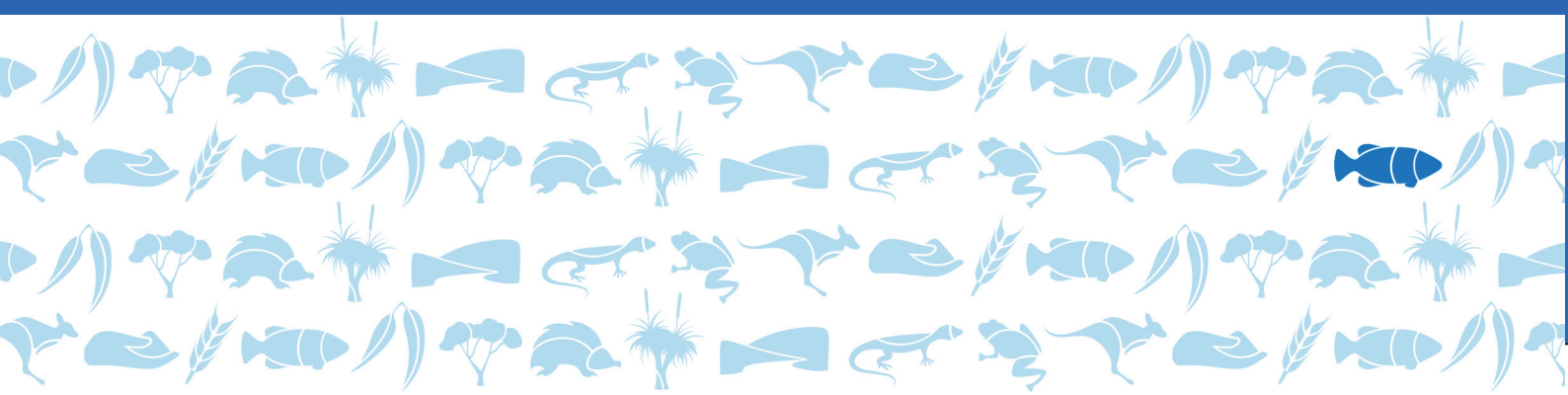
Impacts of Climate Change: Report on Data Preparation and analysis for the SA MDB NRM Board

FINAL
February 2011



Citation: Miles, M. & Gonzalez, D. 2011. Impacts of Climate Change: Report on Data preparation and analysis for the SA MDB NRM Board. A report prepared for the South Australian Murray-Darling Basin Natural Resource Management Board. Department of Environment and Natural Resources. (contact: Matthew.Miles@sa.gov.au)

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Overview

This paper describes the processes applied to capture the spatial relationships of a number of key biota across the MDB system from the Victorian border down to the Lower Lakes region. The biological survey data are unevenly distributed in both space and time and required careful consideration. The design of a grid-based analysis of presence and absence and use of 2 epochs were applied to begin to resolve these problems. The project examines the spatial distribution of species on five different scales, State-wide (~98 million ha), SA MDB region (~5.3 million ha), 1956 floodplain (~230000 ha), geomorphic reach (~55000ha), lock reach (~15000ha) and grid cell (6.25ha).

The outputs of this project include pre and post 1990 tables for flora, fauna and fish species frequencies within each regional boundary. These tables were used by the SA MDB NRM Board to identify key water-dependent species and refine a list for further spatial analysis using a grid re-sampling method. A polygon feature class consisting of a 254m grid across the entire study area (1956 flood plain) was created with unique cell identities to which vegetation mapping attributes were appended. The refined species list was processed through spatial models to associate the number and location of grid cells to the presence of individual species. The grid re-sampling method was applied to remove bias arising from uneven survey effort and differences in data collection methods.

1.0 Study area and regional extents

The set of polygon layers containing regional boundaries required for spatially intersecting biological point records were extracted from the DEH SDE database and a personal geodatabase containing geomorphic and lock reach boundaries. These datasets were processed through spatial models to generate polygon feature classes for each boundary. The following describes the data sources and processes applied to generate the boundary layers. Total areas of the boundaries are given in Table 1 and geographic extents of the study area (above Wellington), and lock and geomorphic reach regions are shown in Figures 1, 2 and 3 respectively.

SDE: TOPO.MurrayFlood1956.....Extracted and consolidated AS2482 codes:
44041 (River Murray Main Channel)
44071 (Land subject to occasional flooding)
ADMIN.NrmRegions.....Extracted SAMDB polygon
TOPO.SouthAust.....Removed 'Sea' polygon

Reaches.mdb: Geomorphic_Reaches.....Generated 4 separate layers, clipped to TOPO.MurrayFlood1956
Lock_Reaches.....Generated 4 separate layers

Boundary	Area (m^2)	Area (ha)	Area (km^2)
South Australia	982288730353	98228873	982289
SA MDB region	56702829898	5670283	56703
1956 floodplain	2281109428	228111	2281
Study Area (Border to Wellington)	1100304879	110030	1100
Mannum - Wellington	101838771	10184	102
Overland Corner - Mannum	290411156	29041	290
Border - Overland Corner	708038299	70804	708
Lower Lakes	1180803521	118080	1181
Border - Lock 6	121292708.2	12129	121
Lock 6 - Lock 5	187884779	18788	188
Lock 5 - Lock 4	165523199	16552	166
Lock 4 - Lock 3	199357543	19936	199
Lock 3 - Lock 2	79113044	7911	79
Lock 2 - Lock 1	94272946	9427	94
Lock 1 - Wellington	219712462	21971	220

Table 1 Summary of regional boundary areas used in this project

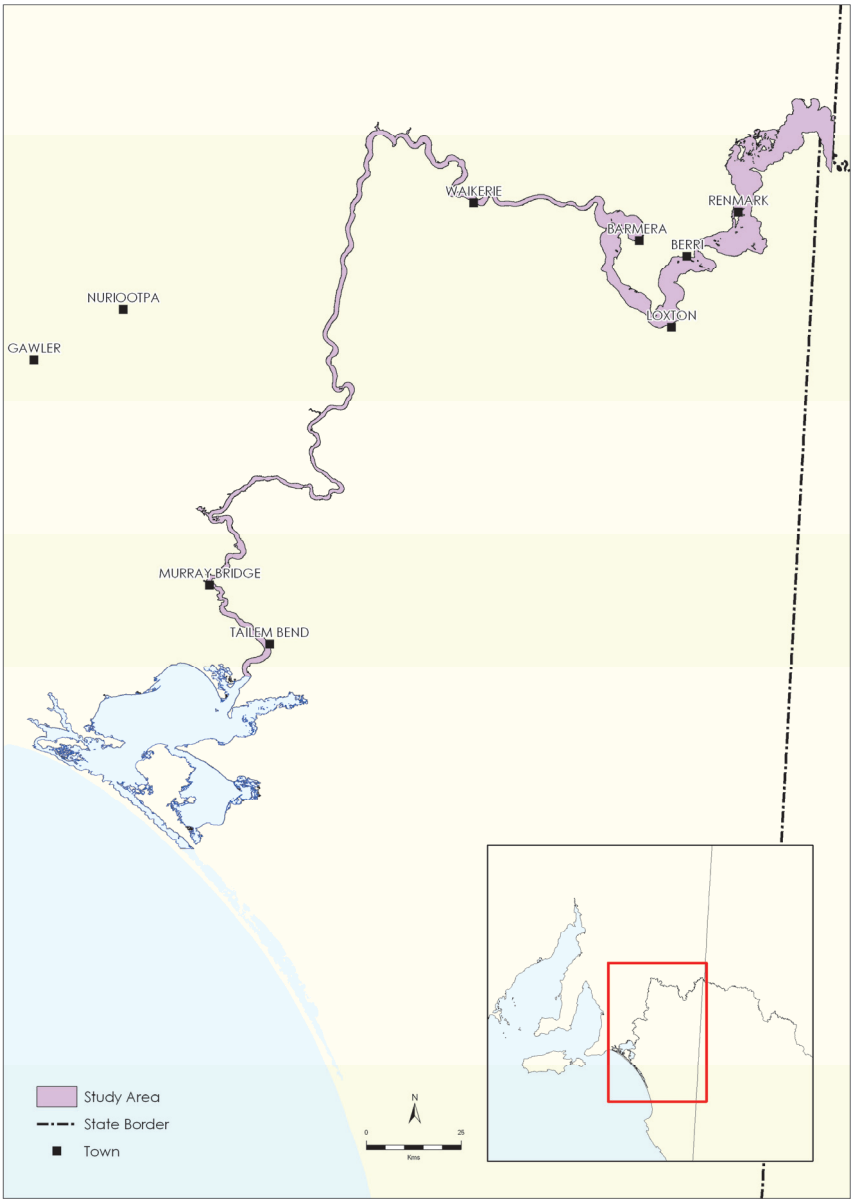


Figure 1 Project study area defined as the 1956 floodplain of the River Murray corridor in South Australia, excluding the Lower Lakes and Coorong.

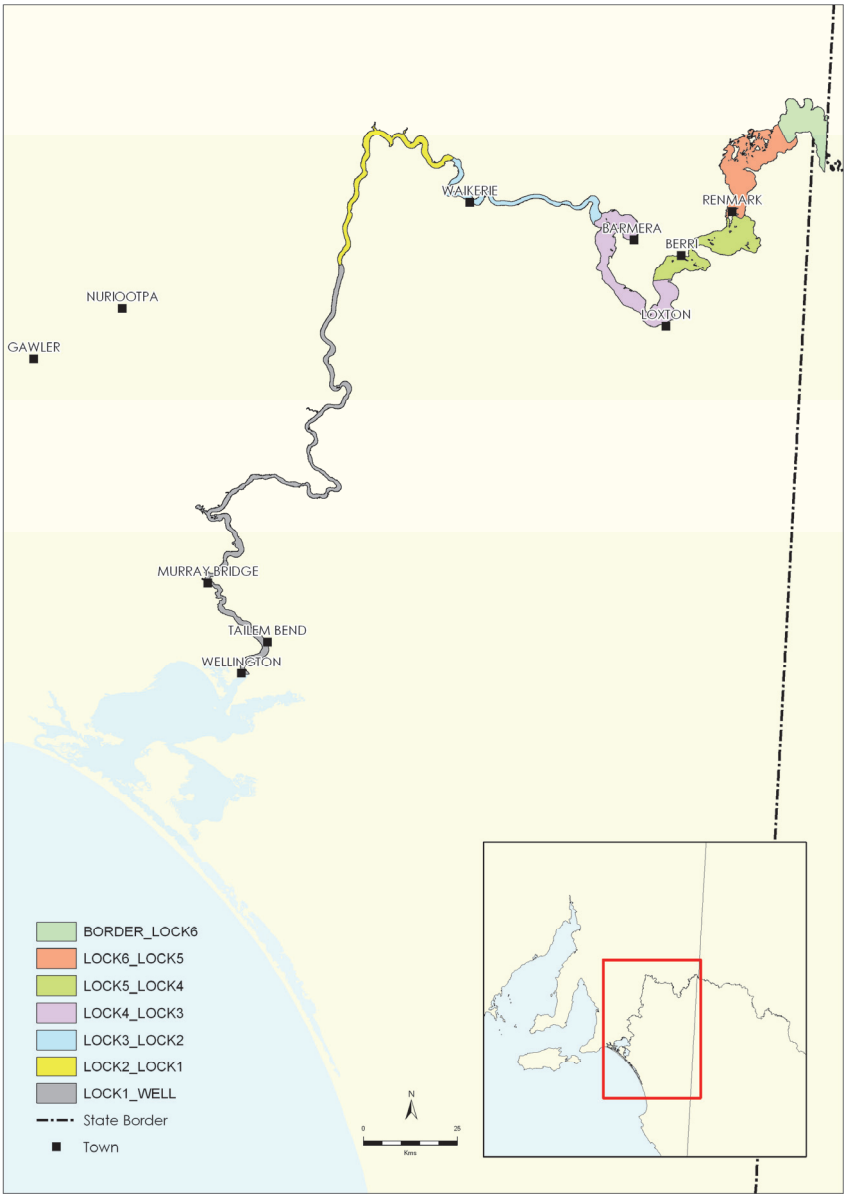


Figure 2 Lock reach regions used in the project.

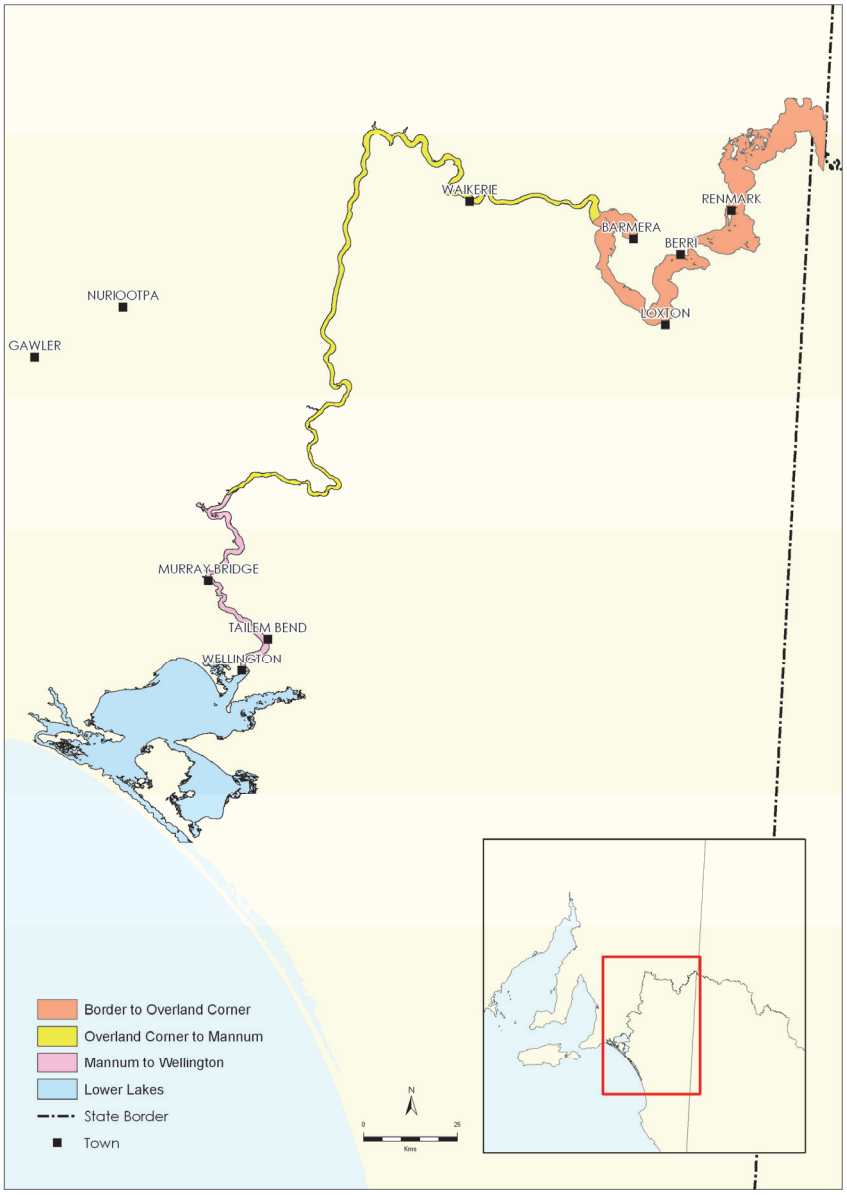


Figure 3 Geomorphic reach regions used in the project (Lower Lakes was not part of final spatial analyses).

2.0 Baseline survey & biological data sources

Additional baseline survey data collected by various agencies including private consultants were collated and prepared for upload to the DENR Biological Database of South Australia (BDBSA). These surveys were conducted as part of the Murray River Wetland Baseline RMCWMB 2004 study (Survey 165). The data were reformatted and mandatory fields added and populated with appropriate information, e.g. survey, site, species and habitat descriptions. For the purposes of BDBSA data management, the data were entered as three separate themes. The first details the nature of the site itself (name and coordinates), the second corresponds to the visit (observer, date, habitat comments) and the third contains species details (species NSX codes, abundance, date, collection method etc.). The new data are summarised below in Table 2 and contain plant, bird, fish and frog records throughout the SA MDB region.

Date	Survey Number	Taxa	Number of Records	Number of Species
2003	165	Fish	1377	19
2004	165	Fish	1030	18
2005	165	Fish	1302	26
2005	165	Plant	2522	189
2007	165	Plant	71	31
2005	165	Bird	968	108
2006	165	Bird	658	109
2007	165	Bird	767	101
2008	165	Bird	122	101
2005	165	Frog	335	10
2006	165	Frog	31	6
2005	165	Frog	14	21
		Total	**9197**	

Table 2 Summary of additional baseline survey data (2003-2008)

Fish survey data was sourced from the SA Freshwater Fish database collated by Michael Hammer for the 'Action Plan for South Australian Freshwater Fishes: 2007-2012'. The dataset includes data from the following sources: NFA (SA), Aquasave, SARDI, SA Water Quality Centre, AMLR & SAMDB NRM Boards, DEH (SE region), DWLBC, University of Adelaide, SA Museum, Victorian Museum, and the Australian Museum. Freshwater fish and BSBSA flora and fauna data are summarised for taxonomic groups in Table 3 limited to records found only within the 1956 flood plain.

Source	Taxa	Number of Records Pre-1990	Number of Species Pre-1990	Number of Records Post-1990	Number of Species Post-1990
BDBSA	Amphibian	133	10	2366	13
BDBSA	Ave	8509	287	87507	312
BDBSA	Mammal	356	35	2974	49
BDBSA	Reptile	407	57	1490	58
BDBSA	Fish	0	0	3256	22
BDBSA	**Total Fauna**	**9405**	**389**	**97593**	**454**
BDBSA	Plant	6310	1118	13201	871
SDE SA Freshwater Fish	Fish	487	35	2747	33

Table 3 Summary of data contained in the BDBSA and Freshwater Fish databases within the 1956 flood plain

A number of records collected within the last 20 years from two additional sources were not included in the distribution and spatial accuracy analyses detailed in Sections 2.0-2.2 in this report. These included DENR wetland monitoring data conducted by Mike Harper (DENR) and data contained within a monitoring database still under construction. These data were however included in the distribution mapping and proximity analyses used to determine spatial associations with wetland and key environmental assets (KEAs) and species richness 'hot spots' at wetland and KEA scales (see Section 3.0).

2.1 Distribution of biological records

This project focussed on water-dependent species distributions at 6 different spatial scales; state-wide, within the SA MDB region, within the 1956 floodplain, within geomorphic reaches, within lock reaches and within the study area. A 20 year cut-off date of 1990 was used to separate more recent data from historical records. The list of potential water-dependant species was complied by extracting the flora and fauna records that fell within the 1956 floodplain and generating frequencies of unique species at the five spatial scales. Spatial models were built in ArcGIS to query, select, intersect and generate frequency tables of species records within each boundary. These data were appended to master tables for flora, fauna and freshwater fish pre and post 1990. These models generated six master tables; pre and post 1990 flora, pre and post 1990 fauna and pre and post 1990 freshwater fish frequency tables.

A summary of the distribution of biological records and species richness at the different spatial scales is given in Table 4. For this summary, all records within State-wide and SA MDB regions were analysed and shows the result of restricting the species list to those found within the 1956 floodplain and the study area above Wellington. No filters (e.g. spatial accuracy, epoch) were applied for this analysis and it served to describe the volume and variety of records (species richness) at the 6 spatial scales.

DATASET	NUMBER OF RECORDS (NUMBER OF SPECIES) POST 1990							
	State-wide	SA MDB	Flood 56	Study Area (Border to Wellington)	Border - Overland Corner	Overland Corner - Mannum	Mannum - Wellington	Lower Lakes
BDBSA Flora	629677 (6549)	90066 (3031)	13213 (874)	10907 (715)	5421 (448)	4212 (498)	1274 (254)	2306 (381)
BDBSA Fauna	1261062 (1139)	369830 (645)	97593 (454)	45179 (381)	18922 (321)	18004 (301)	8141 (236)	52523 (299)
SA Freshwater Fish	6231 (56)	3816 (38)	2747 (33)	1521 (27)	571 (18)	553 (24)	397 (22)	1226 (29)

DATASET	LOCK 1-WELL	LOCK 2-1	LOCK 3-2	LOCK 4-3	LOCK 5-4	LOCK 6-5	BORDER-LOCK 6
BDBSA Flora	2930 (431)	1238 (307)	1319 (257)	1830 (279)	903 (194)	1761 (278)	926 (185)
BDBSA Fauna	13926 (283)	5367 (244)	6847 (241)	6609(242)	5992 (241)	4733 (266)	1585 (184)
SA Freshwater Fish	745 (26)	144 (16)	74 (15)	131 (15)	150 (17)	150 (16)	127 (15)

Table 4 Distribution of post-1990 biological point records and species richness across State and regional boundaries

The first filter for refining the species list was restricting the species list to those found only on the 1956 floodplain. Further to this, a 20 year cut-off date to remove potentially irrelevant historical records was applied (pre and post 1990). The post 1990 tables were provided to the SA MDB NRM Board where consultants and experts in wetland and riverine ecology applied another set of filters to compile a manageable species list for use in the climate risk analysis and endemism calculations at the gird scale. The parameters and decision making tools for the refinement of the species list are detailed in a supporting methodology report (Walker 2010).

2.2 Spatial accuracy of biological records

The spatial accuracy of the biological point data sources was important to recognise as it would have implications on the application of methods and interpretation of results. Table 5 summarises the spatial accuracy of post-1990 records of species within the study area from the Victorian Border to Wellington (see Figure 1). Shaded values in Table 5 show where the spatial accuracy of the largest proportion of the data lies. More than half of all records were accurate to within 250m; flora was the most spatially accurate with 89% of data within 50m of its true location. SA Freshwater Fish records showed the most error with 39% of data accurate to 100m and 79% accurate to 250m. 75% of BDBSA fauna records were accurate to within 100m.

Spatial Accuracy	SA Freshwater Fish			BDBSA Fauna			BDBSA Flora		
	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %
0-5m	0	0	0	20	0	0	11	0	0
5-50m	344	23	23	14858	33	33	9724	89	89
51-100m	245	16	39	19164	42	75	22	0	89
101-250m	609	40	79	516	1	77	105	1	90
251-500m	157	10	89	6275	14	90	0	0	90
501-1000m	3	0	89	1103	2	93	227	2	92
1-10km	1	0	89	1911	4	97	64	1	93
11-30km	5	0	90	16	0	97	0	0	93
31-125km	0	0	90	0	0	97	1	0	93
>25km	142	9	99	0	0	97	3	0	93
>625km	0	0	99	0	0	97	0	0	93
Not Entered	14	1	100	1308	3	100	763	7	100
No. Records	**1520**			**45171**			**10920**		

Table 5 Spatial accuracy of post-1990 biological records within the study area from BDBSA and SA Freshwater Fish. Highlighted values correspond to 1st half of data (>50 Cum. %). Data as at Oct 1, 2010

The spatial accuracy of the pre-1990 data was much more variable compared to later records. 85% of the fauna data had a spatial accuracy of up to 10km and 51% within 1km and 69% within 10km. SA Freshwater Fish data was slightly more accurate with 65% with 500m (see Table 6).

Spatial Accuracy	SA Freshwater Fish			Fauna			Flora		
	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %
0-5m	0	0	0	658	23	23	1329	25	25
5-50m	0	0	0	1	0	23	0	0	25
51-100m	40	14	14	45	2	24	0	0	25
101-250m	0	0	14	28	1	25	80	1	26
251-500m	144	51	65	28	1	26	0	0	26
501-1000m	10	4	68	77	3	29	1332	25	51
1-10km	45	16	84	1638	56	85	977	18	69
11-30km	3	1	85	6	0	85	0	0	69
31-125km	0	0	85	24	1	86	5	0	69
>25km	2	1	86	5	0	86	79	1	71
<625km	0	0	86	0	0	86	0	0	71
Not Entered	40	14	100	413	14	100	1556	29	100
No. Records	**284**			**2923**			**5358**		

Table 6 Spatial accuracy of pre-1990 biological records within the study area from BDBSA and SA Freshwater Fish databases. Highlighted values correspond to 1st half of data (>50 Cum. %). Data as at Oct 1, 2010

3.0 Proximity analyses of 'at-risk' species

Following the completion of the vulnerability assessments, lists of the 'at-risk' species for each taxonomic group were generated. A full description of the assessment process and final prioritised species lists is given in Gonzalez *et al.* (2011). These lists were only applicable to fish, bird and frog groups but not to reptiles or mammals as the latter 2 groups contained only 9 and 4 species respectively. Prioritisation (ranking) of these groups was not valid given the small number of species to compare against and assessments were restricted to comments on the major factors affecting vulnerability under climate change and all species were subsequently treated as 'at-risk'. Recommendations for wetland management were made with respect to these factors for each species.

A critical question this project set out to answer was what wetlands (or other geographic areas) are most important in the distribution of vulnerable or 'at-risk' species. This was determined using the current distribution of records within the DENR's biological databases using a spatial model to calculate distances of species records to the nearest wetlands or key environmental asset (KEA) area within a given radius. Recently uploaded survey data conducted by Mike Harper (DENR) were included in the proximity analyses using data current to December 2010.

The search radius in the proximity model was determined by doubling the spatial error of the records to account for this lack of precision as for example, a point with accuracy of +/-500m that is plotted 500m away from a wetland may in reality be located on the edge of the wetland or up to 1000m away (see Figure 4). The spatial models were set to return only one 'search' result for each record, i.e. only the closest wetland (or KEA) within the set search radius was recorded for any one point record. This avoided issues with multiple/overlapping counts and was also able to account for the spatial error of records. Figure 4 gives a graphic example of how this model worked using a point with a spatial accuracy of +/-500m and using a search radius of 1000m. The spatial accuracy and search radii used in the spatial proximity models is summarised for each taxonomic group in Appendix 5.

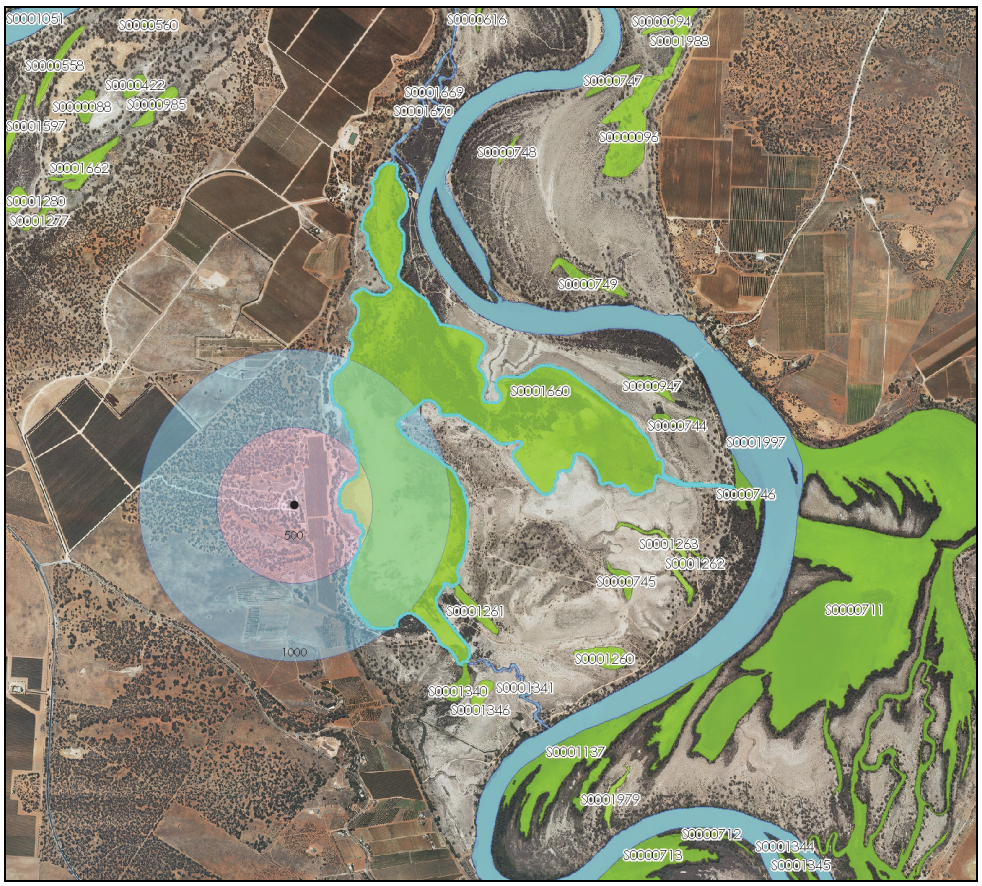


Figure 4 Fauna point record proximity to nearest wetland. 1000m search radius is represented by the blue shaded circle and the spatial accuracy of the point record is shown as the pink circle. The highlighted wetland (AUSWETNR S0001660) is nearest to this point record and would be the wetland associated with this record.

Main outputs from the proximity models included a table giving the frequency of records of each species within the search radii of wetlands (or KEAs) to highlight those areas most frequently associated with each 'at-risk' species. 'Species richness hotspots' were generated through a table listing the number of 'at-risk' species within the search radius of each wetland or KEA. This table was then used to create a polygon feature class of wetlands and KEAs with a 'species richness' attribute field. These 'hot spots' were grouped into taxonomic groups (brids, fish, reptiles etc.) and also combined as overall species richness of all 'at-risk' species. Appendix 2 gives a graphic representation of the wetland proximity model applied to 'at-risk' fish species with text annotations describing the processes. Outputs were designed to inform wetland management by highlighting key areas of species richness of 'at-risk' species.

The coarser scale proximity analyses using key environmental asset (KEA) areas were conducted in an identical fashion to the wetland scale models by substituting the wetland boundaries for the KEA boundaries as described above for wetland models. KEAs essentially represent individual floodplains comprising one or more wetlands (wetland complex) and/or tributaries. This served as a comparison with results from wetland scale proximity models and also to inform management recommendations at a larger spatial scale. Figure 5 shows the Nigra/Schillers KEA with the wetlands Schillers Lagoon, Nigra Lagoon and Nigra Creek contained within.

A caveat with the KEA-scale analytical model is that the main channel of the River Murray is not delineated as a 'KEA'. This would lead to records plotting in the main channel being associated with the nearest KEA regardless of connectivity between underlying wetlands within the KEA and the main channel (see Figure 5). This would over-represent abundance and richness within KEA boundaries. As the main channel was not of interest in terms of determining management outcomes, the main channel polygon from the wetlands layer (AUSWETNR S0001997), was used to clip out all records from the river prior to running the proximity analysis using the 'erase' tool in the model builder. This has the effect of under-representing some KEAs where records plotting in the main channel, due to spatial error, actually corresponded to the adjacent, connected wetland or wetland complex. The occurrence of this situation is much less frequent than the over-representation generated by assigning all records in the main channel with the nearest KEA.

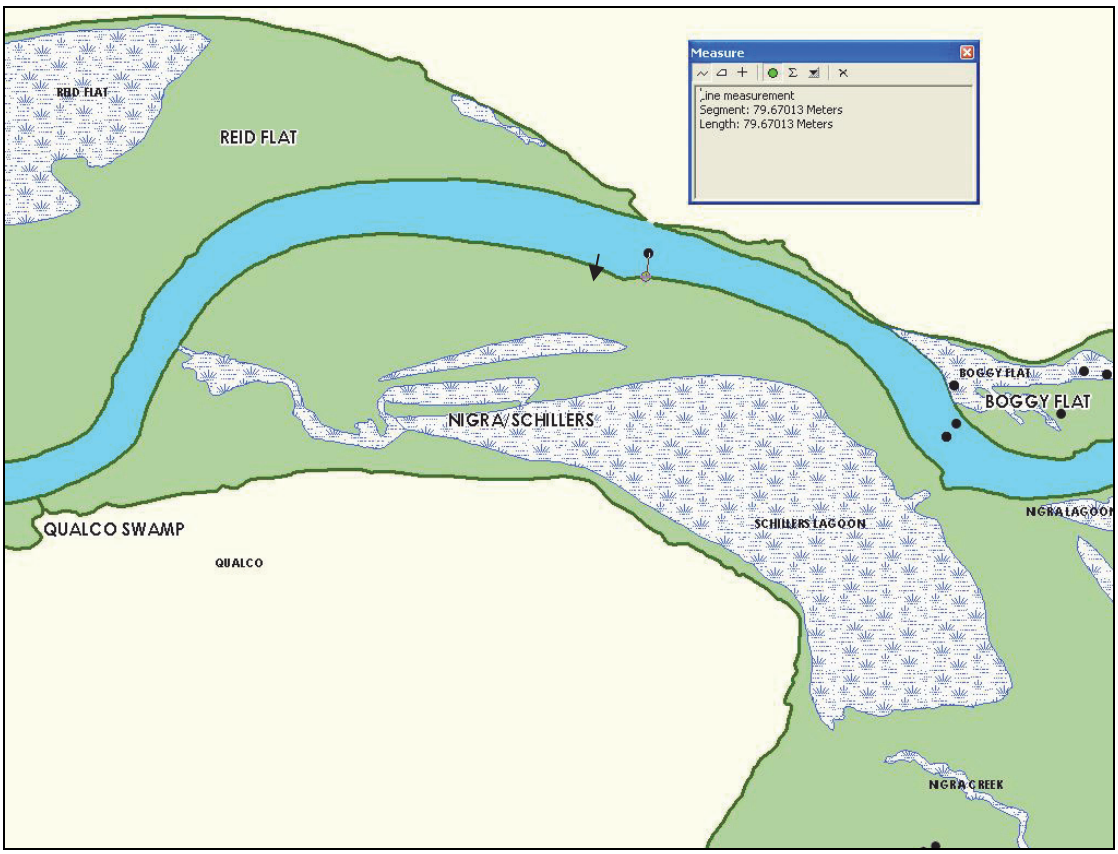


Figure 5 Species record in River Murray main channel would be associated with the nearest KEA (Nigra/Schillers) without realistic connectivity with the underlying wetland (Schillers Lagoon) regardless of spatial error. Records occurring in main channel were removed for the KEA-scale proximity analyses.

Species richness of 'at-risk' species were also summarised for all taxonomic groups combined at both wetland and KEA scales. Separate species richness tables for each group were merged and statistics generated to give the number of taxonomic groups and number of 'at-risk' species associated with wetlands and KEAs to give 'overall' species richness at the 2 spatial scales. Combined taxonomic group 'at-risk' species richness 'hotspots' were mapped across the study area using 8 spatial extents, maps and results are presented and discussed in detail in Gonzalez *et al.* (2011).

4.0 Grid-scale re-sampling of vegetation mapping

These methods and models were set up to trial the predictive mapping of species according to their vegetation spatial relationships. It aimed to create definite relationships between species and the vegetation they occurred in and generate maps of where the species is likely to occur based on vegetation groups for areas where records were sparse or absent. The create fishnet tool in ArcToolbox was used to generate a 254m grid overlay for the study area as polygon feature class. The extent was set to match that of the study area (1956 flood plain above Wellington to the Victorian border) and a cell size of 254m was set to match the scale of the nine-second (~254m) digital elevation model (DEM) of the Australian continent produced by Geoscience Australia. Each cell was assigned a unique identifier that was used as a primary key.

In preparation for species/vegetation group association analyses, each grid cell was to be attributed with the intersecting dominant vegetation groups derived from the DENR SDE South Australian Vegetation System Database (SAVSD). The South Australian vegetation mapping data layer contains the spatial location of vegetation structures across South Australia. The data layer contains information such as vegetation descriptions, species of vegetation and structural information and also provides an indication of the location of native vegetation. The SA Vegetation Description field includes the different vegetation structures visible on the imagery or identified from field work and the species found in each structure.

The data was captured using several techniques but in general, vegetation was mapped by on screen digitising using aerial photography, and field studies were conducted to provide floristic vegetation group information. Where height or cover information was unavailable, the dominant growth form for that area was used for the vegetation description. The first three dominant growth forms are recorded for each vegetation polygon as a SAVEGID number. The vegetation descriptions of these codes are given in Appendix 1.

The mapping is based on extrapolation of point based vegetation sampling and interpretation of imagery and not all mapping is verified in the field. Also, the mapping is based on the dominant over-story distinguishable from the imagery and therefore the understorey may not be included in the vegetation descriptions. Aquatic plant species and inundated vegetation are not mapped as part of this program, therefore many wetlands do not contain mapping. The imagery used for the mapping was of various scales ranging from 1:10000 to 1:250000 and should not be used at scales less than 1:40000. This project mapped to a scale of 1:60000 (~6ha) which is coarser than the scale used for vegetation survey data. Re-sampling these vegetation survey data across a 1km grid to match IBRA sub-regional risk assessment work conducted by DENR was suggested in order to link in with other projects. This may however cloud the vegetation data as effectively this would take the scale from 1:40000 to 1:1000000.

Fields were added to the grid layer to record the types of dominant vegetation groups that intersected each grid cell. A definition query was applied to the vegetation data to isolate each vegetation group and location selections based on intersecting features of vegetation polygons and grid cells allowed counts of vegetation groups to be populated for the grid layer. The vegetation mapping recorded up to three dominant vegetation groups per polygon and grid cells could be intersected by multiple vegetation polygons. Table 7 shows an example subset of the grid layer that resulted in up to twelve vegetation group fields (SA Veg ID) and a group count field. Figure 6 gives a graphic example of this intersection using the highlighted cell as an example.

Cell ID	Geomorphic Reach	Lock Reach	SA Veg ID 1	SA Veg ID 2	SA Veg ID 3...	Vegetation Count
3	Border-Overland Corner	Lock 4-Lock 3	RM0801	RM0803	RM2901	3
4	Border-Overland Corner	Lock 4-Lock 3	RM0801	RM0803	RM2902	3
5	Mannum-Wellington	Lock 1 -Wellington	RM3501	RM3701		2
6	Mannum-Wellington	Lock 1 -Wellington	RM2201	SP0013		2
7	Overland Corner-Mannum	Lock 3-Lock 2	RM3501			1

Table 7 Example of grid layer with geomorphic reach, lock reach and vegetation group attributes.

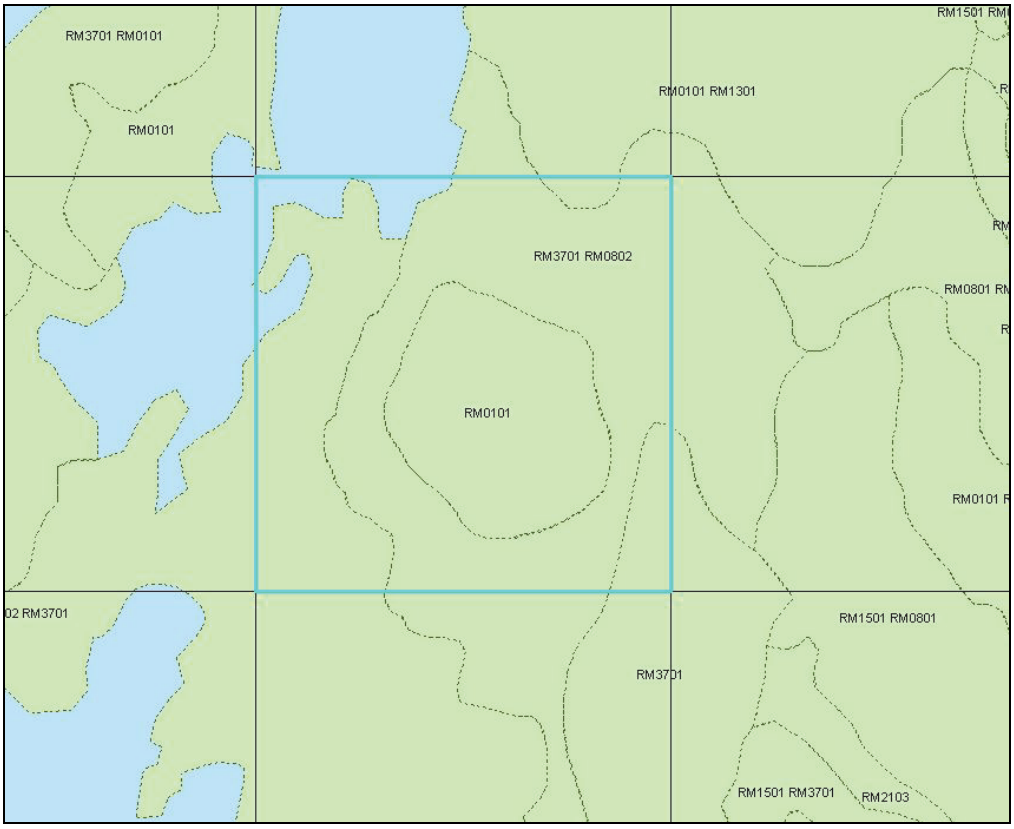


Figure 6 Attributing grid cells with vegetation group codes. The highlighted cell would be attributed with RM0101, RM1301, RM3701 and RM0802 vegetation groups from interesting vegetation polygons (green with dashed outline labelled with codes).

4.1 Vegetation/habitat associations

Once the grid layer was constructed and vegetation group associations were attached, the fauna and fish data were processed through spatial models to re-sample these data from point-scale to grid-scale presence/absence representation.

A list of the 'at-risk' species was generated through the species risk assessment process discussed in Gonzalez *et al.* (2011). This list was a subset of the 75 species originally tabled for assessment and included all 4 mammal species, all 9 reptile species and ranked subsets of the 'at-risk' bird, frog and fish species whose original lists contained numerous species. These lists are described in detail in Gonzalez *et al.* (2011). These final 'at-risk' species lists represent the species considered important potential indicators of system stress and those species liable to respond negatively to changes in climate and associated flow-on effects e.g. increased river regulation and salinity, lowered river heights, flow and system connectivity.

Post 1990 records of the 'at-risk' were extracted and filtered for spatial accuracy in spatial models. These models then intersected (using the ArcGIS identity tool) the species records with the coded vegetation grid layer. Frequencies of species intersects with vegetation group IDs were generated and summary tables added these frequencies resulting in a final list showing the number of times each species intersected the SAVSD vegetation groups. See Appendix 4 for an annotated graphic example of this spatial model using the fish group. Results from these models were assessed to be too general for effective prediction of the potential distributions of 'at-risk' species. Vegetation group IDs that were strongly associated species were achieved however when these groups were highlighted on a map of the study area, the majority of the floodplain is highlighted due to the widespread occurrence of the groups regardless of the species or taxonomic group examined.

A major limitation of these methods is that up to 3 different dominant vegetation group types are recorded per vegetation polygon in the SAVSD layer, and up to 12 different vegetation groups could intersect each grid cell and all were treated with equal importance in the association analysis. That is, the most and least dominant vegetation groups held equal weight when it came to counting how many times a species occurred within that vegetation type at the grid scale. This is likely to have contributed to the generality of results described above. This could be circumvented in later iterations by intersecting only vegetation groups above a prescribed coverage e.g. 50%, and may yield less variable results. Another factor could be that the most frequently interested vegetation groups were also the most common and widely mapped across the study area/floodplain scale. Time and budget restrictions on the project forced the discarding of further work on this model and results were not included in the final report.

References

Gonzalez, D., Scott, A. & Miles, M. (2011) Identifying Climate Change Adaptation strategies to inform wetland and floodplain management along the River Murray in SA. Report prepared for the South Australian Murray-Darling Basin Natural Resource Management Board.

Walker, K. F., 2010. A Method to Assess the Vulnerability to Climate Change of Regional Fauna and Flora. Report prepared for the South Australian Murray-Darling Basin Natural Resource Management Board.

Appendix 1: Vegetation mapping code descriptions

SA VEG ID	VEGETATION DESCRIPTION
KI1802	Tecticornia arbuscula low shrubland over Suaeda australis, Sarcocornia quinqueflora, Sarcocornia blackiana
MM0801	Callitris gracilis low open woodland over Austrostipa sp., Enchylaena tomentosa var. tomentosa, Senecio pinnatifolius, Einadia nutans ssp., +/-Danthonia sp. tussock grasses
MM0901	Eucalyptus porosa mid open mallee woodland over Austrostipa sp., Lomandra effusa, Helichrysum leucopsideum, Senecio pinnatifolius tussock grasses
MM1101	Eucalyptus dumosa, +/-Eucalyptus leptophylla mid open mallee forest over Danthonia sp., Austrostipa sp., Lepidosperma concavum tussock grasses
MM1201	Eucalyptus cyanophylla, +/-Eucalyptus socialis ssp. mid mallee woodland over +/-Beyeria opaca, +/-Chenopodium desertorum ssp. shrubs over Triodia irritans, Sclerolaena diacantha/uniflora, Maireana pentatropis, Helichrysum leucopsideum hummock grasses
MM1301	Eucalyptus diversifolia ssp. diversifolia mid mallee woodland over Acacia longifolia ssp. sophorae, Olearia axillaris shrubs over Asparagus asparagoides, Isolepis nodosa, Muehlenbeckia gunnii, Tetragonia implexicoma, Dianella revoluta var. forbs
MM1401	Eucalyptus leptophylla, Eucalyptus socialis ssp. mid mallee woodland over +/-Melaleuca lanceolata shrubs over Triodia irritans, Austrostipa sp., +/-Helichrysum leucopsideum hummock grasses
MM1801	Eucalyptus gracilis, Eucalyptus oleosa ssp. oleosa mid open mallee woodland over +/-Melaleuca lanceolata shrubs over Sclerolaena diacantha/uniflora, Austrostipa sp., Zygophyllum apiculatum, Maireana pentatropis shrubs
MM1901	Eucalyptus incrassata, +/-Eucalyptus leptophylla mid mallee woodland over Leptospermum coriaceum, Melaleuca uncinata, Callitris verrucosa, Babingtonia behrii shrubs over Hibbertia australis, Glischrocaryon behrii shrubs
MM2002	Myoporum insulare, Acacia longifolia ssp. sophorae, Leucopogon parviflorus tall shrubland
MM2802	Maireana sedifolia mid sparse shrubland over Enchylaena tomentosa var. tomentosa, Rhagodia spinescens, Austrostipa sp. shrubs
MM3101	Muehlenbeckia florulenta tall shrubland over Suaeda australis, Samolus repens, Sarcocornia quinqueflora shrubs
MM3501	Austrostipa sp., +/-Sclerolaena diacantha/uniflora, +/-Enchylaena tomentosa var. tomentosa, +/-Sclerolaena obliquicuspis low open tussock grassland
MM3801	Myoporum platycarpum ssp. low woodland
MM3901	Dodonaea viscosa ssp. angustissima low shrubland
MM4001	Alectryon oleifolius ssp. canescens low open woodland over Enchylaena tomentosa var. tomentosa, Austrostipa sp., Sclerolaena obliquicuspis shrubs
MN0101	Lomandra effusa, Austrostipa nitida, Austrodanthonia caespitosa, Enneapogon nigricans, Austrostipa eremophila low open tussock grassland
MN3801	Eucalyptus brachycalyx, +/-Eucalyptus oleosa ssp. ampliata, +/-Eucalyptus gracilis mid mallee woodland over Enchylaena tomentosa var. tomentosa, Atriplex vesicaria ssp., Sclerolaena diacantha, Maireana pyramidata shrubs
MN5601	+/-Maireana brevifolia, +/-Atriplex stipitata, +/-Atriplex paludosa ssp. cordata low sparse shrubland over Enchylaena tomentosa var. tomentosa
NP0004	Maireana sedifolia, Maireana pyramidata low open shrubland over Sclerolaena obliquicuspis, Eriochiton sclerolaenoides, Carrichtera annua, Austrostipa scabra ssp., Rhodanthe pygmaea
NP0019	Dodonaea viscosa ssp. angustissima, +/-Eremophila sturtii, +/-Senna artemisioides ssp., +/-Acacia sp. tall open shrubland over Maireana pyramidata, Rhagodia spinescens low sparse shrubland over Atriplex limbata, Sclerolaena diacantha, Enneapogon avenaceu
NP0028	emergent Acacia victoriae ssp. mid sparse shrubland over Maireana pyramidata, Rhagodia spinescens, Atriplex vesicaria ssp., Maireana astrotricha low open shrubland over Tetragonia eremaea/tetragonoides, Enneapogon avenaceus, Calotis hispidula, Sclerolaen
NP0032	Atriplex vesicaria ssp., Maireana astrotricha, +/-Maireana pyramidata, +/-Rhagodia spinescens low open shrubland over Enneapogon avenaceus, Sclerolaena ventricosa, Sclerolaena brachyptera, Sclerolaena obliquicuspis, Dissocarpus paradoxus
RM0101	Eucalyptus camaldulensis var. camaldulensis mid open forest over Muehlenbeckia florulenta tall shrubs over +/-Cyperus gymnocaulos mid sedges
RM0102	Eucalyptus camaldulensis var. camaldulensis mid open forest over +/-Acacia stenophylla over Cyperus gymnocaulos, Setaria jubiflora low tussock grasses

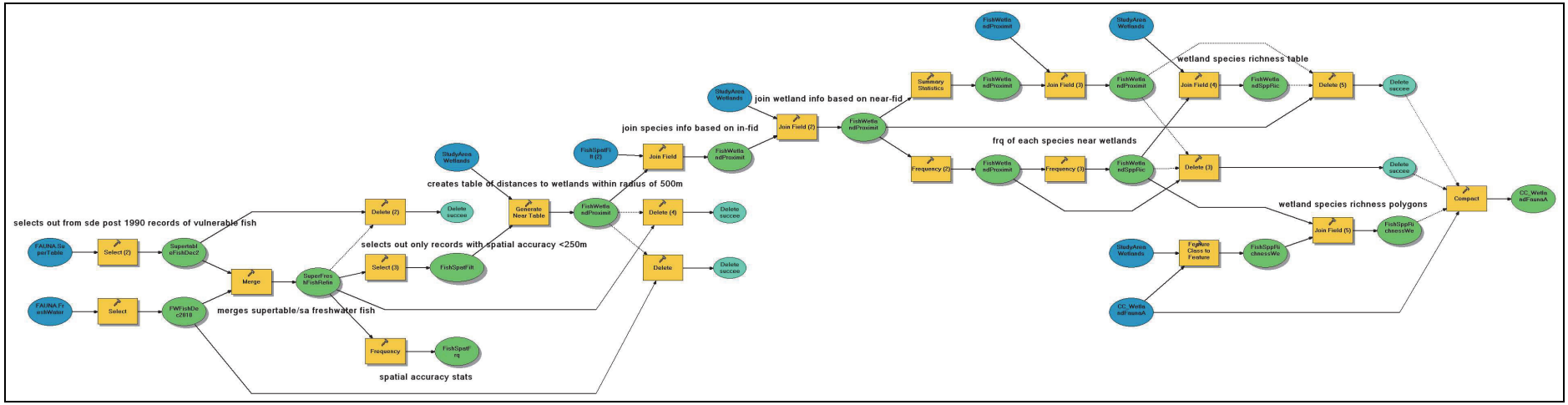
SA VEG ID	VEGETATION DESCRIPTION
RM0103	Eucalyptus camaldulensis var. camaldulensis mid open forest over Muehlenbeckia florulenta tall shrubs over Phragmites australis tall grasses
RM0201	Eucalyptus camaldulensis var. camaldulensis, Eucalyptus largiflorens mid open forest over Acacia stenophylla over Enchylaena tomentosa var. tomentosa low shrubs
RM0202	Eucalyptus camaldulensis var. camaldulensis, Eucalyptus largiflorens mid woodland over Senecio cunninghamii var. cunninghamii, +/-Phragmites australis tall grasses
RM0203	Eucalyptus camaldulensis var. camaldulensis, +/-Eucalyptus largiflorens mid open forest over +/-Acacia stenophylla over Chenopodium nitrariaceum, +/-Muehlenbeckia florulenta tall shrubs
RM0301	Eucalyptus largiflorens, Eucalyptus camaldulensis var. camaldulensis low open woodland over Callistemon brachyandrus tall shrubs over Enchylaena tomentosa var. tomentosa low shrubs
RM0402	Eucalyptus largiflorens low woodland over Chenopodium nitrariaceum, +/-Muehlenbeckia florulenta mid shrubs over Eremophila divaricata ssp. divaricata low shrubs over +/-Disphyma crassifolium ssp. clavellatum
RM0403	Eucalyptus largiflorens mid woodland over Enchylaena tomentosa var. tomentosa, +/-Setaria jubiflora low shrubs
RM0501	Eucalyptus largiflorens, Acacia stenophylla low woodland over Muehlenbeckia florulenta tall shrubs over Enchylaena tomentosa var. tomentosa low shrubs
RM0601	Melaleuca lanceolata, Eucalyptus largiflorens low open forest over Enchylaena tomentosa var. tomentosa, +/-Disphyma crassifolium ssp. clavellatum low shrubs
RM0801	Eucalyptus camaldulensis var. camaldulensis mid woodland over +/-Acacia stenophylla over Muehlenbeckia florulenta tall shrubs over +/-Setaria jubiflora, +/-Cyperus gymnocaulos low tussock grasses
RM0802	Eucalyptus camaldulensis var. camaldulensis low woodland over Muehlenbeckia florulenta tall shrubs over Phragmites australis tall grasses
RM0803	Eucalyptus camaldulensis var. camaldulensis mid woodland over +/-Senecio cunninghamii var. cunninghamii mid shrubs over +/-Cyperus gymnocaulos
RM0901	Eucalyptus camaldulensis var. camaldulensis, Acacia stenophylla low open forest over Muehlenbeckia florulenta tall shrubs over Setaria jubiflora low tussock grasses
RM1001	Eucalyptus camaldulensis var. camaldulensis, Eucalyptus largiflorens mid woodland over Acacia stenophylla over Muehlenbeckia florulenta tall shrubs over Enchylaena tomentosa var. tomentosa low shrubs
RM1002	Eucalyptus camaldulensis var. camaldulensis, Eucalyptus largiflorens mid woodland over +/-Muehlenbeckia florulenta tall shrubs over +/-Enchylaena tomentosa var. tomentosa, +/-Cyperus gymnocaulos low shrubs
RM1101	Eucalyptus largiflorens, +/-Eucalyptus camaldulensis var. camaldulensis mid woodland over Tecticornia pergranulata ssp. pergranulata, +/-Tecticornia indica ssp. leiostachya, +/-Disphyma crassifolium ssp. clavellatum low shrubs
RM1202	Eucalyptus largiflorens low woodland over +/-Atriplex rhagodioides mid shrubs over Enchylaena tomentosa var. tomentosa, +/-Disphyma crassifolium ssp. clavellatum low shrubs
RM1203	Eucalyptus largiflorens mid woodland over Maireana pyramidata low shrubs
RM1301	Acacia stenophylla low woodland over Muehlenbeckia florulenta tall shrubs over Enchylaena tomentosa var. tomentosa low shrubs
RM1302	Acacia stenophylla low woodland over Enchylaena tomentosa var. tomentosa low shrubs
RM1303	Acacia stenophylla low woodland over Chenopodium nitrariaceum mid shrubs
RM1401	Eucalyptus porosa, Acacia stenophylla low open woodland over Muehlenbeckia florulenta mid shrubs
RM1501	Muehlenbeckia florulenta tall shrubland over +/-Enchylaena tomentosa var. tomentosa, +/-Tecticornia pergranulata ssp. pergranulata, Suaeda australis low shrubs
RM1502	Muehlenbeckia florulenta mid open shrubland over +/-Sporobolus mitchellii, +/-Sporobolus virginicus low grasses
RM1601	Dodonaea viscosa ssp. angustissima tall open shrubland over Bromus rubens, Schismus barbatus, +/-Enchylaena tomentosa var. tomentosa low shrubs

SA VEG ID	VEGETATION DESCRIPTION
RM1701	Atriplex rhagodioides mid open shrubland over Enchylaena tomentosa var. tomentosa, +/-Tecticornia pergranulata ssp. pergranulata, +/-Disphyma crassifolium ssp. clavellatum low shrubs
RM1801	Chenopodium nitrariaceum mid shrubland over Atriplex lindleyi ssp. lindleyi, Sclerolaena tricuspis low shrubs
RM1901	Suaeda australis, +/-Sarcocornia quinqueflora, +/-Samolus repens low open shrubland
RM2001	Atriplex lindleyi ssp. lindleyi, +/-Sclerolaena muricata var. muricata, +/-Atriplex semibaccata low open shrubland
RM2101	Tecticornia halocnemoides ssp. halocnemoides, Tecticornia arbuscula, Disphyma crassifolium ssp. clavellatum, Maireana oppositifolia low shrubland
RM2102	Tecticornia indica ssp. leiostachya low shrubland over +/-Disphyma crassifolium ssp. clavellatum, +/-Suaeda australis
RM2103	Tecticornia pergranulata ssp. pergranulata, Tecticornia indica ssp. leiostachya, Disphyma crassifolium ssp. clavellatum low open shrubland
RM2104	Tecticornia pergranulata ssp. pergranulata, +/-Hordeum marinum, +/-Suaeda australis, +/-Disphyma crassifolium ssp. clavellatum low open shrubland
RM2105	Tecticornia arbuscula low sparse shrubland over +/-Sarcocornia quinqueflora, +/-Hordeum marinum, +/-Suaeda australis
RM2201	Sarcocornia quinqueflora, +/-Samolus repens, +/-Suaeda australis low shrubland
RM2301	Atriplex vesicaria ssp., +/-Maireana sedifolia low open shrubland
RM2501	Maireana oppositifolia mid open shrubland over Austrostipa stipoides, Atriplex paludosa ssp. cordata, Lawrencia squamata
RM2601	Maireana pyramidata low sparse shrubland over +/-Schismus barbatus, +/-Atriplex lindleyi ssp. lindleyi
RM2701	Tecticornia triandra, +/-Disphyma crassifolium ssp. clavellatum low open shrubland
RM2801	Sclerolaena tricuspis, Sclerolaena brachyptera, +/-Brachyscome lineariloba, +/-Plantago cunninghamii low sparse shrubland
RM2901	emergent +/-Muehlenbeckia florulenta tall open shrubland over Phragmites australis tall closed grassland over +/-Bolboschoenus caldwellii, +/-Aster subulatus, +/-Suaeda australis
RM2902	Phragmites australis, +/-Typha domingensis, +/-Schoenoplectus validus tall closed grassland over +/-Paspalum vaginatum, +/-Paspalum distichum
RM3001	Agrostis avenacea var. avenacea (NC), +/-Polypogon monspeliensis, +/-Eleocharis acuta low tussock grassland
RM3101	Sporobolus virginicus, +/-Sporobolus mitchellii, +/-Sclerolaena tricuspis low grassland
RM3301	Eragrostis australasica, Muehlenbeckia florulenta tall open hummock grassland over Trichanthodium skirrophorum, Senecio glossanthus (NC)
RM3401	Baumea juncea mid closed sedgeland over Samolus repens, Distichlis distichophylla
RM3501	Gahnia filum, +/-Gahnia trifida, +/-Juncus kraussii mid sedgeland over Suaeda australis, +/-Samolus repens
RM3601	Juncus kraussii mid open sedgeland over +/-Samolus repens, +/-Suaeda australis, +/-Sarcocornia quinqueflora
RM3701	Typha domingensis tall open sedgeland over +/-Paspalum vaginatum, +/-Paspalum distichum
RM3702	Typha orientalis, +/-Schoenoplectus validus tall sparse sedgeland
RM3801	Angianthus tomentosus, Atriplex lindleyi ssp. lindleyi low forbland
RM3901	Disphyma crassifolium ssp. clavellatum, Atriplex lindleyi ssp. lindleyi, +/-Eriochiton sclerolaenoides low sparse forbland
RM4001	Polycalymma stuartii, Enchylaena tomentosa var. tomentosa low forbland

SA VEG ID	VEGETATION DESCRIPTION
RM4101	Salix babylonica low closed forest
SE0017	Melaleuca brevifolia, +/-Leptospermum continentale mid shrubland over Apodasmia brownii, Baumea juncea sedges
SE0021	Emergent +/-Melaleuca halmaturorum shrubs over Gahnia filum, +/-Juncus kraussii tall sedgeland over Samolus repens, +/-Tetragonia implexicoma, +/-Selliera radicans, +/-Acaena novae-zelandiae
SE0026	Leucopogon parviflorus, Acacia longifolia ssp. sophorae, Olearia axillaris, +/-Myoporum insulare tall shrubland over Lepidosperma gladiatum, Pimelea serpyllifolia ssp. serpyllifolia, Isolepis nodosa sedges over Carpobrotus rossii, Clematis microphylla va
SE0027	Spinifex sericeus (NC), Ozothamnus turbinatus, Isolepis nodosa, +/-Olearia axillaris mid grassland over Leucophyta brownii, Apium prostratum var., Cakile maritima ssp. maritima
SE0029	Sarcocornia sp., Tecticornia sp., Suaeda australis low shrubland over Frankenia pauciflora var., Samolus repens, Distichlis distichophylla
SE0086	Melaleuca lanceolata low woodland
SE0098	Phragmites australis, Typha domingensis tall grassland
SM0601	Melaleuca halmaturorum low closed forest over Juncus kraussii, +/-Suaeda australis tall sedges over Sarcocornia quinqueflora, +/-Samolus repens, +/-Frankenia pauciflora var.
SM1401	Eucalyptus viminalis ssp. cygnetensis, Eucalyptus camaldulensis var. camaldulensis mid woodland over Acacia pycnantha, Banksia marginata over Hibbertia sericea var. sericea (NC), Leptospermum myrsinoides, Neurachne alopecuroidea low shrubs
SM2207	Allocasuarina verticillata low woodland over Bursaria spinosa ssp. spinosa tall shrubs over Ehrharta calycina, Ammophila arenaria, Poa poiformis var. poiformis mid tussock grasses
SM2403	Eucalyptus fasciculosa low woodland over Acacia pycnantha over Acacia spinescens, Astroloma conostephioides, Calytrix tetragona low shrubs over Lepidosperma carphoides, Asparagus asparagoides, +/-Ehrharta calycina
SM3501	Muehlenbeckia florulenta, +/-Gahnia filum mid open shrubland over Samolus repens, Isolepis nodosa, +/-Sarcocornia quinqueflora, Cynodon dactylon
SM4001	Sarcocornia quinqueflora, Tecticornia arbuscula, +/-Suaeda australis, +/-Sarcocornia blackiana low shrubland over Atriplex paludosa ssp., Lawrencia squamata, Distichlis distichophylla, +/-Maireana oppositifolia, +/-Samolus repens
SM4003	Tecticornia halocnemoides ssp. halocnemoides, Tecticornia arbuscula low open shrubland over Sarcocornia quinqueflora, Suaeda australis, Samolus repens, Lawrencia squamata, +/-Maireana oppositifolia, +/-Disphyma crassifolium ssp. clavellatum
SM4004	Tecticornia pergranulata ssp. pergranulata, Sarcocornia quinqueflora, Enchylaena tomentosa var., Frankenia pauciflora var. low shrubland
SM4101	Olearia axillaris, Acacia longifolia ssp. sophorae, +/-Myoporum insulare, +/-Leucopogon parviflorus mid sparse shrubland over Rhagodia candolleana ssp. candolleana, +/-Ehrharta longiflora mid tussock grasses over Pimelea serpyllifolia ssp. serpyllifolia,
SM4102	Olearia axillaris, Leucopogon parviflorus, Acacia longifolia ssp. sophorae, +/-Myoporum insulare mid open shrubland over Rhagodia candolleana ssp. candolleana low shrubs over Pimelea serpyllifolia ssp. serpyllifolia, Tetragonia implexicoma, +/-Muehlenbec
SM4103	Myoporum insulare, Acacia longifolia ssp. sophorae, Leucopogon parviflorus, Olearia axillaris, Exocarpos syrticola mid shrubland over Rhagodia candolleana ssp. candolleana low shrubs
SM4701	Spinifex sericeus (NC), Thinopyrum junceiforme, Euphorbia paralias, Cakile maritima ssp. maritima low open grassland
SM4702	Austrostipa stipoides mid tussock grassland
SM4901	Typha domingensis, Phragmites australis, +/-Aster subulatus, +/-Muehlenbeckia florulenta, +/-Suaeda australis tall sedgeland over Paspalum distichum, Persicaria lapathifolia
SM5001	Gahnia trifida, Gahnia filum, Juncus kraussii, Sarcocornia sp. low open sedgeland
SP0001	Eucalyptus gracilis, Eucalyptus oleosa ssp. oleosa, Eucalyptus socialis ssp., +/-Eucalyptus dumosa mid mallee woodland over Enchylaena tomentosa var., Senna artemisioides ssp., Senna artemisioides ssp. petiolaris (NC), Grevillea huegelii, Olearia mueller

SA VEG ID	VEGETATION DESCRIPTION
SP0006	Casuarina pauper, +/-Alectryon oleifolius ssp. canescens low open woodland over Senna artemisioides ssp. coriacea, Senna artemisioides ssp. petiolaris (NC), Senna artemisioides ssp. filifolia mid open shrubland over Maireana sedifolia, Enchylaena tomento
SP0012	Lycium australe, Nitraria billardierei mid open shrubland over Tecticornia tenuis, Maireana pyramidata, Atriplex vesicaria ssp., Maireana aphylla, +/-Eragrostis australasica low open shrubland over Disphyma crassifolium ssp. clavellatum, Sclerolaena brac
SP0013	emergent +/-Alectryon oleifolius ssp. canescens, +/-Myoporum platycarpum ssp. low open woodland over emergent +/-Maireana pyramidata over Enneapogon avenaceus, Carrichtera annua, Sclerolaena obliquicuspis, Sclerolaena diacantha, Enneapogon intermedius lo
WM0401	Eucalyptus phenax ssp. phenax, +/-Eucalyptus leptophylla mid open mallee forest over Rhagodia crassifolia, Enchylaena tomentosa var. tomentosa, +/-Triodia irritans, +/-Austrostipa scabra group, +/-Vittadinia cuneata var. cuneata forma cuneata shrubs
WM0501	Geijera linearifolia, Myoporum platycarpum ssp., +/-Alectryon oleifolius ssp. canescens low open woodland over Acacia nyssophylla, Senna artemisioides ssp. coriacea shrubs over Zygophyllum aurantiacum ssp., Eriochiton sclerolaenoides, Sclerolaena obliqui
WM0801	Maireana sedifolia, +/-Lycium australe mid shrubland over Sclerolaena obliquicuspis, Rhagodia ulicina, Rhagodia spinescens shrubs
WM1601	Eucalyptus camaldulensis var. camaldulensis, +/-Eucalyptus leucoxylon ssp. low open woodland over Linum trigynum, Briza maxima, Anagallis arvensis, Avena barbata forbs
WM1801	Eucalyptus baxteri, +/-Eucalyptus leucoxylon ssp., +/-Allocasuarina verticillata low woodland over Xanthorrhoea semiplana ssp. semiplana, Acacia pycnantha shrubs over Astroloma conostephioides, Geranium retrorsum, Pimelea humilis, +/-Spyridium parvifoliu
WM6501	Eucalyptus gracilis, Eucalyptus oleosa ssp. oleosa mid mallee woodland over Maireana sedifolia, Atriplex sp. shrubs
WM8001	Atriplex stipitata, +/-Maireana trichoptera, +/-Maireana pentatropis, +/-Zygophyllum sp. low open shrubland
WM8101	Eucalyptus largiflorens mid open woodland over +/-Muehlenbeckia florulenta shrubs over +/-Enchylaena tomentosa var. tomentosa low shrubs
WM8401	Tecticornia sp., Tecticornia sp. low open shrubland

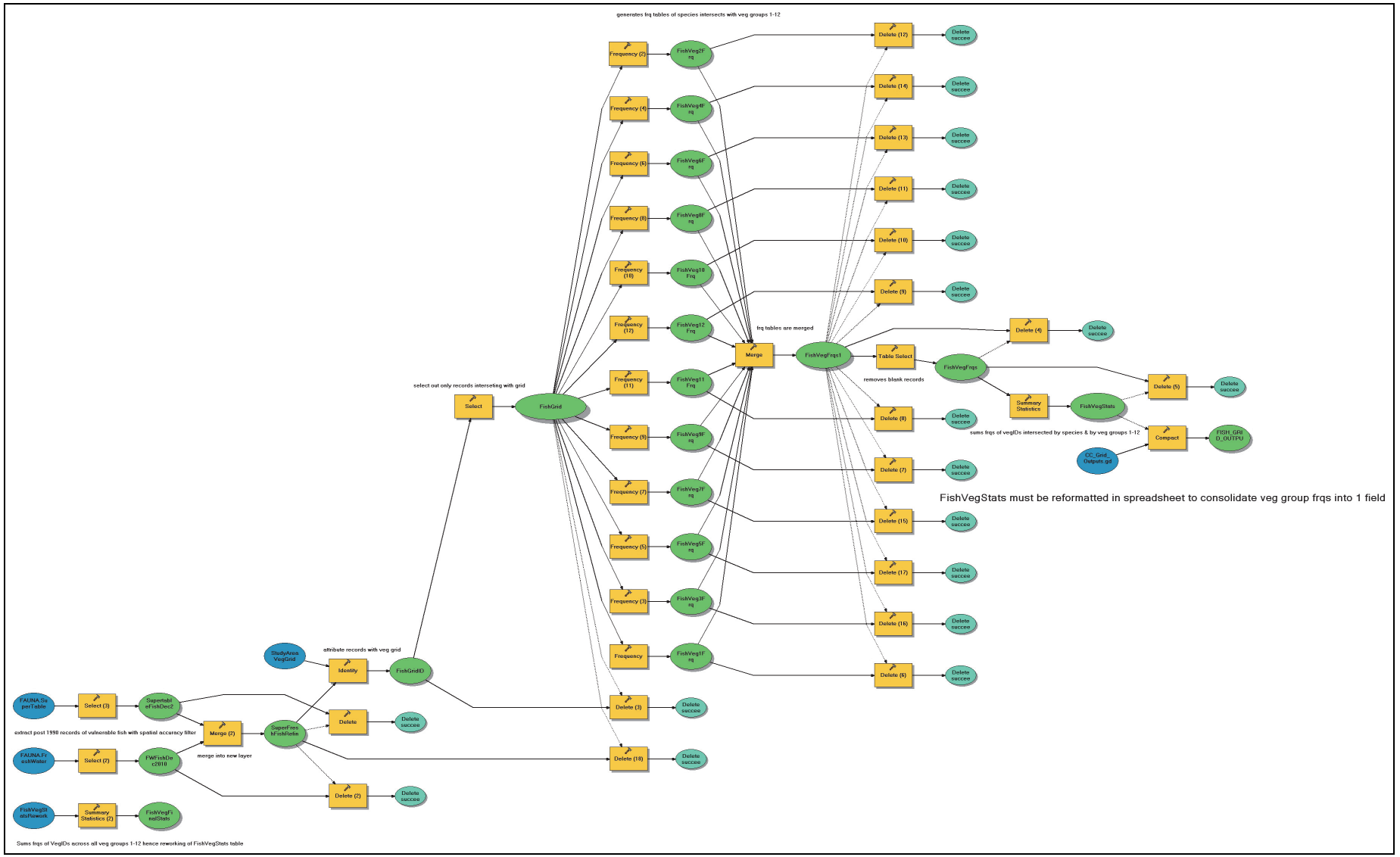
Appendix 2: ArcGIS Spatial proximity modelling of wetland associations with 'at-risk' fish species



Appendix 3: Draft refined fauna list

	CLASS	Common Name	Scientific name	EPBC (Threatened)	NPW 1972 (or FMA 2007)	International - Migratory Agreement/ IUCN.
1	AMPHIBIA	Banjo Frog	*Limnodynastes dumerilii*			
2	AMPHIBIA	Brown Toadlet	*Pseudophryne bibronii*			
3	AMPHIBIA	Brown Tree Frog	*Litoria ewingii*			
4	AMPHIBIA	Burrowing frog	*Neobatrachus pictus*			
5	AMPHIBIA	Common Froglet	*Crinia signifera*			
6	AMPHIBIA	Long-thumbed Frog	*Limnodynastes fletcheri*			
7	AMPHIBIA	Murray Valley Froglet	*Crinia parinsignifera*			
8	AMPHIBIA	Peron's Tree Frog	*Litoria peronii*			
9	AMPHIBIA	Southern Bell Frog	*Litoria raniformis*	Vulnerable	Vulnerable	
10	AMPHIBIA	Spotted Marsh Frog	*Limnodynastes tasmaniensis*			
11	AMPHIBIA	Striped Marsh Frog	*Limnodynastes peronii*			
12	AMPHIBIA	Sudell's Frog	*Neobatrachus sudellii*			
13	AVES	Australian Shelduck	*Tadorna tadornoides*			
14	AVES	Australasian Shoveler	*Anas rhynchotis*		Rare	
15	AVES	Black Swan	*Cygnus atratus*			
16	AVES	Blue-billed Duck	*Oxyura australis*		Rare	
17	AVES	Chestnut Teal	*Anas castanea*			
18	AVES	Freckled Duck	*Stictonetta naevosa*		Vulnerable	
19	AVES	Musk Duck	*Biziura lobata*		Rare	
20	AVES	Hoary-headed Grebe	*Poliocephalus poliocephalus*			
21	AVES	Australian Spotted Crake	*Porzana fluminea*			
22	AVES	Baillon's Crake	*Porzana pusilla*			
23	AVES	Buff-banded Rail	*Gallirallus philippensis*			
24	AVES	Purple Swamphen	*Porphyrio porphyrio*			
25	AVES	Spotless Crake	*Porzana tabuensis*		Rare	
26	AVES	Black-fronted Dotterel	*Elseyornis melanops*			
27	AVES	Black-winged Stilt	*Himantopus himantopus*			
28	AVES	Red-capped Plover	*Charadrius ruficapillus*			
29	AVES	Red-kneed Dotterel	*Erythrogonys cinctus*			
30	AVES	Great Egret	*Ardea alba*			CAMBA/ JAMBA
31	AVES	Australian White Ibis	*Threskiornis molucca*			
32	AVES	Straw-necked Ibis	*Threskiornis spinicollis*			
33	AVES	Yellow-billed Spoonbill	*Platalea flavipes*			
34	AVES	Australasian Bittern	*Botaurus poiciloptilus*		Vulnerable	IUCN Red List (Endangered).
35	AVES	Nankeen Night-Heron	*Nycticorax caledonicus*			
36	AVES	Darter	*Anhinga novaehollandiae*		Rare	
37	AVES	Great Cormorant	*Phalacrocorax carbo*			
38	AVES	Little Black Cormorant	*Phalacrocorax sulcirostris*			
39	AVES	Little Pied Cormorant	*Microcarbo melanoleucos*			
40	AVES	Swamp Harrier	*Circus approximans*			
41	AVES	White-bellied Sea-Eagle	*Haliaeetus leucogaster*		Endangered	CAMBA
42	AVES	Australian Reed Warbler	*Acrocephalus stentoreus*			BONN (A2H)
43	AVES	Regent Parrot	*Polytelis anthopeplus*	Vulnerable	Vulnerable	
44	AVES	Yellow Rosella	*Platycercus elegans flaveolus (NC)*			
45	MAMMALIA	Common Brushtail Possum	*Trichosurus vulpecula*		Rare	
46	MAMMALIA	Giles' Planigale (Paucident Planigale)	*Planigale gilesi*			
47	MAMMALIA	Southern Myotis	*Myotis macropus*		Endangered	
48	MAMMALIA	Water-rat	*Hydromys chrysogaster*			
49	OSTEICHTHYES	Australian Smelt	*Retropinna semoni*			
50	OSTEICHTHYES	Bony Bream	*Nematalosa erebi*			
51	OSTEICHTHYES	Callop	*Macquaria ambigua ambigua*			
52	OSTEICHTHYES	Common Jollytail/ Common Galaxis	*Galaxias maculatus*			
53	OSTEICHTHYES	Crimson-spotted Rainbow Fish	*Melanotaenia fluviatilis*			
54	OSTEICHTHYES	Dwarf Flathead Gudgeon	*Philypnodon macrostomus*			
55	OSTEICHTHYES	Estuary Perch	*Maquaria colonorum*	Endangered		
56	OSTEICHTHYES	Flat-headed Gudgeon	*Philypnodon grandiceps*			
57	OSTEICHTHYES	Fly-specked Hardyhead	*Craterocephalus stercusmuscarum fulvus*			
58	OSTEICHTHYES	Freshwater Catfish	*Tandanus tandanus*		Protected (FMA 2007)	
59	OSTEICHTHYES	Lagoon goby	*Tasmanogobius lasti*			
60	OSTEICHTHYES	Murray Cod	*Maccullochella peelii peelii*	Vulnerable	Closed fishing'	
61	OSTEICHTHYES	Murray Hardyhead	*Craterocephalus fluviatilis*	Vulnerable		
62	OSTEICHTHYES	Purple -spotted gudgeon	*Mogurnda adspersa*		Protected (FMA 2007)	
63	OSTEICHTHYES	Short-finned Eel	*Anguilla australis*			
64	OSTEICHTHYES	Short-headed Lamprey	*Mordacia mordax*			
65	OSTEICHTHYES	Silver Perch	*Bidyanus bidyanus*		Protected (FMA 2007)	
66	OSTEICHTHYES	Western Carp Gudgeon	*Hypseleotris spp. (complex)*			
67	REPTILIA	Broad-shelled Turtle	*Chelodina expansa*		Vulnerable	
68	REPTILIA	Common Long-necked Turtle	*Chelodina longicollis*			
69	REPTILIA	Macquarie (Murray Short-necked) Turtle	*Emydura macquarii*		Vulnerble	
70	REPTILIA	Carpet Python	*Morelia spilota*		Rare	
71	REPTILIA	Eastern Tiger Snake	*Notechis scutatus*			
72	REPTILIA	Red-bellied Black Snake	*Pseudechis porphyriacus*			
73	REPTILIA	Eastern Water Skink	*Eulamprus quoyii*			
74	REPTILIA	Lace Monitor	*Varanus varius*			
75	REPTILIA	Southern Water Skink	*Eulamprus tympanum*		Rare	
76	INVERTEBRATA	Floodplain Mussel	*Velesunio ambiguus*			
77	INVERTEBRATA	Murray Crayfish	*Euastacus armatus*		Protected (FMA)	IUCN Red List (Vulnerable).
78	INVERTEBRATA	River Mussel	*Alathyria jacksoni*			
79	INVERTEBRATA	River Snail	*Notopala sublineata hanleyi*			

Appendix 4: ArcGIS spatial modelling of vegetation group and 'at-risk' fish species associations



Appendix 5: Spatial accuracy of post-1990 state-wide records of 'at-risk' species

	Fish			Mammals			Birds			Reptiles			Frogs		
Spatial Accuracy	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %	Frequency	% Records	Cum. %
0-5m	0	0.0	0.0	77	4.1	4.1		#DIV/0!	#DIV/0!	22	1.4	1.4	1089	3.9	3.9
5-50m	1015	57.2	57.2	697	37.1	41.1		#DIV/0!	#DIV/0!	157	10.0	11.4	1470	5.3	9.3
51-100m	229	12.9	70.0	281	14.9	56.1		#DIV/0!	#DIV/0!	127	8.1	19.5	1202	4.3	13.6
101-250m	196	11.0	81.1	313	16.6	72.7		#DIV/0!	#DIV/0!	94	6.0	25.4	438	1.6	15.2
251-500m	77	4.3	85.4	132	7.0	79.7		#DIV/0!	#DIV/0!	96	6.1	31.6	20310	73.5	88.7
501-1000m	27	1.5	86.9	30	1.6	81.3		#DIV/0!	#DIV/0!	32	2.0	33.6	50	0.2	88.9
1-10km	64	3.6	90.5	265	14.1	95.4		#DIV/0!	#DIV/0!	902	57.4	91.0	2833	10.3	99.1
11-25km	21	1.2	91.7	19	1.0	96.4		#DIV/0!	#DIV/0!	0	0.0	91.0	0	0.0	99.1
>25km	70	3.9	95.7	0	0.0	96.4		#DIV/0!	#DIV/0!	1	0.1	91.0	0	0.0	99.1
11-30km	14	0.8	96.5	0	0.0	96.4		#DIV/0!	#DIV/0!	32	2.0	93.1	0	0.0	99.1
31-125km	1	0.1	96.5	0	0.0	96.4		#DIV/0!	#DIV/0!	0	0.0	93.1	0	0.0	99.1
<625km	3	0.2	96.7	0	0.0	96.4		#DIV/0!	#DIV/0!	9	0.6	93.6	23	0.1	99.2
Not entered	59	3.3	100.0	67	3.6	100.0		#DIV/0!	#DIV/0!	100	6.4	100.0	218	0.8	100.0
No. Selected Records	**1440**			**1500**						**496**			**24509**		
No. Records	**1776**			**1881**			**0**			**1572**			**27633**		

NB. Shaded cells correspond to 'bulk' of data used to determine search radii for calculating wetland proximity associations.