENT FLOODPLAIN	1.10	1.3, 1.8	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100021		1.10	1.8	dry	8	6	0.5	yes	12 months	4 years	< 6500		
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100022		1.8	1.3	dry	8	6	0.5	yes	9 months	several years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4		2							
S0100026		1.10		dry	8		0.5	yes	12 months	4 years	< 6500		
				waterlogged	2								
				0.3	2								
S0100027		1.10	1.3	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100030		1.10	1.3, 1.8	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity (µS.cm^{-1})		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0100037	BONNEYS CAMP NORTH	1.10	1.3, 1.4	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100038	MORELLA BASIN	2.15	1.1, 1.4, 1.12	dry	6	4	0.8	yes	9 months	3 years	< 5000		
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6		2							
S0100039		1.12	1.3, 1.4	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100040		1.12	1.3, 1.4	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100042	BUNBURY SWAMP	1.12	1.3, 1.4, 1.13	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	Key WVC is not deepest WVC
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100047	BONNEYS CAMP SOUTH	1.10	1.2, 1.3, 1.4, 1.12	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology: Target Hydrology: Depth (m)	Target Hydrology: Duration (months): Annual	Duration (months): 1 year in 3	Tolerance Range: Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Surface Water Salinity (µS.cm^{-1}): Target	Tolerance Range	Comments
S0100051	FRESHWATER WELL & WATERHOLE	1.12	1.3, 1.4	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100052	MARTINS WASHPOOL	1.8	1.3, 1.4, 1.9	dry	8	6	0.5	yes	9 months	several years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							
S0100054	TILLEY SWAMP	1.12	1.3, 1.4, 1.8, 1.9	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100055		1.12	1.3, 1.4	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100075	TILLEY SWAMP	1.12	1.3, 1.4, 1.8	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100090	MANDINA MARSHES	1.2	1.3, 1.4, 1.8, 1.10	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity (μS.cm^{-1})		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0100091	NAEN NAEN SWAMP	1.3	1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0100098	BUTCHERS LAKE	2.15	1.4, 1.12	dry	6	4	0.8	yes	9 months	3 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6		2							
S0100099	CORTINA LAKE	1.4		dry	10	8	0.5	yes	24 months	4 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	n/a	2							
S0100102		1.12	1.1, 1.3, 1.4	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100117	MANDINA LAKE	2.15	1.4	dry	6	4	0.8	yes	9 months	3 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6		2							
S0100118	THE FLOODWAYS (GUM LAGOON)	1.3	1.1, 1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0100120	THE FLOODWAYS (GUM LAGOON)	1.3	1.1, 1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity (μS.cm^{-1})		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0100146	TILLEY SWAMP CP	1.12	1.3, 1.4, 1.8	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100154	MUNDULLA SWAMP	1.1		dry	12	10	> 2.0	yes	48 months	36 months	< 5000		
				waterlogged	n/a	1							
				0.1	n/a	1							
S0100167	PRETTY JOHNNYS	1.12	1.1, 1.3, 1.4	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100172	HENRY CREEK (The Folley, Creek and Pools)	1.6		dry	4		0.3	no	indefinite (waterlogged)	8 months	< 3000	0 to 10000	More detailed information is available regarding the water requirements of this wetland
				waterlogged	4								
				0.1	4								
S0100177	JIP JIP	1.2	1.1, 1.3, 1.4, 1.8, 1.9, 1.10	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100178	LAKE NEWRY	1.2	1.1, 1.4, 1.12	dry	4	2	2	no	several years	2 years	< 5000		
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0100199		1.2	1.1, 1.3, 1.4, 1.12	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100203	DOUBLE SWAMP	1.2	1.4	dry	4	2	2	no	several years	2 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100208	DOUBLE SWAMP	1.2	1.4	dry	4	2	2	no	several years	2 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100210	DOUBLE SWAMP	1.2	1.3, 1.4	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0100211	DOUBLE SWAMP	1.2	1.4	dry	4	2	2	no	several years	2 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100212	DOUBLE SWAMP	1.2	1.1, 1.4	dry	4	2	2	no	several years	2 years	< 5000		
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100217	ROCKY SWAMP	2.20	1.1, 1.4, 1.11	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0100220	SMITH SWAMP	2.20	1.4	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology: Target Hydrology: Depth (m)	Hydrology: Target Hydrology: Duration (months): Annual	Hydrology: Target Hydrology: Duration (months): 1 year in 3	Hydrology: Tolerance Range: Maximum Depth Tolerance	Hydrology: Tolerance Range: Dry Phase Required?	Hydrology: Tolerance Range: Maximum Continuous Inundation	Hydrology: Tolerance Range: Maximum Continuous Dry Phase	Surface Water Salinity ($\mu S.cm^{-1}$): Target	Surface Water Salinity ($\mu S.cm^{-1}$): Tolerance Range	Comments
S0100231	PARK HILL	1.2		dry	4		2	no	several years	2 years	3000 to 16600		
				waterlogged	2								
				0.2	2								
				0.4	2								
				0.6	2								
S0100240	JAFFRAY SWAMP	1.1	1.13	dry	12	10	> 2.0	yes	48 months	36 months	< 5000		Key WVC is not deepest WVC
				waterlogged	n/a	1							
				0.1	n/a	1							
S0100243	JAFFRAY SWAMP FLOODPLAIN	1.10	1.1, 1.3, 1.4, 1.8, 1.9	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100307	SCHOFIELDS SWAMP	1.2	1.1, 1.3, 1.4	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100320	COCKATOO LAKE	2.20	1.1	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0100338	FAIRVIEW SWAMP	1.2	1.3, 1.4, 1.5	dry	4	2	2	no	several years	2 years	< 3000		
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0100340	KANGOORA LAGOON	1.12	1.3, 1.4, 1.5	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 3000		
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0100353	MULLINGER SWAMP	1.1?	?	dry	12	10	> 2.0	yes	48 months	36 months	< 5000		Survey required to ascertain WVCs present
				waterlogged	n/a	1							
				0.1	n/a	1							
S0101105	MANDINA MARSHES	1.2	1.3, 1.4, 1.8, 1.10	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0101265		1.8		dry	8	6	0.5	yes	9 months	several years	8000	3000 to 16600	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							
S0101491													Survey required to ascertain WVCs present
S0101493	WETLANDS AND WILDLIFE CENTRE	1.3		dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0101509													Survey required to ascertain WVCs present
S0101523		1.8		dry	8	6	0.5	yes	9 months	several years	8000	3000 to 16600	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							
S0101545		1.2	1.3, 1.4, 1.8, 1.10, 1.11	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0101818	LAKE GEORGE	2.15	1.4, 1.6, 1.12, 2.19	dry	6	4	0.8	yes	9 months	3 years	6000	5000 to 30000	Key WVC is not deepest WVC. Salinity targets based on WVC 1.4
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6		2							
S0101959	RUSHY SWAMP	1.4?	?	dry	10	8	0.5	yes	24 months	4 years	6000	5000 to 30000	Survey required to ascertain WVCs present
				waterlogged	2	2							
				0.2	n/a	2							
S0101999	KATANI PARK WETLAND	2.20	1.1, 1.5	dry	3	1	2	no	indefinite	4 years	< 3000		
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity (µS.cm^{-1})		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0104320	BONNEYS CAMP SOUTH	1.2	1.3, 1.4, 1.10, 1.12	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0104731		2.15	1.8	dry	6	4	0.8	yes	9 months	3 years	8000	3000 to 16600	Survey required to ascertain WVCs present
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6		2							
S0104859													Survey required to ascertain WVCs present
S0105053		1.3	1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0105159		1.12	1.3, 1.4	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0105337	BONNEYS CAMP NORTH	1.10	1.3, 1.4	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology: Target Hydrology: Depth (m)	Duration (months): Annual	Duration (months): 1 year in 3	Tolerance Range: Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Surface Water Salinity ($\mu S.cm^{-1}$): Target	Tolerance Range	Comments
S0105592	MULLINS SWAMP	2.20	1.4, 1.6, 1.9, 1.10, 2.15, 2.17	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0105778													Survey required to ascertain WVCs present
S0105943	LAKE FROME	2.20	1.3, 1.4, 1.6, 1.9, 1.10, 1.11, 1.12, 2.17	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0107004	MIDDLE POINT SWAMP	2.17	1.6, 1.8, 2.15	dry	6	4	2	no	indefinite	4 years	< 3000	0 to 10000	
				waterlogged	2	2							
				0.2	2	2							
				0.5	2	2							
				0.7		2							
S0107052		1.11	1.8, 1.10	dry	6	4	1	no	indefinite (waterlogged)	4 years	< 5000	0 to 15000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6		2							
S0107058		1.8	1.6	dry	8	6	0.5	yes	9 months	several years	< 3000	0 to 10000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range				Target	Tolerance Range	
				Depth (m)	Duration (months) Annual	Duration (months) 1 year in 3	Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase			
S0107060	BUCKS LAKE	1.11	1.4, 1.8	dry	6	4	1	no	indefinite (waterlogged)	4 years	< 5000	0 to 15000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6		2							
S0107062		1.2	1.4, 1.8	dry	4	2	2	no	several years	2 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0108130	LAKE NUNAN	1.4	1.6	dry	10	8	0.5	yes	24 months	4 years	< 3000	0 to 10000	
				waterlogged	2	2							
				0.2	n/a	2							
S0108314	LAKE HAWDON SOUTH	1.2	1.6, 1.8, 1.9, 1.10, 1.11, 3.22	dry	4	2	2	no	several years	2 years	< 5000		Current water regime is near-natural and does not require modification. Salinity target based on WVC 1.9
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0108578	BROADLANDS	2.20	1.1	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology: Target Hydrology: Depth (m)	Duration (months): Annual	Duration (months): 1 year in 3	Tolerance Range: Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Surface Water Salinity (μS.cm^{-1}): Target	Tolerance Range	Comments
S0108757	MCINNES WETLAND	1.9	1.6	dry	8	6	0.5	yes	indefinite (waterlogged)	several years	< 3000	0 to 10000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							
S0109028	LAKE HAWDON NORTH	1.2	1.4, 1.8, 1.11, 3.22	dry	4	2	2	no	several years	2 years	< 5000	0 to 15000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0109071	HACKS LAGOON	2.20	1.4, 2.17	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	More detailed information is available regarding the water requirements of this wetland
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0110108	SHEEPWASH SWAMP	2.20	1.5, 1.11	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0110344	SALT LAKE (Butchers Gap complex)	1.2	1.4, 1.6, 1.12	dry	4	2	2	no	several years	2 years	6000	5000 to 30000	Salinity target based on WVC 1.4
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology: Target Hydrology: Depth (m)	Duration (months): Annual	Duration (months): 1 year in 3	Tolerance Range: Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Surface Water Salinity (μS.cm^{-1}): Target	Tolerance Range	Comments
S0110443	LITTLE BOOL LAGOON	1.12	1.13	dry	8		0.5	yes	indefinite (waterlogged)	5 years	< 10000		Key WVC is not deepest WVC. More detailed information is available regarding the water requirements of this wetland
				waterlogged	2								
				0.3	2								
S0110446	BOOL LAGOON	2.20	1.4, 1.8, 1.9, 1.10, 1.11, 1.12, 2.17, 3.22	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	More detailed information is available regarding the water requirements of this wetland
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0110901	CLAYPANS EAST	2.20	1.11, 2.16	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0110944	THE EVERGLADES	2.20	1.11, 2.16	dry	3	1	2	no	indefinite	4 years	< 3000	0 to 15000	
				waterlogged	3	3							
				0.2	2	2							
				0.4	2	2							
				0.7	2	2							
				0.9		2							
S0111024	WESTSLOPES FLOODPLAIN SOUTH	1.3	1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity (μS.cm⁻¹)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0111028	WEST AVENUE FLOODPLAIN	1.10	1.3, 1.4, 1.8, 1.9	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0111033	WEST AVENUE FLOODPLAIN	1.3	1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0111052	DEEP SWAMP FLOODPLAIN	1.10	1.3, 1.4, 1.8	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4		2							
S0111080	HANSON SCRUB FLOODPLAIN	1.10	1.3, 1.4, 1.8	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4		2							
S0111133	MOUNT SCOTT FLOODPLAIN	1.4	1.1	dry	10	8	0.5	yes	24 months	4 years	< 5000		
				waterlogged	2	2							
				0.2	n/a	2							
S0111276	MOOT YANG GUNYA SWAMP	1.1		dry	12	10	> 2.0	yes	48 months	36 months	< 5000		
				waterlogged	n/a	1							
				0.1	n/a	1							
S0111474	MANDINA MARSHES	1.2	1.3, 1.4, 1.8, 1.10, 1.11	dry	4	2	2	no	several years	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)								
				Depth (m)	Annual	1 year in 3	Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
S0111507	TILLEY SWAMP FLOODPLAIN	1.8	1.4	dry	8	6	0.5	yes	9 months	several years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							
S0111509		1.3	1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0111743		1.3		dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0111826		1.3	1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0111829	HERRIOT SWAMP	1.3	1.4	dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0111841		1.3		dry	10	8	0.5	yes	6 months	2 years			
				waterlogged	2	2							
				0.2	n/a	2							
S0111907	DEEP SWAMP FLOODPLAIN	1.8	1.3, 1.4	dry	8	6	0.5	yes	9 months	several years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							
S0113840		1.6		dry	4		0.3	no	indefinite (waterlogged)	8 months	< 3000	0 to 10000	
				waterlogged	4								
				0.1	4								

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology							Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Target Hydrology			Tolerance Range						
					Duration (months)		Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
				Depth (m)	Annual	1 year in 3							
S0114945		1.8		dry	8	6	0.5	yes	9 months	several years	8000	3000 to 16600	
				waterlogged	2	2							
				0.2	2	2							
				0.4	n/a	2							
S0114971		1.6		dry	4		0.3	no	indefinite (waterlogged)	8 months	< 3000	0 to 10000	
				waterlogged	4								
				0.1	4								
S0114982	CRESS CREEK SPRING	1.6		dry	4		0.3	no	indefinite (waterlogged)	8 months	< 3000	0 to 10000	
				waterlogged	4								
				0.1	4								
S0114989	JERUSALEM CREEK SPRING	1.6	2.18	dry	4		0.3	no	indefinite (waterlogged)	8 months	< 3000	0 to 10000	Key WVC is not deepest WVC
				waterlogged	4								
				0.1	4								
S0116933	MARY SEYMOUR CONSERVATION PARK	1.10	1.3	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0116936	SALT LAKE (Butchers Gap complex)	1.2	1.4, 1.8, 1.12	dry	4	2	2	no	several years	2 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.4	2	2							
				0.6	2	2							
				0.8		2							
S0120280	BUTCHERS LAKE	2.15	1.12	dry	6		0.8	yes	9 months	3 years	16600 to 58300		
				waterlogged	2								
				0.2	2								
				0.4	2								

AUS_WETNR	NAME	Key WVC	Secondary WVCs	Hydrology: Target Hydrology			Hydrology: Tolerance Range				Surface Water Salinity ($\mu S.cm^{-1}$)		Comments
				Depth (m)	Duration (months): Annual	Duration (months): 1 year in 3	Maximum Depth Tolerance	Dry Phase Required?	Maximum Continuous Inundation	Maximum Continuous Dry Phase	Target	Tolerance Range	
S0120842	TWIG RUSH LAGOONS	1.12	1.8	dry	8	6	0.5	yes	indefinite (waterlogged)	5 years	8000	3000 to 16600	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0120854	EWENS PONDS	2.17	2.18	dry	6		2	no	indefinite	4 years	< 3000		Key WVC is not deepest WVC
				waterlogged	2								
				0.2	2								
				0.5	2								
S0120855	BIG HEATH CP	1.10	1.3	dry	8	6	0.5	yes	12 months	4 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.3	2	2							
				0.5		2							
S0120856	REEDY CREEK LF	1.1		dry	12	10	> 2.0	yes	48 months	36 months	< 5000		
				waterlogged	n/a	1							
				0.1	n/a	1							
S0120859	MARY SEYMOUR CONSERVATION PARK	1.3		dry	10	8	0.5	yes	6 months	2 years	< 4000	0 to 6500	
				waterlogged	2	2							
				0.2	n/a	2							
S0121483	LAKE BONNEY S.E.	2.17	1.4, 2.19	dry	6	4	2	no	indefinite	4 years	6000	5000 to 30000	
				waterlogged	2	2							
				0.2	2	2							
				0.5	2	2							
				0.7		2							

Strengths, Limitations and Recommendations

Summary

This report has been prepared using currently available information from a variety of sources to define the environmental water requirements of high value wetland ecosystems of the South East region. Establishing a link between the ecology and hydrology of complex ecosystems is not straightforward. This project is most usefully interpreted as the first step in an adaptive approach to the management of the water and wetland ecosystems of the South East. As such, the project sets a benchmark rather than providing a definitive description of wetland water requirements. Monitoring is intrinsic to the adaptive management approach and future monitoring should test the assumptions of this report. Specific suggestions follow.

List of Priority Wetlands

The list of priority wetlands has been obtained based on a considerable body of previous work undertaken for the Upper South East Dryland Salinity and Flood Management Program, the South Australian Wetland Inventory Database and the Lower South East Wetland Inventory. That the list includes the highest conservation value wetlands of the South East can be stated with a high degree of confidence. The concept of 'manageability' of a wetland is simple and clear in theory (see Section 2.1). In practice it can be difficult to determine the degree of surface water connectivity between wetlands and the larger hyrologic network. The assignment of the attribute 'manageable' to wetland has a moderate degree of confidence, and scope for refinement exists.

Assignment of WVCs to Wetlands

Information regarding wetland vegetation types present at priority wetlands in the South East was generally readily transferable into WVCs. Therefore, the assignment of WVCs to wetlands has a relatively high degree of confidence. However, at some sites information was poor or unavailable and WVCs have not been assigned, or have been assigned incompletely. These sites are identified in Table 4 and Appendix A and are high priority for future survey.

It is important to note that the assignment of WVCs to wetlands is based upon their contemporary presence or absence. Use of this information to estimate the required wetland water regime and salinity is based upon the assumption that what exists currently at a site is what should be maintained at that site. There are examples where this may not be the case. The vegetation of many wetlands, particularly the 'floodplain' wetlands of the Upper South East watercourses, has changed in response to the construction of drains. Many have become drier and highly water dependent WVCs have been displaced by those with greater drought tolerance.

WVC Models

All water regime and salinity targets and tolerance ranges for all WVC models should be regarded as hypotheses that require testing over time. The WVC Models contained in this report should be viewed as a first step in the development of a comprehensive method for determining the water requirements of wetlands in the South East of South Australia.

The WVC Models do not refer to the optimal season of inundation, however it is anticipated that provision of surface water to wetlands will generally be possible only during winter/spring, which corresponds with the natural seasonality of the wetlands of the South East. Inundation at other times of the year may have undesirable ecological consequences (e.g. inundation of mudflat habitat (WVC 1.2) during summer may render it unavailable to migratory waders). A precautionary approach should be taken to the provision of surface water to wetlands outside the winter/spring period.

The target hydrology for the WVCs currently includes both 'annual' and '1 year in 3' components. The '1 year in 3' component refers to a 0.2 m depth surcharge for a duration of 2 months and aims to replicate the water regime anticipated in years of above average rainfall. The need for an additional component that replicates the water regime anticipated in dry years could be further explored. The periodic provision of inundation that is shallower and of shorter duration than that recommended annually may be important for the maintenance of optimal ecological condition for some WVCs.

For several wetlands in the South East (e.g. Bool Lagoon), water requirements have been recommended previously based upon far more exhaustive studies than this project. Where more detailed information regarding wetland water requirements is available, that information should take precedence over the approach proposed by this project.

Investigation of Elevation Assumptions

Assumptions concerning the elevations occupied by adjacent WVCs are implicit in the WVC models and the proposed approach for the use of WVCs to estimate wetland hydrology. In general, WVCs that are adjoining within a single wetland basin are assumed to be separated by 0.2 m of elevation. For example, it is assumed that at Lake Hawdon North, when WVC 1.4 is waterlogged, WVC 1.8 is inundated to a depth of 0.2 m, WVC 1.11 is inundated to a depth of 0.4 m and WVC 1.2 is inundated to a depth of 0.6 m. These assumptions could be readily verified or revised. A project to investigate these assumptions would have the objective to:

- determine the average elevation range occupied by adjacent WVCs within individual wetlands; and
- revise the recommended depths required to inundate adjacent WVCs.

Fieldwork undertaken for such an investigation would also provide an opportunity to confirm or revise the assignment of WVCs to priority wetlands. One week in the field would be adequate to measure approximately 50 transects and should provide enough data to calculate an average elevation range for all 20 WVCs.

WVC Mapping

For the priority wetlands identified in this report, mapping of WVCs present could be undertaken to assist with the determination of wetland water requirements. Using the regional DEM, the elevations occupied by the different WVCs present could then be determined, which would enable determination of a target hydrology in absolute terms (m AHD).

Wetland Vegetation Survey

As previously discussed, it was not possible to confidently assign WVCs to a number of priority wetlands (see Table 4 and Appendix A), and these sites are a high priority for future survey.

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Appendix A
Priority Wetlands and Component WVCs

Note: wetlands highlighted yellow have not had WVCs assigned with confidence and require on-site assessment.

AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0100020	MESSENT FLOODPLAIN	1.10	DEH veg mapping	40.45	
S0100020	MESSENT FLOODPLAIN	1.3	DEH veg mapping	40.45	
S0100020	MESSENT FLOODPLAIN	1.8	DEH veg mapping	40.45	
S0100021		1.10	DEH veg mapping	19.85	
S0100021		1.8	DEH veg mapping	19.85	
S0100022		1.3	DEH veg mapping	18.68	
S0100022		1.8	DEH veg mapping	18.68	
S0100026		1.10	DEH veg mapping	20.52	
S0100027		1.10	DEH veg mapping	24.68	
S0100027		1.3	DEH veg mapping	24.68	
S0100030		1.10	DEH veg mapping	20.46	
S0100030		1.3	DEH veg mapping	20.46	
S0100030		1.8	DEH veg mapping	20.46	
S0100037	BONNEYS CAMP NORTH	1.10	SAWID	29.33	
S0100037	BONNEYS CAMP NORTH	1.3	SAWID	29.33	
S0100037	BONNEYS CAMP NORTH	1.4	SAWID	29.33	
S0100038	MORELLA BASIN	1.4	SAWID	27.09	
S0100038	MORELLA BASIN	1.1	SAWID	27.09	
S0100038	MORELLA BASIN	1.12	SAWID	27.09	
S0100038	MORELLA BASIN	2.15	Mark de Jong, pers. com.	27.09	
S0100039		1.3	SAWID	17.90	
S0100039		1.4	SAWID	17.90	
S0100039		1.12	SAWID	17.90	
S0100040		1.3	SAWID	17.36	
S0100040		1.4	SAWID	17.36	
S0100040		1.12	SAWID	17.36	
S0100042	BUNBURY SWAMP	1.12	SAWID	34.08	
S0100042	BUNBURY SWAMP	1.13	SAWID	34.08	
S0100042	BUNBURY SWAMP	1.3	SAWID	34.08	
S0100042	BUNBURY SWAMP	1.4	SAWID	34.08	

Appendix A
Priority Wetlands and Component WVCs

AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0100047	BONNEYS CAMP SOUTH	1.10	SAWID	33.51	
S0100047	BONNEYS CAMP SOUTH	1.12	SAWID	33.51	
S0100047	BONNEYS CAMP SOUTH	1.2	SAWID	33.51	
S0100047	BONNEYS CAMP SOUTH	1.3	SAWID	33.51	
S0100047	BONNEYS CAMP SOUTH	1.4	SAWID	33.51	
S0100051	FRESHWATER WELL & WATERHOLE	1.12	DEH veg mapping	23.44	
S0100051	FRESHWATER WELL & WATERHOLE	1.3	SAWID	23.44	
S0100051	FRESHWATER WELL & WATERHOLE	1.4	SAWID	23.44	
S0100052	MARTINS WASHPOOL	1.3	SAWID	21.09	
S0100052	MARTINS WASHPOOL	1.4	SAWID	21.09	
S0100052	MARTINS WASHPOOL	1.8	SAWID	21.09	
S0100052	MARTINS WASHPOOL	1.9	SAWID	21.09	
S0100054	TILLEY SWAMP	1.3	SAWID	21.67	
S0100054	TILLEY SWAMP	1.4	SAWID	21.67	
S0100054	TILLEY SWAMP	1.12	SAWID	21.67	
S0100054	TILLEY SWAMP	1.8	SAWID	21.67	
S0100054	TILLEY SWAMP	1.9	SAWID	21.67	
S0100055		1.3	SAWID	18.86	
S0100055		1.4	SAWID	18.86	
S0100055		1.12	SAWID	18.86	
S0100075	TILLEY SWAMP	1.3	SAWID	28.49	
S0100075	TILLEY SWAMP	1.4	SAWID	28.49	
S0100075	TILLEY SWAMP	1.12	SAWID	28.49	
S0100075	TILLEY SWAMP	1.8	SAWID	28.49	
S0100090	MANDINA MARSHES	1.3	SAWID	38.33	
S0100090	MANDINA MARSHES	1.4	SAWID	38.33	
S0100090	MANDINA MARSHES	1.10	SAWID	38.33	
S0100090	MANDINA MARSHES	1.2	SAWID	38.33	
S0100090	MANDINA MARSHES	1.8	SAWID	38.33	
S0100091	NAEN NAEN SWAMP	1.3	SAWID	27.07	
S0100091	NAEN NAEN SWAMP	1.4	SAWID	27.07	
S0100098	BUTCHERS LAKE	1.12	SAWID	19.69	

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Priority Wetlands and Component WVCs

AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0100098	BUTCHERS LAKE	1.4	SAWID	19.69	
S0100098	BUTCHERS LAKE	2.15	SAWID	19.69	
S0100099	CORTINA LAKE	1.4	claire, mark pers.com	27.65	
S0100102		1.3	SAWID	17.65	
S0100102		1.4	SAWID	17.65	
S0100102		1.1	SAWID	17.65	
S0100102		1.12	SAWID	17.65	
S0100117	MANDINA LAKE	1.4	SAWID	27.71	
S0100117	MANDINA LAKE	2.15	claire, mark pers.com	27.71	
S0100118	THE FLOODWAYS (GUM LAGOON)	1.3	SAWID	24.03	
S0100118	THE FLOODWAYS (GUM LAGOON)	1.4	SAWID	24.03	
S0100118	THE FLOODWAYS (GUM LAGOON)	1.1	SAWID	24.03	
S0100120	THE FLOODWAYS (GUM LAGOON)	1.3	SAWID	22.18	
S0100120	THE FLOODWAYS (GUM LAGOON)	1.4	SAWID	22.18	
S0100120	THE FLOODWAYS (GUM LAGOON)	1.1	SAWID	22.18	
S0100146	TILLEY SWAMP CP	1.3	SAWID	31.71	
S0100146	TILLEY SWAMP CP	1.4	SAWID	31.71	
S0100146	TILLEY SWAMP CP	1.12	SAWID	31.71	
S0100146	TILLEY SWAMP CP	1.8	SAWID	31.71	
S0100154	MUNDULLA SWAMP	1.1	SAWID	18.00	
S0100167	PRETTY JOHNNYS	1.3	SAWID	23.83	
S0100167	PRETTY JOHNNYS	1.4	SAWID	23.83	
S0100167	PRETTY JOHNNYS	1.1	SAWID	23.83	
S0100167	PRETTY JOHNNYS	1.12	SAWID	23.83	
S0100172	HENRY CREEK (The Folley, Creek and Pools)	1.6	SAWID	22.90	
S0100177	JIP JIP	1.3	SAWID	28.03	
S0100177	JIP JIP	1.4	SAWID	28.03	
S0100177	JIP JIP	1.1	SAWID	28.03	
S0100177	JIP JIP	1.10	SAWID	28.03	
S0100177	JIP JIP	1.2	SAWID	28.03	
S0100177	JIP JIP	1.8	SAWID	28.03	
S0100177	JIP JIP	1.9	SAWID	28.03	

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0100178	LAKE NEWRY	1.4	SAWID	17.50	
S0100178	LAKE NEWRY	1.1	SAWID	17.50	
S0100178	LAKE NEWRY	1.12	SAWID	17.50	
S0100178	LAKE NEWRY	1.2	SAWID	17.50	
S0100199		1.3	SAWID	19.23	
S0100199		1.4	SAWID	19.23	
S0100199		1.1	SAWID	19.23	
S0100199		1.12	SAWID	19.23	
S0100199		1.2	SAWID	19.23	
S0100203	DOUBLE SWAMP	1.2	SAWID	17.98	
S0100203	DOUBLE SWAMP	1.4	SAWID	17.98	
S0100208	DOUBLE SWAMP	1.2	SAWID	17.54	
S0100208	DOUBLE SWAMP	1.4	SAWID	17.54	
S0100210	DOUBLE SWAMP	1.2	SAWID	28.53	
S0100210	DOUBLE SWAMP	1.3	SAWID	28.53	
S0100210	DOUBLE SWAMP	1.4	SAWID	28.53	
S0100211	DOUBLE SWAMP	1.2	SAWID	20.14	
S0100211	DOUBLE SWAMP	1.4	SAWID	20.14	
S0100212	DOUBLE SWAMP	1.1	SAWID	27.49	
S0100212	DOUBLE SWAMP	1.2	SAWID	27.49	
S0100212	DOUBLE SWAMP	1.4	SAWID	27.49	
S0100217	ROCKY SWAMP	1.4	SAWID	41.87	
S0100217	ROCKY SWAMP	1.1	SAWID	41.87	
S0100217	ROCKY SWAMP	1.11	SAWID	41.87	
S0100217	ROCKY SWAMP	2.20	SAWID	41.87	
S0100220	SMITH SWAMP	1.4	SAWID	23.15	
S0100220	SMITH SWAMP	2.20	SAWID	23.15	
S0100231	PARK HILL	1.2	SAWID	23.21	
S0100240	JAFFRAY SWAMP	1.1	SAWID	28.05	
S0100240	JAFFRAY SWAMP	1.13	claire, mark pers.com	28.05	
S0100243	JAFFRAY SWAMP FLOODPLAIN	1.1	claire, mark pers.com	28.05	
S0100243	JAFFRAY SWAMP FLOODPLAIN	1.10	claire, mark pers.com	28.05	

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0100243	JAFFRAY SWAMP FLOODPLAIN	1.3	claire, mark pers.com	28.05	
S0100243	JAFFRAY SWAMP FLOODPLAIN	1.4	claire, mark pers.com	28.05	
S0100243	JAFFRAY SWAMP FLOODPLAIN	1.8	claire, mark pers.com	28.05	
S0100243	JAFFRAY SWAMP FLOODPLAIN	1.9	claire, mark pers.com	28.05	
S0100307	SCHOFIELDS SWAMP	1.3	SAWID	26.76	
S0100307	SCHOFIELDS SWAMP	1.4	SAWID	26.76	
S0100307	SCHOFIELDS SWAMP	1.1	SAWID	26.76	
S0100307	SCHOFIELDS SWAMP	1.2	SAWID	26.76	
S0100320	COCKATOO LAKE	1.1	SAWID	18.10	
S0100320	COCKATOO LAKE	2.20	SAWID	18.10	
S0100338	FAIRVIEW SWAMP	1.2	claire, mark pers.com	21.78	
S0100338	FAIRVIEW SWAMP	1.3	SAWID	21.78	
S0100338	FAIRVIEW SWAMP	1.4	SAWID	21.78	
S0100338	FAIRVIEW SWAMP	1.5	claire, mark pers.com	21.78	
S0100340	KANGOORA LAGOON	1.3	SAWID	23.29	
S0100340	KANGOORA LAGOON	1.4	SAWID	23.29	
S0100340	KANGOORA LAGOON	1.12	SAWID	23.29	
S0100340	KANGOORA LAGOON	1.5	SAWID	23.29	
S0100353	MULLINGER SWAMP	1.1	DEH veg mapping	22.07	
S0100353	MULLINGER SWAMP			22.07	
S0101105	MANDINA MARSHES	1.3	SAWID	25.24	
S0101105	MANDINA MARSHES	1.4	SAWID	25.24	
S0101105	MANDINA MARSHES	1.10	SAWID	25.24	
S0101105	MANDINA MARSHES	1.2	SAWID	25.24	
S0101105	MANDINA MARSHES	1.8	SAWID	25.24	
S0101265		1.8	DEH veg mapping	20.02	
S0101491				20.03	
S0101493	WETLANDS AND WILDLIFE CENTRE	1.3	DEH veg mapping	19.01	
S0101509				20.02	
S0101523		1.8	DEH veg mapping	17.09	
S0101545		1.3	SAWID	20.72	
S0101545		1.4	SAWID	20.72	

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0101545		1.10	SAWID	20.72	
S0101545		1.11	claire, mark pers.com	20.72	
S0101545		1.2	SAWID	20.72	
S0101545		1.8	SAWID	20.72	
S0101818	LAKE GEORGE	1.4	Lake George Man Plan	20.72	
S0101818	LAKE GEORGE	1.12	Lake George Man Plan	20.72	
S0101818	LAKE GEORGE	1.6	Lake George Man Plan	20.72	
S0101818	LAKE GEORGE	2.15	Jason Nicol, pers. Com.	20.72	
S0101818	LAKE GEORGE	2.19	Lake George Man Plan	20.72	
S0101959	RUSHY SWAMP	1.4	SAWID	37.40	
S0101959	RUSHY SWAMP			37.40	
S0101999	KATANI PARK WETLAND	1.1	SAWID		17.11
S0101999	KATANI PARK WETLAND	1.5	SAWID		17.11
S0101999	KATANI PARK WETLAND	2.20	SAWID		17.11
S0104320	BONNEYS CAMP SOUTH	1.10	SAWID	17.71	
S0104320	BONNEYS CAMP SOUTH	1.12	SAWID	17.71	
S0104320	BONNEYS CAMP SOUTH	1.2	SAWID	17.71	
S0104320	BONNEYS CAMP SOUTH	1.3	SAWID	17.71	
S0104320	BONNEYS CAMP SOUTH	1.4	SAWID	17.71	
S0104731		1.8	DEH veg mapping	20.13	
S0104731		2.15	claire, mark pers.com	20.13	
S0104731				20.13	
S0104859				20.23	
S0105053		1.3	DEH veg mapping	23.89	
S0105053		1.4	DEH veg mapping	23.89	
S0105159		1.12	DEH veg mapping	19.41	
S0105159		1.3	SAWID	19.41	
S0105159		1.4	SAWID	19.41	
S0105337	BONNEYS CAMP NORTH	1.10	SAWID	18.04	
S0105337	BONNEYS CAMP NORTH	1.3	SAWID	18.04	
S0105337	BONNEYS CAMP NORTH	1.4	SAWID	18.04	
S0105592	MULLINS SWAMP	1.10	John Mullins, pers. com.)	21.70	

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0105592	MULLINS SWAMP	1.4	John Mullins, pers. com.)	21.70	
S0105592	MULLINS SWAMP	1.6	DEH veg mapping	21.70	
S0105592	MULLINS SWAMP	1.9	John Mullins, pers. com.)	21.70	
S0105592	MULLINS SWAMP	2.15	John Mullins, pers. com.)	21.70	
S0105592	MULLINS SWAMP	2.17	mark dj pers com	21.70	
S0105592	MULLINS SWAMP	2.20	John Mullins, pers. com.)	21.70	
S0105592	MULLINS SWAMP	2.21	John Mullins, pers. com.)	21.70	
S0105778					21.32
S0105943	LAKE FROME	1.3	SAWID	40.55	
S0105943	LAKE FROME	1.4	SAWID	40.55	
S0105943	LAKE FROME	1.10	SAWID	40.55	
S0105943	LAKE FROME	1.11	SAWID	40.55	
S0105943	LAKE FROME	1.12	SAWID	40.55	
S0105943	LAKE FROME	1.6	SAWID	40.55	
S0105943	LAKE FROME	1.9	SAWID	40.55	
S0105943	LAKE FROME	2.17	SAWID	40.55	
S0105943	LAKE FROME	2.20	John Mullins, pers. com.)	40.55	
S0107004	MIDDLE POINT SWAMP	1.6	SAWID	21.76	
S0107004	MIDDLE POINT SWAMP	1.8	DEH veg mapping	21.76	
S0107004	MIDDLE POINT SWAMP	2.15	B. Taylor, pers. obs.	21.76	
S0107004	MIDDLE POINT SWAMP	2.17	SAWID	21.76	
S0107052		1.10	SAWID		17.38
S0107052		1.11	SAWID		17.38
S0107052		1.8	SAWID		17.38
S0107058		1.6	DEH veg mapping		17.67
S0107058		1.8	DEH veg mapping		17.67
S0107060	BUCKS LAKE	1.11	SAWID	24.61	
S0107060	BUCKS LAKE	1.4	SAWID	24.61	
S0107060	BUCKS LAKE	1.8	SAWID	24.61	
S0107062		1.2	assumed based on available information		18.56
S0107062		1.4	SAWID		18.56
S0107062		1.8	SAWID		18.56

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0108130	LAKE NUNAN	1.4	SAWID		16.60
S0108130	LAKE NUNAN	1.6	SAWID		16.60
S0108314	LAKE HAWDON SOUTH	1.10	Ecological Associates 2008	35.24	
S0108314	LAKE HAWDON SOUTH	1.11	Ecological Associates 2008	35.24	
S0108314	LAKE HAWDON SOUTH	1.2	Ecological Associates 2008	35.24	
S0108314	LAKE HAWDON SOUTH	1.8	Ecological Associates 2008	35.24	
S0108314	LAKE HAWDON SOUTH	1.9	Ecological Associates 2008	35.24	
S0108314	LAKE HAWDON SOUTH	2.22	Ecological Associates 2008	35.24	
S0108314	LAKE HAWDON SOUTH	2.22	Ecological Associates 2008	35.24	
S0108314	LAKE HAWDON SOUTH	2.22	Ecological Associates 2008	35.24	
S0108578	BROADLANDS	1.1	SAWID	19.29	
S0108578	BROADLANDS	2.20	SAWID	19.29	
S0108757	MCINNES WETLAND	1.6	SAWID		17.38
S0108757	MCINNES WETLAND	1.9	SAWID		17.38
S0109028	LAKE HAWDON NORTH	1.4	Stewart et al.2001	27.76	
S0109028	LAKE HAWDON NORTH	1.8	Stewart et al.2001	27.76	
S0109028	LAKE HAWDON NORTH	3.22	B. Taylor, pers. obs.	27.76	
S0109028	LAKE HAWDON NORTH	1.11	B. Taylor, pers. obs.	27.76	
S0109028	LAKE HAWDON NORTH	1.2	B. Taylor, pers. obs.	27.76	
S0109071	HACKS LAGOON	1.4	DEH 2006	33.70	
S0109071	HACKS LAGOON	2.17	DEH 2006	33.70	
S0109071	HACKS LAGOON	2.20	SAWID	33.70	
S0110108	SHEEPWASH SWAMP	1.11	SAWID		16.76
S0110108	SHEEPWASH SWAMP	1.5	SAWID		16.76
S0110108	SHEEPWASH SWAMP	2.20	SAWID		16.76
S0110344	SALT LAKE (Butchers Gap complex)	1.12	SAWID		21.40
S0110344	SALT LAKE (Butchers Gap complex)	1.2	assumed based on available information		21.40
S0110344	SALT LAKE (Butchers Gap complex)	1.4	SAWID		21.40
S0110344	SALT LAKE (Butchers Gap complex)	1.6	SAWID		21.40
S0110443	LITTLE BOOL LAGOON	1.12	DEH 2006	32.25	
S0110443	LITTLE BOOL LAGOON	1.13		32.25	
S0110446	BOOL LAGOON	1.10		54.02	

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0110446	BOOL LAGOON	1.11	DEH 2006	54.02	
S0110446	BOOL LAGOON	1.12	DEH 2006	54.02	
S0110446	BOOL LAGOON	1.4	DEH 2006	54.02	
S0110446	BOOL LAGOON	1.8	DEH 2006	54.02	
S0110446	BOOL LAGOON	1.9	DEH 2006	54.02	
S0110446	BOOL LAGOON	2.17	DEH 2006	54.02	
S0110446	BOOL LAGOON	2.20	DEH 2006	54.02	
S0110446	BOOL LAGOON	2.22	DEH 2006	54.02	
S0110901	CLAYPANS EAST	1.11	SAWID		16.52
S0110901	CLAYPANS EAST	2.16	SAWID		16.52
S0110901	CLAYPANS EAST	2.20	SAWID		16.52
S0110944	THE EVERGLADES	1.11	SAWID		16.88
S0110944	THE EVERGLADES	2.16	SAWID		16.88
S0110944	THE EVERGLADES	2.20	SAWID		16.88
S0111024	WESTSLOPES FLOODPLAIN SOUTH	1.3	DEH veg mapping	17.58	
S0111024	WESTSLOPES FLOODPLAIN SOUTH	1.4	DEH veg mapping	17.58	
S0111028	WEST AVENUE FLOODPLAIN	1.3	SAWID	40.08	
S0111028	WEST AVENUE FLOODPLAIN	1.4	SAWID	40.08	
S0111028	WEST AVENUE FLOODPLAIN	1.10	SAWID	40.08	
S0111028	WEST AVENUE FLOODPLAIN	1.8	SAWID	40.08	
S0111028	WEST AVENUE FLOODPLAIN	1.9	SAWID	40.08	
S0111033	WEST AVENUE FLOODPLAIN	1.3	SAWID	19.63	
S0111033	WEST AVENUE FLOODPLAIN	1.4	SAWID	19.63	
S0111052	DEEP SWAMP FLOODPLAIN	1.10	SAWID	29.84	
S0111052	DEEP SWAMP FLOODPLAIN	1.3	SAWID	29.84	
S0111052	DEEP SWAMP FLOODPLAIN	1.4	SAWID	29.84	
S0111052	DEEP SWAMP FLOODPLAIN	1.8	SAWID	29.84	
S0111080	HANSON SCRUB FLOODPLAIN	1.10	SAWID	22.94	
S0111080	HANSON SCRUB FLOODPLAIN	1.3	SAWID	22.94	
S0111080	HENRY CREEK	1.4	SAWID	22.94	
S0111080	HANSON SCRUB FLOODPLAIN	1.4	SAWID	22.06	
S0111080	HANSON SCRUB FLOODPLAIN	1.8	SAWID	22.94	

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0111133	MOUNT SCOTT FLOODPLAIN	1.4	SAWID	27.85	
S0111133	MOUNT SCOTT FLOODPLAIN	1.1	SAWID	27.85	
S0111276	MOOT YANG GUNYA SWAMP	1.1	SAWID	17.18	
S0111474	MANDINA MARSHES	1.3	SAWID	27.94	
S0111474	MANDINA MARSHES	1.4	SAWID	27.94	
S0111474	MANDINA MARSHES	1.10	SAWID	27.94	
S0111474	MANDINA MARSHES	1.11	claire, mark pers.com	27.94	
S0111474	MANDINA MARSHES	1.2	SAWID	27.94	
S0111474	MANDINA MARSHES	1.8	SAWID	27.94	
S0111507	TILLEY SWAMP FLOODPLAIN	1.4	SAWID	25.79	
S0111507	TILLEY SWAMP FLOODPLAIN	1.8	SAWID	25.79	
S0111509		1.3	DEH veg mapping	24.46	
S0111509		1.4	DEH veg mapping	24.46	
S0111743		1.3	DEH veg mapping	23.43	
S0111826		1.3	DEH veg mapping	17.34	
S0111826		1.4	DEH veg mapping	17.34	
S0111829	HERRIOT SWAMP	1.3	DEH veg mapping	21.08	
S0111829	HERRIOT SWAMP	1.4	DEH veg mapping	21.08	
S0111841		1.3	DEH veg mapping	17.13	
S0111907	DEEP SWAMP FLOODPLAIN	1.3	DEH veg mapping	23.01	
S0111907	DEEP SWAMP FLOODPLAIN	1.4	DEH veg mapping	23.01	
S0111907	DEEP SWAMP FLOODPLAIN	1.8	DEH veg mapping	23.01	
S0113840		1.6	DEH veg mapping		17.52
S0114945		1.8	DEH veg mapping		16.51
S0114971		1.6	Bachmann 2002		16.83
S0114982	CRESS CREEK SPRING	1.6	Bachmann 2002		16.57
S0114989	JERUSALEM CREEK SPRING	1.6	SAWID		16.48
S0114989	JERUSALEM CREEK SPRING	2.18	SAWID		16.48
S0116933	MARY SEYMOUR CONSERVATION PARK	1.3	DEH veg mapping		17.78
S0116933	MARY SEYMOUR CONSERVATION PARK	1.10	B. Taylor, pers. obs.		17.78
S0116936	SALT LAKE (Butchers Gap complex)	1.12	SAWID		21.61
S0116936	SALT LAKE (Butchers Gap complex)	1.2	SAWID		21.61

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AUS_WETNR	NAME	WVC MODEL	SOURCE	SigScore	LSE BCV Score
S0116936	SALT LAKE (Butchers Gap complex)	1.4	SAWID		21.61
S0116936	SALT LAKE (Butchers Gap complex)	1.8	SAWID		21.61
S0120280	BUTCHERS LAKE	1.12	SAWID	18.12	
S0120280	BUTCHERS LAKE	2.15	SAWID	18.12	
S0120842	TWIG RUSH LAGOONS	1.12	SAWID	17.00	
S0120842	TWIG RUSH LAGOONS	1.8	SAWID	17.00	
S0120854	EWENS PONDS	2.17	SAWID	24.85	
S0120854	EWENS PONDS	2.18	SAWID	24.85	
S0120855	BIG HEATH CP	1.3	DEH veg mapping	56.41	
S0120855	BIG HEATH CP	1.10	B. Taylor, pers. obs.	56.41	
S0120856	REEDY CREEK LF	1.1	SAWID	30.47	
S0120859	MARY SEYMOUR CONSERVATION PARK	1.3	DEH veg mapping		18.60
S0121483	LAKE BONNEY S.E.	1.4	SAWID	39.04	
S0121483	LAKE BONNEY S.E.	2.17	SAWID	39.04	
S0121483	LAKE BONNEY S.E.	2.19	Nichol 2006	39.04	

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Model 1.1 Eucalyptus camaldulensis woodland

There are a wide variety of *Eucalyptus camaldulensis* (River Red Gum) woodlands in the South East, not all of which are subject to inundation. This WVC model refers to the *E. camaldulensis* woodland that occurs as a fringing band around a number of wetlands in the South East and occasionally as the deepest parts of shallowly inundated basins. When inundated this WVC is characterised by fringing sedges (*Juncus* spp., *Isolepis nodosa*, *Lepidosperma laterale*/*L. concavum*, *Cyperus gymnocaulos*) in riparian areas and occasionally Lignum (*Muehlenbeckia florulenta*) shrubland. Submerged aquatic macrophytes (*Myriophyllum* spp., *Potamogeton* spp., *Marsilea* spp.) are common.

Where they occur, *Eucalyptus camaldulensis* woodlands in the South East are typically the most highly elevated WVC of the wetland (i.e. the least frequently and most shallowly inundated). The ideal water regime consists of both a wet and dry phase, however annual inundation is not required to maintain vigour. Inundation is likely to occur only in above average rainfall years. In the Murray-Darling Basin an inter-flood dry period of 6 to 18 months is recommended (MDBC 2003). However, the tolerance range for duration of inundation and exposure is very broad. *Eucalyptus camaldulensis* forest in the Murray-Darling Basin can tolerate up to 36 months without inundation (MDBC 2003). In contrast, continuous inundation of up to four years can be tolerated (Roberts and Marston 2000). *Eucalyptus camaldulensis* seedlings are vulnerable to both desiccation and immersion (CSIRO 2004) and seedling establishment is more important than germination for stand regeneration. An inundation depth of approximately 10 to 60 cm is recommended to favour the establishment of one year old *E. camaldulensis* seedlings (MDBC 2003). Mature trees are up to 45 m tall (CSIRO 2004) and can tolerate inundation of several meters.

Surface water salinity should be fresh (< 5000 $\mu S.cm^{-1}$). It is assumed that groundwater salinity is also required to be fresh, but regular inundation with freshwater may compensate for higher groundwater salinities. Benyon *et al.* (1999) recorded reduced growth of *E. camaldulensis* at soil salinity of $\geq$ 2000 $\mu S.cm^{-1}$ on the River Murray floodplain. Inundation is thought to be necessary to provide a vertical flushing mechanism that removes salt from the root zone.

Regular drying and reflooding promotes productivity of these wetland areas. Reflooding provides a flush of nutrients that stimulates macroinvertebrate and aquatic macrophyte production. These resources are in turn utilised by other fauna, such as feeding by dabbling ducks like Grey Teal, Chestnut Teal and Pacific Black Duck. Flooded vegetation provides breeding habitat and shelter for frogs and fish, which also feed on macroinvertebrates.

River Red Gums are noted for hollow development that provide breeding opportunities for waterfowl when flooded, and for parrots, bats and possums when dry. Waterfowl breeding in River Red Gum Swamps is a significant feature of this habitat, in a region where waterfowl breeding does not often occur. The canopy layer supports occasional breeding by herons, egrets and spoonbills, and roosting by these and other waterbirds. Dry periods see River Red Gum habitat provide nesting sites for raptors, crows, honeyeaters and Australian Magpies. Nectivorous birds such as honeyeaters and lorikeets make extensive use of River Red Gums when flowering occurs, and insectivorous birds and reptiles utilise the ample resources of the canopy and bark to hunt for invertebrate prey. Large woody debris deposited by River Red Gums is a valuable habitat for ground dwelling reptiles (snakes, goannas) and echidnas, and when flooded for yabbies, fish, macroinvertebrates and waterbird loafing.

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Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry	12	10
	Waterlogged	N/A	1
	0.1	N/A	1
Max. Depth Tolerance	> 2 m		
Surface Water Salinity	Target	Tolerance Range	
	< 5000		
Dry Phase Required	Yes		
Max. Continuous Inundation	48 months		
Max. Continuous Dry Phase	36 months		
Groundwater Regime	Prefers fresh (< 2000 µS.cm^{-1}) groundwater but occurs in areas with high groundwater salinity where surface soil salinity is maintained < 2000 µS.cm^{-1} by inundation and/or rainfall.		
Soil Conditions	< 2000 µS.cm^{-1} ideal Heavy soils – sand over clay and self-mulching grey clays		
Perennial Flora	*Eucalyptus camaldulensis* over sedgeland understorey – *Juncus* spp., *Lepidosperma* spp., *Isolepis* spp., *Cyperus* spp. +/- emergent understorey shrubs – *Muehlenbeckia florulenta* / *Callistemon rugulosus*		
Aquatic Flora (inundated)	*Potamogeton* spp., *Myriophyllum* spp., *Triglochin* spp., *Crassula* spp., *Marsilea* spp.		
Aquatic flora (dry)	Herbland species (*Selliera radicans*, *Wilsonia* spp., *Samolus repens*, *Mimulus* spp. etc)		

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Feature Category	Habitat Feature/Management Objective
Aquatic Fauna	When flooded nesting by colonial nesting waterbirds (Egrets; Herons; Spoonbills; Ibis). Aquatic macroinvertebrate production stimulated by reflooding. Large Woody Debris: when flooded - yabbies, fish, macroinvertebrates, Waterbird perching. When flooded roosting by waterbirds. Dabbling duck eat vegetation, seeds and macroinvertebrates. Diving ducks - eats fish, and large macroinvertebrate - 4 month flooding generally required. Large waders, eat frogs, provide food source when breeding. Hollows: breeding for ducks. Macrophytes provide shelter for Fish and Frogs.
Terrestrial Fauna	Nesting sites: Raptors; Honeyeaters; Crows; Magpies. Hollows: breeding for Parrots; ducks; bats; possums; goannas. Insectivores: In bark and in canopy. Nectivores: Parrots; Honeyeaters when flowering. Terrestrial Fauna Large Woody Debris: Habitat for ground dwelling reptiles, echidna.

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WVC Detailed Descriptions

Model 1.2 Seasonal brackish aquatic bed

This vegetation is exists on brackish to saline friable clays. When inundated this WVC supports aquatic species such as *Myriophyllum muelleri*, *Myriophyllum verrucosum, *Potamogeton pectinatus*, *Lepilaena cylindrocarpa*, *Crassula helmsii, Lilaeopsis polyantha, *Cotula coronopifolia* and charophytes. More salt sensitive species such as *Triglochin procerum*, *Villarsia reniformis*, *Ranunculus* spp. and **Rorippa nasturtium-aquaticum* are typically sparse or absent and vegetation cover/abundance may be lower than for fresher wetlands (Model 2.20). The dry cycle of this WVC is characterised by low herbland colonising species such *Wilsonia rotundifolia, W. backhousei*, *Selliera radicans, Mimulus* spp., *Distichlis distichophylla* and *Samolus repens* that are dormant when the area is inundated. Inundation for 3 - 6 months with water of 3000 to 16 600 $\mu S.cm^{-1}$ is required at least two years in three to provide for establishment and completion of lifecycle, and to prevent colonisation by more drought tolerant species (e.g. *Juncus kraussii*, *Gahnia* spp., *Melaleuca halmaturorum*). Maximum depth is typically 0.4 – 0.8 m, but these species can persist in deeper water (< 2 m) if turbidity is low. The colonising herbland species generally require periods of drawdown commencing in December-January. Aquatic species can tolerate extended periods of continuous inundation.

Aquatic macrophytes provide breeding and shelter for macroinvertebrates, crustaceans, and fish. When combined with shallow open water habitat these resources provide feeding for dabbling and diving ducks, large and small wading birds, grebes coots and cormorants. Initial productivity can be high and inundation stimulates colonising macroinvertebrate productivity (e.g. the emergence of Chironomid larvae) that attracts dabbling ducks and other waterbirds. Abundant food resources such as these can stimulate breeding of dabbling ducks in suitable adjacent habitat. At least four months inundation is required to sustain productivity beyond primary colonising invertebrates, and longer term flooding promotes the establishment of secondary macroinvertebrates such as dragonfly and mayfly larvae. The extended period also allows for production of fish and frogs, and when combined with secondary macroinvertebrates attracts tortoises, diving ducks, terns and large waders, and supports waterbird fledging after breeding. Shallow open water with semi-emergent macrophytes is the preferred feeding habitat for many waterbirds in the South East.

Summer/autum drawdown is important for nutrient recycling. Drawdown during this time provides exposed and shallowly inundated mudflats, a key feeding habitat for small migratory waders (e.g. Sharp-tailed Sandpiper, Curlew Sandpiper) and resident wading birds (e.g. Red-capped and Red-kneed Dotterels). The flooded habitat supports the feeding of bats and birds on aerial insects, and the drying habitat supports grazing by Black Swans, Australian Shelduck, kangaroos and wombats.

Seasonal brackish aquatic bed at Lake Hawdon North (S0109028), 24/11/2008.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.2 0.4 0.6	4 2 2 2 2	
Max. Depth Tolerance	2 m		
Surface Water Salinity	Target	Tolerance Range	
	3000 to 16600		
Dry Phase Required	No		

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Feature Category	Habitat Feature/Management Objective
Max. Continuous Inundation	several years
Max. Continuous Dry Phase	2 years
Groundwater Regime	Unknown, likely to vary between sites
Soil Conditions	Heavy soils, clays, can have high soil salinity
Perennial Flora	
Aquatic Flora (inundated)	*Myriophyllum muelleri*, *Myriophyllum verrucosum, *Potamogeton pectinatus*, *Lepilaena cylindrocarpa*, *Crassula helmsii, Lilaeopsis polyantha* and charophytes
Aquatic flora (dry)	*Wilsonia rotundifolia, W. backhousei*, *Selliera radicans, Mimulus* spp., *Distichlis distichophylla* and *Samolus repens*
Aquatic Fauna	Frogs seek shelter and breeding opportunities in macrophytes when flooded. Aquatic macroinvertebrates. Tortoise - eats frogs, tadpoles when flooded. Fish use macrophytes for shelter, feeding and breeding. Dabbling duck eats macroinvertebrates in vegetation - immediately after flooding - food source when breeding - 4 month flooding generally required for breeding. Diving ducks - eats molluscs, fish, and large macroinvertebrate - later after flooding - food source when breeding - 4 month flooding generally required. Large waders, eat frogs, provide food source when breeding. Migratory/small waders. Large waders (herons egrets, ibis).
Terrestrial Fauna	Grazing kangaroos

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Model 1.3 **Melaleuca brevifolia** *low shrubland*

This floodplain WVC often forms extensive, dense, low shrubland areas but can also exist as a narrow fringe around deeper waterbodies. It is often less than 2 m in height, although it can occur as a shrubland over 2 m in height and with less dense cover. *Melaleuca brevifolia* shrublands are favoured by seasonal waterlogging but can tolerate short duration seasonal to intermittent shallow inundation to a depth of ~ 0.5 m. Intermittent shallow inundation may play a role in the maintenance of this WVC by preventing the invasion of inundation intolerant terrestrial plant species. Optimal surface water salinity is thought to be less than 4000 µS.cm^{-1}. Less optimum (but tolerated) is temporary inundation (3 - 4 months) with water that is up to 6500 µS.cm^{-1}. Permanent or frequent prolonged inundation is not tolerated and will result in die-back. This habitat component has some groundwater dependence but records show that it can occur over groundwater of salinity up to 30 000 µS.cm^{-1}, suggesting that depth to groundwater and its influence on perched freshwater lenses may be more important than quality. Invasion of this WVC by terrestrial species such as *Darwinia micropetala*, *Eutaxia* spp., *Hakea* spp. and *Banksia* spp. can occur during extended, continuous periods without inundation.

When wet the understorey includes emergent aquatic vegetation (*Myriophyllum* spp., *Triglochin* spp., *Crassula* spp.), and sedge species (*Baumea juncea*, *Leptocarpus* spp. *Chorizandra enodis* and *Lepidosperma* spp.), which provides habitat for cryptic birds (Latham's Snipe, Australasian Bittern) and frog breeding habitat (*Crinia signifera* and *Litoria dumerillii*). Aquatic salt sensitive plants such as *Villarsia reniformis* (Running Marsh Flower) and *Eryngium vesiculosum* (Prostrate Blue Devil) also occur. Inundation supports Tortoises, which feed on detritus, frogs and tadpoles.

When dry the shrubland provides shelter, feeding and breeding habitat for a rich assemblage of birds and other fauna, noteworthy species including pygmy possums and Southern Emu-wren that are primarily insectivorous and Beautiful Firetail which feed on seeds. When flowering *Melaleuca brevifolia* can support an abundant population of Nectivorous birds, including occasional use by nomadic arid region birds such as the Black Honeyeater. Ground-dwelling reptiles inhabit the understorey searching for reptilian prey such as skinks and birds eggs.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry	10	8
	Waterlogged	2	2
	0.2	N/A	2
Max. Depth Tolerance	0.5 m		
Surface Water Salinity	Target	Tolerance Range	
	< 4000	0 to 6500	

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Feature Category	Habitat Feature/Management Objective
Dry Phase Required	Yes
Max. Continuous Inundation	6 months
Max. Continuous Dry Phase	2 years
Groundwater Regime	Groundwater salinity recorded up to 30 000 $\mu S.cm^{-1}$, but more likely to rely on shallower freshwater lenses and/or perched watertables.
Soil Conditions	Mainly sandy loam to loam (range: sand-clay to loam) (Foulkes and Heard 2003)
Perennial Flora	Shrubland overstorey – *Melaleuca brevifolia*, +/- emergent *Melaleuca halmaturorum* (drier areas – *Darwinia micropetala*, *Leptospermum continentale*, *Eutaxia microphylla, Pultenaea tenuifolia*). Known habitat for USE endemic *Cassinia tegulata* (critically endangered). Sedgeland understorey –*Gahnia trifida*., *Leptocarpus* spp., *Lepidosperma* spp., *Baumea juncea*, *Chorizandra enodis*, V*illarsia reniformis, Schoenus nitens*.
Aquatic Flora (inundated)	When wet - emergent aquatic herbs, *Myriophyllum* spp., *Crassula* spp., *Triglochin* spp.
Aquatic flora (dry)	Prostrate Blue Devil (*Eryngium vesiculosum*)- grows in open patches in flood recession.
Aquatic Fauna	Frogs breeding when flooded, Crinia sp, Banjo Frogs. Sedgeland understorey habitat for cryptic birds – snipe. Tortoise - eats frogs, tadpoles when flooded. Macro-invertebrates (Tadpole Shrimp in late Spring)
Terrestrial Fauna	South Emu-Wren, Pygmy possum, beautiful firetail - eat seeds, shelter, breeding, babblers - breeding, shelter. When flowering - can support terrestrial nectivores (honeyeaters). When Dry - goannas (eat skinks, dragons, eggs etc).

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Model 1.4 Melaleuca halmaturorum *tall shrubland*

Melaleuca halmaturorum spp. *halmaturorum* tall shrubland is generally a floodplain WVC that can form extensive stands or exist as scattered clumps amongst other WVCs. It is also associated with fringing areas surrounding deeper fresh to semi-saline waterbodies. These shrublands can develop under varying hydration regimes. Alteration to a regime can result in significant changes, examples being formerly seasonally inundated open water areas of the Upper South East that have become dominated by *M. halmaturorum* with a reduction in flows, and in paradox the recent documented examples of declining health of these shrublands with reduced groundwater influence and surface water inundation.

The optimal requirement to maintain vegetation vigour is for winter/spring waterlogging every year, and up to 6 months of shallow (up to 0.5 m depth) winter/spring inundation 3 to 4 times per decade. Depths greater than 0.5 m can be tolerated for shorter duration. Surface water salinity should be less than 6000 $\mu S.cm^{-1}$, though this WVC has been noted to tolerate regular inundation up to 30 000 $\mu S.cm^{-1}$ if freshwater flushing flows occur soon after. Continuous inundation for several years is thought to have been responsible for decline in vegetation vigour and suppression of recruitment at Bool Lagoon (DEH 2006), however the WVC persists there. It has been noted that this habitat can tolerate short periods (< 3 months) of inundation with saline water up to 30 000 $\mu S.cm^{-1}$ *Melaleuca halmaturorum* tall shrubland is considered to be a groundwater dependent ecosystem and normally occurs above shallow groundwater with a salinity of up to 30 000 $\mu S.cm^{-1}$, higher in some areas. Mensforth and Walker (1996) reported *M. halmaturorum* at a site with groundwater of 64 000 $\mu S.cm^{-1}$ fluctuating between 0.3 and 1.2 m below the sediment surface. Hydraulic pressure and its influence on perched freshwater may be more important than quality.

In saline sites the understorey is dominated by samphire (*Sarcocornia quinqueflora*) when dry, and *Ruppia* spp. when (rarely) inundated. In fresher areas *Gahnia trifida* is often present as a co-dominant and the understorey can support *Baumea juncea*, *Leptocarpus* spp., mosses and lichens. When inundated the shrubland can support various aquatic macrophytes including *Myriophyllum* spp., *Triglochin striatum* and *Villarsia reniformis*. The flooded shrubland can support colonial nesting waterbirds (herons, egrets, ibis, spoonbills and cormorants) if inundated to adequate depth greater than 4 months. It provides roosting habitat for these and other waterbirds, and the Freckled Duck is often noted to have a preference for sites dominated by this flooded habitat. Frogs and tortoises are present in these areas where salinity allows.

When dry the shrubland supports terrestrial insectivores such as Southern Emu-wren, pygmy possums and bats by providing shelter, feeding and breeding habitat. Beautiful Firetail and Malleefowl are two noteworthy graminivores that forage and shelter amongst the shrubland when dry. Flowering shrubs provide nectar for honeyeaters and invertebrates. Terrestrial inhabitants include reptiles such as Shingleback Lizard, Lowland Copperhead and Common Brown Snake. Tiger Snakes will also inhabit the fringes of the wet habitat feeding on tadpoles and other prey items.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3

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Feature Category	Habitat Feature/Management Objective		
	Dry Waterlogged 0.2	10 2 N/A	8 2 2
Max. Depth Tolerance	0.5		
Surface Water Salinity	Target	Tolerance Range	
	6000	5000 to 30000	
Dry Phase Required	Yes		
Max. Continuous Inundation	24 months		
Max. Continuous Dry Phase	4 years		
Groundwater Regime	Shallow groundwater and salinity up to approx. 70 000 μS.cm^{-1} (depth more important).		
Soil Conditions	Heavy soils, sometimes with calcareous influence. Can tolerate mild soil salinity.		
Perennial Flora	Shrubland overstorey – *Melaleuca halmaturorum*, +/- emergent *M. brevifolia* *Gahnia trifida* / *Gahnia filum* is often present as a co-dominant. fresh sites *Baumea juncea*, *Baumea arthrophylla*, *Leptocarpus* spp,; *Isolepis* spp., *Schoenus nitens*, moss and lichen. Saline/brackish sites *Sarcocornia* spp., *Selliera radicans*, *Samolus repens*, *Wilsonia* spp, *Angianthus preissianus*, *Lawrencia* spp.		
Aquatic Flora (inundated)	(Fresh sites): – *Myriophyllum* spp.; *Triglochin striatum*; *Villarsia reniformis*.		
Aquatic flora (dry)			

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Feature Category	Habitat Feature/Management Objective
Aquatic Fauna	Colonial Nesting Waterbirds - breeding, minimum 4 months inundation required. Freckled Duck - provides shelter. Roosting habitat for ducks and other waterbirds. Cormorants - roosting habitat, breeding. Provide shelter and breeding for frogs when flooded. Tortoise - eats frogs, tadpoles when flooded.
Terrestrial Fauna	

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Model 1.5 Leptospermum continentale shrubland

This vegetation typically forms a thin band around the margins seasonal freshwater wetlands in the Lower South East, although in some wetlands in dominates the entire wetland bed. The upper elevation range of this WVC provides an approximate measure of the typical extent of surface water inundation. Given its up-slope location, This WVC is waterlogged in typical rainfall years and shallowly (< 0.3 m) inundated in high rainfall years. The surface water of such wetlands is fresh, typically < 3000 $\mu S.cm^{-1}$ (DEH 2008). Inundation is not required and vegetation is sustained by seasonal waterlogging or the presence of soil moisture from rainfall. However, regular waterlogging or inundation may help prevent displacement by terrestrial species.

This WVC occurs on predominantly sandy soils with good drainage, which is also reflected in the presence of *Baumea juncea*, *Leptocarpus* spp., *Lepidosperma* spp., and *Isolepis nodosa*, specie that often dominate the understorey. The main habitat use is from arboreal Little Brown Birds including Thornbills, Beautiful Firetail, and Superb Fairywren. Honeyeaters also utilise the heath/shrubland areas in search of invertebrate prey. Cryptic waterbirds such as crakes and rails shelter in the dense shrubs. Lowland Copperheads browse for prey in this habitat also. *Leptospermum continentale* is indicative of the maximum water level in a wetland and is susceptible to ill-health caused by prolonged dry and/or salinity. Extended inundation is likely to cause senescence and displacement by more inundation tolerant species.

With regard to ecological function and water regime requirements, *Leptospermum continentale* shrubland is likely to be very similar to *Melaleuca squarrosa* shrubland.

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Leptospermum continentale **shrubland in a wetland (S0110738) in Honan Native Forest Reserve, 24/6/2004.**

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.2	10 2 N/A	8 2 2
Max. Depth Tolerance	0.5 m		
Surface Water Salinity	Target	Tolerance Range	
	< 3000		
Dry Phase Required	Yes		

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Feature Category	Habitat Feature/Management Objective
Max. Continuous Inundation	6 months
Max. Continuous Dry Phase	2 years
Groundwater Regime	Likely to require shallow, fresh groundwater with a watertable at or above the land surface for several months each year
Soil Conditions	Sand to loam (Foulkes and Heard 2003)
Perennial Flora	*Baumea juncea*; *Leptocarpus* spp.; *Lepidosperma* spp., *Isolepis* spp..
Aquatic Flora (inundated)	
Aquatic Flora (dry)	
Aquatic Fauna	Shelter for cryptic waterbirds such as crakes and rails
Terrestrial Fauna	Provides food and shelter for small passerines: Superb Fairywren, Beautiful Firetail, Thornbills. Snakes - copper heads forages for prey.

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Model 1.6 Leptospermum lanigerum shrubland

Leptospermum lanigerum (silky tea-tree) shrublands occur predominantly in the Lower South East. Co-dominant overstorey species may include *Ozothamnus ferrugineus*, *Melaleuca squarrosa* and *Leucopogon parviflorus.* Understorey species may include the tall tussock sedges *Gahnia trifida* and *G. clarkei*, emergent sedges including *Phagmites australis., Typha domingensis*, *Baumea arthrophylla*, *B. juncea*, *Juncus* spp., *Eleocharis gracilis* and *Schoenoplectus* spp. and an herbaceous groundlayer that may feature *Epilobium billardieranum* ssp. *billardieranum*, *Acaena novae-zelandiae*, *Samolus repens*, *Centella cordifolia*, *Hydrocotyle* spp., *Triglochin* spp., *Senecio biserratus*, *Lobelia alata*, *Brachycome graminea* and *Cotula* spp. At some locations a saline influence is demonstrated by the presence of *M. halmaturorum*, *Selliera radicans*, *Sarcocornia quinqueflora*, *Mimulus* spp., and *Juncus kraussii*.

Leptospermum lanigerum shrubland is closely associated with surface expressions of fresh groundwater (generally < 3000 $\mu S.cm^{-1}$) (springs and soaks) and soils with high organic matter, such as peat-dominated soils. Ecological Associates (2006) recorded relatively variable groundwater conditions at sites dominated by *L. lanigerum*. Groundwater depth ranged from 0 to 1.6 m and groundwater salinity from less than 2000 to 8000 $\mu S.cm^{-1}$. Semi-permanent to seasonal inundation with freshwater is favoured but is not considered necessary to maintain vegetation vigour. However, shallow (~ 0.1 m) inundation provides habitat for small-bodied native fish, particularly the nationally vulnerable Dwarf Galaxias (*Galaxiella pusilla*). Permanent surface water may restrict shrub recruitment, as has been implicated for *Melaleuca halmaturorum* shrubland (Denton and Ganf 1994).

The habitat supports small arboreal birds such as Thornbills, Beautiful Firetail, Superb Fairy-wren and Southern Emu-wren, and riparian areas can support the cryptic Australian Spotted Crake, Painted Button-quail, and Lewin's Rail.

Karstic spring pools (Model 2.18) often occur within *Leptospermum lanigerum* shrubland and sustain populations of rare native fish with Dwarf Galaxias, Southern Pygmy Perch, Yarra Pygmy Perch, River Blackfish and Murray-Darling Carp Gudgeon being noteworthy. These and shallower ponds also provide refuge for yabbies and macro-invertebrates that can exist amongst submerged and emergent aquatic macrophytes such as *Myriophyllum* spp., *Triglochin* spp. and *Juncus kraussii*.

***Leptospermum lanigerum* shrubland at Pick Swamp (S0110343), 12/8/2008.**

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.1	4 4 4	
Max. Depth Tolerance	0.3 m		
Surface Water Salinity	Target	Tolerance Range	
	< 3000	0 to 10000	
Dry Phase Required	No		
Max. Continuous Inundation	Indefinite (waterlogged)		

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Feature Category	Habitat Feature/Management Objective
Max. Continuous Dry Phase	8 months
Groundwater Regime	Typically associated with permanent freshwater (< 3000 μS.cm^{-1}) springs and seeps
Soil Conditions	Surface soil is typically loam (Foulkes and Heard 2003), however peat may be present at depth
Perennial Flora	Shrubland overstorey: *Leptospermum lanigerum, Ozothamnus ferrugineus*, *Melaleuca squarrosa, +/- Leucopogon parviflorus, +/- Melaleuca halmaturorum* Emergent sedge understorey: *Gahnia trifida*, *G. clarkei*, *Phagmites australis., Typha domingensis*, *Baumea arthrophylla*, *B. juncea*, *Juncus* spp., *Eleocharis gracilis* and *Schoenoplectus* spp. Herbaceous groundlayer: *Epilobium billardieranum* ssp. *billardieranum*, *Acaena novae-zelandiae*, *Samolus repens*, *Centella cordifolia*, *Hydrocotyle* spp., *Triglochin* spp., *Senecio biserratus*, *Lobelia alata*, *Brachycome graminea* and *Cotula* spp.
Aquatic Flora (inundated)	*Myriophyllum* spp., *Triglochin striatum*, *T. procerum, Potamogeton* spp., *Isolepis* spp., *Lilaeopsis polyantha, Mimulus* spp., *Samolus repens, Selliera radicans*
Aquatic Flora (dry)	
Aquatic Fauna	Native Fish – Dwarf Galaxias, Yarra Pygmy Perch, Southern Pygmy Perch, River Blackfish, Carp Gudgeon; Refuge in permanent ponds. Cryptic Birds: Crakes and Rails. Provide shelter and breeding for frogs when flooded. Tortoise - eats frogs, tadpoles when flooded. Yabbies and macroinvertebrates.
Terrestrial Fauna	Insectivores Southern Emu-wren, Superb Fairywren, Beautiful Firetail, Thornbills - food and shelter

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Model 1.7 Callistemon rugulosus Shrubland (under Eucalyptus leucoxylon Woodland)

This habitat component comprises a dense or mid-dense Scarlet Bottlebrush (*Callistemon rugulosus*) Shrubland beneath an overstorey of SA Blue Gum (*Eucalyptus leucoxylon*). SA Blue Gum can exist as drier woodland, but when located in lower lying areas on heavy soils with a clay or loam influence often exist with Scarlet Bottlebrush, the combination forming a naturally rare wetland habitat. River Red Gum (*Eucalyptus camaldulensis*) can exist as overstorey replacing SA Blue Gum in rare locations. *Callistemon rugulosus* is salt sensitive and provides a dependable indicator of freshwater influence (surface water generally < 500 - 2000 $\mu S.cm^{-1}$).

This WVC is subject to seasonal waterlogging and inundation with freshwater up to a depth of 0.2 m on an irregular and temporary basis. Waterlogged conditions can last up to nine months and groundwater salinity is likely to be < 500 $\mu S.cm^{-1}$. Few intact examples remain from which to assess understorey but remnant areas support sedges such as *Lepidosperma* spp. and deeper pools of water support *Villarsia reniformis*. Flowering plants provide resources for nectivores including honeyeaters, lorikeets and rosellas. Habitat use by wetland fauna is likely to be rare, possibly restricted to frog breeding and use by crakes and rails.

There is generally poor knowledge of this WVC for the Upper South East. Further field survey is required to fill information gaps for conceptual model development.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged	6 6	
Max. Depth Tolerance	0.2 m		
Surface Water Salinity	Target	Tolerance Range	
	< 2000		
Dry Phase Required	Yes		
Max. Continuous Inundation	9 months		
Max. Continuous Dry Phase	?		
Groundwater Regime	Expected to occur on groundwater < 500 $\mu S.cm^{-1}$		

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Feature Category	Habitat Feature/Management Objective
Soil Conditions	heavy clay soils with a low salinity < 500 µS.cm^{-1}
Perennial Flora	Shrubland overstorey: *Callistemon rugulosus, +/- Melaleuca* spp. Normally occurs in association with *Eucalyptus leucoxylon*, but can be found under *E. camaldulensis*, or as small isolated patches. Sedgeland understorey Riparian understorey: *Lepidosperma* spp.
Aquatic Flora (inundated)	Emergent macrophytes – *Villarsia reniformis (unknown)*
Aquatic Flora (dry)	
Aquatic Fauna	Cryptic Birds: Crakes and Rails. Provide shelter and breeding for frogs when flooded.
Terrestrial Fauna	Flowering plants provide nectar for honeyeaters

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Model 1.8 Gahnia filum *tussock sedgeland*

Gahnia filum tussock sedgeland is a habitat component that generally exists in floodplain areas with heavy soils that are typically subject to brief (2 – 4 months), shallow (< 0.2 m) winter/spring inundation or waterlogging and summer/autumn drying. It also occurs as a fringing vegetation around seasonal and semi-permanent waterbodies. Co-dominant species may include *Melaleuca brevifolia* and *M. halmaturorum*. The seasonally waterlogged/inundated nature of the habitat provides conditions suitable for a ground layer of aquatic plants, however the high cover of the *G. filum* canopy can limit the cover of the groundlayer. Typically a very sparse aquatic herb layer exists as the understorey and may include *Selliera radicans*, *Wilsonia rotundifolia, W. backhousei*, *Samolus repens, Sarcocornia quinqueflora, Angianthus preissianus* and *Schoenus nitens*. Emergent sedges may include *Baumea juncea*, *Juncus kraussii* and *Leptocarpus* spp.. Mosses and lichens are a feature in undisturbed sites. The high cover of *G. filum* may reduce evaporation and allow the persistence of soil moisture into summer. Lack of inundation can lead to invasion by less inundation tolerant shrubs (e.g. *M. halmaturorum*) and pasture weeds. Deeper inundation in high rainfall years may help prevent shrub invasion by drowning shrub recruits (e.g. Denton and Ganf 1994). However inundation of excessive depth and/or duration may lead to loss of vigour and displacement by more inundation tolerant species.

In the South East *Gahnia filum* tussock sedgeland typically occurs in the elevation zone above samphire low shruband (Model 1.12), seasonal brackish meadow (Model 3.22) or drier emergent macrophytes mixed sedgeland (Model 1.10) and below *Melaleuca* spp. shrublands (Models 1.3 and 1.4). This suggests its required water regime is intermediate between these neighboring WVCs. The water regime requirements of *Gahnia filum* tussock sedgeland are somewhat similar to those of *Gahnia trifida* tussock sedgelands, however *G. trifida* tussock sedgelands have a lower salinity tolerance, with *G. trifida* more abundant in the Lower South East and *G. filum* more abundant in the Upper South East (Bachmann 2002). Co-occurrence of *G. filum* and *G. trifida* is rare but does occur in some locations such as Lake Hawdon South (S0108314). The salinity at this site is likely to represent the lower end of the tolerance range for *G. filum* tussock sedgeland. When depth is maximal, the salinity of Lake Hawdon South is around 3000 $\mu S.cm^{-1}$ (DEH 2008). In nearby Lake Hawdon North (S0109028) shallow pools (Model 1.2 Seasonal brackish aquatic bed) within a matrix of *G. filum* tussock sedgeland have been measured at 14 000 $\mu S.cm^{-1}$ in late November (B. Taylor, pers. obs.). It is likely that *Gahnia filum* tussock sedgeland is generally restricted to locations with surface water salinities between 3000 and 16 600 $\mu S.cm^{-1}$ (i.e. brackish sites), however further investigation is required to confirm this. Where salinities persist outside this range *G. filum* tussock sedgeland is likely to be displaced by other vegetation types. Ecological Associates (2006) documented groundwater depths of 0.5 to over 1.2 m and groundwater salinities of up to 25 000 $\mu S.cm^{-1}$ at sites dominated by *G. filum*, however surface soil salinities were generally between 170 and 2000 $\mu S.cm^{-1}$.

Gahnia filum tussock sedgeland supports crakes and rails, and the waterlogged conditions and dense cover provide known habitat for Latham's Snipe, Australasian Bittern and Brown Quail. When inundated the tussocks can provide nesting sites for waterfowl and feeding/roosting platforms for Swamp Harrier. Small passerines such as Golden-headed Cisticola, Clamorous Reed-Warbler, Southern Emu-wren and Striated Fieldwren are noteworthy inhabitants of this habitat type.

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Gahnia filum tussock sedgeland was once a wide-spread floodplain vegetation component in the South East. This wetland landscape component is now relatively rare (identified as regionally 'vulnerable' (Croft *et al.* 1999)) in its intact form in the region due to regional scale drainage resulting in lack of inundation, invasion by shrubland species and reclamation for agricultural purposes.

Gahnia filum **tussock sedgeland at Lake Hawdon North (S0109028), 20/11/2008.**

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.2 0.4	8 2 2 n/a	6 2 2 2
Max. Depth Tolerance	0.5 m		
Surface Water Salinity	Target	Tolerance Range	
	8000	3000 to 16600	

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Feature Category	Habitat Feature/Management Objective
Dry Phase Required	Yes
Max. Continuous Inundation	9 months
Max. Continuous Dry Phase	several years
Groundwater Regime	Groundwater depth 0.5 to 1.5 m Groundwater salinity up to 25 000 µS.cm^{-1}
Soil Conditions	Sand to medium clay (Foulkes and Heard 2003) Surface soil salinity < 2000 µS.cm^{-1}
Perennial Flora	Often found in association with *Melaleuca brevifolia / M. halmaturorum*. Understorey very sparse herbland: *Selliera radicans*, *Wilsonia* spp., *Samolus repens* , *Pratia platycalyx*, *Zoysia matrella* Very sparse sedges: *Baumea juncea, Juncus kraussii*, *Leptocarpus* spp. Mosses and lichens are a feature of undisturbed sites.
Aquatic Flora (inundated)	
Aquatic Flora (dry)	
Aquatic Fauna	Cryptic Birds: Latham's Snipe, Brown Quail, Crakes and Rails. Breeding platforms for Swamp Harrier, and nesting sites for waterfowl when flooded.
Terrestrial Fauna	Terrestrial Fauna Golden-headed Cisticola, Blue-winged Parrot, Clamorous Reed-Warbler, Southern Emu-wren and Striated Fieldwren – breeding, food and shelter.

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Model 1.9 Gahnia trifida *tussock sedgeland*

Gahnia trifida tussock sedgeland occurs on similar heavy soils to that of *Gahnia filum* tussock sedgeland and has similar water regime requirements. However, *G. trifida* is thought to have a lower salinity tolerance than *G. filum* (Bachmann 2002). The required salinity of surface and groundwater is considered to be < 5000 $\mu S.cm^{-1}$. Shallow, semi-permanent inundation or waterlogging can be tolerated and annual drying is not considered a necessity. *Gahnia trifida* can be the only dominant in this WVC or form a mixed co-dominant habitat with shrub species including *Melaleuca halmaturorum*, *M. brevifolia* and *Leptospermum lanigerum*. It may occur as fringing vegetation around deeper waterbodies. An increase in salinity and/or reduction in flows may be causing the displacement of *Gahnia trifida* tussock sedgeland by *Gahnia filum* tussock sedgeland in some areas of the South East (e.g. Bucks Lake (S0107060) (Foulkes and Heard 2003)). Similarly, reduced inundation may result in invasion of waterlogging tolerant shrubs (e.g. *M. halmaturorum*) and pasture weeds. Deeper inundation in high rainfall years may help prevent shrub invasion by drowning shrub recruits (e.g. Denton and Ganf 1994).

This habitat component is known to occur in the Upper South East over deeper groundwater with high salinity (20 000 to 30 000 $\mu S.cm^{-1}$), but under these circumstances requires the existence of freshwater lenses and/or a perched freshwater layer above salty groundwater to exist. Depth to groundwater and its influence on perched freshwater lenses may therefore be more important than quality.

Regular inundation supports salt-sensitive semi-emergent and submerged aquatic macrophytes including *Myriophyllum verrucosum*, *Crassula helmsii* and *Triglochin striatum*, and emergent sedges include *Baumea juncea*, *Schoenus nitens*, *Juncus kraussii* and *Leptocarpus brownii*. Herbland species include *Lobelia alata*, *Pratia platycalyx* and *Lythrum hyssopifolia*.

Macrophytes provide habitat that sustains macroinvertebrates and frogs. Cryptic waterbirds such as Australian Spotted Crake, Australasian Bittern and Latham's Snipe are attracted to the fresh water, dense cover and food source provided by this habitat. When flooded for > 4 months the tussocks support opportunistic waterfowl breeding, sometimes including Australasian Shoveler, Chestnut Teal and Pacific Black Duck. Small passerines are a feature of *Gahnia trifida* tussock sedgelands with Golden-headed Cisticola, Clamorous Reed-Warbler and Striated Fieldwren often present in this habitat. Water rats are an irregular inhabitant using the tussocks for shelter and feeding.

The high density of plants and associated cover may assist in reducing the effects of evaporation allowing persistence of soil moisture into summer. In some areas the growth of *Melaleuca* shrubs appears inhibited despite prevailing elsewhere, probably due to dense cover and prolonged flooding and waterlogging (approximately 0.4 m depth for longer than 6 months) during the *Melaleuca's* germination window.

Further field survey is required to fill information gaps for conceptual model development. *Gahnia trifida* tussock sedgelands were once a wide-spread floodplain vegetation component in the South East. This wetland landscape component is now relatively rare (identified as regionally 'vulnerable' (Croft *et al.* 1999)) in its intact form due to regional scale drainage resulting in lack of inundation, increased salinity, invasion by shrubland species, and reclamation for agricultural purposes.

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<table>
<tr><th>Feature Category</th><th colspan="3">Habitat Feature/Management Objective</th></tr>
<tr><td rowspan="6">Target Hydrology</td><td></td><td colspan="2">Duration (months)</td></tr>
<tr><td>Level (m)</td><td>Annual</td><td>1 year in 3</td></tr>
<tr><td>Dry</td><td>8</td><td>6</td></tr>
<tr><td>Waterlogged</td><td>2</td><td>2</td></tr>
<tr><td>0.2</td><td>2</td><td>2</td></tr>
<tr><td>0.4</td><td>n/a</td><td>2</td></tr>
<tr><td>Max. Depth Tolerance</td><td colspan="3">0.5 m</td></tr>
<tr><td rowspan="2">Surface Water Salinity</td><td>Target</td><td colspan="2">Tolerance Range</td></tr>
<tr><td>< 5000</td><td colspan="2"></td></tr>
<tr><td>Dry Phase Required</td><td colspan="3">Yes</td></tr>
<tr><td>Max. Continuous Inundation</td><td colspan="3">indefinite (waterlogged)</td></tr>
<tr><td>Max. Continuous Dry Phase</td><td colspan="3">several years</td></tr>
<tr><td>Groundwater Regime</td><td colspan="3">Shallow groundwater < 5000 $\mu S.cm^{-1}$</td></tr>
<tr><td>Soil Conditions</td><td colspan="3">Sand to medium clay (Foulkes and Heard 2003)</td></tr>
<tr><td>Perennial Flora</td><td colspan="3">Gahnia trifida, ± Melaleuca brevifolia, ± M. halmaturorum.

Understorey low swedgeland: Baumea juncea, Schoenus nitens, Juncus kraussii and Leptocarpus brownii.

Understorey herbland: Lobelia alat , Pratia platycalyx, Lythrum hyssopifolia</td></tr>
<tr><td>Aquatic Flora (inundated)</td><td colspan="3">Submerged macrophytes Myriophyllum verrucosum, Lilaeopsis polyantha, Crassula helmsii and Triglochin striatum</td></tr>
<tr><td>Aquatic Flora (dry)</td><td colspan="3"></td></tr>
<tr><td>Aquatic Fauna</td><td colspan="3">Cryptic Birds: Australian Spotted Crake, Australasian Bittern, Latham’s Snipe attracted to fresh water.

Nesting sites for waterfowl when flooded: Australasian Shoveler, Chestnut Teal and Pacific Black Duck.

Water Rat an irregular inhabitant for feeding and shelter</td></tr>
</table>

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Feature Category	Habitat Feature/Management Objective
Terrestrial Fauna	Insectivores Golden-headed Cisticola, Clamorous Reed-Warbler and Striated Fieldwren – breeding, food and shelter.

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*Model 1.10 Drier Emergent Macrophytes (*Baumea juncea/Leptocarpus *spp./*Lepidosperma *spp.) Mixed Sedgeland*

These perennial sedgelands support a mixture of *Lepidosperma spp*., *Baumea juncea, Apodasmia brownii* and/or *Leptocarpus tenax, Chorizandra sp.,* and *Hypolaena fastigiata* and occur on well drained soils influenced by sands. Common soil types include sand over clay and sands/sandy clays with calcareous rock. Many of the species present represent terrestrial species that occur in deeper sands associated with dry woodlands and heaths, and their presence reflects their ability to quickly colonize wetland areas post long duration flooding, or indicate floodplain areas that are only temporarily or intermittently inundated. It may take at least three years for a sedgeland to fully re-establish in an area that was subject to prolonged inundation. This habitat can also occur as a fringe surrounding sumplands and they survive on regular seasonal waterlogging. Prolonged and frequent inundation will result in thinning and displacement by other species with a greater tolerance to flooding. Alternatively a long-term reduction in inundation will allow establishment of true terrestrial shrub species.

Surface water salinity is expected to be < 6500 μS.cm^{-1} and low salinity, soil moisture and surface water followed by a drying phase over summer/autumn are necessary to ensure these salt-sensitive plants are maintained. Groundwater rise will cause die-back both through waterlogging and salinity. Use by wildlife is not a feature amongst emergent sedges above water, being restricted to low level use by waterbirds such as crakes, rails, ducks and frogs. The Golden-headed Cisticola and Superb Fairy-wren are two passerines associated with the habitat. Feeding platforms constructed from the sedge materials by Swamp Harrier and Australasian Bittern are often found in areas subject to shallow inundation.

The principal value of the sedges is the contribution to a wetland's ecology when completely submerged. Decomposition of the sedges provides a food source for detritivore macroinvertebrates and contributes to nutrient release, which stimulates other processes, including the establishment of submerged aquatic vegetation. The sclerophyllous leaves form a mat on the bed of the wetland that provides breeding habitat for frogs, fish and macroinvertebrates, which in turn provides a food source for grazers and predators including tortoises, ducks, swans, terns and other waterbirds.

When dry these sedgeland areas are inhabited by skinks, dragons and Eastern Brown Snake, and support threatened plant species such as Metallic Sun-orchid (*Thelymitra epipactoides*) and Large-fruited Groundsel (*Senecio macrocarpus*). The sedgelands contributes to the home-range of terrestrial birds such as honeyeaters and the Southern Emu-wren, which searches for food from key adjacent habitats.

Feature Category	**Habitat Feature/Management Objective**		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.3	8 2 2	
Max. Depth Tolerance	0.5 m		

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Feature Category	Habitat Feature/Management Objective	
Surface Water Salinity	Target	Tolerance Range
	< 6500	
Dry Phase Required	Yes	
Max. Continuous Inundation	12 months	
Max. Continuous Dry Phase	4 years	
Groundwater Regime	Groundwater salinity < 10 000 µS.cm^{-1} Groundwater depth > 2 m in summer Expect thinning with prolonged elevated groundwater	
Soil Conditions	Well drained soils over clay, sandy clays with calcareous rock Low soil salinity	
Perennial Flora	Mixed community may include *Lepidosperma spp*., *Baumea juncea, Apodasmia brownii* and/or *Leptocarpus tenax, Chorizandra enodis, Hypolaena fastigata +/- emergent Gahnia* spp. Drier sites: +/- emergent *Senecio squarrosa*, *Olearia ramulosa*, *Banksia ornata*	
Aquatic Flora (inundated)	Submerged macrophytes *Myriophyllum verrucosum*, *Crassula helmsii* and *Triglochin striatum.*	
Aquatic Flora (dry)		
Aquatic Fauna	Low level use by crakes, rails and ducks. Provides material for feeding/roosting platforms for Swamp Harrier and Australasian Bittern. Breeding habitat and shelter for grassland frogs Macroinvertebrate productivity on rotting plants tough leaves provide material that supports breeding of frogs, fish and macroinvertebrates which in turn feed tortoises, ducks, terns, swans and other waterbirds.	

Feature Category	Habitat Feature/Management Objective
Terrestrial Fauna	Feeding and shelter for skinks, dragons and Eastern Brown Snake when dry. Insectivores New Holland Honeyeater, Tawny-crowned Honeyeater and Southern Emu-wren feed in area from adjacent habitats.

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Model 1.11 Seasonal freshwater emergent sedgeland

Seasonal freshwater emergent sedgeland is typically dominated by *Baumea arthrophylla*, which forms a monocultural sward within many wetland basins in the South East. However, other emergent sedge species may be codominant or even dominant in some locations. Such species include *Juncus procerus*, *J. holoschoenus*, *Baumea articulata*, *B. juncea*, *Eleocharis acuta* and *Chorizandra australis*. In some rare, very freshwater (< 500 $\mu S.cm^{-1}$) examples *Baloskion tetraphyllum* ssp. *tetraphyllum* is codominant or dominant. Submerged floating-leaf aquatic species such as *Triglochin procerum*, *Myriophyllum simulans* and *Villarsia reniformis* and aquatic herbs such as *Selliera radicans* may comprise a minor component of total cover/abundance. Subtle variations in abiotic factors such as elevation, soil type and salinity are likely to be responsible for shifts in species dominance. However, it is appropriate to group these species into a single habitat type based on water regime and salinity.

This vegetation occurs in locations typically subject to inundation to a depth of 0.4 m. Inundation to 0.6 m is recommended 1 year in 3 to mimic natural variability. Occasional, brief inundation to a depth of up to approximately 1 m can be tolerated. In a pond experiment 12 months of continuous inundation of 1 m depth led to a critical decline in biomass in *B. arthrophylla* (Rea and Ganf 1994). The researchers concluded that *B. arthrophylla* is better adapted to seasonally fluctuating water levels than to permanent water levels. However at Piccaninnie Ponds (S0101060) *B. arthrophylla* sedgeland is subject to near-permanent, shallow (< 0.5 m) inundation (Ecological Associates 2008). In dry years seasonal freshwater emergent sedgeland may not be inundated at all (e.g. Bool Lagoon (S0110446), 2005 to present), however persistently dry conditions are likely to lead to senescence of the component species of this WVC and their displacement by more drought tolerant species. Most wetlands featuring this WVC are subject to seasonal inundation for 4 to 8 months followed by exposure. Longer duration of inundation may lead to a decline vegetation health. For example, continuous inundation at Bool Lagoon during the mid 1980s to mid 1990s corresponded with a decline in the extent of *B. arthrophylla* sedgeland and its replacement by *Triglochin procerum* aquatic herbland (Model 2.20) (DEH 2006).

Seasonal freshwater emergent sedgeland occurs in wetlands with a relatively wide range of salinities in the South East. Examples include Lake Hawdon South (S0108314, 4350 $\mu S.cm^{-1}$, 16/11/2005) and Marshes Native Forest Reserve (S0110595, 135 $\mu S.cm^{-1}$, 14/7/2005) (DEH 2008). However, wetlands featuring this WVC do not generally exceed 5000 $\mu S.cm^{-1}$. An exception is Rocky Swamp (S0100217), where salinities during two consecutive inundation events (2004 and 2005) ranged from 3170 to 17 500 $\mu S.cm^{-1}$ (Harley 2006). Salinities this high are likely to be at or near the upper tolerance of this WVC.

Emergent sedges provide shelter and breeding habitat for Southern Bell Frog, Eastern Banjo Frog, Common Froglet, Long Necked Tortoise and other reptiles and amphibians. Murray- Darling Carp-Gudgeon and Southern Pygmy Perch are native fish species that can also be found using this resource. These animals feed on macroinvertebrates and organic matter that is supported by the leaves of the sedges. Yabbies (*Cherax destructor*) are a feature of this habitat type, and the exoskeletons discarded by herons, egrets, ibis and Australasian bitterns can be found on feeding platforms or littering the ground.

A variety of waterbirds utilise these areas, with sedges providing cover for feeding and breeding of Baillon's crake, buff-banded rail and dusky moorhen, and as a mooring for the floating nests of whiskered tern, great crested grebe and hoary-headed grebe. Other birds that breed in these areas include purple swamphen, Australasian bittern, swamp harrier, black swan and brolga. Use by ducks can vary – if the distribution of sedges is too dense in large expanses then the habitat would provide little access for feeding, but when found as a fringe adjacent open water dense sedgeland acts as a secure refuge. When the larger areas are flooded semi-open sedgeland habitat is created that attracts Australasian shoveler, grey teal and Pacific black duck that dabble for macroinvertebrates, seed and soft-leaved plants on the water's surface. If the habitat is subject to deep flooding (1 m or greater) feeding opportunities for diving ducks such as musk duck, hardhead and blue-billed duck are created. These birds feed on plant matter and macroinvertebrates that reside within the submerged sedges.

The establishment of dryland herbs during periods of drawdown is not a feature of these areas, probably due to the relative frequency and duration of inundation. Nevertheless terrestrial fauna including eastern grey kangaroo and common wombat forage for herbaceous food in the habitat, and snakes and lizards can also be observed. Ground-dwelling birds including Richards pipit and stubble quail make limited use of dry sites, as do superb fairy-wren and New Holland honeyeater, which hunt for insects.

Seasonal freshwater emergent sedgeland was once a widespread wetland vegetation component in the South East. This wetland landscape component is now relatively rare (identified as regionally 'vulnerable') in its intact form due to regional drainage, resulting in lack of inundation, and increased salinity.

Seasonal freshwater emergent sedgeland featuring monocultural swards of *B. arthrophylla* (foreground) and *B. articulata* (middle ground), Marshes Native Forest Reserve (S0107304), 14/4/2006.

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<table>
<tr><th>Feature Category</th><th colspan="3">Habitat Feature/Management Objective</th></tr>
<tr><td rowspan="3">Target Hydrology</td><td></td><td colspan="2">Duration (months)</td></tr>
<tr><td>Level (m)</td><td>Annual</td><td>1 year in 3</td></tr>
<tr><td>Dry
Waterlogged
0.2
0.4
0.6</td><td>6
2
2
2
n/a</td><td>4
2
2
2
2</td></tr>
<tr><td>Max. Depth Tolerance</td><td colspan="3">1 m</td></tr>
<tr><td rowspan="2">Surface Water Salinity</td><td>Target</td><td colspan="2">Tolerance Range</td></tr>
<tr><td>< 5000</td><td colspan="2">0 to 15000</td></tr>
<tr><td>Dry Phase Required</td><td colspan="3">No</td></tr>
<tr><td>Max. Continuous Inundation</td><td colspan="3">indefinite (waterlogged)</td></tr>
<tr><td>Max. Continuous Dry Phase</td><td colspan="3">4 years</td></tr>
<tr><td>Groundwater Regime</td><td colspan="3">Groundwater quality is unknown, depth up to 2 m in summer. Expect thinning with prolonged elevated groundwater.</td></tr>
<tr><td>Soil Conditions</td><td colspan="3">Heavy soils with low soil salinity.</td></tr>
<tr><td>Perennial Flora</td><td colspan="3">Baumea arthrophylla, B. articulata, B. juncea, Juncus procerus, J. holoschoenus, Eleocharis acuta, Chorizandra australis, Baloskion tetraphyllum ssp. tetraphyllum may be codominant or dominant. Selliera radicans may be present.</td></tr>
<tr><td>Aquatic Flora (inundated)</td><td colspan="3">Triglochin procerum, Myriophyllum simulans, Villarsia reniformis</td></tr>
<tr><td>Aquatic flora (dry)</td><td colspan="3"></td></tr>
</table>

Feature Category	Habitat Feature/Management Objective
Aquatic Fauna	Macroinvertebrates and yabbies are a feature of the habitat. Herons, Egrets, Ibis and Australasian Bittern feed on yabbies, fish and frogs. Breeding and shelter for Southern Bell Frog; Eastern Banjo Frog, Common Froglet; Long Necked Tortoise. Sedges support breeding and feeding of Baillon's Crake, Buff-banded Rail, Dusky Moorhen, Purple Swamphen, Australasian Bittern, Swamp Harrier, Black Swan and Brolga. Sedges provide a mooring for floating nests of Whiskered Tern, Great Crested Grebe and Hoary-headed Grebe. Fish breeding: Murray-Darling Carp-Gudgeon and Southern Pygmy Perch. Use by ducks can be restricted by dense distribution, but when open/flooded can support dabbling and diving ducks and provide shelter on fringe.
Terrestrial Fauna	Kangaroos and Wombats forage for herbs when dry. Feeding and shelter for skinks, dragons and Eastern Brown Snake when dry. Ground-dwelling Richards Pipit and Stubble Quail use dry sites, as do the insectivores Superb Fairy-wren and New Holland Honeyeater.

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Model 1.12 Samphire low herbland

This WVC dominated by *Sarcocornia quinqueflora* occurs on heavy (clay-influenced) soils in shallow sumplands and floodplain areas. It is indicative of high soil salinity and can often be found above very shallow groundwater that is > 30 000 $\mu S.cm^{-1}$. Ecological Associates (2006) documented groundwater depths of less than 1 m and groundwater salinities of greater than 10 000 $\mu S.cm^{-1}$ at sites dominated by *Sarcocornia quinqueflora*. Surface water salinity can vary from fresh (< 4000 $\mu S.cm^{-1}$) to marine (~60 000 $\mu S.cm^{-1}$). Salinity may be less important than duration as long-term inundation will result in waterlogging and dieback, though samphire recovers from regular seasonal inundation if inundated for less than six months and followed by a drying phase. Excessive waterlogging caused by elevated groundwater will also result in thinning and dieback.

The salinity of surface water influences the establishment of associated vegetation, such that inundation with fresh/brackish water will allow establishment of *Distichlis distichophylla*, *Wilsonia rotundifolia*, *Samolus repens*, and *Selliera radicans* during the drying phase, and inundation with saline water will stifle the establishment of these herbs, but allow the growth of other halophytes and the salt tolerant *Ruppia tuberosa* when inundated. At Twig Rush Lagoons (S0120842 and S0110991) in Bool Lagoon Game Reserve, samphire low herbland occurs in the elevation zone above seasonal saline low aquatic bed (Model 2.15) and below *Gahnia filum* tussock sedgeland (Model 1.8), suggesting its water regime requirements are intermediate between these two neighbouring WVCs.

Aerial invertebrates (midges and mosquitos) are a feature of samphire swamps suggesting optimum aquatic conditions for larval development of salt tolerant species. These insects provide food for Welcome Swallows, which feed in the air, and White-fronted Chats, which search for invertebrate prey and seeds on the ground amongst the shrubs themselves. Soil and surface water salinity limits the diversity of aquatic macroinvertebrate that occur in samphire. *Sarcocornia quinqueflora* is a favoured food plant of the nationally critically endangered Orange-bellied Parrot (Orange-bellied Parrot Recovery Team 2006).

Waterbird use can be limited given the high salinities associated with the habitat, and high abundance and/or diversity is rarely observed. Flooded areas can support Chestnut Teal and Grey Teal, which dabble for aquatic invertebrates, and waterlogged areas provide opportunities for Sharp-tailed Sandpiper and Red-necked Stint to search for seeds and invertebrate prey.

Samphire low herbland (foreground) at Twig Rush Lagoon (S0120842), 3 June 2004. Adjacent WVCs at higher elevations are *Gahnia filum* tussock sedgeland (Model 1.8) (middleground) and *Melaleuca halmaturorum* tall shrubland (Model 1.4) (background).

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.3	8 2 2	
Max. Depth Tolerance	0.5 m		
Surface Water Salinity	Target	Tolerance Range	
	< 6000		
Dry Phase Required	Yes		

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Feature Category	Habitat Feature/Management Objective
Max. Continuous Inundation	Indefinite (waterlogged)
Max. Continuous Dry Phase	5 years
Groundwater Regime	Groundwater depth < 1.0 m depth Groundwater salinity > 10 000 µS.cm^{-1} Expect thinning with prolonged waterlogging
Soil Conditions	Heavy soils with high soil salinity
Perennial Flora	*Sarcocornia quinqueflora* and other halophytes Saline soils inundated with brackish water can support *Distichlis distichophylla*, *Wilsonia rotundifolia*, *Samolus repens* and *Selliera radicans*
Aquatic Flora (inundated)	Submerged macrophytes *Ruppia tuberosa* in saline water
Aquatic flora (dry)	
Aquatic Fauna	Macroinvertebrates – midges and mosquitos are a feature Macroinvertebrates support feeding of migratory waders Chestnut Teat and Grey Teal use inundated areas for feeding and shelter
Terrestrial Fauna	Invertebrates support aerial insectivores – Welcome Swallow Feeding for White-fronted Chats on insects and seeds

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Model 1.13 Semi-permanent Deep / Open Water

The larger sumplands that exist along Upper South East watercourses can provide areas of fresh (< 6000 µS.cm^{-1}) water, sometimes exceeding 1.5 m deep. Under traditional climatic conditions these areas of open water would persist in most years, though decrease in depth with evaporation and seepage during summer and autumn. Retention of water would occur for 3 or 4 years in five, irregularly becoming completely dry (during drought), and rarely remaining dry for up to 4 years. Some areas maintain water at a slightly higher salinity (6000 – 10 000 µS.cm^{-1}).

A feature of this habitat component is the absence of emergent vegetation, except on the extreme fringes of the waterline. Submerged aquatic vegetation such as *Vallisneria spiralis*, C*hara, Nitella, Myriophyllum* spp. and *Potamogeton* spp. are present in this habitat, particularly where turbidity is low. The submerged vegetation provides refuge and breeding opportunities for large predatory macroinvertebrates (yabbies, Odonata – Dragonfly and Damselfly larvae), and in addition to breeding and feeding, provides secure drought refuge for fish, frogs and tortoises. These waterbodies are often fringed by *Eucalyptus camaldulensis* Woodland with sedge understorey.

A familiar characteristic is the presence of large numbers of waterbirds. The depth of water and available food resources make semi-permanent deep open water the favoured habitat for diving ducks, Blue-billed Duck, Musk Duck and Hardhead which dive for fish, molluscs and invertebrate larvae in the water or amongst the aquatic vegetation. The presence of fish provides a food source for piscivores such as Little Black Cormorant, Little Pied Cormorant, Australian Pelican, Darter and Hoary-headed Grebe. Great-crested Grebe can also be observed diving for food. Terns are aerial piscivores that are attracted to these areas, and Gull-billed Tern, Whiskered Tern and less frequently Caspian Tern utilise the habitat.

Dabbling ducks do not benefit greatly from the habitat when more optimum shallow habitat is available, but use by Grey Teal, Chestnut Teal, Pacific Black Duck, Australasian Shoveler and Freckled Duck still occurs during winter/spring. However these opportunistic/nomadic species do derive great benefit from deep water habitats during summer and through drought conditions when they seek a secure refuge. Other waterbirds also seek refuge in these habitats, and great congregations of waterbirds can be observed on these open water areas.

Establishment to terrestrial vegetation, sedgelands or herblands when dry is limited by the frequency and duration of inundation and the dry basins are often characterised by exposed clay soils and a few low herbs only.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Deeply Inundated	0 12	
Max. Depth Tolerance	No upper limit		

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Feature Category	Habitat Feature/Management Objective	
Surface Water Salinity	Target	Tolerance Range
	< 10000	
Dry Phase Required	No	
Max. Continuous Inundation	indefinite	
Max. Continuous Dry Phase	several years	
Groundwater Regime	Groundwater quality is unknown. Surface water can contribute to groundwater mounding in some circumstances.	
Soil Conditions	Heavy soils with low soil salinity.	
Perennial Flora	Emergent and/or perennial vegetation is not a feature of these open water habitats.	
Aquatic Flora (inundated)	Open water with sparse fringing submerged macrophytes *Vallisneria spiralis*, *Chara, Nitella, Myriophyllum verrucosum* and *Potamogeton pectinatus* are a feature in low turbidity water.	
Aquatic flora (dry)		

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Feature Category	Habitat Feature/Management Objective
Aquatic Fauna	Refuge and breeding opportunities for large predatory macroinvertebrates (yabbies, Odonata – Dragonfly and Damselfly larvae. Breeding and shelter for native fish, frogs, Long Necked Tortoise. Secure drought refuge for fish, frogs and tortoises. Refuge and feeding habitat for dabbling and grazing ducks and other waterbirds. Fish provide food for aerial piscivores Gull-billed Tern, Whiskered Tern and Caspian Tern. Fish provide food for diving piscivores, Great Crested Grebe, Hoary-headed Grebe, Australian Pelican, Little Black Cormorant and Little Pied Cormorant. Favoured habitat for diving ducks, Musk Duck, Blue-billed Duck, Hardhead.
Terrestrial Fauna	Not a regular feature.

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Model 1.14 Hypersaline Wetlands

The northern areas of the Upper South East support a variety of wetlands that are inundated with water often at sea water salinity or greater (≥ 58 300 µS.cm^{-1}). The source of the water is often derived from groundwater that has risen to discharge in low sumpland areas. These direct expressions of regional groundwater are saline in winter, rising in salinity with evapo-concentration during summer and autumn. Other areas are closed depression sumplands inundated with local run-off that for a short duration may provide limited access to fresh water. The mobilisation of salts from the surrounding landscape and from the bed of the depression results in increasing salinity. Interaction with groundwater in these circumstances is currently not well known.

Hypersaline wetlands can be naturally occurring, but most inland hypersaline swamps exhibit evidence of past shrubland and/or woodland cover that has deceased due to the effects of salinity and waterlogging. Biological productivity is not well researched but is apparently low, being restricted to salt tolerant species including the aquatic macrophyte *Ruppia tuberosa* and a limited number of macroinvertebrates such as ostracods, gastropods and copepods. Aerial invertebrates such as midges congregate above these waterbodies providing food for aerial insectivores including Welcome Swallow and Tree Martin.

Waterbird use is generally low, normally supporting the 'common' ducks such as Grey Teal and Chestnut Teal. The Banded Stilt, one of a few waterbirds known to have a *preference* for hypersaline lakes is often observed probing for benthic invertebrates, often in a mixed flock with Red-necked Avocet, which uses its recurved beak to capture prey items from the shallow water.

When dry the sumplands support very little colonising vegetation because of the highly saline nature of the soil, and they exist as white, clayey pans in the summer. Even halophytes such as samphire are rare during these drying phases, and as a result there is very little use by terrestrial fauna.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry 1.5 approx.	0 12	
Max. Depth Tolerance	2.5 m		
Surface Water Salinity	Target	Tolerance Range	
	> 58300		
Dry Phase Required	No		
Max. Continuous Inundation	indefinite		

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WVC Detailed Descriptions

Feature Category	Habitat Feature/Management Objective
Max. Continuous Dry Phase	several years
Groundwater Regime	Areas are often direct expressions of groundwater discharge. Groundwater salinities often high, equal to surface water. Groundwater Regime Some will not dry unless groundwater levels drop.
Soil Conditions	Heavy soils with high soil salinity.
Perennial Flora	No living emergent vegetation but long-dead remnants of shrubs can be seen in some areas, indicating former fresher hydrological conditions.
Aquatic Flora (inundated)	Submerged salt tolerant macrophytes *Ruppia tuberosa*, *Lepilaena sp*, C*hara sp. Nitella sp..*
Aquatic flora (dry)	
Aquatic Fauna	Macroinvertebrates ostracods, gastropods and copepods Breeding and shelter for salt tolerant fish Small-mouthed Hardyhead and Congolli. Preferred habitat for Banded Stilt and Red-necked Avocet. Refuge and feeding habitat for common dabbling ducks Grey Teal and Chestnut Teal. Fish provide food for aerial piscivores, Crested Tern and Caspian Tern. Fish provide food for diving piscivores, Hoary-headed Grebe, Australian Pelican, Little Black Cormorant and Little Pied Cormorant. Mudflats provide feeding opportunities for migratory and resident waders, Sharp-tailed and Curlew Sandpipers, Red-necked Avocet, Red-capped Plovers.
Terrestrial Fauna	Invertebrates support aerial insectivores - Welcome Swallow.

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WVC Detailed Descriptions

Model 2.15 Seasonal saline low aquatic bed

This WVC occurs at the lowest elevations of some seasonal wetlands and at the margins of some permanent wetlands with seasonally fluctuating water levels. When inundated, a submerged vegetation develops that is dominated by *Ruppia tuberosa* or *Ruppia polycarpa* (Nicol 2005), but may also include other fine leaf macrophytes such as *Lepileana* spp., *Potamogeton pectinatus*, the more salinity tolerant species of *Myriophyllum* and charophytes such as *Lamprothamnium succinctum* (J. Nicol, pers. com.). The aquatic vegetation is intolerant of desiccation. Exposure produces a mat of decomposing plant material and/or bare sediment. However, exposure is required to stimulate plant reproduction (both sexual and asexual), with subsequent inundation leading to germination of propagules from the previous season (Nicol 2005). The sediment of such sites is typically a fine, white pipeclay. This WVC is similar to the Victorian ecological vegetation communities 'Brackish Aquatic Herbland' (EVC 537) and 'Saline Aquatic Meadow' (EVC 842) (DSE 2006).

Seasonal saline low aquatic bed was a feature of the 'mudflats' of the Coorong South Lagoon (not a site considered for this project) prior to the development of hypersaline conditions there. Historically these mudflats experienced seasonal inundation to a depth of up to 0.8 m (Paton 2003), typically 0.2 - 0.6 m (Freebairn 1999), with brackish to saline water (Gell and Haynes 2005), with exposure occurring in summer/autumn. At Lake George (S0101818) annual water level fluctuations of approximately 1 m occur under 'normal' conditions, a similar degree of fluctuation as occurs in the Coorong. It is likely that component plant species can tolerate continuous exposure for one or two years, however extended exposure may reduce viability. Laboratory trials have reported a low proportion (10 – 30 %) of viable *Ruppia tuberosa* seed germination under favourable conditions (Nicol 2005), indicating this species is likely to produce a seed bank that can persist for several years. Other sites featuring this vegetation type include Lake Eliza (S0108474), Lake Robe (S0108357), Butchers Lake (S0100098), Hog Lake (S0120847) and The Salt Swamp (S0110507). The timing and duration of inundation recommended for the Coorong mudflats is 7 months during winter/spring (Phillips and Muller 2006). The surface water salinity of Butchers Lake was 16 000 $\mu S.cm^{-1}$ in late winter of 2004 (DEH 2008), a relatively high rainfall year. Historically, the salinity of the Coorong South Lagoon averaged approximately 8300 $\mu S.cm^{-1}$ (Gell and Haynes 2005). *Ruppia tuberosa* can tolerate salinities up to approximately 180 000 $\mu S.cm^{-1}$ (CLLAMMecology Research Cluster 2008), however reproduction may be inhibited at salinities greater than seawater (58 300 $\mu S.cm^{-1}$) (J. Nicol, pers. com.).

Seasonal saline low aquatic bed is one of the most important vegetation types in the South East for shorebirds. Migratory shorebirds typically arrive in the region from early November and depart in mid February (Morcombe 2003). The presence of shallow (< 5 cm) and recently exposed brackish to saline low aquatic bed during this period provides access to food resources, such as *Ruppia* spp. propagules and infauna, for these birds. Areas inundated to a depth of less than 30 cm provide potential feeding habitat for larger, non-migratory waders such as oystercatchers, stilts, avocets and spoonbills and for waterfowl including black swans and diving ducks.

Inundated seasonal saline low aquatic bed (foreground) at Hog Lake (S0120847), 31/8/2004.

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Exposed seasonal saline low aquatic bed at The Salt Swamp (S0110507, Bool Lagoon Complex), 3/6/2004, showing dense decaying plant material. The sparse samphire present here is atypical of this WVC.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.2 0.4	6 2 2 2	
Max. Depth Tolerance	0.8 m		
Surface Water Salinity	Target	Tolerance Range	
	16600 to 58300		
Dry Phase Required	Yes		

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Feature Category	Habitat Feature/Management Objective
Max. Continuous Inundation	9 months
Max. Continuous Dry Phase	3 years
Groundwater Regime	Likely to be shallow and to have a strong influence on surface water levels
Soil Conditions	Surface sediments typically fine, white pipeclay
Perennial Flora	Absent or very sparse samphire or salt tolerant emergent sedges
Aquatic Flora (inundated)	*Ruppia tuberosa, Ruppia polycarpa, Lepilaena* spp.*, Potamogeton pectinatus, Triglochin striata*, charophytes (e.g. *Lamprothamnium* spp.)
Aquatic flora (dry)	none
Aquatic Fauna	Migratory and Australian shorebirds, diving ducks, black swans, spoonbills
Terrestrial Fauna	

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Model 2.16 Melaleuca squarrosa *mid shrubland*

Melaleuca squarrosa mid shrubland is typically dominated by *M. squarrosa* of up to 2 m in height. Co-dominant species may include *Leptospermum lanigerum*, *L. continentale*, *Melaleuca squamea*, *Gahnia clarkei* and *Gahnia trifida*. *Xanthorrhea* spp. may be present. Rarely, *M. squarrosa* is sparse to absent with *M. squamea* or *G. clarkei* locally dominant. This vegetation should not be confused with *Leptospermum lanigerum* shrubland, which is typically taller (≥ 3 m) and occurs at slightly higher elevations. *Melaleuca squarrosa* mid shrubland occurs predominantly in the Lower South East around the margins of freshwater wetlands. In shallow wetlands it may dominate large areas of the wetland bed (e.g. at Piccaninnie Ponds). This vegetation type is similar to the Victorian ecological vegetation community 'Wet Heathland' (EVC 8) (DSE 2006).

Sites in the South East at which this vegetation type has been recorded have surface water salinities ranging from approximately 135 to 2655 $\mu S.cm^{-1}$ (DEH 2008). Maximum depth of up to 0.3 m has been observed in high rainfall years (B. Taylor, pers. obs.), however 0.1 m is more typical during winter/spring. In summer/autumn these sites are exposed but typically remain waterlogged, although permanent waterlogging does not persist at all such sites. In dry years, peripheral *Melaleuca squarrosa* mid shrubland may not be inundated, however persistent lack of inundation / waterlogging is likely to lead to senescence and displacement. At Piccaninnie Ponds water levels vary only slightly (± 0.1 m approx.) seasonally and the vegetation is subject to permanent shallow inundation. At Burks Island (S0106076) *Melaleuca squarrosa* mid shrubland occurs at elevations that are never subject to inundation but on peat soil that is likely to retain high moisture content throughout the year. Foulkes and Heard (2003) recorded this vegetation type at sites with sand to sandy-loam surface soils. Peat is likely to be the favoured sub-surface soil type. Ecological Associates (2006) documented groundwater depths of 0.5 to 1.3 m and groundwater salinities of less than 2500 $\mu S.cm^{-1}$ at sites dominated by *M. squarrosa*.

The dense, shrubby vegetation provides habitat for small, cryptic water birds such as crakes and rails, particularly where it adjoins aquatic herbland and sedgeland. Various bush birds including honeyeaters, wrens and finches also utilise this habitat. Swamp wallabies may shelter in the dense shrubs.

***Melaleuca squarrosa* mid shrubland at Piccaninnie Ponds (S0101060).**

<table>
<tr><th>Feature Category</th><th colspan="3">Habitat Feature/Management Objective</th></tr>
<tr><td rowspan="3">Target Hydrology</td><td></td><td colspan="2">Duration (months)</td></tr>
<tr><td>Level (m)</td><td>Annual</td><td>1 year in 3</td></tr>
<tr><td>Dry
Waterlogged
0.2
0.4</td><td>8
2
2
n/a</td><td>6
2
2
2</td></tr>
<tr><td>Max. Depth Tolerance</td><td colspan="3">0.3 m</td></tr>
<tr><td rowspan="2">Surface Water Salinity</td><td>Target</td><td colspan="2">Tolerance Range</td></tr>
<tr><td>< 5000</td><td colspan="2"></td></tr>
<tr><td>Dry Phase Required</td><td colspan="3">Yes</td></tr>
<tr><td>Max. Continuous Inundation</td><td colspan="3">12 months</td></tr>
</table>

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Feature Category	Habitat Feature/Management Objective
Max. Continuous Dry Phase	2 years
Groundwater Regime	Groundwater depth < 2 m Groundwater salinity < 2500 $\mu S.cm^{-1}$
Soil Conditions	Sandy to sandy-loam soils (Foulkes and Heard 2003), peat soils at some locations
Perennial Flora	*Melaleuca squarrosa*, *Leptospermum lanigerum*, *L. continentale*, *Melaleuca squamea*, *Gahnia clarkei*, *Gahnia trifida*, *Xanthorrhea* spp.
Aquatic Flora (inundated)	As above
Aquatic flora (dry)	As above
Aquatic Fauna	Cryptic waterbirds (e.g. crakes and rails)
Terrestrial Fauna	Bush birds, Swamp Wallaby

Model 2.17 **Typha** *sp.,* **Phragmites australis** *grassland*

Typha sp.*, Phragmites australis* grassland consists of dense reeds, typically but not exclusively taller than 2 m, dominated by *Typha* sp. (*T. domingensis* or *T. orientalis*) and/or *Phragmites australis*. Other species are usually present but low in cover and may include *Baumea juncea*, *B. laxa*, *Urtica incisa*, *Juncus procerus*, *Eleocharis sphacelata*, *Schoenoplectus validus*, *Triglochin procerum*, *Berula erecta* and *Epilobium pallidiflorum*. Rarely, *Typha* sp. and *P. australis* are sparse to absent, with another tall emergent macrophyte species locally dominant (e.g. *Juncus procerus*, *Eleocharis sphacelata* or *Schoenoplectus validus*). *Typha* sp.*, Phragmites australis* grassland is similar to the Victorian ecological vegetation community 'Tall Marsh' (EVC 821) (DSE 2006).

The invasion of wetlands by *Typha* is a widespread phenomenon that is thought to be indicative of degradation (Roberts and Marston 2000). Ecological changes such as nutrient enrichment, sedimentation and stabilisation of water levels are thought to be responsible. Lake Frome (S0105943) is a wetland in the South East that may be experiencing such changes.

Sites in the South East featuring *Typha* sp.*, Phragmites australis* grassland include Piccaninnie Ponds Eastern Wetland (S0107026), Lake Frome (S0105943), Bool Lagoon (S0110446) and Lake Bonney (S0121483). At Piccaninnie Ponds, a site with limited water level fluctuations, this WVC occurs at elevations typically inundated to a depth of 0.1 to 0.3 m (B. Taylor, pers. obs.). At Lake Bonney, *Typha domingensis* is most abundant at 0 cm above the water surface (Nicol 2006). At Bool Lagoon *Typha* sp.*, Phragmites australis* grassland can remain dry for extended periods (3 to 4 years) but is inundated to a depth of up to 1 m when the wetland fills. There are a number of wetlands in the Lower South East in which this vegetation type occurs at similar or very slightly deeper elevations to seasonal freshwater emergent sedgeland (Model 1.11) and experiences a very similar water regime (DEH 2008, B. Taylor, pers. obs.). Roberts and Marston (2000) suggest that *Typha* is strongly favoured by either spring/summer inundation or stable water levels, that it does not tolerate a water depth of 2 m or more and that it can survive for up to a few years without inundation if rhizomes are protected from desiccation by being deep (0.5 m) within heavy clay. *Typha domingensis* occurs on the banks of the River Murray in South Australia at sites inundated for 360 to 365 days per year, typically to a depth of 20 to 60 cm (Blanch *et al.* 1999).

The upper salinity tolerance of *Typha domingensis* is 11 500 $\mu S.cm^{-1}$ (Bailey *et al.* 2002). *Phragmites australis* has a higher salinity tolerance (21 000 EC, Bailey *et al.* 2002), however at most sites in the South East *Typha* sp. is the dominant reed. Vegetation vigour is likely to be maintained at salinities of less than 8000 $\mu S.cm^{-1}$. At most sites in the South East featuring this WVC salinities rarely exceed 6000 $\mu S.cm^{-1}$ (DEH 2008).

Dense reeds provide cover and nesting habitat for a suite of waterbirds including swamphens, moorhens, coots, black swans and grebes (free-floating attached nests), When inundated this vegetation provides nesting habitat for colonial nesting species such as ibis and spoonbills.

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***Typha* sp., *Phragmites australis* grassland at Piccaninnie Ponds Eastern Wetland (S0107026), 14/8/2008.**

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.2 0.5	6 2 2 2	
Max. Depth Tolerance	2 m		
Surface Water Salinity	Target	Tolerance Range	
	< 8000		
Dry Phase Required	No		

Feature Category	Habitat Feature/Management Objective
Max. Continuous Inundation	indefinite
Max. Continuous Dry Phase	4 years
Groundwater Regime	Occurs at sites with a broad range of groundwater salinities and watertable depths
Soil Conditions	Generally heavy clays and silts
Perennial Flora	
Aquatic Flora (inundated)	*Typha domingensis*, *T. orientalis*, *Phragmites australis* as dominants. *Baumea juncea*, *B. laxa*, *Urtica incisa*, *Juncus procerus*, *Eleocharis sphacelata*, *Schoenoplectus validus*, *Triglochin procerum*, *Berula erecta* and *Epilobium pallidiflorum* as generally minor components.
Aquatic flora (dry)	
Aquatic Fauna	swamphens, moorhens, coots, black swans, grebes, ibis, spoonbills
Terrestrial Fauna	

Model 2.18 Karstic spring pool with deeply submerged aquatics

These deep, spring-fed pools with very clear, fresh water are a feature of the coastal zone of the Lower South East. Clear water permits light penetration to a considerable depth, with aquatic vegetation occurring to several meters. Submerged vegetation at depth typically features *Myriophyllum* spp. and *Ranunculus* spp.. Fringing vegetation is typically more species rich and may feature *Triglochin procerum*, **Rorripa nasturtium-aquaticum*, *Baumea articulata*, *Baumea arthrophylla*, *Phragmites australis*, *Typha* spp. and *Cladium procerum*. The deep pools, or sink-holes, are fissures within a limestone matrix. In the more intact examples, the fringing wetland may be extensive and feature a variety of wetland vegetation types. Karstic spring pools correspond with the Victorian ecological vegetation community 'Sink-hole Wetland' (EVC 908) (DSE 2006).

Karstic spring pools typically discharge groundwater throughout the year. Although the rate of discharge may vary seasonally, such changes are inadequate to produce marked water level fluctuations; stable water levels are typical. Water salinities in karstic spring pools in the South East are less than 3000 $\mu S.cm^{-1}$ (DEH 2008), although salinity may increase at depth due to a marine influence.

Karstic spring pools provide critical habitat for a number of South East endemic fish and aquatic invertebrate species, including several threatened species (Hammer 2002).

A karstic spring pool within an area of *Typha* sp., *Phragmites australis* grassland at Piccaninnie Ponds (S0101060).

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Underwater view of karstic spring pool with deply submerged aquatics, Piccaninnie Ponds (S0101060) (photograph by Matthew Skinner).

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Deeply Inundated	0 12	
Max. Depth Tolerance	No upper limit		
Surface Water Salinity	Target	Tolerance Range	
	< 3000		
Dry Phase Required	No		

Feature Category	Habitat Feature/Management Objective
Max. Continuous Inundation	indefinite
Max. Continuous Dry Phase	intolerant of drying
Groundwater Regime	Fresh groundwater is the dominant water source
Soil Conditions	Limestone matrix
Perennial Flora	
Aquatic Flora (inundated)	*Myriophyllum* spp., *Ranunculus* spp., *Triglochin procerum*, **Rorripa nasturtium-aquaticum*, *Baumea articulata*, *Baumea arthrophylla*, *Phragmites australis*, *Typha* spp., *Cladium procerum*
Aquatic flora (dry)	
Aquatic Fauna	Endemic and threatened fish and aquatic invertebrates
Terrestrial Fauna	

Model 2.19 Permanent coastal lake

Lake Bonney (S0121483) and Lake George (S0101818) are essentially permanent waterbodies. The permanently inundated areas of these lakes provides a distinctive environment, albeit one that is poorly documented. Under normal conditions the water level in Lake George fluctuates between – 0.25 and 0.75 mAHD (M. de Jong, pers. com.), providing a maximum depth that fluctuates between approximately 2.5 and 3.5 m (de Jong 2007). The deepest parts of Lake Bonney have an elevation of – 2.7 mAHD and the lake water level is maintained between 0.82 and 1.72 mAHD (Allison and Harvey 1983), thus the deepest parts of the lake have a depth that fluctuates between 3.5 and 4.4 m. Prior to European settlement Lake Bonney would have experienced water level fluctuations of 1 – 1.5 m (Allison and Harvey 1983). Given the depth of these permanently inundated areas and the high turbidity of both lakes, aquatic vegetation is likely to be sparse to absent in the deepest areas. However, the more shallow permanently inundated areas are known to support aquatic vegetation. Such areas in Lake Bonney support *Ruppia megacarpa* and the charophytes *Chara fibrosa* and *Nitella* sp. (Nicol 2006). The seasonally exposed mudflats of Lake George support *Ruppia tuberosa* and *Lamprothamnium succinctum*, and these species also extend some way into the permanently inundated zone (J. Nicol, pers. com.).

Lake Bonney is a fresh to brackish (approx. 2800 to 7800 $\mu S.cm^{-1}$) lake (Allison and Harvey 1983). However, prior to European settlement and the subsequent increase in freshwater inflows from the drainage network, the salinity of the lake fluctuated from brackish to saline (Haynes *et al.* 2007). Under 'normal' conditions, the salinity of Lake George (measured in 'Big Lake') fluctuates between approximately 42 000 and 75 000 $\mu S.cm^{-1}$ (sea water is 58 300 $\mu S.cm^{-1}$) (M. de Jong, pers. com.). However, spikes in salinity can occur in dry years.

These permanently inundated environments provide drought refuge habitat for various species of duck and black swan. Where permanent or occasional connectivity to the sea exists (e.g. Lake George), estuarine fish such as yelloweye mullet may be abundant. The habitat is favoured by piscivorous birds such as terns.

Aerial view of a permanent coastal lake, Lake St Clair (S0110563), 21/3/2006 (photograph by Pip Rasenburg). The exposed lake margins comprise seasonal saline low aquatic bed (Model 2.15).

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	dry 3.5 approx.	0 12	
Max. Depth Tolerance	4.5 m		
Surface Water Salinity	Target	Tolerance Range	
	30000	2500 to 75000	
Dry Phase Required	No		
Max. Continuous Inundation	indefinite		

Feature Category	Habitat Feature/Management Objective
Max. Continuous Dry Phase	intolerant of drying
Groundwater Regime	
Soil Conditions	Fine silts and clays
Perennial Flora	
Aquatic Flora (inundated)	*Ruppia megacarpa R. tuberosa* and the charophytes *Chara* spp., *Nitella* spp., *Lamprothamnium* spp.
Aquatic flora (dry)	none
Aquatic Fauna	Estuarine fish, ducks, swans, terns
Terrestrial Fauna	

Appendix B
WVC Detailed Descriptions

Model 2.20 Seasonal freshwater aquatic bed

The deepest parts of many seasonal freshwater wetlands in the Lower South East support an aquatic herbland that may be dominated by plants such as *Triglochin procerum*, *Myriophyllum* spp., *Potamogeton* spp., *Ranunculus inundatus*, *R. amphitrichus*, *Rorippa nasturtium-aquaticum*, *Crassula helmsii* and, in shallower areas, *Triglochin alcockiae* and *Villarsia reniformis*. Most of these species are tolerant of both inundation and exposure so that as water levels drop in spring vegetation vigour is maintained, however wetland drying is not required. Typically the soil remains waterlogged. Some wetlands featuring this vegetation may remain dry for extended periods (e.g. Bool Lagoon (S0110446), 2005 to present), in which case the wetland bed will be invaded by a suite of opportunistic grasses and herbs, predominantly introduced, that may include **Holcus lanatus*, **Cirsium vulgare*, *Lachnagrostis filiformis* and **Phalaris aquatica*. There are many wetlands in the Dismal Swamp area that are inundated and support this WVC only in years of above average rainfall. These wetlands regularly experience continuous exposure for two to three years. Similarly, Bool Lagoon regularly experiences periods of two to three years without inundation yet maintains its seasonal freshwater aquatic bed vegetation when inundated. An extended period, such as four years or greater, without inundation may lead to senescence of below ground plant propagules, however there is little information available to support this assertion. Pond experiments suggest *T. procerum* is tolerant of prolonged (> 12 months) inundation to depths between 0 and 1 m (Rea and Ganf 1994). The deepest parts of Bool Lagoon were continuously inundated to a depth of at least 0.25 m for 11.5 years between 1983 and 1994 (Ecological Associates in prep) without leading to a noted decline in seasonal freshwater aquatic bed vegetation. Seasonal freshwater aquatic bed is likely to be tolerant of inundation of indefinite duration. This model corresponds with the Victorian ecological vegetation community 'Aquatic Herbland' (EVC 653) (DSE 2006).

At Pick Swamp (S0110343), areas dominated by *Triglochin procerum* were inundated to a maximum depth of approximately 0.8 m in late winter 2008. At Bool Lagoon (S0110446), elevations dominated by *Triglochin procerum* are inundated to a maximum depth of approximately 1.2 m when the wetland is full. The leaves of *T. procerum* can grow to 2 m in length (Sainty and Jacobs 2003), suggesting this species may tolerate inundation to approximately 2 m depth. This is likely to represent the upper depth tolerance for seasonal freshwater aquatic bed. Sites dominated by species such as *Villarsia reniformis*, *Triglochin alcockiae* and *Ranunculus* spp. are less deeply inundated, with a maximum depth closer to 0.4 m (B. Taylor, pers. obs.). Salinities at sites supporting this vegetation are fresh, usually less than 3000 $\mu S.cm^{-1}$, often less than 1000 $\mu S.cm^{-1}$ (DEH 2008). An exception is Rocky Swamp (S0100217), where salinities during two consecutive inundation events (2004 and 2005) ranged from 3170 to 17 500 $\mu S.cm^{-1}$ (Harley 2006). Salinities this high are likely to be at or near the upper tolerance of this WVC. Salinities at Rocky Swamp may be increasing due to reduced flows in the West Avenue Watercourse as a consequence of drain construction (Harley 2006). Thus, the seasonal freshwater aquatic bed present at this site may be in a state of declining health and salinities may not be indicative of those required to maintain vegetation health.

Seasonal freshwater aquatic bed provides habitat for small-bodied native fish (including endemic and threatened species) and waterbirds including moorhens, swmphens, coots, crakes, rails, dabbling ducks and breeding habitat for brolgas and black swans (at shallower sites). Abundant amphibians, including the nationally vulnerable southern bell frog, are a key feature.

Seasonal freshwater aquatic bed dominated by *Triglochin procerum*, Pick Swamp (S0110343), 12/8/2008.

Appendix B
WVC Detailed Descriptions

Seasonal freshwater aquatic bed dominated by *Villarsia reniformis* (foreground) in a wetland (S0110760) in Honan Native Forest Reserve, 7/7/2004.

Feature Category	Habitat Feature/Management Objective		
Target Hydrology		Duration (months)	
	Level (m)	Annual	1 year in 3
	Dry Waterlogged 0.2 0.4 0.7	3 3 2 2 2	
Max. Depth Tolerance	2 m		
Surface Water Salinity	Target	Tolerance Range	
	< 3000	0 to 15000	
Dry Phase Required	No		

Feature Category	Habitat Feature/Management Objective
Max. Continuous Inundation	indefinite
Max. Continuous Dry Phase	4 years
Groundwater Regime	Fresh, shallow groundwater likely, although not essential. Occurs in perched systems.
Soil Conditions	Peat to fine silt
Perennial Flora	
Aquatic Flora (inundated)	*Triglochin procerum*, *Myriophyllum* spp., *Potamogeton* spp., *Ranunculus inundatus*, *R. amphitrichus*, *Rorippa nasturtium-aquaticum*, *Crassula helmsii*, *Triglochin alcockiae*, *Villarsia reniformis*.
Aquatic flora (dry)	
Aquatic Fauna	Dabbling ducks, moorhens, swamphens, coots, crakes, rails, brolga and black swan. Southern bell frog and other amphibians.
Terrestrial Fauna	

Model 3.21 Eucalyptus ovata *woodland*

Eucalyptus ovata woodland is documented for three high value wetlands in the South East; two within Honan Native Forest Reserve (S0110750 and S0110764) and Mullins Swamp (S0105592). Foulkes and Heard (2003) documented the remnant vegetation of the South East. They described a floristic group referred to as "*Melaleuca squarrosa*, ± emergent *Eucalyptus ovata* Tall Shrubland" but did not describe an extant floristic group featuring *E. ovata* as the only dominant. Thus, Model 2.16 *Melaleuca squarrosa* mid shrubland may have very similar water regime and salinity requirements as *Eucalytpus ovata* woodland. For this reason, and given the small number of sites featuring *E. ovata* woodland, this landscape component has not been developed into a model.

Model 3.22 Seasonal brackish meadow

Seasonal brackish meadow is documented for two high value wetlands in the South East, Lake Hawdon South (S0108314) and Lake Hawdon North (S0109028). It is likely to be present at other sites. It comprises low herbs, sedges and grasses that are typically shallowly (approx. 0.3 m depth) inundated each winter/spring with brackish water. Seasonal brackish meadow is located at intermediate elevations. Thus, its water regime requirements are likely to be via provision of the water regime requirements of WVCs at adjacent lower and higher elevations. For this reason, and given the small number of sites featuring seasonal brackish meadow, this WVC has not been developed into a model.

Exposed seasonal brackish meadow at Lake Hawdon South (S0108314), 19/1/2008.