Conservation Planning in the CLLMM Region. Phase I: A Description of the Landscapes of the CLLMM Region

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Executive Summary

As with many Australian agricultural landscapes, the Coorong, Lower Lakes and Murray Mouth region has undergone significant biophysical change since the introduction of European agricultural systems. This resulted in declines and losses of native biodiversity from the region, that in some cases continue today. Where these declines are ongoing, ecological restoration may be required to arrest these declines and reduce the risk of regional extinctions. However, this restoration activity needs to be targeted to those components of biodiversity (landscapes, ecosystems and species) for which the opportunity for intervention still exists, where the risks of extinction are most immediate, and where restoration is critical management activity required to minimise this risk.

This report describes the biophysical features of the landscapes of the CLLMM region, and the impacts of historic and current land use have on the biodiversity of these landscapes. A synthesis of these descriptions was used to develop general recommendations regarding the nature of restoration activity that is required in each landscape.

A summary of the outcomes of these descriptions and synthesis are provided in Table 1 and Figure 1. Based on this synthesis, we recommend that, in the absence of more specific information regarding the state and trajectory of biota within the CLLMM region:

1. Management in landscapes 4, 7 and 10 (Relictual landscapes) should focus on the protection of remnant patches of vegetation, to prevent further loss;
2. Management of landscapes 1, 5, 8 and 9 should focus on identifying and addressing the landscape-scale systemic issues that are associated with decline of biodiversity (including landscape-scale restoration);
3. Management of landscapes 2 and 6 should focus on maintaining the current extent and ecological processes that support native biodiversity, and identify and address novel threats (e.g. pest plants and animals, change in land use) as they emerge.

The assumptions behind these recommendations are based on landscape ecology concepts developed by McIntyre and Hobbs (1999, 2000), who suggest that Relictual landscapes are likely to have already lost native biota that are sensitive to vegetation clearance. On the other hand, Fragmented (10-60%) landscapes are likely to retain these native biota, but they are at risk of being lost as the current landscape is unlikely to support them in the medium-long term. However, the authors of these papers acknowledge that other factors, such as the timing and nature of modification, are also likely to be important determinants of biotic responses to landscape modification. Given that these recommendations are based on limited information (particularly the extent of remnant native vegetation, independent of the state of this vegetation), there is a level of uncertainty associated with them. In particular, ecological processes other than those associated with vegetation clearance are not dealt with effectively in this assessment. For example, the impacts of hydrological change on littoral and groundwater-dependent ecosystems are not effectively addressed in this report. The outcomes of this report, then, should be treated as a first iteration, and updated as new information can be incorporated into these assessments.

This landscape-scale assessment also forms Phase I of a series of assessments that are designed to understand the relative conservation requirements – and required management interventions – at a range of levels in the biological hierarchy (landscape, ecosystem, species). Phase II, which is currently being undertaken, aims to address the relative requirements for intervention at level of ecosystems, prioritising the need for this information to those landscapes that have been identified in this report as requiring landscape-scale restoration in order to achieve nature conservation within the landscapes.

Landscape	Area (ha)	Rain (mm)	Soil	Relief (m)	Vegetation	Land use	Remnancy	Management Recommendation*
1	98,300	359-602	Wet saline soils (N2), shallow sandy loam over calcrete (B3)	0-84	Samphire; open woodlands	Dryland grazing, Irrigated grazing	24% (Fragmented)	restore in such a way that systemic issues are addressed
2	4,960	369-481	Water (WW), Wet Soils (N3)	0-13	Samphire; reedbeds; Lignum shrubland	Grazing (limited)	68% (Variegated)	maintain and address emerging issues
4	29,000	446-787	Deep siliceous sands over clay (G3/H3)	0-230	Shrubby mallee; open woodlands	Dryland grazing, irrigated horticulture	6% (Relictual)*	protect, buffer remnant vegetation
5	110,000	359-614	Shallow soils over calcrete (B2/B3), Deep siliceous sands (G2/H3)	0-75	Open mallee woodland; shrubby mallee	Dryland grazing	17% (Fragmented)	restore in such a way that systemic issues are addressed
6	23,692	450-602	Coastal carbonate sands (H1), Wet saline soils (N2)	0-51	Coastal shrubland	Conservation	60% (Variegated)*	maintain and address emerging issues
7	26,360	380-606	Sand over poorly structured clay (G4), Loam over poorly structured clay (D3)	0-128	Open woodlands/mallee, shrubby mallee	Dryland cropping	6% (Relictual)	protect, buffer remnant vegetation
8	5,500	514-778	Acidic soils over rock (K1/K2/K3)	34-280	Open woodlands, closed forests	Dryland cropping & grazing	18% (Fragmented)	restore in such a way that systemic issues are addressed
9	4,630	440-491	Loam over dark clay (F1), Water (WW), Wet Soils (N3)	0-14	Samphire, reedbeds, Paperbark woodlands	Dryland grazing, cropping	53% (Fragmented)*	restore in such a way that systemic issues are addressed
10	8,373	364-435	Sandy loam over poorly structured clay (F2), Siliceous sand (H2), Deep uniform loams (M1/M2)	0-42	Open woodlands	Irrigated horticulture, dryland cropping & grazing	4% (Relictual)	protect and buffer remnant vegetation

Table 1. Summary information for the nine Vegetation Landscapes described in this report.

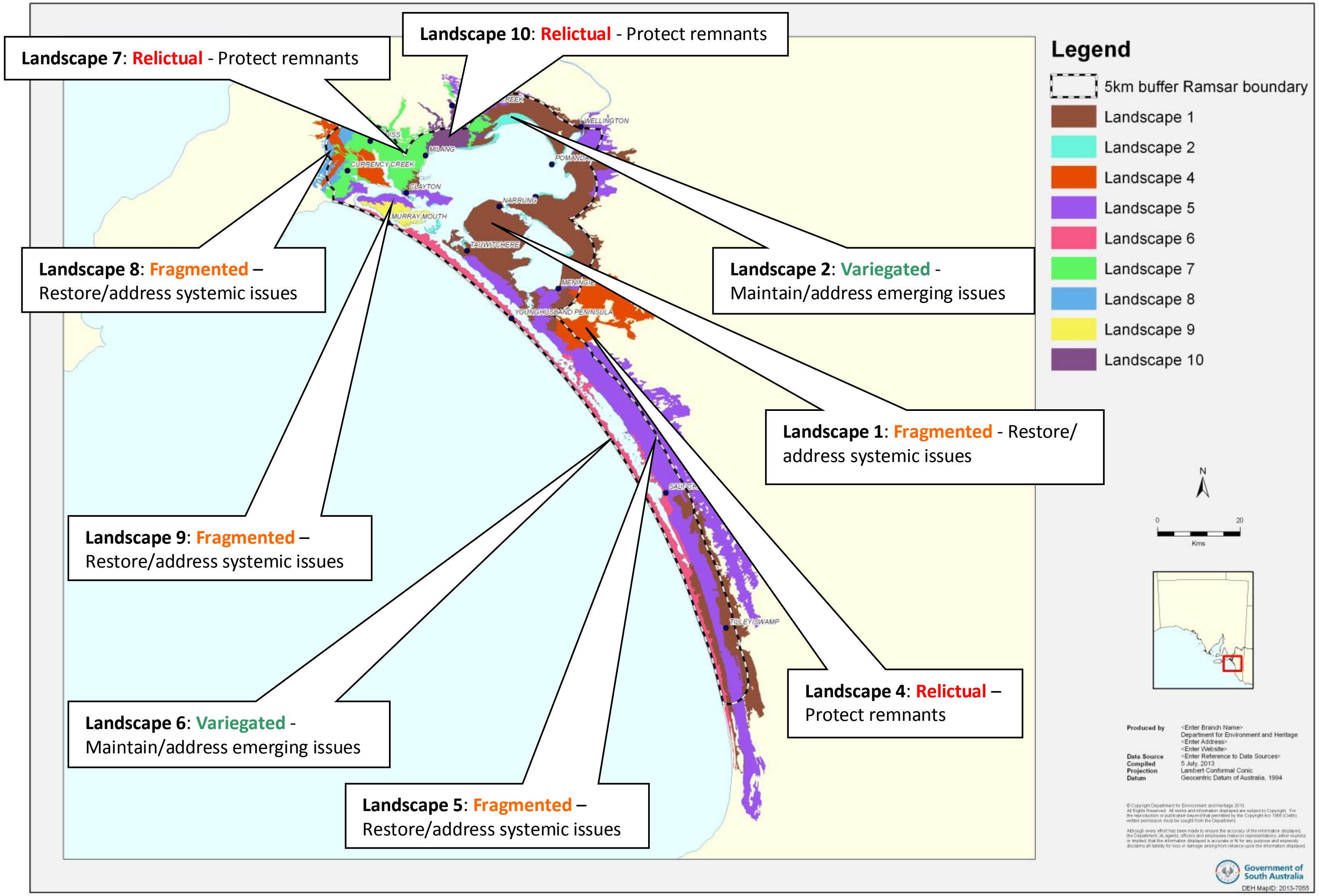

Figure 1. Map of the CLLMM region, showing the distribution of each vegetation landscape, and general recommendations for ecological restoration.

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1.0 Introduction

This report presents a summary description of the landscapes in the regions adjacent to the Coorong, Lower Lakes and Murray Mouth Ramsar site. The primary objective of these summaries is to inform the strategic delivery of ecological restoration programs within the terrestrial and littoral landscapes of the region.

The planning and delivery of nature conservation programs is an extremely challenging pursuit, not least of which because we need to make decisions regarding where to devolve limited investment in nature conservation, and what are the suite of activities required to achieve our conservation outcomes. Essentially, nature conservation planning needs to answer the question: What do we do, where do we do it, and why?

There are a range of established approaches to conservation planning (see Rogers *et al.* 2012). Historically these approaches have relied on the application of general ecological principles, such as island biogeography theory, to determine where protection or restoration should be prioritised. While, in the absence of any specific information about the landscapes of interest, these approaches have some value, "approaches based entirely on general principles would in most cases offer sub-optimal answers from both conservation and agricultural perspectives" (Lambeck 1999). This is primarily because the application of general principles fails to identify the particular requirements of the biota that require intervention for their conservation, or even what biota are likely to benefit from the intervention.

In order to better target the delivery of conservation programs to meet the requirements of particular landscapes, we thus need to understand:

1. Which landscapes, or biotic components of landscapes, are most at risk in the absence of intervention;
2. What are the processes that are placing these biota at risk, that we need to design management activities around to mitigate/reverse these impacts?

One of the challenges of understanding the conservation requirements of particular areas is that biodiversity is extremely complex, operating at a number of interacting levels across multiple spatial and temporal scales. In particular the nested, hierarchical nature of biodiversity (landscapes -> ecosystems -> species) potentially allows for us to organise our conservation requirements in a similar nested way – called the 'coarse-filter / fine-filter' approach (Noss 1987). Under this approach, we assume that if we can identify and meet the requirements of higher levels (e.g. ecosystems), we will meet the requirements of much of the biodiversity at lower levels (e.g. species). This approach then requires an understanding of conservation requirements at each of these levels. The application of this nested approach to nature conservation in South Australia's agricultural landscapes is described in detail in Rogers *et al.* (2012).

Ultimately, then, for a region of interest, we should aim to answer the following questions:

1. Which landscapes in our region appear to be declining with regard to their ability to support native biodiversity (compared with landscapes that either continue to support biodiversity, or have already lost their native biodiversity)?

2. Within these “declining landscapes”, what are the systemic issues associated with decline that we need to address? This particularly includes the identification of ecosystems that are associated with decline.
3. Are there declining species within these landscapes whose requirements will not be met by addressing these landscape-specific systemic issues?

This report addresses the first of these three questions, for the region within which the Coorong, Lower Lakes and Murray Mouth Restoration Program is operating (). It does so by collating biophysical information on each landscape within the CLLMM region, and the post-European impacts on these landscapes, in order to provide a general synthesis on the state and trajectory of each landscape.

More specifically, this report describes:

1. The physical (climatic, edaphic and topographic) properties of each landscape
2. A general description of the ecological communities that are (or were) supported by these physical environments
3. A description of the historic and current European land use
4. Management recommendations for the landscape (based on a synthesis of 1-3).

2.0 Report Format and Information Sources

This report describes the physical and biotic features, and the and land use history, of nine Vegetation Landscapes in the CLLMM region. Each landscape's description follows a consistent format:

1. General Description (Area, Geography)
2. Climate
3. Landforms
4. Soils
5. Land Types
6. Native Vegetation
7. Post-Settlement History and Current Land Use
8. Summary and Management Recommendations

The information used to populate these sections was derived from a variety of sources that were also relatively consistent between the different landscapes. The main information sources for each section were as follows:

1. *General Description*: Area and Geographic descriptions were derived directly from the spatial layers that defined the extent of each landscape. The extent of these Vegetation Landscapes was derived from the Soil and Land Attribute Database (Department of Environment Water and Natural Resources 2009). For more information on how Vegetation Landscapes were derived, see Section 4.0.
2. *Climate*: The climate information presented in this report typically focuses on mean annual rainfall and mean annual evaporation. Statistics for these variables were derived from an interpolated surface model, generated using the BIOCLIM variables within the ANUClim package for the region of interest (Xu and Hutchinson 2010).
3. *Landforms*: Landform information focuses on the elevation range within each Vegetation Landscape, and the typical landform variation of each landscape. These statistics were derived from a Shuttle Radar-derived Digital Elevation Model (Department of Environment Water and Natural Resources 2010), with 30m pixel size.
4. *Soils*: Soil characteristics largely refer to the Soil Subgroup classification of Hall (2009), with the soil subgroups from each landscape derived from the Soil and Land Attribute database (Department of Environment Water and Natural Resources 2009).
5. *Land Types*: Land Types refer to a descriptive combination of soil and topography, and are related spatially to the Soil and Land Attribute Database (Department of Environment Water and Natural Resources 2009).
6. *Native Vegetation*: A general description of the extant and pre-European native vegetation in each landscape was derived from the Native Vegetation spatial layers (Department of Environment Water and Natural Resources 2008b, 2008c).
7. *Post-Settlement History and Current Land Use*: The descriptions of Post-Settlement land use have been derived from a range of largely textual, descriptive sources. Much of the descriptive information was derived from Williams (1974), Jenkin (1979), McCourt (1987) and Faull (1981). Current Land Use was derived from the Land Use 2008 spatial layer (Department of Environment Water and Natural Resources 2008a). Current extent of native vegetation was derived from an intersect of the South Australian native vegetation

layer (Department of Environment Water and Natural Resources 2008b) and the total landscape area, to calculate a proportion by area mapped as native vegetation

3.0 Description of Vegetation Landscapes

This section provides a description of each vegetation landscape, outlining the nature of the physical, biotic and land use impacts on each landscape as described in the methods section.

For the purposes of this report, Vegetation Landscapes are defined as geographic areas within which the relationship between the physical environment and ecological responses to this environment remain consistent. In practical terms, the boundaries of Vegetation Landscapes were identified through the identification of consistent patterns of soil properties, using the Soil and Land Attribute Database (Department of Environment Water and Natural Resources 2009).

3.1 Vegetation Landscape 1

Vegetation Landscape 1 (L1) is the second largest vegetation landscape in the project area with a total area of 98,300 ha; it is also has the second widest distribution (Figure 2). L1 has been divided into four segments: L1a along the northern shore of Lake Alexandrina; L1b along the east of L. Alexandrina, Narrung Peninsula and surrounding Lake Albert; L1c is represented as two long parallel patches in the southern stretches of the project area; and L1d, a small area of L1 on the lake shore between Clayton Bay and Milang.

L1a is approximately 13,150 ha and extends between Tolderol Point and Wellington. It is separated from the lake at most points by a thin strip of L2. L1b is most prominent in the centre of the project area and extends over 57,350 ha. It covers all of the Narrung Peninsula except small areas of L2 around the shore and an approximate rectangle on the Coorong shoreline (8.5 – 1.5 km), which is categorised as L5 (Hundred of Baker).

One patch (smaller) of L1c in the southern stretches of the project area continues SSE as a continuation of the southern lagoon of the Coorong. The larger patch runs parallel approximately 3.5 km inland (Figure 2). It begins approximately 20 km NNW (following the Coorong) and reaches almost as far south as the smaller patch. The entire area of L1c is 26852 ha (Hundreds of Santo, Messent, Neville, Wells, Duffield and Landseer).

L1d, between Clayton Bay and Milang, also has the exception of small areas of L2 around the shore. The area of L1d is 930 ha (Hundreds of Alexandrina, Freeling, Brinkley, Malcolm and Bonney).

3.1.1 Climate

The approximate annual rainfall of Landscape 1 (L1) ranges from 359 mm on the northern and north-eastern shore of Lake Alexandrina to 602 mm at the southern extremity of L1 (and the project area). There is a significant difference between the mean rainfall values of some of the segments, perhaps none more evident than the 194 mm difference between the mean rainfall of L1a and L1c (Table 2). The approximate annual evaporation is 1742 mm.

Table 2. Rainfall data in the sub-landscapes of Vegetation Landscape 1

Landscape segment	Min (mm)	Max (mm)	Range (mm)	Mean (mm)	STD (mm)
L1a	359	399	40	372	7
L1b	378	485	107	428	24
L1c	536	602	66	566	14
L1d	437	452	15	446	3

3.1.2 Landforms

The vast majority of the land in L1 is low lying (<10 m AHD) with the exception of some isolated, comparatively elevated patches on Poltalloch Peninsula and the northern tip of Narrung Peninsula, which rise to between 50 and 80 m AHD (Table 3). The mean elevation of L1 is 7.7 m AHD (± 8.7 m S.E.). By dividing the Landscape into sections, it is clear that there are only hill or peaks in one, reasonably isolated area in L1b.

Considering the low lying terrain of L1, especially in the southern portion of the Coorong, inundation or drainage water may influence soil water content more than the influence of direct rainfall. Moreover, Morella Basin near Salt creek, Martin Washpool CP and Tilley Swamp CP lie 'downstream' of the constructed and natural drainage lines that channel water from the parts of the Southeast of SA into the Coorong; these sites are classified as L1.

Table 3. Soil, area and elevation of Vegetation Landscape 1 and sub-landscapes. Dominant and subdominant soils are only listed for the landscape as a whole. Subdominant soils refer to those soils that make up >10% by area of the landscape, but aren't the most common soil in the landscape.

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
1	**N2**	**B3, H2**	**98,277**	**0 – 84.2**	**7.7 ± 8.7**
1a			13,145	0 – 22.1	22.1 ± 6.0
1b			57,349	0 – 84.2	84.2 ± 8.3
1c			26,852	0 – 27.8	27.8 ± 7.4
1d			930	0 – 12.7	12.7 ± 3.6

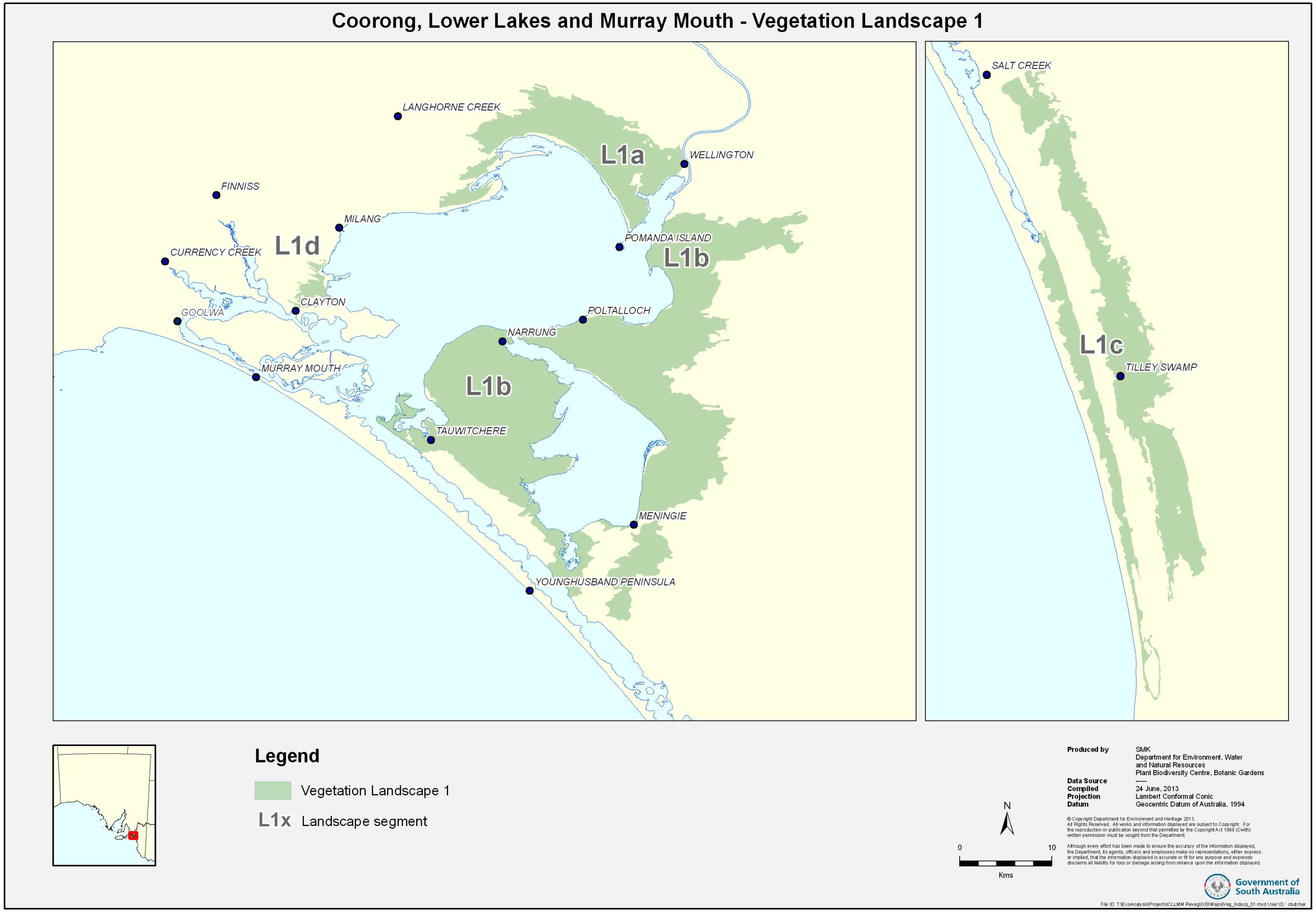


Figure 2. Map showing the location and extent of Vegetation Landscape 1

3.1.3 Soils

The soil of L1 can loosely be classified as saline, sandy, calcareous loamy soil. The most common soil is *N2 – Wet, saline soil* (22% of the landscape by area) and there is also greater than 10% of *B3 – Shallow sandy loam on calcrete* and *H2 – Siliceous sand* (Table 4). There is a reasonably large difference in mean annual rainfall between the northern-most and southern-most areas of L1 (L1a – southern L1c). Within L1, there appears to be a higher presence of sandy soils in the northern section of L1 (more B3, H1, H2 and G3) than can be found in the southern areas (rich with shallow B soils and some calcareous A soils). Wet, N group soils are scattered throughout L1 though they are in greater abundance in the south.

Table 4. Soil Types in Vegetation Landscape 1. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	%
N2	Saline soil	22
H2	Siliceous sand	16
B3	Shallow sandy loam on calcrete	11
B8	Shallow sand on calcrete	8
E1	Black cracking clay	6
B2	Shallow calcareous loam on calcrete	5
-	Others combined (n=22)	32

L1a has a high diversity of types of soil in comparison to the remaining segments, there is not a clearly dominant Soil Type. The eastern length of L1b is considerably different to Narrung Peninsula. There is more *E1* and *H2* on the eastern length, while Narrung has much more *B2* soil. The vast majority of L1c is *N2* soil, with a thin strip of *B8* along most of its length. L1c is mostly *N2* soil with small patches of deep sands (H soils). *N2* soils are in regular patches of varying sizes in each Landscape segment.

3.1.4 Land Types

Land types (LTs) are a description of the terrain expressing the geomorphology and soil types found therein. In comparison to other Vegetation Landscapes, L1 has high complexity and a patchwork of LTs in close proximity, especially in L1a (Figure 3). As expected from the soil data above (where Saline soil was most abundant), the most abundant Land Type is *LT-Z – Saline Land*, which has patchy distribution throughout L1 and comprises most of the southern section.

From north to south, the geomorphic LTs are as follows. There are patches of dune/swale system of various acidities set amongst a patchwork of soils formed on calcrete and soils formed on marine/lagoonal clay or limestone. The soils formed on calcrete (LT-Q) are only found in L1a. Soils formed on relict coastal dunes (LT-M) are the most common LT on the Narrung Peninsula along with a large portion of Poltalloch Peninsula, which also has an abundance of dunes. The dune/swale systems here have mainly neutral to alkaline, unbleached siliceous sand with calcareous subsoil on dunes. The dune system on Poltalloch Peninsula constitutes the highest peaks in the region (> 80 m). The southern shore of Lake Albert is predominantly LTs M, V and Z, which signifies soil formed on relict coastal dunes or formed on marine/lagoonal clay or limestone or that it is saline land.

The area to the south is mostly LT-Z with a large patch of LT-N and a thin strip of LT-M.

3.1.5 Native Vegetation

The dominant, pre-European vegetation communities of L1 is expected to be *Allocasuarina verticillata* low woodland with an open grassy and herbaceous understory and a low shrubland dominant with *Tecticornia* spp. fringing inland lagoons and stranded tidal zones. These vegetation communities were expected to be widespread in the segments north of Meningie. Mallee scrub (*Eucalyptus diversifolia*) is thought to have been on Narrung and Poltalloch Peninsulas and farther south in L1c. There were also several other woodlands, shrublands, low open forests, tussock grasslands, sedgelands, etc. spread throughout L1.

The current vegetation communities in L1 have relatively high diversity, although samphire shrublands are the most widespread and abundant vegetation community. There are many pockets of native woodlands and forests that have been preferentially cleared over many years. L1a is dominated by samphire shrubland (*Tecticornia* spp., *Sarcocornia quinqueflora*). L1b has a similar abundance and dominance of samphire shrublands with the addition of widespread *Phragmites australis* grasslands (reed beds), , *Melaleuca* spp. shrubland and *Eucalyptus* mallee. *Typha* spp. rushlands and *Gahnia filum* sedgeland is common surrounding the shorelines of the lakes. *Melaleuca* spp. shrubland is common in L1c, along with samphire shrubland (*Sarcoconia* sp.) and *Leucopogan parviflorus* coastal shrubland. *Eucalyptus diversifolia* mixed mallee woodland is less common but widespread, so too is *Gahnia filum* tall sedgeland. The dominant vegetation community in L1d is samphire shrubland (*Tecticornia pergranulata*).

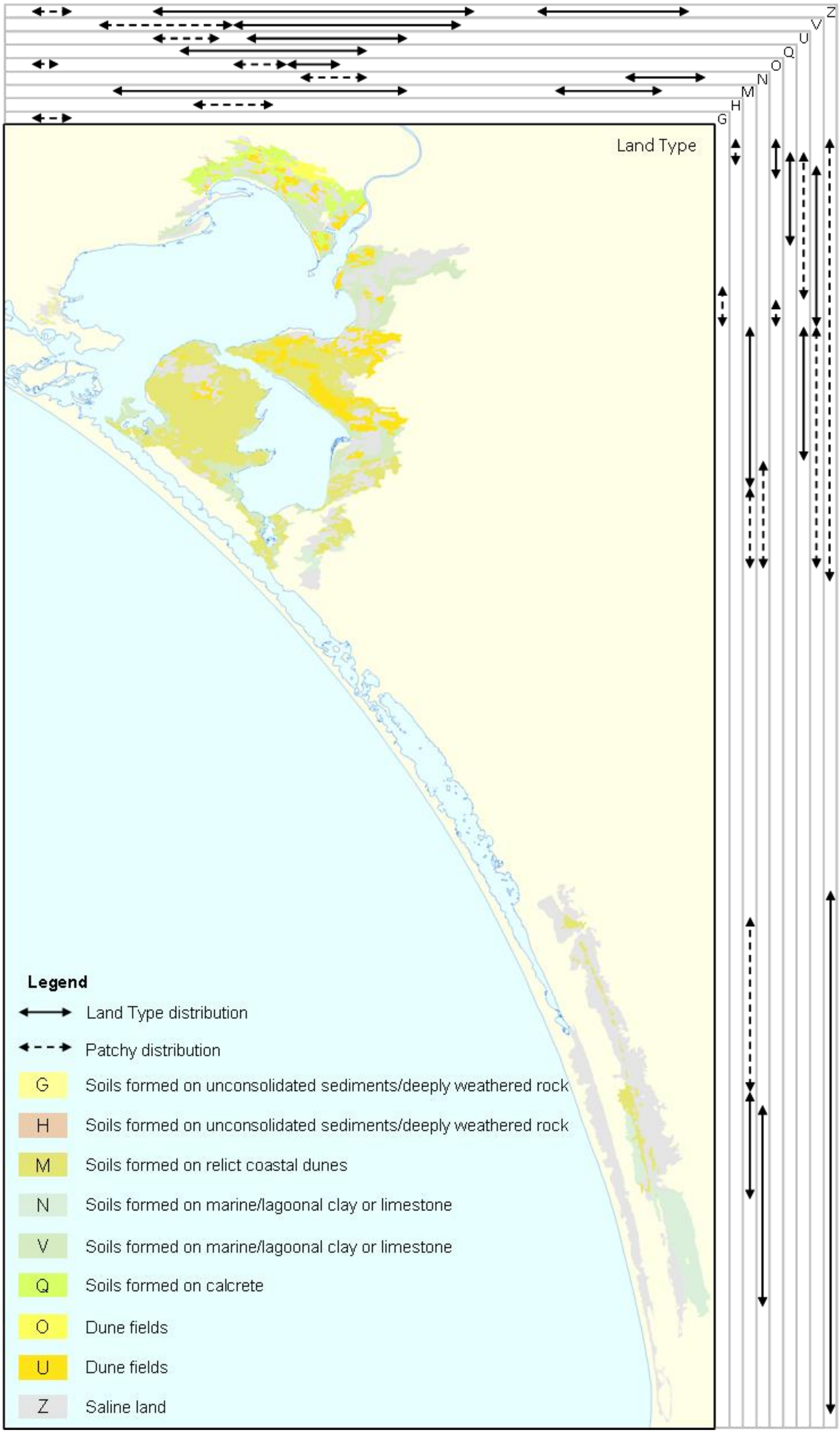


Figure 3. Location of Land Types in Vegetation Landscape 1

3.1.6 Post-settlement History and Current Use

Pastoralists were the first to attempt settlement in L1 in the early 1840s when the South Australian Company made the land surrounding Lake Albert available for pastoral leases. By 1850 cattle were grazing on Narrung Peninsula. Much of the land around the lakes (set back from the shore) was classified as Mallee Scrub and held very low appeal for pastoralists and farmers due to its 'low quality' soil and hardy, persistent woody vegetation that was very difficult to clear.

In 1859 a Mission was established at Point McLeay for the Ngarrindjeri people. The Mission was led by George Taplin, who worked very closely with the Aborigines. Bird and fish were abundant in the area and a popular destination for sport (hunting) and fresh produce that was carted to the Adelaide markets. The Ngarrindjeri were employed to hunt and catch fish for the Adelaide markets for a short period. In 1866 Meningie was created to fill the need of better overland mail and transport services between Adelaide, the Southeast and Victoria. In 1867 a steamer going between Meningie and Milang replaced the need for the overland mail run.

Several Acts were written to encourage settlement in this area but it was not until the invention of the Stump Jump Plough in 1876 that there was a rapid purchase of land (particularly Mallee Scrub) for agriculture. The Stump Jump Plough allowed effective turning of partially cleared land while avoiding (jumping) Mallee stumps. The Mallee stumps were later recognised as effective soil erosion control and the shoots were burnt annually and the ashes dispersed to fertilise the soil.

The hunting and fishing activities in and around the Lower Lakes increased in 1883 when the railway was extended to Milang. The railway allowed faster, easier transport of fresh produce to Adelaide and better access for hunters.

In 1907 the state government bought Narrung Station and subdivided Narrung Peninsula for the use by farmers, and created the township of Narrung. Once the land was made available to farmers, most of the native vegetation was cleared and the indigenous people were no longer permitted to use the land as they did prior to settlement.

Six weirs and locks were constructed upstream along the Murray in 1940. These reduced the amount of water filling the Lower Lakes. Salt water had been noted in the Lower Lakes and the barrages were built to preserve the water levels and freshness of the water. This change in the water regime effected vegetation and resulted in lakeshore erosion.

The area of scrub east of Lake Albert and the Coorong was unsuitable for grazing or cropping due to a deficiency of some trace elements in the soil. This deficiency hindered early attempts at crop farming in the area. The addition of these elements resulted in an agricultural boom in the area in the years after World War 2. The Playford government of South Australia (between 1940-1965) promoted vast areas of land clearance on the mainland side of the Coorong. This had notable, major impacts on bird populations.

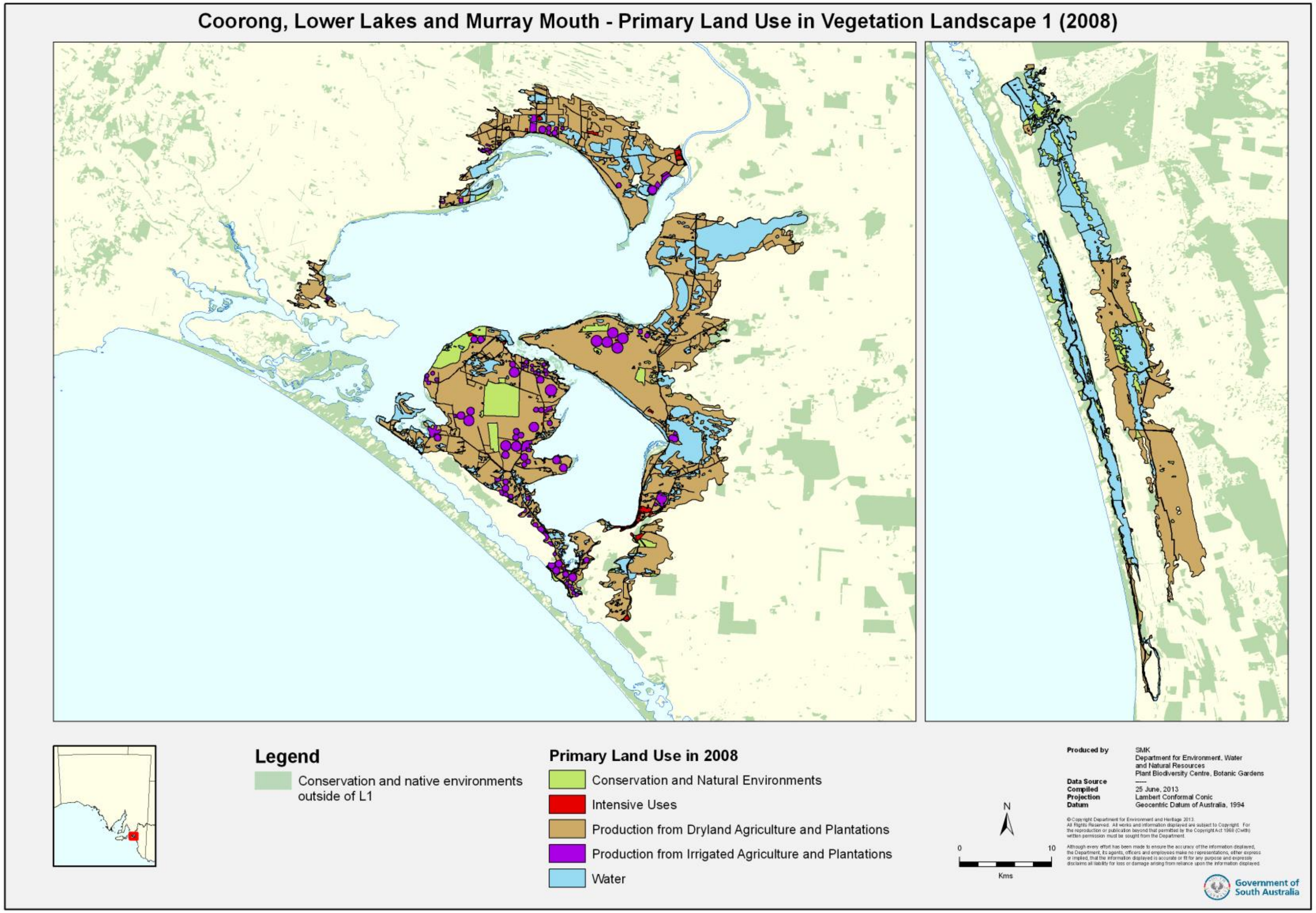


Figure 4. Vegetation Landscape 1 Land Use (2008). This map suggests that the dominant land uses of L1 are production from dryland agriculture, although significant areas of irrigated agriculture are also present. Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008a).

Grazing is currently widespread and wind erosion can be severe in the sand dunes (Figure 4). There is an estimated 24% of remnant, vegetation in L1, which is classified by McIntyre and Hobbs (1999) as a ‘Fragmented’ landscape. Common to most of the Vegetation Landscapes, the major land use is dryland agriculture, which likely consists of dryland cropping that is rotated with grazing. Irrigated agriculture (centre pivot) is reasonably widespread on the Narrung Peninsula, along with several centre pivot irrigators near the northern shore of Lake Alexandrina and Poltalloch Peninsula. Large coverage impact (impulse) sprinklers are also likely to be used in the area. The largest areas set aside for conservation are on the Narrung Peninsula (L1b), followed by patches amongst ephemeral wet areas in the southeast (L1c). There are some reasonably large areas of native vegetation on Poltalloch Peninsula and surrounding Meningie. There is little recognised conservation land along the north and northeast shore of Lake Alexandrina, however there is considerable areas of samphire vegetation amongst ephemeral water bodies and salt marshes.

3.1.7 Summary and Recommendations

L1 is physically dominated by low, rolling plains of shallow soils over calcrete, along with large areas of saline wetlands. Historically, the terrestrial soils of this landscape are likely to have supported open woodlands (e.g. *Allocasuarina verticillata*, *Eucalyptus leucoxylon*). Land use is dominated by dryland agriculture (grazing, cropping) with some irrigated agriculture (dairy) also present.

Based on the nature of the soils, the historic and current land use, and the proportion of the landscape mapped as native vegetation, our initial recommendation for this landscape is to undertake landscape-scale restoration to support native biota in this landscape, in such a way that the systemic issues associated with decline are addressed. However, while the overall landscape is considered fragmented (24% remnancy), this remnant vegetation is likely to be heavily skewed to the wet saline parts of the landscape, with the remaining terrestrial components likely to contain very little remnant native vegetation. A further recommendation for this landscape is that further investigations be undertaken to determine if nature conservation opportunities remain for the restoration of the terrestrial ecosystems of this landscape.

3.2 Vegetation Landscape 2

Vegetation Landscape 2 (L2) is found exclusively on the shorelines and low-lying islands in the Lower Lakes. It comprises a thin strip of land and small islands that are periodically inundated and has a total area of 4,960 ha. The longest continuous strip of L2 spans the shoreline between Milang and Pomanda ‘Island’ near Wellington (Figure 13). The shoreline of both lakes is a relatively high energy area with regular winds and waves impacting on the plants and soil. L2 is found within the following Hundreds: Nangkita; Alexandrina; Bremer; Freeling; Brinkley; Malcolm; Bonney and Baker.

3.2.1 Climate

The approximate annual rainfall of L2 ranges from 369 mm on the northern shore of Lake Alexandrina to 481 mm at the southern shore of Lake Albert. The approximate annual evaporation is 1750 mm.

3.2.2 Landforms

The vast majority of the land in L2 is low lying (<5 m AHD) and much of the terrain is periodically inundated. The altitude in L2 ranges from 0 – 13.8 m AHD (Table 5). The mean elevation of L2 is 2.1 ± 1.7 (SD) mAHD.

Table 5. Soil, area and elevation of Vegetation Landscape 2. Dominant and subdominant soils are only listed for the landscape as a whole. Subdominant soils refer to those soils that make up >10% by area of the landscape, but aren’t the most common soil in the landscape.

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
2	WW	N3	5,297	0 – 13.8	2.1 ± 1.7

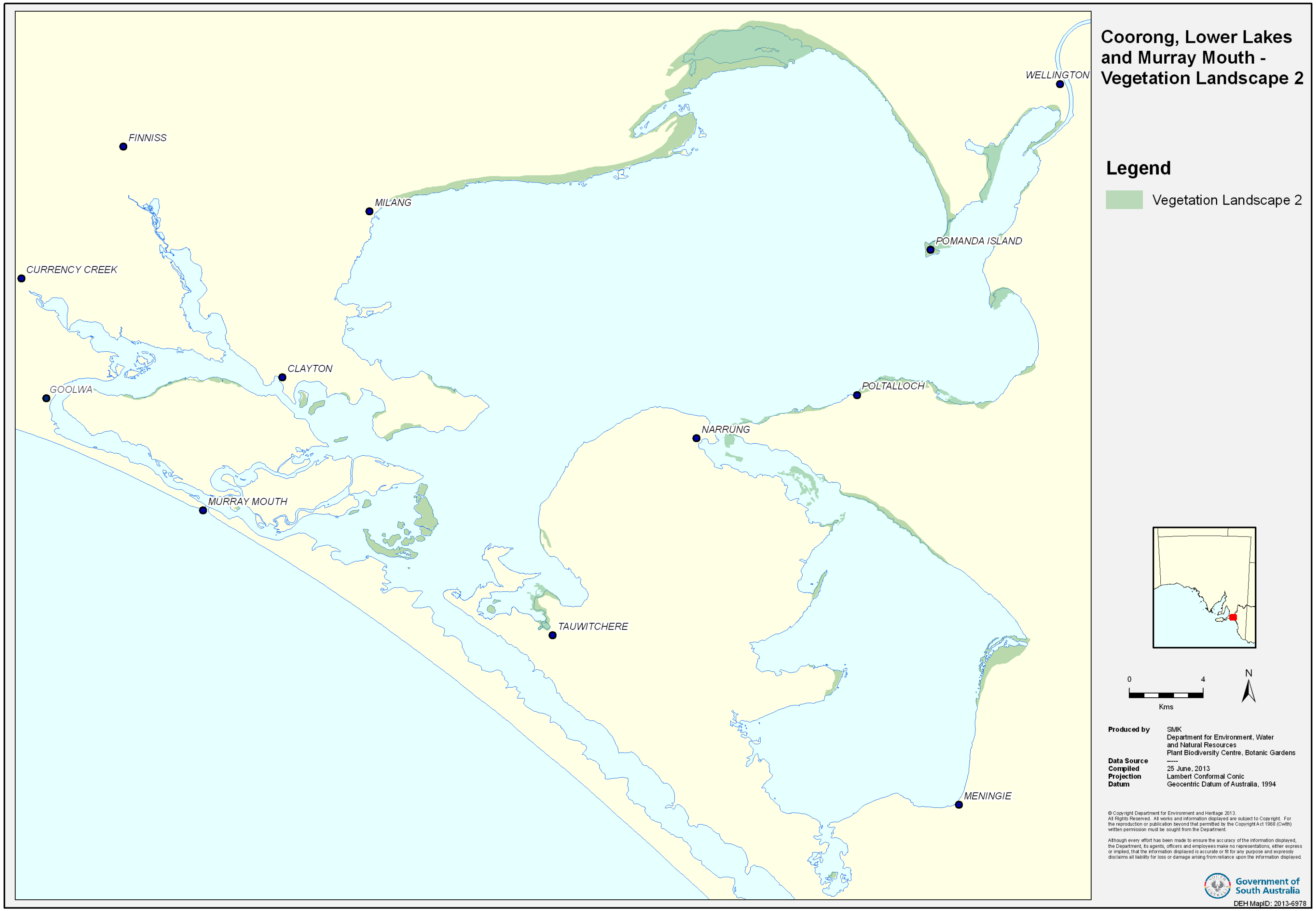


Figure 5. Map showing the location and extent of Vegetation Landscape 2

3.2.3 Soils

The defining feature of L2 is wet soil that is not saline to moderately saline soil that is found at lake shores or as the small islands (namely Goat Island, Goose Island and Mud Islands). When not classified as water (WW), the soil is predominantly classified as wet soil with low to moderately high salinity (45% N3). There are some small patches of shallow soil on calcrete.

The most common soil in L2 that is not classified as water (WW) is *N3 – Wet soil with non to moderately high salinity* (Table 6). There are some very small patches (<5% of L2) of various 'B' soils (shallow soils on calcrete or limestone) near Clayton and at the southern shore of Lake Albert.

Table 6. Soil Types in Vegetation Landscape 2. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	%
WW	Water	54
N3	Wet soil (low to moderately high salinity)	43
B2	Shallow calcareous loam on calcrete	1
B3	Shallow sandy loam on calcrete	> 1
-	Others combined	≈ 1

3.2.4 Land Types

Land types (LTs) are a description of the terrain expressing the geomorphology and soil types found therein. L2 has three LTs, however the vast majority is classified as *LT-V – Soils formed on marine/lagoonal clay or limestone. Plains with mainly neutral to alkaline gradational or texture contrast soil, often marginally saline* (Figure 3), which is widespread throughout L2.

There appears to be no latitudinal or longitudinal trends of LT within L2, or perhaps not enough variability or area to indicate any such trends. The small patches of LTs M and Q within L2 are in fact amongst larger areas of their respective LTs when not categorised by Vegetation Landscapes; the neighbouring Vegetation Landscapes, with similar LTs are L1 and L5.

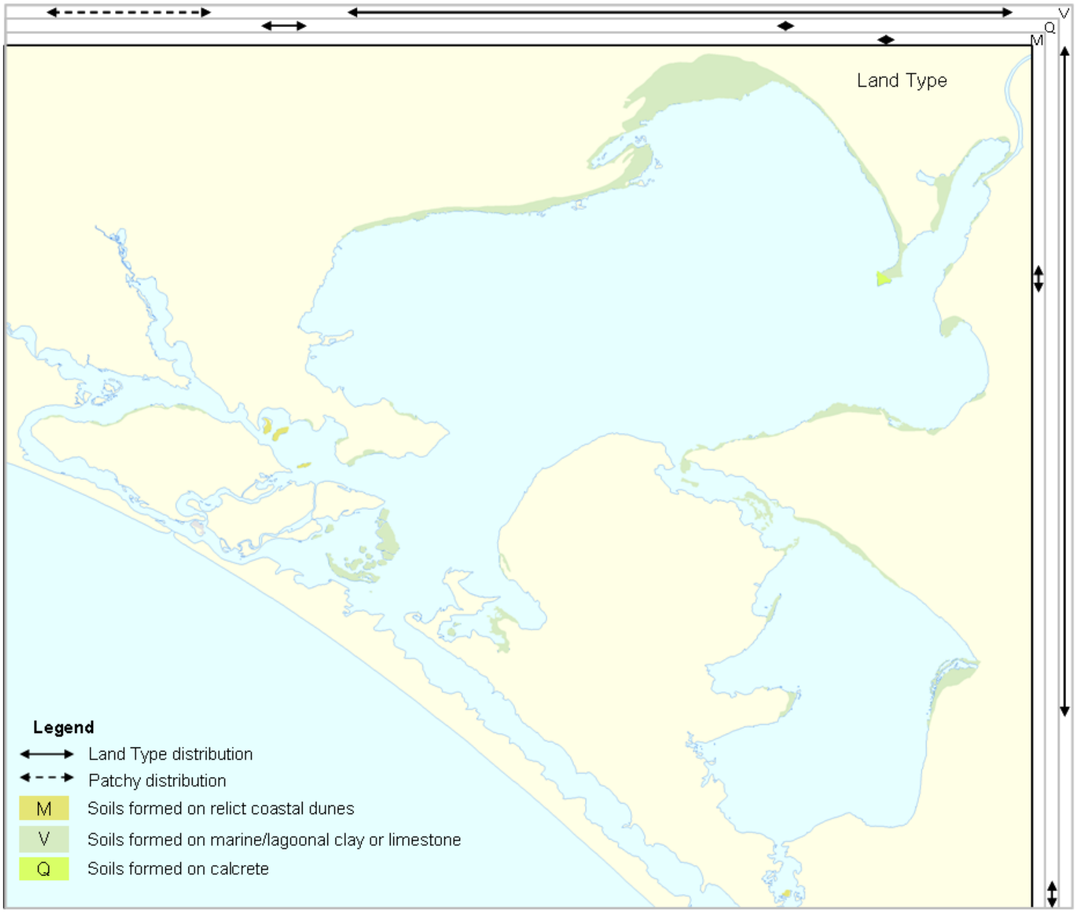


Figure 6. Location of Land Type in Vegetation Landscape 2

3.2.5 Vegetation

The expected pre-European vegetation of L2 was primarily low shrublands with *Tecticornia* spp. with often *Maireana opposotifolia* over *Frankenia* spp. *Lawrencia* spp. *Disphyma crassifolium* ssp *clevellatum*. These communities are believed to have been set slightly inland from a thin strip of *Phragmites australis* grassland (reed bed). Several patches of *Allocasuarina verticillata are also expected to have grown throughout L2.*

Large areas of native vegetation remain in L2. *Phragmites australis* grasslands continue to line much of the lake shores, however there is a 'greater' abundance of various samphire wetlands (*Sarcoconia* spp. or *Tecticornia* spp. dominant) in comparison to the expected, pre-European settlement vegetation communities. There is a fairly widespread abundance of *Muehlenbeckia florulenta* shrubland across most parts of L2, along with widespread *Typha* dominant sedgelands.

When viewing the land use data of 2008 (Figure 4), it should be considered that much of the land classified as 'Water' is in fact covered with samphire, reeds, sedges and other halophytic and/or hydrophilic plant species. It is believed by Pedler and Mallen (2001) that the tree *Melaleuca halmaturorum ssp. halmaturorum* (swamp paperbark) used to line the lake shores and wetlands prior to dramatic changes to land use. The species thrives in varying levels of salinity and inundation and acted as an excellent soil binder, energy buffer (waves and wind) and resource (habitat, shelter, fuel etc.) for animals and humans alike.

3.2.6 Post-settlement History and Current Use

The history of L2 is largely nested within the history of L1 as most of L2 is found on the outer boundary of L1. The early pastoralists who settled in the area in the early 1840s on land surrounding Lake Albert were amongst the first Europeans to begin altering the landscape. By 1850 cattle were grazing on Narrung Peninsula.

Both of the lakes were the direct water source for the majority of the grazing cattle, both stationary and cattle that were on a stock route. Therefore, vegetation of L2 was frequently cleared, trampled and consequently often eroded as livestock traversed L2 to the shoreline to drink. The impact of livestock on L2 was increased in parts where flood irrigation was used to irrigate pasture for grazing; this is still practiced along L2.

As commercial and sport hunting of birds and fishing increased in popularity in the Lower Lakes (from 1860 and especially in 1883) it is expected that more of L2 would have been impacted by the activity. Access paths would have been cleared, areas razed to improve lines of site and trees felled for firewood or the construction of bird hides; this was most likely to have occurred in the large areas near Boggy Lake in the north and The Narrows between Narrung and Poltalloch Peninsula.

Clear passage for boats was likely to have been maintained in The Narrows in times of low water inflow and consequent low water levels in the lakes. This may have included clearing of vegetation and modification of the benthic environment (dredging). This would have been most relevant between 1867 and 1930 when a steamer going between Meningie and Milang.

In 1907 the state government bought Narrung Station and subdivided Narrung Peninsula for the use by farmers, and created the township of Narrung. Once the land was made available to farmers, most of the native vegetation was cleared, including the *Cyperus gymnocaulos* (Spiny flat sedge), which was (and remains) culturally important to the Ngarrindjeri. The new farmers on Narrung no longer permitted the Ngarrindjeri to use the land as they did prior to settlement.

Six weirs and locks were constructed upstream along the Murray River in 1940. These reduced the amount of water filling the Lower Lakes. Salt water had been noted in the Lower Lakes and the barrages were built to preserve the water levels and freshness of the water. This change in the water regime effected vegetation that was suited to a fluctuating water level and added to lake shore erosion.

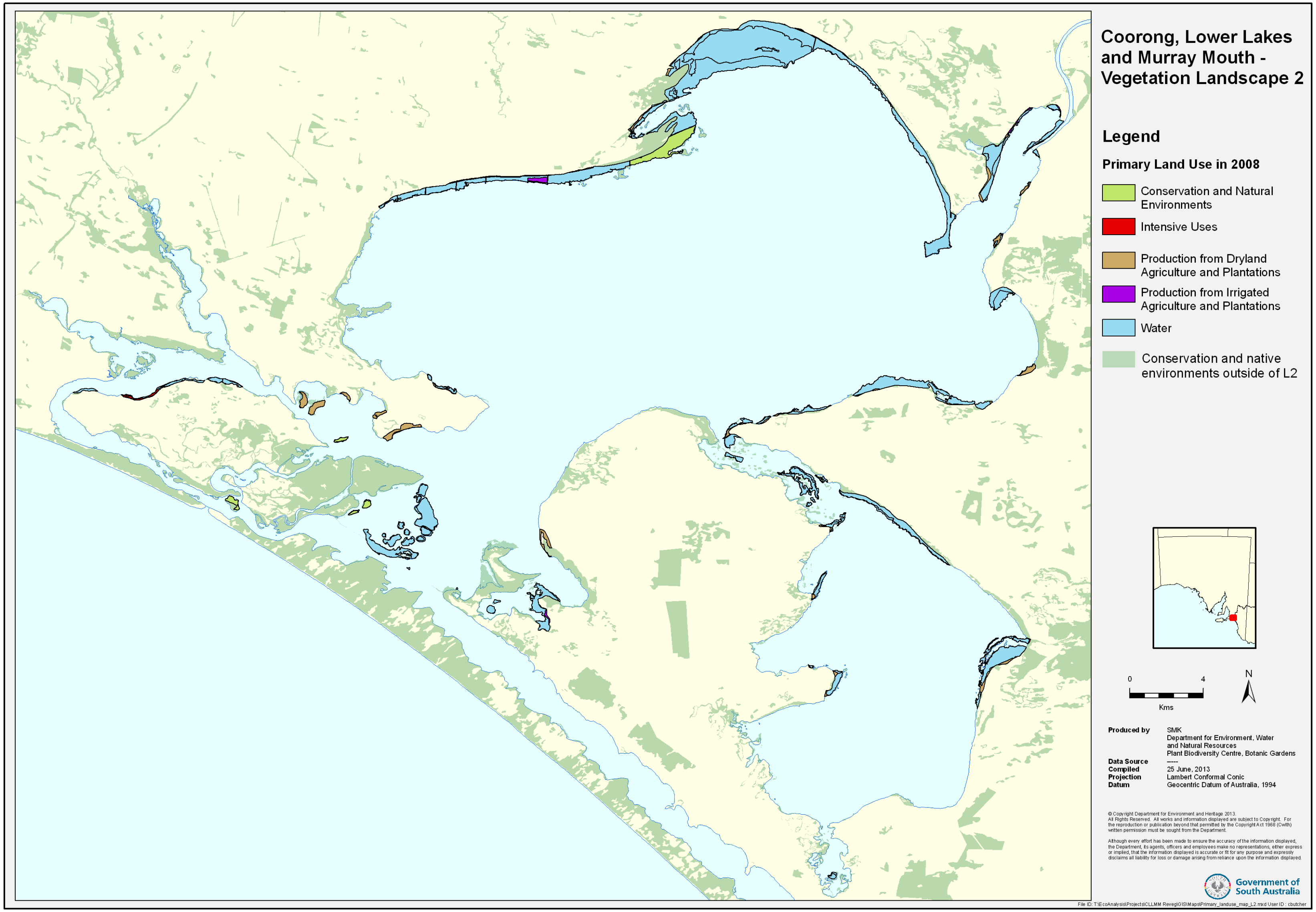


Figure 7. Vegetation Landscape 2 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008a).

Most of L2 has been impacted by agricultural use (Figure 7) yet the soft wet terrain has kept it clear from intensive grazing pressure. Consequently there is an estimated 68% of remnant, native vegetation; much of which is non-woody reeds, rushes and sedges. This amount of remnancy is classified by McIntyre and Hobbs (1999) as a 'Variegated' landscape.

The landscape is often between a road/vehicle track and the lake shore and is frequently broken by vehicle tracks or channels that have been dug to connect water pumps to the lake. This thin strip of land appears to be used as an occasional pasture for livestock and as such is often in an intermediate state between the native shoreline vegetation and permanent pasture. There are often scattered trees, shrubs, sedges, reeds and rushes amongst exotic pasture grasses.
A site visit revealed several areas of planned revegetation at varying stages of maturity (from seedling to mature shrubs). Recent revegetation sites (with seedlings) were often in areas with shrubs or extant trees.

In areas where L2 is not contained by the road, there is often a clearly visible change in soil type and vegetation between L2 and the neighbouring Vegetation Landscapes. In such cases there is no physical barrier that prevents grazing livestock from entering or crossing L2; this often results in visible tracks and trampled vegetation and soil.

There is a thin strip of L2 across approximately 50% of Hindmarsh Island. In this strip there are several dwellings (holiday shack, sheds, etc.), many of which have small jetties. There is evidence that many of the jetties have had the (usually) underwater soil dredged to allow boat access in times of low water levels. Furthermore, in this section with residential development, there are many gardens, lawns and planted trees. Therefore it can be assumed that there are many non-native potentially invasive plant species in this part of L2.

The small islands near Clayton Bay (Goose Island, Goat Island and Rat Island) and near Tauwitchere Channel (Mud Islands) are not intensively grazed by livestock if they are grazed at all. It in not clear if there is the presence of exotic grazers such as rabbits and there appears to be some exotic grass species growing.

3.2.7 Summary and Recommendations

L2 is almost exclusively associated with physical environments that are periodically or permanently inundated, namely the shoreline and fringing wetlands of Lakes Alexandrina and Albert. Much of the area of this landscape (68%) is mapped as native vegetation, with this native vegetation typically being aquatic or semi-aquatic communities such as samphire, reedbeds and Lignum *Muehlenbeckia florulenta* shrublands. Based on the recommendations of McIntyre and Hobbs (1999, 2000), we consider this landscape to be Variegated, with a general management recommendation being that the current extent of native vegetation be maintained to support native biota. However, given the strong hydrological dependence of native ecosystems in this landscape, there may be systemic issues associated with biodiversity decline that require restoration or manipulation of hydrological processes (rather than revegetation).

3.4 Vegetation Landscape 4

Vegetation Landscape 4 (L4) is in two geographic regions of the project area and three separate areas. The largest segment of L4 is located approximately 3 km inland from Meningie on the south-eastern corner of Lake Albert; this has been labelled L4a. The Landscape extends patchily inland (east) for ≈ 20km and south ≈ 17 km near Snake, Needles and Rabbit Islands in the Coorong. The remaining segments of L4 are in the western part of the project area: the peninsula formed by Currency Creek and Finniss River (L4b); and the foothills of the southern Mount Lofty Ranges (L4c). L4 is found within the following Hundreds: Nangkita; Alexandrina; Bremer; Freeling; Brinkley; Malcolm; Bonney and Baker. The total area of L4 is approximately 29,000 ha (Figure 8).

3.4.1 Climate

The approximate annual rainfall of L4 ranges from 446 mm in L4a to 787 mm in L4c. The annual mean rainfall in L4 is 495 mm (± 57 mm SD). The approximate annual evaporation is 1740 mm.

3.4.2 Landforms

Terrain varies greatly within L4. Segment L4a is quite low and flat with a mean relief of 9.8 m AHD and a range of 30.6 m (which is also the maximum relief). The range of relief is increased on L4b (67.1 m) and there is a clear and steady increase in relief from the southeast tip (lowest) heading inland. The highest altitudes and the greatest variations are found in L4c where low gullies are approximately 33 m AHD and the highest peaks reach 230 m (range ≈200 m).

For simplicity, all topographical data have been limited to a minimum of 0 m AHD. The altitude in L4 ranges, therefore, between 0 – 230.3 m AHD (Table 7). The mean elevation of L4 is 30.6 m AHD with a standard error of 44.9 m. The large standard error illustrates the suitability of dividing L4 into smaller segments or similar land forms.

Table 7. Soil, area and elevation of Vegetation Landscape 4 and sub-landscapes. Dominant and subdominant soils are only listed for the landscape as a whole. Subdominant soils refer to those soils that make up >10% by area of the landscape, but aren't the most common soil in the landscape.

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
4	**G3**	**H3**	**28,949**	**0 – 230.3**	**30.6 ± 44.9**
4a			20,183	0 - 35.6	9.8 ± 4.1
4b			3,911	0 – 67.1	21.9 ± 11.5
4c			4,855	33.2 – 230.3	123.7 ± 36.5

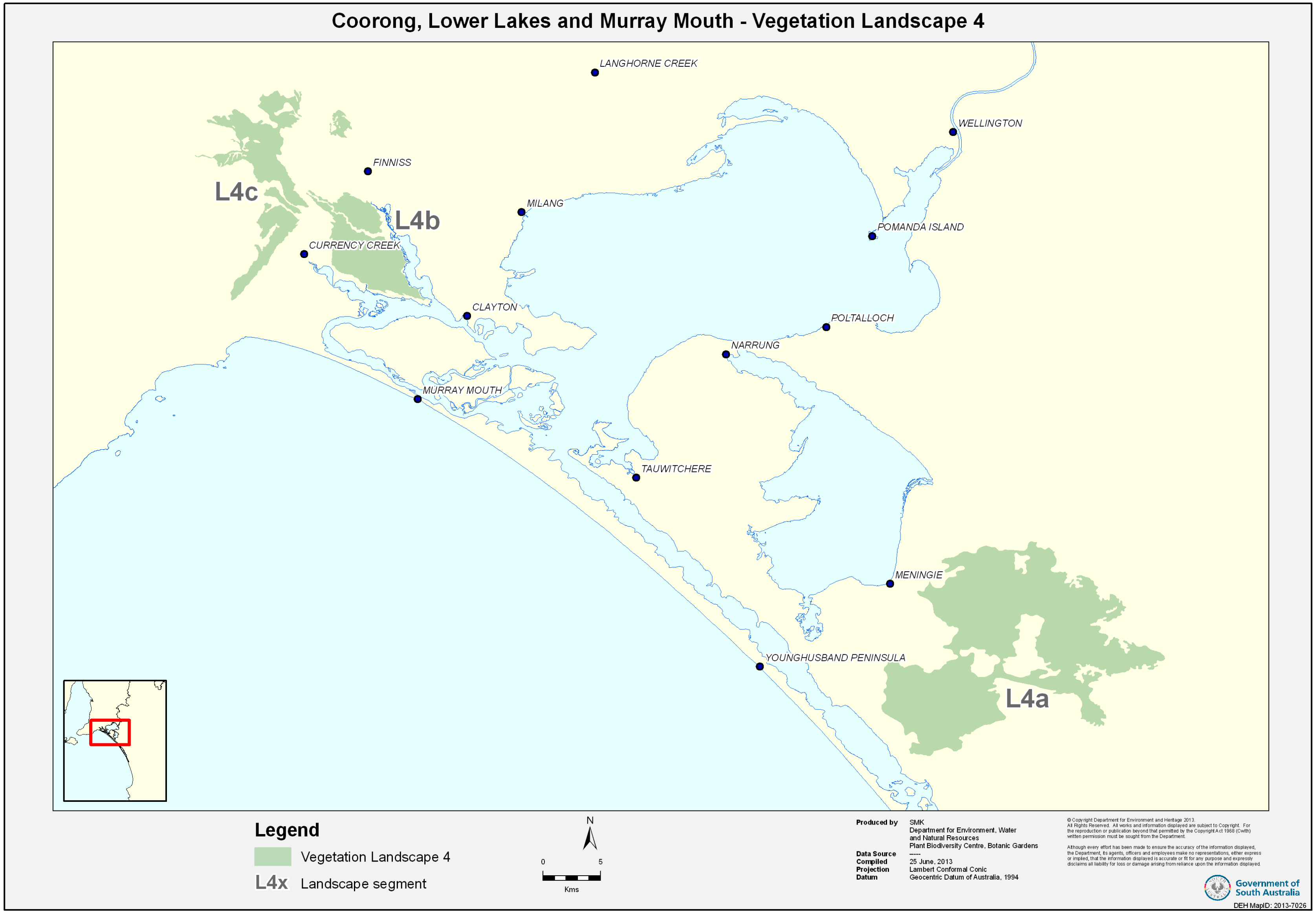


Figure 8. Map showing the location and extent of Vegetation Landscape 4

3.4.3 Soils

The soils in L4 are predominantly varieties of sand over clay soils or deep sands (Table 8). Soil diversity within L4 varies with each segment. L4a is the least diverse segment and has two major types of soil, *G3 – thick sand over clay* and *H3 – bleached siliceous sand* in very large patches alongside a small patch saline soil (with 30% H3). Segment L4b has the highest soil diversity. However, it is predominantly H3 soil with bands of G3 and *D5 – Hard loamy sand over red clay*, and small patches of other soil types. Segment L4c is mostly comprised of G type soils, with large areas of *G5 – Sand over acid clay*. There is a thin line of *I2 – Wet highly leached sand* and *N1 – Peat* that follows the path of the Tookayerta Creek.

Table 8. Soil Types in Vegetation Landscape 4. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	%
G3	Thick sand over clay	57
H3	Bleached siliceous sand	27
G5	Sand over acidic clay	7
I1	Highly leached sand	2
-	Others combined (n= 22)	≈ 7

3.4.4 Land Types

A Land Type (LT) is a classification that describes the terrain, expressing the geomorphology and soil types found therein (**Error! Reference source not found.**). L4 has many LTs, however the vast majority are small and spatially isolated (Figure 9). The four main LTs of L4 are:

- *G - Soils formed on unconsolidated sediments/deeply weathered rock. Rises and plains with mainly neutral to alkaline, sandy texture contrast soil with calcareous subsoil. The major part of this LT is located L4b in the west of the project area.*
- *N - Soils formed on marine / lagoonal clay or limestone. Corridor plains between relict coastal dunes (M) with mainly neutral to alkaline sandy texture contrast soil or shallow soil on limestone. This is found in L4a with Land Type O.*
- *O – Dune Fields. Dune/swale systems with mainly acid to neutral bleached siliceous sand on dunes. This is found in parallel bands across L4b.*
- *P - Soils formed on unconsolidated sediments/deeply weathered rocks. Rises, plains and low hills, with mainly acid to neutral, sandy texture contrast soil or deep sand. This is found exclusively in the hilly portion of L4.*

There is a clearly defined boundary of differing Land Types, which corresponds to the change in geology, soil type and topography. The clear difference between LTs of the eastern and the western portions of L4 is that the eastern portion is formed from Marine/lagoonal clay or limestone and the western LTs are formed from deeply weathered or basement rock. The start of the transition of Land Types (clay/limestone to rock) can be seen in L4b. Small patches of LT-S and LT-V are at the base of a large patch of LT-G.

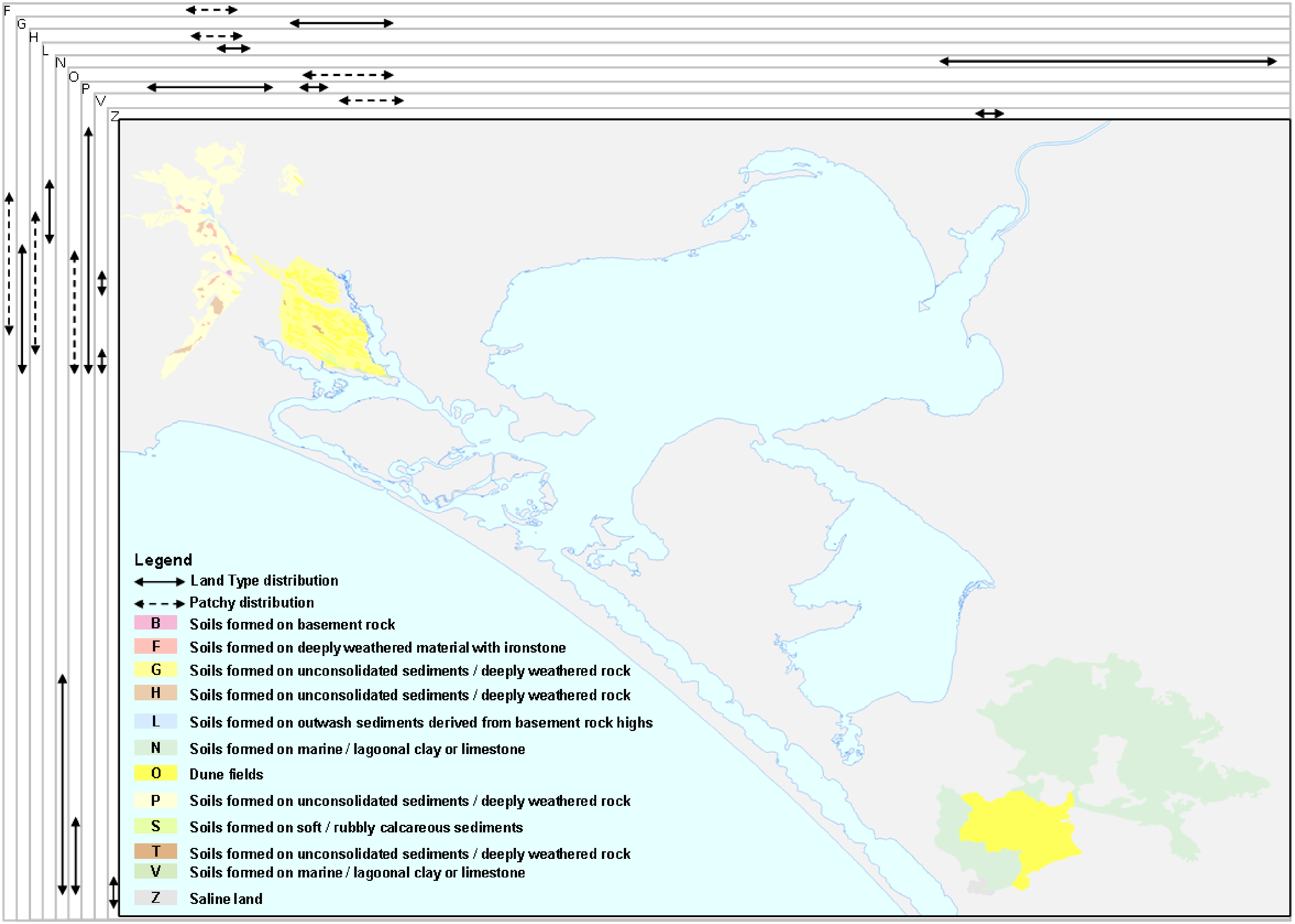


Figure 9. Location of Land Types in Vegetation Landscape 4.

3.4.5 Vegetation

The expected pre-European vegetation of L4a was a combination of *Eucalyptus incrassate* + *E. diversifolia* mallee and *Banksia ornata* shrubland. This variety remains today, however the abundance has been greatly reduced.

Sub-landscape L4b is likely to have been made up of mostly *Eucalyptus fasciculosa* woodland on the inland areas and *Allocasuarina verticillata* low woodland on the lower areas nearing the water's edge. The current vegetation communities of L4b are mostly *Eucalyptus fasciculosa* over *Acacia* spp. low trees and shrubs; or *Eucalyptus baxteri* woodland over *Leptospermum* spp. Shrubs. There are thin strips of samphire shrubland, *Phragmites australis* grassland and *Gahnia filum* sedgeland in the lower and wetter parts of L4b.

The higher, inland segment L4c likely had a variety of *Eucalyptus* woodlands including *E. fasciculosa, E. leucoxylon, E. baxteri, E. odorata* and others. Most of these communities are likely to have had a grassy and herbaceous understorey or a sclerophyllous shrub understorey. Currently, *E. baxteri* (mixed) woodland or forest is dominant in L4c. So too is *E. fasciculosa* and *E. cosmophylla* mixed woodland or forest dominant in other areas.

3.4.6 Post-settlement History and Current Use

The history of L4 is somewhat disconnected due to the geographic distance between the two landscape segments. It can be said with some confidence that certain areas (L4a and L4b) were used as a part of a stock route for the cattle that were grazing on Narrung Peninsula and around Meningie and Lake Albert by 1850.

The discovery of gold in 1851 in Victoria resulted in large number of international prospectors (predominantly Chinese) landing in Port Adelaide and travelling to the gold fields by foot. This increase of traffic would have impacted on the natural environment through the clearing of trees, grasses and other vegetation for firewood and shelter, damage to the shoreline, the killing of wildlife for food and sport and the potential introduction of exotic species. A telegraph line extended from Adelaide to Goolwa, Hindmarsh, Ewe and Tauwichere Islands in 1855, opening the areas around L4b and L4c to greater trade.

In 1866 the township of Meningie, which was adjacent to Lake Albert and vast mallee woodland, was created to fill the need of better overland mail and transport services between Adelaide, the Southeast and Victoria. The Murray Lands around L4a were particularly difficult to clear and land clearing was not the responsibility of the government but of the landowner. New legislation was targeted at encouraging settlers to clear mallee woodland, because it was very difficult to do so. The new legislation (Scrub Land Act of 1867) allowed for up to 640 acres of 'unsold and unoccupied land of scrubby and inferior character' or mallee to be bought for £1 an acre. The condition of the Bill was that one twentieth of the land must be cleared each year. Only 50 of the 132 new land owners were able to clear scrub adequately. The Act was not very successful.

In 1867 a steamer ran mail between Milang and Meningie, which soon also took passengers. Later in that year, a coach service began to run between Meningie and Kingston. These two services opened up the area for tourism, sport and business.
By 1870 a process called Mullenizing became an effective way of clearing the mallee scrub surrounding L4a. By 1876 the Stump Jump Plough was invented, with the specific purpose of clearing mallee woodland. The new plough allowed better land turning while retaining root mass. This reduced soil erosion. Regenerating Mallee shoots would be grown then burnt, ashed fertilising the soil. This presented a change in thinking for landowners. This new technology combined with a review of the Scrub Land Act (1867) offered more land and required less clearance per year. This led to greater interest in the land surrounding Bremer, Alexandrina and in L4a. By 1881 the proven technology of the stump jump plough led to a scramble for land, particularly in the cheaper Mallee scrub.

The railway was extended to Milang in 1883, allowing faster, easier transport of fresh produce from the lakes to Adelaide and better access for hunters from Adelaide. By 1907 the State government made additional land around Meningie suitable for settlement (L4a).

A drought from 1911-1914, where the Murray River ceased flowing into the lakes, led to a rapid drop in the rate of land clearance. Combined with the loss of the labour and export problems during World War II, the wheat acreage plummeted. By 1920, increased mechanisation and soldier settlement schemes led to increase settlement in the region. However, drought and the Great Depression led to intensive farming practices, over cropping and frequent tilling. Soil deterioration and erosion resulted from overworking the land.

Between 1940 and 1965 the Playford Government led to excessive clearing along the mainland side of the Coorong including the southern part of L4a. This impacted heavily on the bird populations. Most of the visitors to the region came to hunt birds and their numbers were greatly reducing.

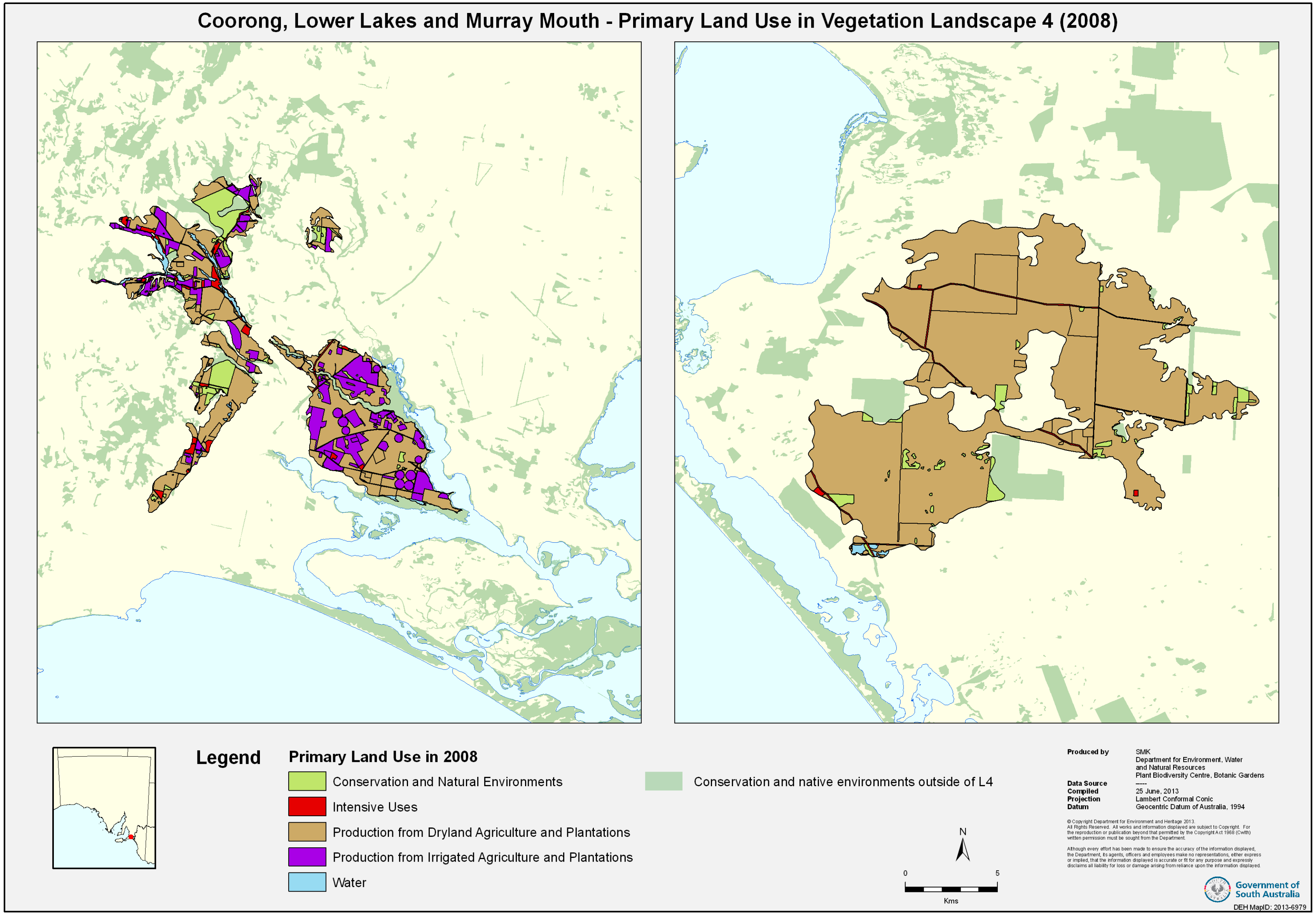


Figure 10. Vegetation Landscape 4 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008a).

There is a difference in the amount of native vegetation between the sections of L4 (Figure 10). The overall classification of the remnant vegetation in L4 is 'Relictual' with and estimation of 6% of native vegetation remaining. However, as with topographic relief, this percentage does not illustrate the variety of vegetation within L4.

Segment L4a has been extensively cleared for agricultural use. The northern portion of L4a, in particular, has very few scattered trees, small areas of conservation reserve and trees/shrubs along most of the few roads. The southern patch of L4a (south of Meningie) is placed between three large patches of conservation reserve and contains several small patches of trees and several scattered trees, which are likely in pastures (**Error! Reference source not found.**). This implies that there is good opportunity to expand upon areas of native vegetation (revegetate) with a relatively good understanding/example of functioning native vegetation communities.

The L4b segment between Currency Creek and Finniss River has many more scattered trees as fields of crops give way to pastures (Figure 4). There is a much higher presence of irrigated agriculture, represented by many vineyards and centre pivot irrigation systems. Unlike some other parts of the project area, the parallel dunes that span the peninsula are low enough as to not have led to a change in the land use (vineyard, pasture, crops, etc) as the surrounding flat ground (Figure 4).
While the primary land use in L4c is rain-fed agriculture there is a much higher presence of conservation reserves than can be found in the eastern portion (including the area surrounding L4). Most of the patches of native vegetation that are not found in reserves are in the many gullies that are common in this portion (**Error! Reference source not found.**). The dominance of pasture over cropping in this portion corresponds to many more scattered trees than the eastern portion.

The defining feature of L4 is sandy soil over a variety of subsoils, the majority of which are suitable for agriculture. The thick sand over clay and bleached siliceous sand soils of segment L4a is used almost exclusively for crop agriculture, which may be rotated with grazing livestock. There are several roads lined with woody vegetation and very few scattered trees in the fields in the northern part of L4a. The northern section of L4a appears to be more dedicated to crops whereas the southern section has more fields dedicated to grazing livestock. The southern section has more scattered trees and patches of vegetation, which, as stated above, are situated between three large patches of conservation/native vegetation.

Segment L4b is also used almost exclusively for agriculture including viticulture, a large portion of which is irrigated (Figure 10). Dunal bands approximately parallel to the water bodies can be seen across the peninsula, but this does not appear to strongly affect (change) the land use.
Segment L4c is hilly, with several steep slopes and gullies that lead towards Mount Compass. It is more wooded than the other segments, with more scattered trees and several reserves (both in and surrounding L4). The major land use is dryland crop agriculture but due to the hilly terrain, grazing is more common amongst scattered vineyards and crop fields.

3.4.7 Summary and Recommendations

L4 is dominated by sandy soils over alluvial clays, and occurs in one of the higher rainfall parts of the CLLMM region. This physical environment would have been dominated by open woodlands and mallee, often with a patchy shrubland understorey. However, 94% of this native vegetation has been cleared, and the landscape can be considered relictual. We recommend that the management of this landscape focus on protecting remaining native vegetation, through mechanisms such as pest management and appropriately designed buffers. However, given the geographic split for this landscape, there may be differences in the state and trajectory of the native biodiversity of the different units.

3.5 Vegetation Landscape 5

Vegetation Landscape 5 (L5) is the largest of the project area, at approximately 110,000 ha (Table 10, Figure 11). It is represented as several patches ranging from small to very large, the largest spanning between Meningie and Kingston (≈ 140 km). It is almost always adjacent to areas of L1, often in alternating patches. It has been divided into four sub-landscapes:

- L5a – Patchy segment approximately 3 km inland from Boggy Lake in the north of the project area.
- L5b – Two patches, east and southeast of Wellington separated by L1
- L5c – Strip along the southern shore of Narrung Peninsula (3 x 17 km); a 3 km wide strip that extends south from Meningie to the Coorong, which expands to a much wider strip that follows the shore south; L5c forks at Salt Creek and continues SSE for many kilometres (≈ 80 and ≈ 40 km).
- L5d – latitudinal strip between Goolwa, northern Hindmarsh Island, Clayton Bay and Point Sturt.

L5 is found within the following Hundreds: Alexandrina; Baker; Bonney; Duffield; Field; Freeling; Glyde; Lacepede; Malcolm; Messent; Nangkita; Neville; Santo; Seymour; and Wells.

3.5.1 Climate

The approximate annual rainfall of L5 ranges from 359 mm in L5a to 614 mm in L5c. The annual mean rainfall in L5 is 511 mm with a standard deviation of 60 mm. The approximate annual evaporation is 1733 mm. There is a clear difference of mean rainfall between segments L5a/L5b and L5c/L5d (Table 9). This can be attributed proximity to the Mt. Lofty Ranges and the southern position of the landscape segments**.**

Table 9 – Annual rainfall in subregions of Vegetation Landscape 5

Zone	Area (ha)	Min (mm)	Max (mm)	Range (mm)	Mean (mm)	STD (mm)
5	**109768**	**359**	**614**	**255**	**511**	**60**
5a	4678	359	416	57	380	11
5b	7295	360	412	52	385	11
5c	92512	440	614	174	532	38
5d	5589	432	507	75	465	21

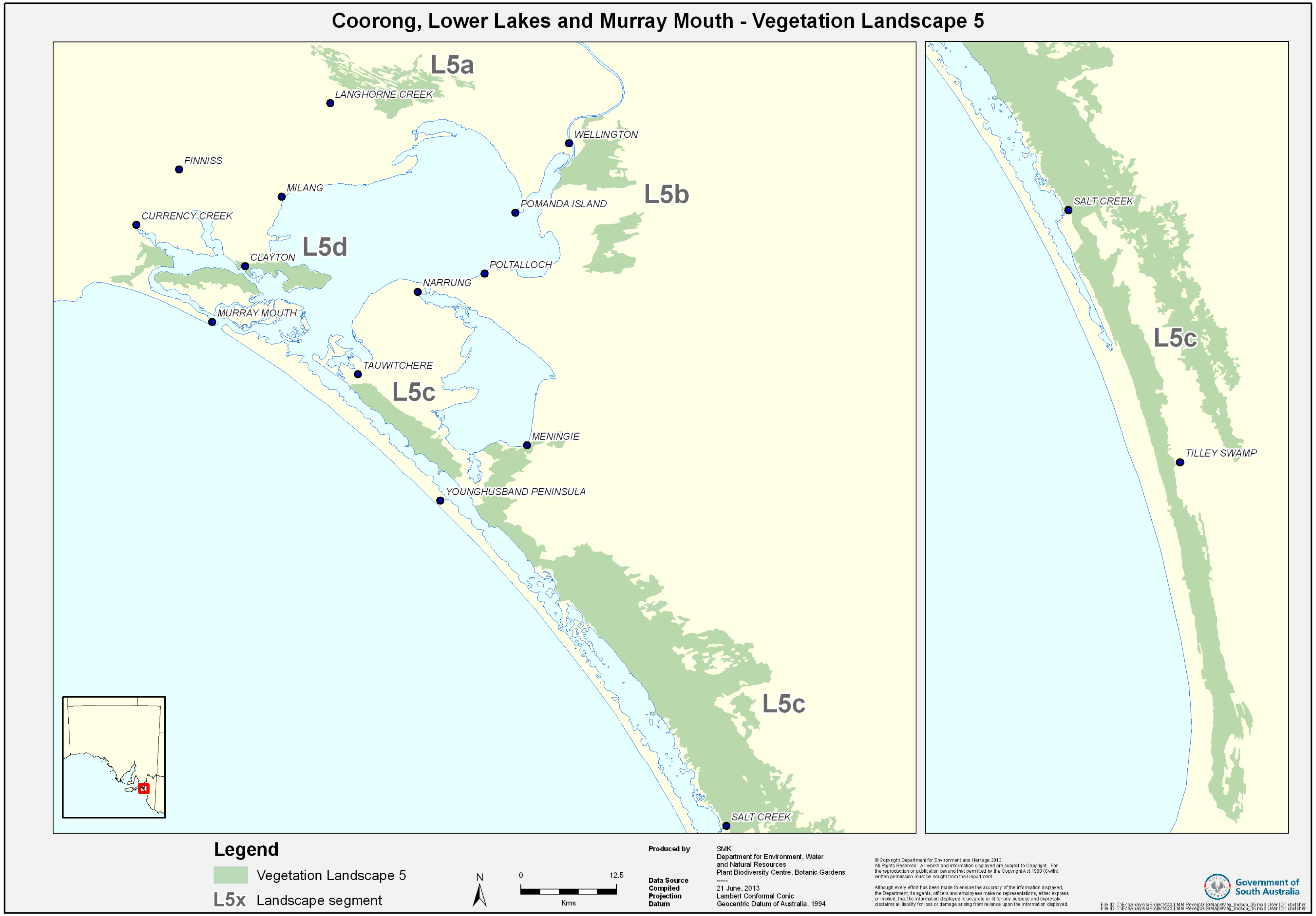


Figure 11. Map showing the location and extent of Vegetation Landscape 5

3.5.2 Landforms

The relief of L5 is neither hilly nor distinctly flat and low. Absolute soil elevation ranges between sea level (0 m AHD) and ≈75 m AHD (in L5d). The mean elevation from sea level of the four segments varies between 10.0 m AHD and 19.4 m AHD; the mean elevation for all of L5 is 16.6 m AHD (Table 10).

Table 10. Soil, area and elevation of Vegetation Landscape 5 and sub-landscapes. Dominant and subdominant soils are only listed for the landscape as a whole. Subdominant soils refer to those soils that make up >10% by area of the landscape, but aren't the most common soil in the landscape.

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
5	**B3**	**H3, B2, G2, B7**	**111,586**	**0 – 74.9**	**16.6 ± 10.0**
5a			5,494	1.4 – 53.0	19.4 ± 8.8
5b			5,971	0 – 36.4	10.2 ± 6.1
5c			7,759	0 – 33.1	10.0 ± 5.2
5d			92,362	0 – 74.9	17.4 ± 10.2

3.5.3 Soils

The six soils most common to L5 are quite different but share certain similarities. Firstly, they all have either a bleached sand or a shallow soil on calcrete at the surface layer; secondly, clays are not common, but sands, calcrete and loams are (Table 11). Soil diversity within L5 varies between segments. L5a, L5b and L5c consist mostly of large patches of one soil type that is scattered with patches of 2-4 other soil types. L5d has a much more even distribution soils, which is represented by patchy areas of 3-6 soil types.

The most common soil type in L5a is *B2 – Shallow calcareous loam on calcrete*. There are several parallel strips of *H3 – Bleached siliceous sand*, which appear in the landscape as old dunes that have been created through aeolian processes.

Sub-landscape L5b is divided into a northern patch and a southern patch. The northern patch is mostly comprised of B2 soil similar to L5a, whereas the southern patch is mostly comprised of *B3 – Shallow sandy loam on calcrete soil*, which is common throughout L5c.

For almost the entire inland shore of the Coorong (L5c), B3 soil is found with patches of G, H and N group soils of various size and form. South of Salt Creek, B2 soils are again found with a very large patch of B8 – Shallow sand on calcrete that extends to the town of Kingston.

With the exception of the presence of *E1 – black cracking clay soils*, L5d has similar soil types as the other three segments; the only difference being the distribution of the soil types as there is no single dominant soil.

Table 11: Soil Types in Vegetation Landscape 5. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	%
B3	Shallow sandy loam on calcrete	23
H3	Bleached siliceous sand	17
B2	Shallow calcareous loam on calcrete	15
G2	Bleached sand over sandy clay loam	13
B7	Shallow sand over clay on calcrete	12
B8	Shallow sand on calcrete	6
-	Others combined (n= 21)	≈ 14

3.5.4 Land Types

A Land Type (LT) is a classification that describes the terrain, expressing the geomorphology and soil types found therein. L5 has many LTs, however the majority are small and spatially isolated. The six significant LTs of L5 are:

- *G - Soils formed on unconsolidated sediments/deeply weathered rock. Rises and plains with mainly neutral to alkaline, sandy texture contrast soil with calcareous subsoil.*
- *M – Soils formed on relict coastal dunes. Relict coastal dunes with shallow soil on calcrete, sandy texture contrast soil and/or deep sand.*
- *N - Soils formed on marine / lagoonal clay or limestone. Corridor plains between relict coastal dunes (M) with mainly neutral to alkaline sandy texture contrast soil or shallow soil on limestone.*
- *O – Dune Fields. Dune/swale systems with mainly acid to neutral bleached siliceous sand on dunes.*
- *S – Soils formed on soft/rubbly calcareous sediments. Plains and rises with mainly loamy calcareous soil.*
- *Z – Saline land. Saline land, saline to brackish lakes and lagoons, and associated gypsum deposits and lunettes.*

The rising plains of calcareous loam on calcrete dominate L5a with small bands of LT-O (dunes) and very small patches of LT-Z. Where the was a difference in soil types between the northern and southern parts of L5b there is no such obvious difference in Land Types; as both parts are mostly LT-M and LT-N. It is these two Land Types that identify L5b from the surrounding Vegetation Landscape, L1. The surrounding landscape is low-lying or swampy in part and it is the raised relict coastal dunes and corridor plains that set this land apart.

The southern sub-landscape, L5c, is by far the largest but not as diverse as the other three segments. The vast majority of it consists of LT-M with scattered relatively small patches of LT-N and LT-Z. Segment L5d is mostly raised relict coastal dunes on calcrete, which is considerably different to the surrounding Land Types. There are considerably more areas of LT-O (dune fields) and a large area north of Goolwa of LTs formed on unconsolidated sediments or deeply weathered rock.

3.5.5 Vegetation

The vast majority of the expected pre-European vegetation of L5a was mallee scrub. The most widespread community was *Eucalyptus phenax* + *E. dumosa* +/- *E. socialis* ssp. *socialis*. There are likely to have been many long strips of a different type of mallee (*Eucalyptus incrassata* +/- *E.*

leptophylla +/- *E. socialis* ssp. *socialis*), mostly on the deep dunes. Lastly, mallee dominant with *Eucalyptus gracilis* + *E. oleosa* +/- *E. brachycalyx* communities are likely to have been growing in the northern edges of the segment. Currently, the remaining vegetation communities are essentially the same three mallee woodlands, though represented in greatly reduced patches.

Most of the expected pre-European vegetation of L5b was either *Allocasuarina verticillata* low woodland, *Callitris gracilis* low open forest, *Lomandra effusa* dominant tussock grassland or *Eucalyptus* spp. mallee woodland. Currently, the remaining vegetation communities are greatly reduced, very small patches of *Callitris gracilis* woodland and *Eucalyptus incrassata* or *E. diversifolia* mallee woodland.

The pre-European vegetation communities of L5c are likely to have been a diverse patchwork of *Allocasuarina verticillata* low woodland, *Banksia ornata* shrubland, various *Eucalyptus* woodland/forest/mallee communites and various *Melaleuca* low open forest /woodland. *Melaleuca brevifolia* shrubland commonly grew on the western edge of the Landscape segment, facing the Coorong or nearby ocean. There are currently some relatively large areas of *Banksia ornata* (mixed) shrubland and widespread areas of *Eucalyptus diversifolia* mallee forest in L5c. The southern section of L5c exhibits regular patches of *E. fasciculosa* and *Gahnia filum* mixed sedgeland. *Leucopogan parviflorus* (mixed) shrubland grows in thin strip along the Coorong shore near Salt Creek, while *Phragmites australis* grasslands grow on the 'southern' shore of Narrung Peninsula along the Coorong. Various *Melaleuca* shrublands (>1 m) are common in L5c.

Most of the expected pre-European vegetation of L5d was *Allocasuarina verticillata* and there was a large patch of *Eucalyptus odorata* inland from the township of Goolwa. Grasslands of *Phragmites australis* + *Typha* spp. And *Tecticornia* spp. lined most of the shorelines in L5d. Various samphire shrubland, *Phragmites australis* grassland and Typha spp. sedgeland are now the most common native vegetation communities in L5d. There as several small patches of *Allocasuarina verticillata* woodland, *Melaleuca* forest/woodland and various *Eucalyptus* spp. forest and woodland scattered across L5d.

Due to the increase in population density in L5d, there appears to be a much greater presence of exotic vegetation in place of native vegetation. Scattered trees are fairly common amongst infrastructure such as a golf course, light industrial sites, lagoons and houses. The dominant tree species of Hindmarsh Island is *Pinus halepensis* (Aleppo pine), which is a declared weed in South Australia that must be controlled (excluding cultivated trees).

3.5.6 Post-settlement History and Current Use

In 1839, Hindmarsh Island was discovered but not surveyed until 1853. Soon after it was discovered, Dr Rankine began paying South Australian Company 10 pound a year to run cattle on the island (L5d). When the South Australian Company began to promote the area for agriculture, the Coorong and Younghusband Peninsula was mostly used as a passage between Adelaide and Robe, between which a regular mail run began in 1847. Traffic in the region increased greatly with the discovery of gold in Victoria in 1851. During this time, it was not uncommon for several hundred prospectors (predominantly Chinese) to be camped on McGrath's Flat in The Narrows (L6) on their way to the gold fields. This increase of traffic would have impacted on the natural environment through the clearing of trees, grasses and other vegetation for firewood and shelter, damage to the shoreline, the killing of wildlife for food and sport and the potential introduction of exotic species. The greatest impact of this force would have been seen in L5c.

By 1850, cattle and sheep were grazing on the Narrung Peninsula, the land around the Lower Lakes, along the Coorong and further south beyond Robe. Most of this land falls within Vegetation Landscapes 1, 4 and 5. Between 1851 – 1864 the Cooke brothers ran sheep on a 11655 ha property near Tilley's Swamp in the southern half of L5c.

In 1855 a telegraph line extended from Adelaide to Goolwa, Hindmarsh, Ewe and Tauwichere Islands, opening up L5d for increased settlement and increased business (farming) practices. The mallee woodlands of L5a and parts of L5b and L5c were particularly difficult to clear and land clearing was not the responsibility of the government but of the landowner. New legislation was targeted at encouraging settlers to clear mallee woodlands, because it was very difficult and expensive to do so.

Meningie was created in 1866 to fill the need of better overland mail and transport services between Adelaide, the Southeast and Victoria. A coach service between Meningie and Kingston began in 1867, which greatly increased the traffic in the region, attracting sport shooters (mostly water fowl) and commercial fishermen. Birds and fish were plentiful and the Ngarrindjeri often worked with or for the settlers in exchange for goods. This attracted new settlers (including pastoralists and farmers) to the region to start working the land around northern L5c.

New legislation called the Scrub Land Act (1867) allowed for up to 640 acres of 'unsold and unoccupied land of scrubby and inferior character' or mallee land to be bought for £1 an acre. The condition of the Bill was that one twentieth of the land must be cleared each year. Only 50 of the 132 new land owners were able to clear scrub adequately. The Act was not very successful. By 1870 a process called Mullenizing became an effective way of clearing the mallee. New technology was invented in 1876 in response to a competition calling for a better way to clear mallee woodland. The Stump Jump Plough had the specific purpose of clearing mallee scrub. The new plough allowed better land turning while retaining root mass. This reduced soil erosion. Regenerating mallee shoots would be grown then burnt, ash fertilising the soil. This presented a change in thinking for landowners.

In 1877 a review of the Scrub Land Act (1867) offered more land and required less clearance per year. This led to greater interest in the land. This added incentive combined with the proven technology of the stump jump plough led to a scramble for land, particularly in the cheaper mallee woodlands of L5a and L5c. Concurrently, between 1864 and 1880 many drains were cut into the south eastern landscape of South Australia (Between Lake Bonney, Penola and Salt Creek) in an attempt to drain the surface water and make the land arable (southern L5c). One of these drains was cut between Tilley's Swamp and Salt Creek, changing the hydrodynamics of the region.

In 1892, prospectors dug a series of bores in the hope to establish an oil industry around Salt Creek (mid L5c in L6). The supply proved to be unsuitable for commercial use; a replica oil rig stands at Salt Creek in commemoration of these events.

In 1907 the State government made additional land around Meningie suitable for settlement. The building of the barrages that separated the Lower Lakes from the Coorong commenced in 1935. Once completed, they changed the hydrodynamics of the Coorong as well as the water chemistry (especially salinity levels). This led to changes in the ecological communities that relied on the Coorong and surrounding area.

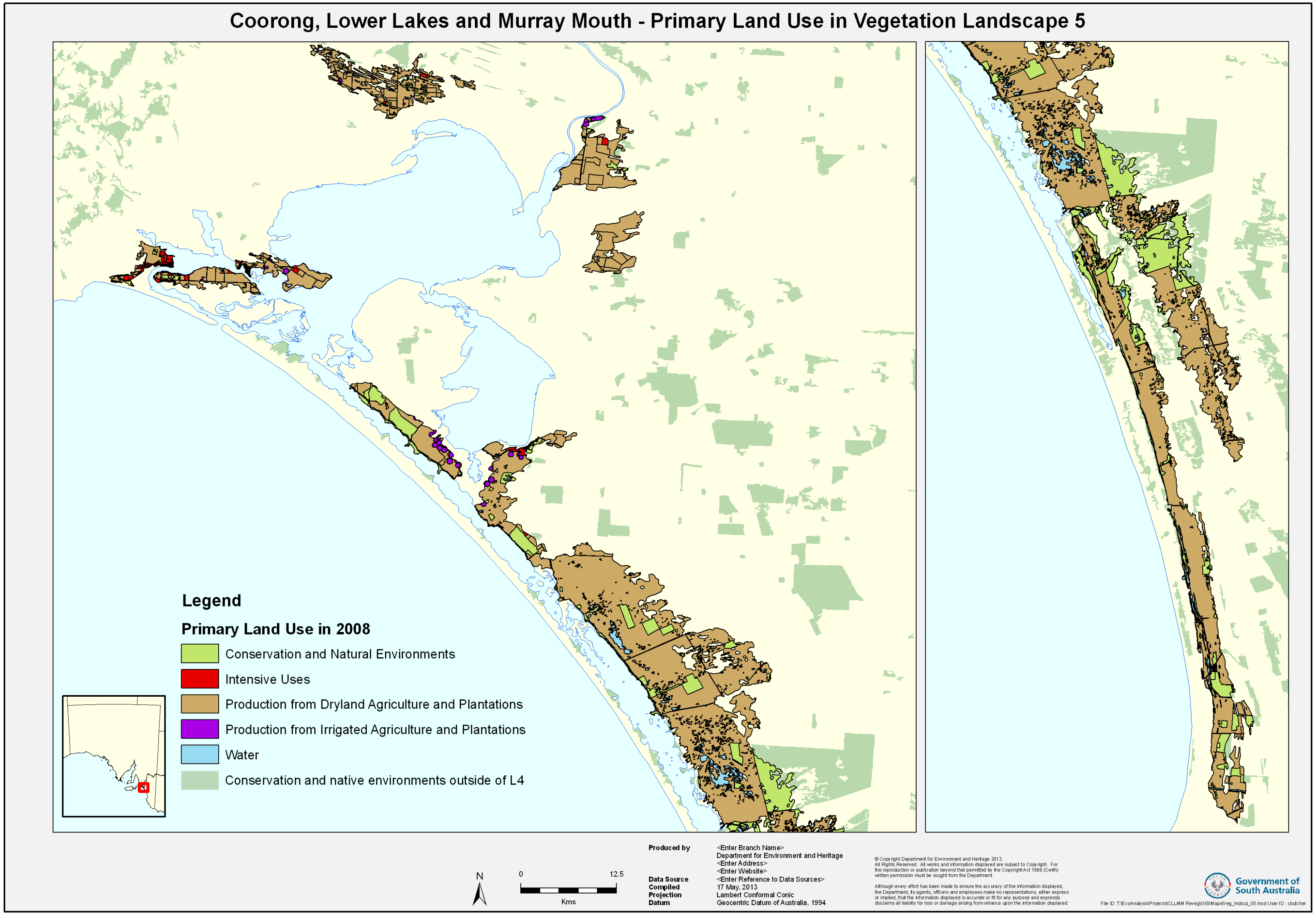


Figure 12. Vegetation Landscape 5 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008a).

There is very little remnant / native vegetation in L5 with respect to its size. As is common throughout most of the Vegetation Landscapes, most of the land has been cleared for agricultural use. Remnant native vegetation comprises a total of 17% of the landscape, and is thus classified as Fragmented (McIntyre and Hobbs, 1999).

Areas where native vegetation remains are generally (and historically) areas that have 'poor' soil or that were unfeasible to clear for agriculture. Therefore, many of the dunal bands in L5a retain (mostly) Mallee scrub. However, very few trees can be found beyond these bands or along roadsides. Another area where this is evident is on the southern shore of the Narrung Peninsula. There the Peninsula has been widely cleared for agriculture since the 1850s as there are large amounts of *B3 – shallow sandy loam on calcrete*, which is good for crops or pasture. There are two large areas of native vegetation that have remained more-or-less intact; the most common soil in these patches is *H3 – bleached siliceous sand*.

L5b has been extensively cleared and almost no trees remain. As the segment borders some low-lying swampy land, there are some areas, which will contain samphire vegetation.
Along the Coorong, much of the vegetation has been cleared to make way for pasture. However, well-defined blocks of native vegetation are not uncommon and scattered trees, shrubs and samphire vegetation increases in density to the south.

The land use varies slightly between the four segments of L5 (Figure 12). Segment L5a has good soil for crops and is therefore mostly dedicated to crop fields. There are only a few areas within the boundaries of L5 that have not been cleared and those that have not are mostly old sand dunes. Some of these dunes have been cleared, while others remain vegetated.

To the east and south of Wellington, L5b appears to be used as pasture for grazing livestock and crops.

Southern Narrung, pivot irrigators, some areas of sandy blowouts, two large patches of native veg. Along the Coorong, mostly livestock grazing and less cropping. Around Meningie and south to the Coorong – some pivot irrigation, some salty ponds. Along the Coorong, mostly patchy raised dunes on dunes formed by aeolian processes. Old Dunes are historic versions of the coastline. Heavy grazing visible at some sites, piosphere and trampling evident around water points and gates. Large areas of conservation adjacent to and entering L5, especially in the area surrounding Salt Creek. Small dunes formed by aeolian processes visible and sometimes exposed as blowouts.

3.5.7 Summary and Recommendations

L5 is the largest landscape in the CLLMM region by area. The landscape is physically dominated by shallow loams and sandy loams over calcrete, along with some deep siliceous sands. These soils would have supported open mallee woodlands (e.g. those dominated by *Eucalyptus diversifolia*). The current land use is largely dominated by dryland grazing. The landscape retains 17% of its original native vegetation, and is considered Fragmented. We recommend that this landscape be considered for landscape-scale restoration, to address the systemic issues associated with loss of biodiversity.

3.6 Vegetation Landscape 6

Vegetation Landscape 6 (L6) is perhaps the most unique Landscape in the project area. The major segment of L6 comprises the very long and narrow Younghusband Peninsula that separates the relatively calm waters of the Coorong from the high energy waves of the Southern Ocean. Aside from Younghusband Peninsula, L6 includes the small islands, most of the peninsulas and strips of shoreline of the Coorong. By virtue of the Peninsula, L6 is almost always adjacent to only water, however when it is not, it is adjacent to water and areas of L1 or L5.

L6 is found within the following Hundreds: Nangkita; Baker; Bonney; Glyde; Santo; Neville; and Duffield. The total area of L6 is approximately 23692 ha (Figure 13Figure 13).

3.6.1 Climate

The annual rainfall maxima and minima of L6 ranges from 450 mm near the Murray Mouth to 602 mm in the south of the project area. The mean annual rainfall in L6 is 523 (± 42 SD) mm. The approximate annual evaporation is 1700 mm.

3.6.2 Landforms

The relief of L6 is characterised by large sand dunes; approximately half of which are vegetated. Absolute elevation ranges between sea level (0 m AHD) and 51 m AHD. The mean elevation of L6 from sea level is 11.2 m AHD (Table 12).

Table 12 - Soil, area and elevation of Vegetation Landscape 6 and sub-landscapes. Dominant and subdominant soils are only listed for the landscape as a whole. Subdominant soils refer to those soils that make up >10% by area of the landscape, but aren't the most common soil in the landscape.

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
6	H1	N2	23,692	0 – 51.0	11.2 ± 7.3

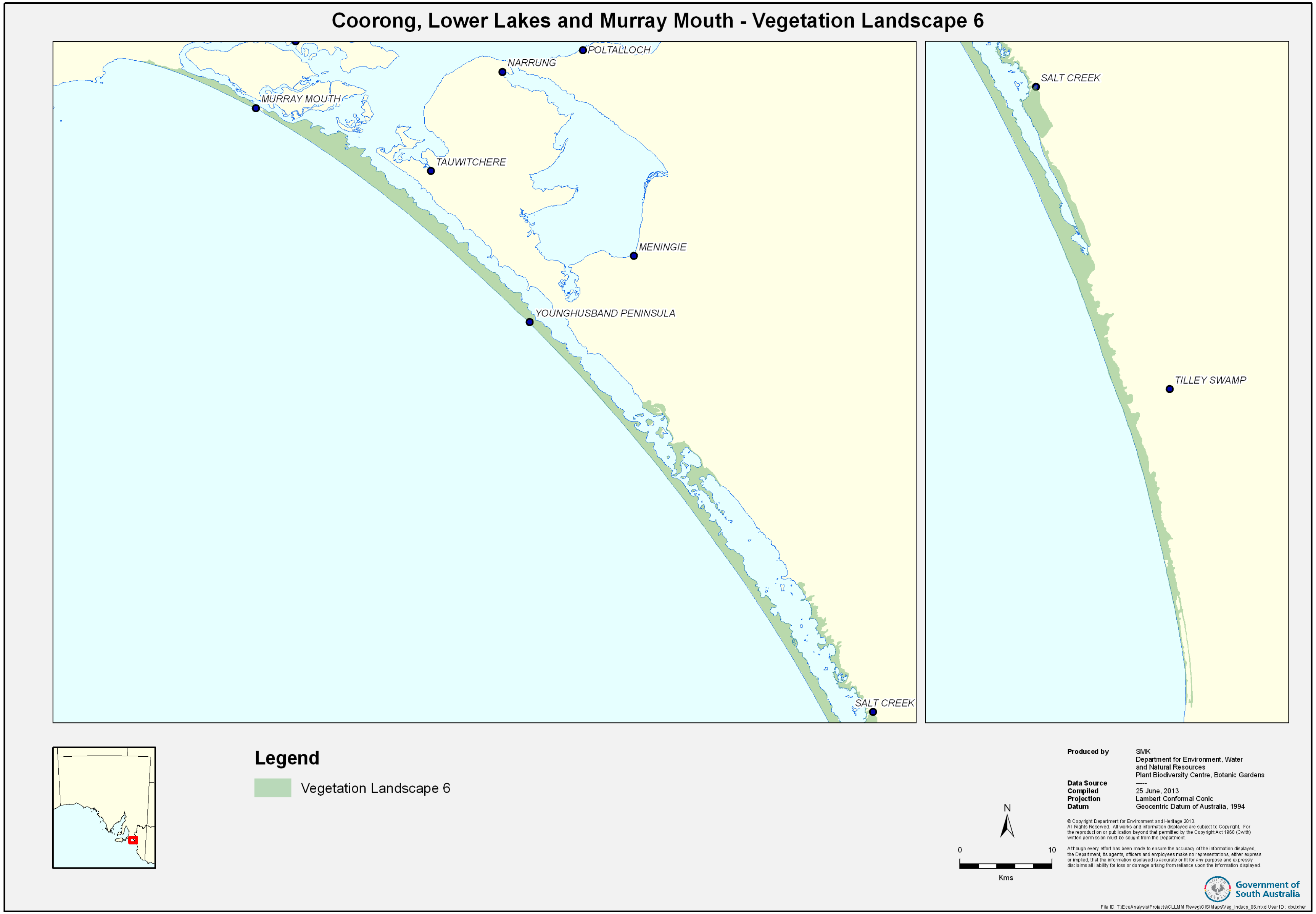


Figure 13. Map showing the location and extent of Vegetation Landscape 6

3.6.3 Soils

The vast majority of the soil in L6 is carbonate sand (76% of all major soil types, Table 13). The remaining soil is saline soil and there is a small percentage of shallow sandy loam on calcrete. Younghusband Peninsula is recorded as being almost entirely composed of *H1 – Carbonate sand*, which continues south along the coast almost to the town of Kingston. Patches of *N2 – Saline soil* are found in low-lying areas, including ephemeral salt flats. The largest patches of N2 are on the mainland shoreline near the separation of the northern and southern lagoons (The Narrows), increasing in abundance towards the southern end of the Coorong surrounding Salt Creek. The *B3 – Shallow sandy loam on calcrete* is mostly found in the islands and peninsula that separate the northern and southern lagoons (Needles Island, Snake Island, Rabbit Island, Parnka Point, etc.).

Table 13. The Soil Types in Vegetation Landscape 6. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	%
H1	Carbonate sand	76
N2	Saline soil	14
B3	Shallow sandy loam on calcrete	6
-	Others combined (n= 6)	≈ 4

3.6.4 Land Types

A Land Type (LT) is a classification that describes the terrain, expressing the geomorphology and soil types found therein. L6 has two LTs, however the vast majority of L6 has been classified as LT-W (Figure 14). The two LTs of L6 are:

- *M – Soils formed on relict coastal dunes. Relict coastal dunes with shallow soil on calcrete, sandy texture contrast soil and/or deep sand.*
- *W – Coastal land. Beaches, dunes, swamps, back plains, mud and samphire plain, shellgrit flats, tidal flats, mangroves and coastal cliffs.*

The current form of the Younghusband Peninsula is a vast expanse of coastal dunes that, when analysing topographic data, appears to have shifted gradually seaward (west-southwest) over a geological timeframe. The current peninsula is formed on an old, low ridge of consolidated sand. There is a limestone cap visible in several places, so too are areas of red soil. The landforms protruding into the Coorong are mostly LT-M; these areas are mostly around The Narrows and Salt Creek. These landforms are mostly flat or with smoothly undulating hillocks.

Figure 14. Location of Land Types in Vegetation Landscape 6.

3.6.5 Vegetation

The pre-European vegetation communities of L5c are likely to have been various mallee communities and *Allocasuarina verticillata* low woodland on the islands, peninsulas and along the mainland section of L6, but this has almost exclusively been removed. The Younghusband Peninsula is likely to have had communities of *Olearia axillaris* + *Leucopogon parviflorus* shrubland and *Spinifex hirsutus* + *Ficinia nodosa* grassland.

Currently, a large proportion of the exposed soils in L6 are in the form of bare sand dunes of the Younghusband Peninsula. While these bare areas may have always occurred on the Younghusband Peninsula, this pattern may have been exacerbated by (mostly) feral grazing and disturbance. The most dominant vegetation communities of the landscape are *Olearia axillaris* + *Leucopogon parviflorus* coastal shrubland and *Acacia sophorae* var. *longifolia*, which are widespread on near coastal carbonate sands throughout south-eastern Australia. Other vegetation communities within L6 contain species with similar attributes, including several species of grass and rush such as *Gahnia filum* on saline flats, or *Spinifex hirsutus* on the Southern Ocean fore-dune. *Myoporum insulare* (mixed) coastal shrubland is common amongst the *Leucopogon parviflorus* coastal shrubland on the stretch of the Younghusband Peninsula along the North Lagoon, whereas *Olearia axillaris* (mixed) coastal shrubland is more dominant on the dunes surrounding the Murray Mouth. There are small but ecologically significant areas with quite diverse vegetation communities in L6. An example of these areas is the salt marshes near Salt Creek that extend into areas of coastal mallee.

3.6.6 Post-settlement History and Current Use

The Coorong and Younghusband Peninsula (and surrounding land) have long been used by the nation of Ngarrindjeri people. When the South Australian Company began to promote the area for agriculture, the Coorong and Younghusband Peninsula was mostly used as a passage between Adelaide and Robe, between which a regular mail run began in 1847. Traffic in the region increased greatly with the discovery of gold in Victoria. During this time, it was not uncommon for several hundred prospectors (predominantly Chinese) to be camped on McGrath's Flat in The Narrows (L6) on their way to the gold fields. This increase of traffic would have impacted on the natural environment through the clearing of trees, grasses and other vegetation for firewood and shelter, damage to the shoreline, the killing of wildlife for food and sport and the potential introduction of exotic species.

By 1850, cattle and sheep were grazing on the Narrung Peninsula, the land around the Lower Lakes, along the Coorong and further south beyond Robe. While most of this land falls within Vegetation Landscapes 1, 4 and 5, much of this land is adjacent to L6 and some secondary impacts are expected to have been observed.

In 1856 the Dodd brothers bought a 5700 ha run of land on Younghusband Peninsula with the intention to graze cattle and sheep. The conditions proved unsuitable for the animals and the property was then dedicated to the breeding of horses.

Between 1864 and 1880 many drains were cut into the south eastern landscape of South Australia (Between Lake Bonney, Penola and Salt Creek) in an attempt to drain the surface water and make the land arable. One of these drains was cut between Tilley's Swamp and Salt Creek (in L6), changing the hydrodynamics of the region.

A coach service between Meningie and Kingston began in 1867, which greatly increased the traffic in the region, attracting sport shooters (mostly water fowl) and commercial fishermen. Birds and fish were plentiful and the Ngarrindjeri often worked with or for the settlers in exchange for goods. In the early 1890s, a duck canning factory was opened on Younghusband Peninsula approximately 16 km from Meningie. The facility opened only during hunting season (6 months) and mostly produced canned wild duck (teal). It ceased operations in approximately 1896.

The South African grass called Pyp Grass (*Ehrharta villosa*), was introduced in response to growing damage and soil erosion caused by cattle grazing or traversing the sand dunes of Sir Richard Peninsula. It is now widespread across the Peninsula.

In 1892, prospectors dug a series of bores in the hope to establish an oil industry around Salt Creek. The supply proved to be unsuitable for commercial use; a replica oil rig stands at Salt Creek in commemoration of these events.

Feral rabbits are known to have populated and heavily grazed in L6 (including Younghusband Peninsula). There are no clear records of their first appearance in L6 but it is expected to have occurred several years after their release near Melbourne in 1859. The release of the myxoma virus (causing myxomatosis) in the 1950s almost eradicated rabbits on Younghusband. This resulted in a noticeable and rapid recovery of native vegetation on the Peninsula. However, rabbit populations recovered after some years.

The building of the barrages that separated the Lower Lakes from the Coorong commenced in 1935. Once completed, they changed the hydrodynamics of the Coorong as well as the water chemistry (especially salinity levels). This led to changes in the ecological communities that relied on the Coorong and surrounding area.

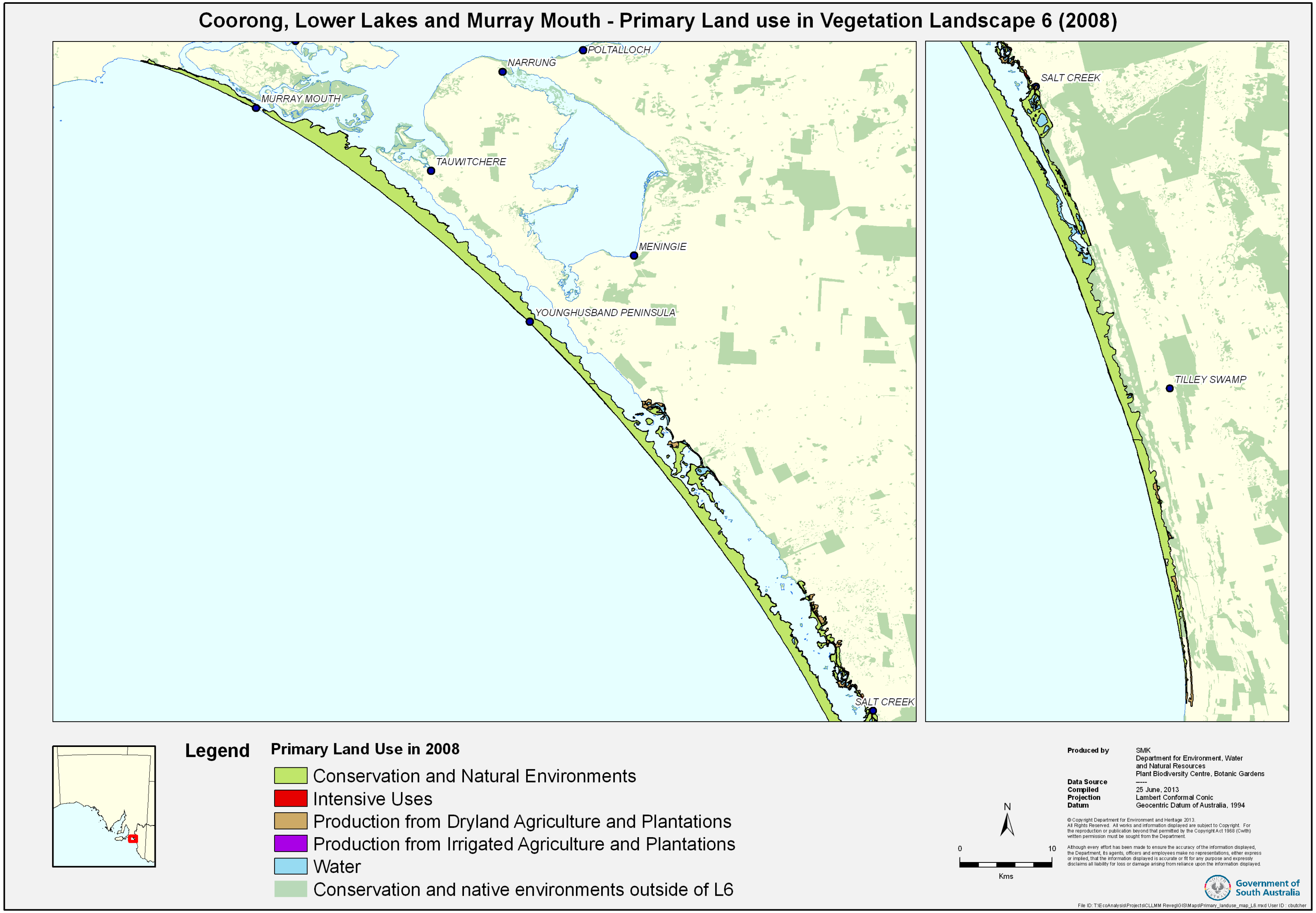


Figure 15. Vegetation Landscape 6 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008a).

The current land use in L6 is almost exclusively Conservation and Natural Environments (Figure 15Figure 4), as the bulk of the landscape occurs within the Coorong National Park. It retains approximately 60% remnant native vegetation, and the remainder is either bare sand or abandoned modified pasture. All of the Younghusband Peninsula is now free from livestock grazing, as is the vast majority of the remainder of L6. Small runs of grazing pasture are found in the southern portion of L6 and there are also small areas dedicated to ecotourism (accommodation structures and related infrastructure). The major recreational uses of the area include camping, fishing, bird watching and off-road driving (4x4). The major commercial use of the area is tourism and fishery; especially the collection of Goolwa Cockles. Steps have been taken to discourage negative impact on the landscape by restricting vehicles to designated tracks (or the beach), avoiding the disturbance of key species such as the Hooded Plover (*Charadrius rubricollis*) and restricting pet access and the removal of wood (for fires, etc.). There are several access tracks that traverse L6, however these are few in comparison to the length of the peninsula.

3.6.7 Summary and Recommendations

L6 is largely comprised of coastal carbonate sand dunes of marine origin, being made up of the Younghusband and Sir Richard Peninsulas. While there have been some historical attempts at agriculture in the past, these were small scale and short-term. Based on mapped remnant vegetation, the landscape is considered Variegated (60% remnancy), much of the unvegetated land is likely to be 'naturally' occurring bare sand. The landscape also largely occurs within the Coorong National Park. We recommend that this landscape be managed to maintain existing ecological functions, through the protection of these functions and management of emerging issues as they arise.

3.7 Vegetation Landscape 7

Vegetation Landscape 7 (L7) is entirely contained in the northwest of the project area. It spans from Middleton in the west to Boggy Lake in the east. The Landscape is broken with a ≈9 km north/south corridor east of Milang, which encompasses most of the Langhorne Creek wine region; this area is classified as Vegetation Landscape 10. For clarity of explanation, this corridor signifies a separation of L7 into two segments: L7a in the west and L7b in the east. L7a is the larger segment (22,730 ha) and comprises the area inland from Goolwa to Middleton and north to Finniss. It then occupies the major part of the peninsula between Finniss and Milang (the Peninsula). L7b (3630 ha) occupies a patchy area between Langhorne Creek and Boggy Lake.

L7 is found within the following Hundreds: Goolwa; Nangkita; Bremer; and Freeling. The total area of L7 is approximately 26,360 ha (Figure 16).

3.7.1 Climate

The annual rainfall maxima and minima of L7 ranges from 380 mm near the Boggy Lake to 606 mm in the hills near Currency Creek. The annual mean rainfall in L7 is 463 mm (± 44 SD). There is a difference of 85 mm.pa in the mean rainfall between L7a and L7b (475 – 390 mm.pa). This difference can be attributed to the proximity of L7a to the Mount Lofty Ranges. The approximate annual evaporation is 1740 mm.

3.7.2 Landforms

Unlike some other Vegetation Landscapes, topography does not appear to a defining feature of L7. The relief of L7 is characterised by large sand dunes; approximately half of which are vegetated. Absolute soil elevation ranges between sea level (0 m AHD) and 51 m AHD. The mean elevation of L7 from sea level is 11.2 m AHD (**Error! Reference source not found.**).

Table 14. Soil, area and elevation of Vegetation Landscape 7. Dominant and subdominant soils are only listed for the landscape as a whole. Subdominant soils refer to those soils that make up >10% by area of the landscape, but aren't the most common soil in the landscape.

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
7	G4	D3	26,511	0 – 128.1	25.2 ± 20.1

3.7.3 Soils

Landscape 7 contains 35 of the soil types described by Hall et al. (2012). However, this variety of soils is not evenly distributed and more than half of the soil types represent less than one percent of the soil in L7. Major soil types in L7 (with abundance greater than the arbitrary value of 5%) are a combination of sand or loam (or sandy loam) over some type of clay (Table 15), the greatest abundance being *G4 – Sand over poorly structured clay*. The distribution of the soil types is very patchy and exhibits the greatest variety of soil type and patch size in the project area. This is most evident in the approximate triangle formed between Finniss, Milang and Clayton Bay.

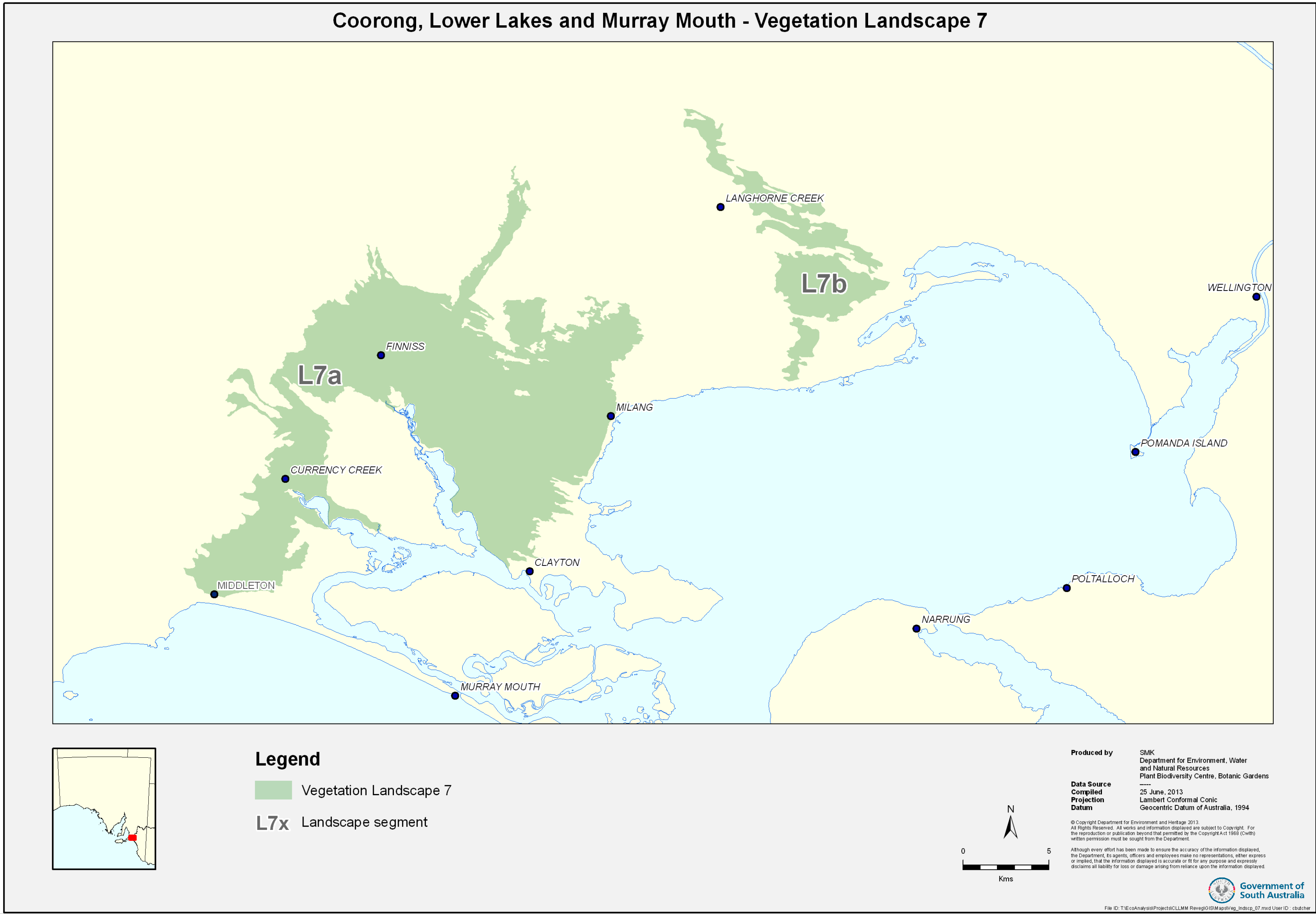


Figure 16. Map showing the location and extent of Vegetation Landscape 7

Table 15. Soil Types in Vegetation Landscape 7. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	%
G4	Sand over poorly structured clay	26
D3	Loam over poorly structured red clay	17
F2	Sandy loam over poorly structured brown or dark clay	9
A4	Calcareous loam	7
D2	Loam over red clay	6
-	Others combined (n= 29)	≈ 35

3.7.4 Land Types

A Land Type (LT) is a classification that describes the terrain, expressing the geomorphology and soil types found therein. L7 has nine LTs of varying abundance and patchy distribution (Figure 17). The most common Land Type group in L7 is in the group of LTs with soils formed on unconsolidated sediments or deeply weathered rock (e.g. LT-G, H, P and T, Figure 3).

The most common land type in L7 is LT-G, which describes rises and plains with mainly neutral to alkaline, sandy, texture-contrast soil with calcareous subsoil. This is consistent with the reasonably high value for range in topographic relief (128 m). Land Types T and H are less abundant that LT-G but more wide spread. LT-S is found in increasing abundance in the east.

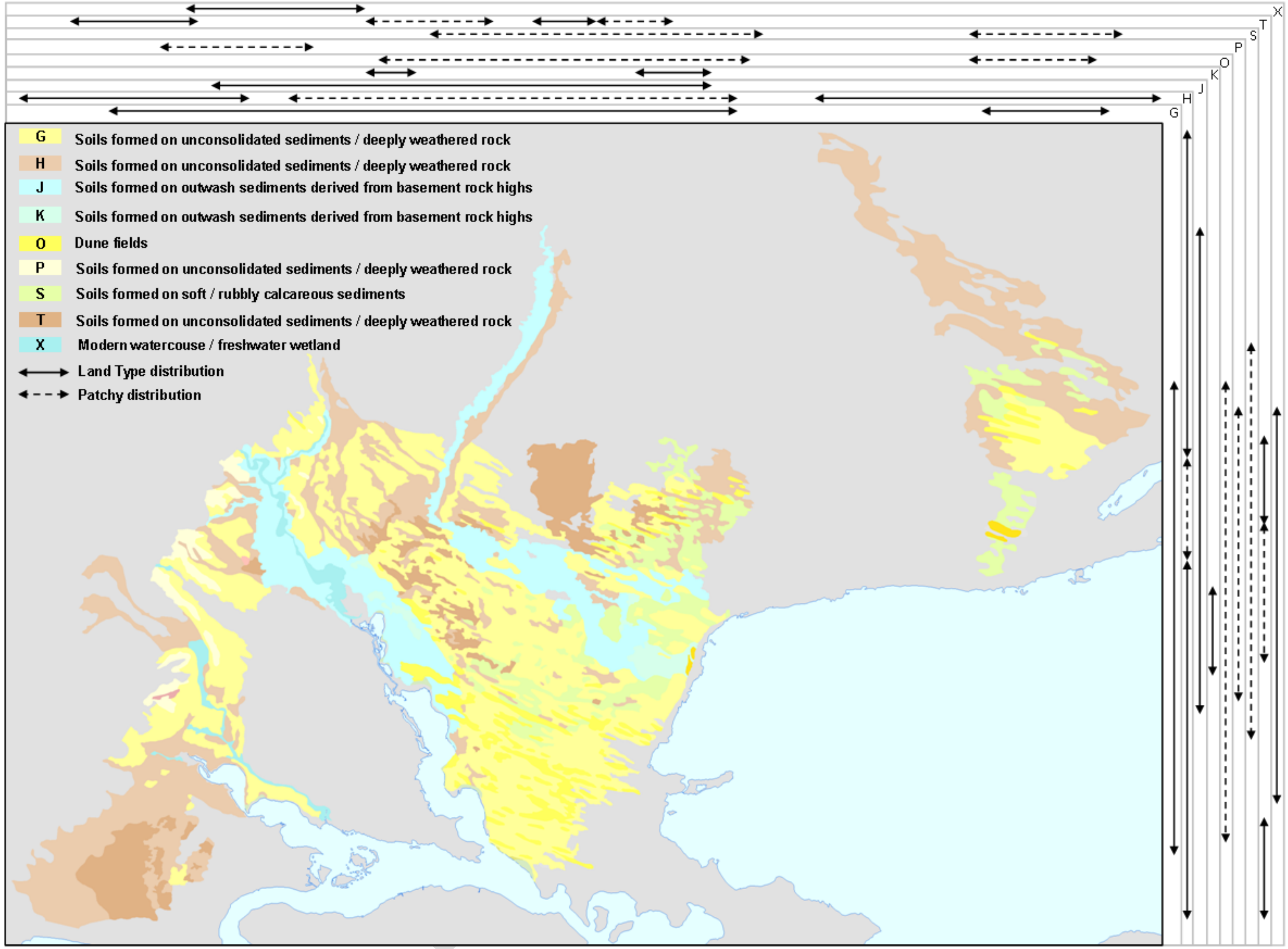


Figure 17. Location of Land Types in Vegetation Landscape 7

3.7.5 Vegetation

The pre-European vegetation communities of L7a are likely to have been a diverse mix of *Eucalyptus* woodlands, forests and mallee including *E. odorata*, *E. fasciculosa*, *E. baxteri*, *E. camaldulansis*, *E. incrassata*, *E. leucoxylon*, *E. phenax* + *E. dumosa*, etc. *Phragmites australis* grasslands and *Tecticornia* spp. shrublands likely lined the water's edge in L7a. There are currently small but relatively numerous patches of *Eucalyptus odorata* forest amongst and generally connected to patches of *E. fasciculosa*, *E. incrassata* (mixed) and *E. baxteri* (mixed) woodlands. The water's edge and water ways are currently lined with *Phragmites australis* grasslands, *Tecticornia* spp. & *Sarcocornia quinqueflora* samphire shrubland and *Typha domingenis* sedgeland.

The pre-European vegetation communities of L7b are likely to have been mallee (*Eucalyptus phenax* + *E. dumosa* +/- *E.socialis* ssp. *Socialis* with a grassy or herbaceous understorey) farther inland and *Allocasuarina verticillata* closer to the coast. Most of the native vegetation in L7b has been cleared to allow for agricultural development. Only very small patches of *Callitris gracilis* woodland and various *Eucalyptus* woodlands/forests remain.

The little remaining native vegetation is slightly different between the two landscape segments. The patches in L7a are mostly Eucalyptus forest and woodland or Melaleuca shrubland with dominant species such as *Eucalyptus fasciculosa, E. odorata, E. incrassata, Melaleuca uncinata,* etc. Patches in L7b are mostly eucalyptus mallee forest and mallee woodland or *Callitris* forest and woodland with dominant species such as *Callitris gracilis* and *Eucalyptus incrassata*.

The roadsides throughout L7 are generally well vegetated with mature trees. Many of the vehicle tracks on the Peninsula in L7a are lined with a 10-25 m wide band of native vegetation.

3.7.6 Post-settlement History and Current Use

When the South Australian Company began to promote the area for agriculture, the land around the Lower Lakes, Coorong and Younghusband Peninsula was mostly used as a passage between Adelaide and Robe, between which a regular mail run began in 1847. Traffic in the region increased greatly with the discovery of gold in Victoria in 1851. During this time, it was not uncommon for several hundred prospectors (predominantly Chinese) to way to the gold fields every week. This increase of traffic would have impacted on the natural environment through the clearing of trees, grasses and other vegetation for firewood and shelter, damage to the shoreline, the killing of wildlife for food and sport and the potential introduction of exotic species. The greatest impact of this force would have been seen in L7c.

In 1853 a survey for the town of Milang had begun and by 1855 a telegraph line extended from Adelaide to Goolwa, Hindmarsh, Ewe and Tauwichere Islands, opening up L5d for increased settlement and increased business (farming) practices.

The *Eucalyptus* forests and woodlands of L7a were systematically cleared both for their timber and to make way for the pastoralist and farmers who were being encouraged to take up land. The mallee woodlands of L7a and particularly L7b were difficult to clear and a deterrent for settlers as land clearing was not the responsibility of the government but of the landowner. New legislation was targeted at encouraging settlers to clear mallee woodlands, because it was very difficult and expensive to do so.

In 1867 a steamer mail service ran between Milang and Meningie 3 times a week, which Wellington strongly opposed as it directed produce, business, etc. away from its township. This also reduced the overland traffic around the lakes.

New legislation called the Scrub Land Act (1867) allowed for up to 640 acres of 'unsold and unoccupied land of scrubby and inferior character' or mallee land to be bought for £1 an acre. The condition of the Bill was that one twentieth of the land must be cleared each year. Only 50 of the 132 new land owners were able to clear scrub adequately. The Act was not very successful. By 1870 a process called Mullenizing became an effective way of clearing the mallee. New technology was invented in 1876 in response to a competition calling for a better way to clear mallee woodland. The Stump Jump Plough had the specific purpose of clearing mallee scrub. The new plough allowed better land turning while retaining root mass. This reduced soil erosion. Regenerating mallee shoots would be grown then burnt, ash fertilising the soil. This presented a change in thinking for landowners.

In 1877 a review of the Scrub Land Act (1867) offered more land and required less clearance per year. This led to greater interest in the land. This added incentive combined with the proven technology of the stump jump plough led to a scramble for land, particularly in the cheaper mallee woodlands of L7b.

The railway was extended to Milang in 1883, allowing faster, easier transport of timber, milk and other fresh produce from the lakes to Adelaide and better access for hunters from Adelaide.

A drought from 1911-1914, where the Murray River ceased flowing into the lakes, led to a rapid drop in the rate of land clearance. Combined with the loss of the labour and export problems during World War II, the wheat acreage plummeted.

By 1920, increased mechanisation and soldier settlement schemes led to increase settlement in the region. However, drought and the Great Depression led to intensive farming practices, over cropping and frequent tilling. Soil deterioration and erosion resulted from overworking the land.

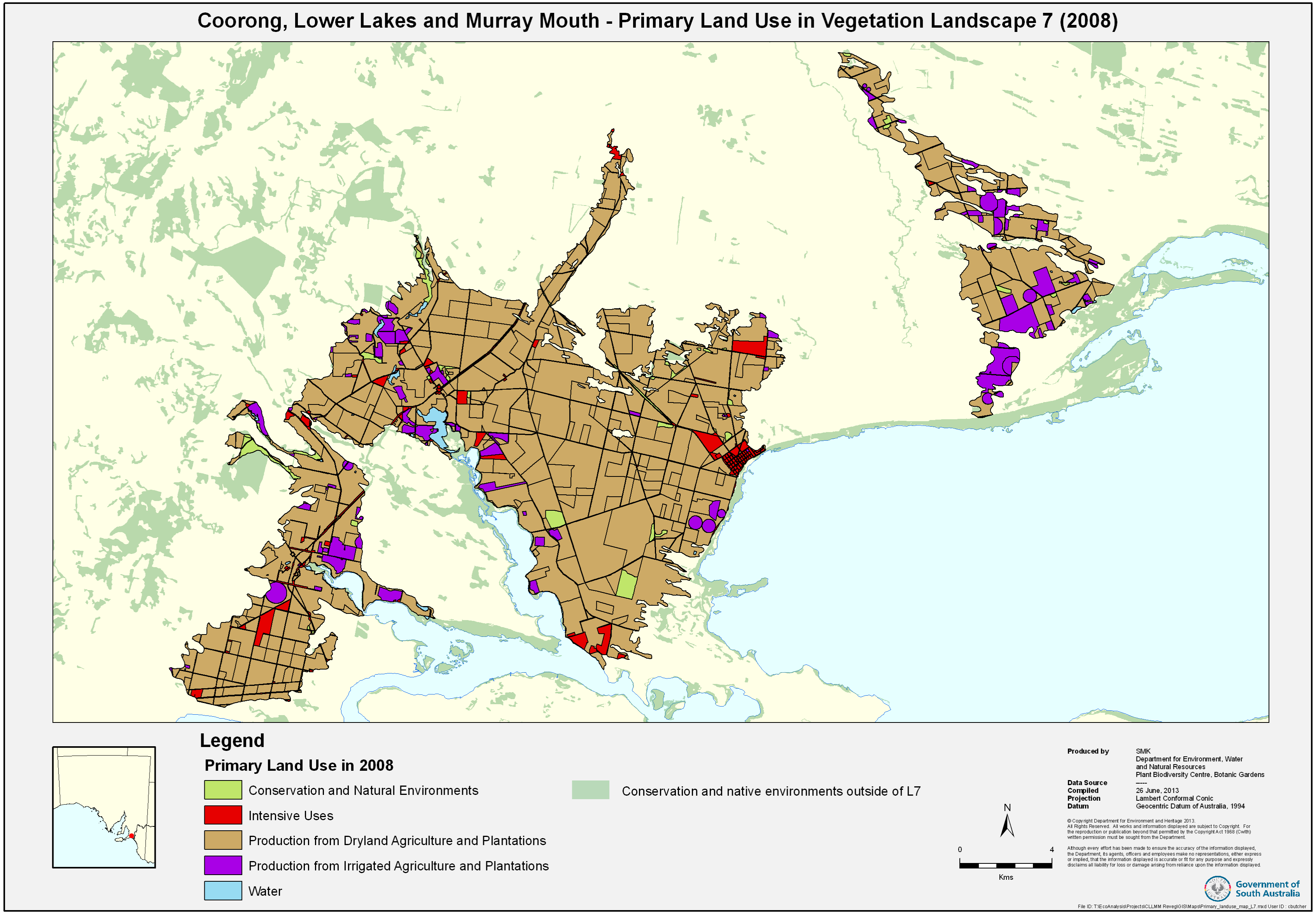


Figure 18. Vegetation Landscape 7 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008).

The dominant land use in L7 is dryland cropping (Figure 18). This type of agriculture is consistent with the dominant soil types of L7. There is a comparatively low but reasonably high percentage of irrigated agriculture in L7. Most of these fields are fringing the wine region of Langhorne Creek (L10), waterbodies (lakes and rivers) or Vegetation Landscape L4.

Native vegetation has been extensively cleared within L7 and there is a recognised 6% remnancy, which is classified by McIntyre and Higgs (1997) as a ‘Relictual’ landscape. Outside of L7 there are large areas of native vegetation in Boggy Lake, east of L7b and several areas to the west of L7a (Scott Reserve, etc.).

Bands of Dune Fields (LT-O) can be seen with satellite imagery. It is these areas on L7a where most of the remnant vegetation appears to be situated. This is not true for the entire Landscape and there are some areas where land use appears to be little affected by the dunes; they are cropped or grazed in very much the same way as the surrounding land.

3.7.7 Summary and Recommendations

L7 is dominated by a matrix of loam over poorly structured clay, interspersed with longitudinal dunes of siliceous sands. Coupled with moderately high rainfall (up to 600mm/y), this landscape provides ideal opportunities for dryland agriculture (particularly cereal cropping), and as a result 94% of the native vegetation of this landscape has been cleared. This landscape is considered Relictual, and we recommend that management for nature conservation focuses on the protection of patches of remnant vegetation (e.g. through pest management, buffers etc.).

3.8 Vegetation Landscape 8

Vegetation Landscape 8 (L8) is relatively small, at 5,500 ha (Table 16). L8 is entirely contained within 13 km of the western border of the project area (Figure 19). Its southern boundary is 2-3 km from Middleton and its northern border is approximately 6 km NW of Finniss. The Landscape is broken into three segments by segments of Vegetation Landscapes 4 and 7. The segments of L8 are: L8a in the northeast, L8b in the southeast and L8c in the west; they have approximate areas of 1563 ha, 1095 ha and 2843 ha respectively.

3.8.1 Climate

Vegetation Landscape 8 receives on average nearly 100 mm more rainfall than any other Landscape. The annual rainfall minima and maxima of L8 range from 514 mm near Currency Creek to 778 mm in the hills in the northwest of L8. The mean annual rainfall in L8 is 629 mm (± 65 SD). There is approximately 100 mm difference between the annual rainfall between 8b and 8c, which is considerable in such a small area. The annual evaporation in L8 is 1700 mm.

3.8.2 Landforms

The southern hills of the Mount Lofty Ranges make up this Vegetation Landscape. It is therefore quite hilly and the only Landscape that has its minimum elevation above sea level (0 m AHD). The land form has a rich combination of steep valleys, creek beds, rising slopes and smooth hills. The greatest change in elevation within a segment of L8 is 225 m (from 55 – 280 m AHD) in L8c.

Table 16. Soil, area and elevation of Vegetation Landscape 8 and sub-landscapes. Dominant and subdominant soils are only listed for the landscape as a whole. Subdominant soils refer to those soils that make up >10% by area of the landscape, but aren't the most common soil in the landscape.

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
8	**K3**	**K2, K1**	**5,500**	**34.8 – 280.0**	**144.8 ± 51.8**
8a			5,494	36.4 – 258.9	139.2 ± 46.9
8b			5,971	34.8 – 158.8	92.8 ± 25.0
8c			92,362	54.7– 280.0	167.9 ± 46.5

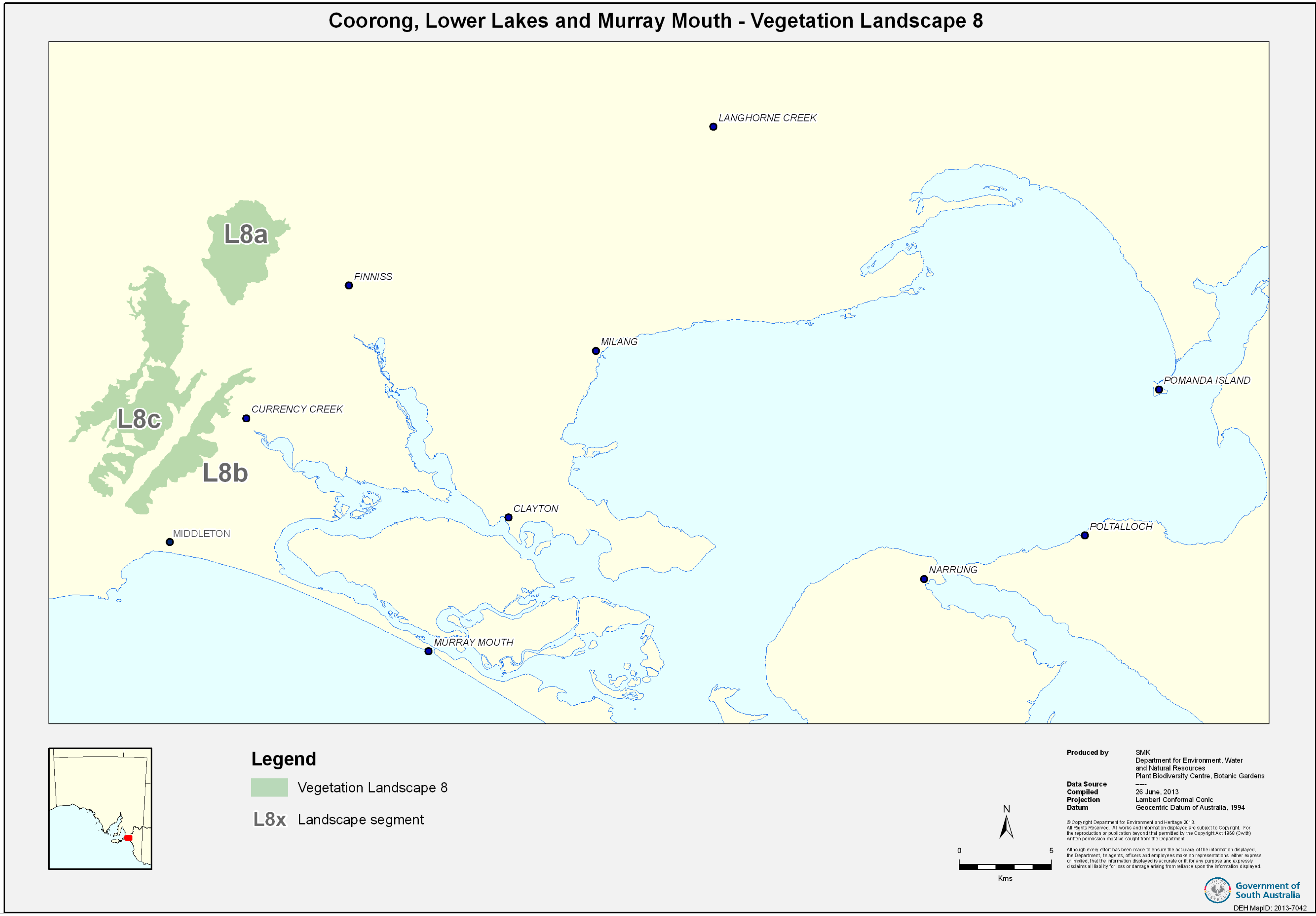


Figure 19. Map showing the location and extent of Vegetation Landscape 8

3.8.3 Soils

The soils of L8 are generally acidic soils on rock. This is true for most of the soils in L8; there are only few patches where an acid-over-rock *K* Soil Type is not the most abundant type of soil (Table 17). The areas where other Soil Types are present are where L8 has been divided by L4 and the water course of Currency Creek.

L8a and L8b have similar soils, the majority of which are comprised of combinations of *K1 – Acidic gradational loam on rock*, *K2 – Acidic loam over clay on rock*, *K3 – Acidic sandy loam over red clay on rock* and *L1 – Shallow soil on rock*. There are some medium sized patches of *F1 – Loam over brown or dark clay*, *D5 – Hard loamy sand over red clay* and *D2 – Loam over red clay* adjacent to the waterway.

The dominant Soil Type of L8b is *K3*. However, most of the segment has between 15-30% of *D1 – loam over clay on rock*, but never more *D1* than it has *K3*.

Table 17. The Soil Types in Vegetation Landscape 7. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	%
K3	Acidic sandy loam over red clay on rock	34
K2	Acidic loam over clay on rock	28
K1	Acidic gradational loam on rock	14
L1	Shallow soil on rock	8
D1	Loam over clay on rock	5
-	Others combined (n= 14)	≈ 11

3.8.4 Land Types

A Land Type (LT) is a classification that describes the terrain, expressing the geomorphology and soil types found therein. There are six LTs of varying abundance and patchy distribution (Figure 20). The most common Land Type group in L8 is in the group of LTs with soils formed on basement rock (e.g. LT-A, B and D,
Figure 20).

The most common land type in L8 is *Land Type A – Non-arable hills and rises with shallow stony soil and variable rock outcrop*, which describes rises and valleys described above. This is also consistent with the high values for range in topographic relief (245 m across L8). L8c is comprised of *LT-A* and the only occurrence in L8 of *Land Type D – Low hills and rises with mainly sandy to loamy, texture-contrast soil with calcareous subsoil*. The remaining LTs are found in various patches in line with the Soil Types described above.

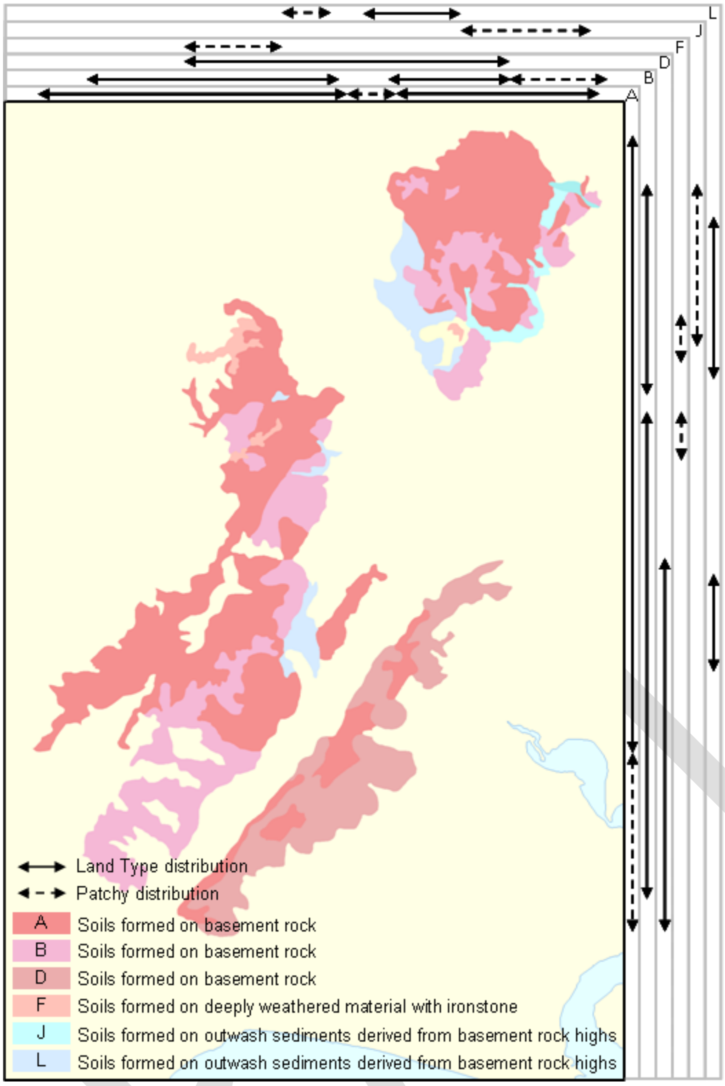


Figure 20. Location of Land Types in Vegetation Landscape 8

3.8.5 Vegetation

The pre-European vegetation of L8 likely to have consisted of *Allocasuarina verticillata* low woodland in the southeast, *Eucalyptus baxteri* low woodland in the northeast and a combination of *Eucalyptus odorata*, *E. fasciculosa*, *E. baxteri*, *E. camaldulansis* and *E. leucoxylon* woodlands throughout.

Most of the (greatly reduced) native vegetation that remains in L8a is *Eucalyptus fasciculosa* woodland with some small patches of *E. odorata* forest, *E. viminalis* mixed woodland and *E. baxteri* woodland. The only recognised patch of native vegetation remaining in L8b is a very small patch of *Eucalyptus baxteri* low open forest. There are some tree-lined roadways and scattered trees remaining, however almost all native trees have been removed from L8b.
There are large patches of native vegetation in L8c however they are not entirely intact. Large patches of both *Eucalyptus fasciculosa* (to the south) and *E. baxteri* (to the north) exist in L8c but appear to have very little understorey and are therefore likely to have and agricultural land use. Despite this, there is considerably more native vegetation within and surrounding L8 than most of the other Vegetation Landscapes.

3.8.6 Post-settlement History and Current Use

The history of L8 is closely nested within the histories of L4(c) and L7(a). Due to the combination of hilly terrain and acidic and/or shallow soil on rock, the land was not widely cleared for crops. Sheep and cattle (especially dairy) were grazed widely across L8.

The amount of cleared land is likely to be in part due to land clearance for cropping and grazing or alternatively due to the timber industry.

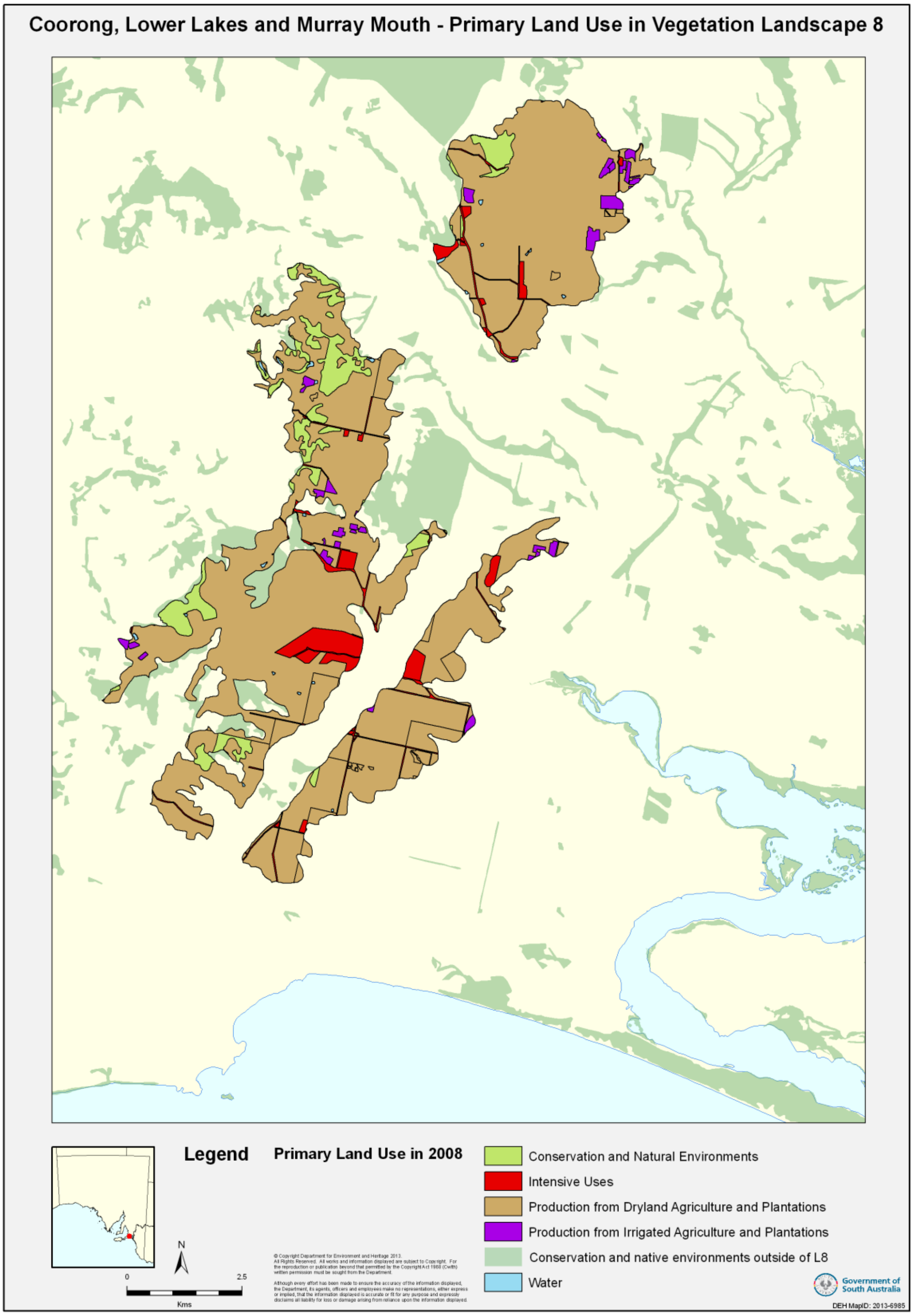


Figure 21. Vegetation Landscape 8 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008).

The major land use category for L8 is dryland crop agriculture but in the hilly terrain, grazing is more common amongst scattered vineyards and crop fields (Figure 21). There is a fairly large area that has been categorised as 'Intensive uses', this corresponds to a collection of approximately 40 houses (and related structures) built in open hilly fields. There are some large patches of Conservation and Natural Environments, with good vegetation cover, in close proximity to Cox Scrub Conservation Reserve and the smaller Scott Conservation Park.

There is a recognised 18% of native vegetation in L8, which has been classified as a 'Fragmented' landscape by McIntyre and Hobbs (1997).

3.8.7 Summary and Recommendations

L8 sits within the south-eastern footslopes of the Mount Lofty Ranges, and is dominated by acidic soils over rock with relatively high topographic relief (elevation ranges from 34-280m). These environments support open woodlands on the lower slopes, and closed stringybark forests on the crests. While dryland cropping is present on the lower slopes and flats, the topographic relief prevents broad-acre cropping of much of this landscape, and as such agricultural activity has been largely restricted to dryland grazing (particularly sheep). The landscape is considered Fragmented (18% remnancy), and we recommend that management focus on landscape-scale restoration to address the systemic issues associated with species decline.

This landscape has also been identified as a priority for restoration for the broader southern Mount Lofty Ranges landscape (Rogers 2011).

3.8 Vegetation Landscape 9

Vegetation Landscape 9 (L9) consists of the Mundoo Island, Long Island, Ewe Island and the southern two-thirds of Hindmarsh Island (Figure 22). The separation of Landscapes on Hindmarsh Island is caused by the presence of a calcrete shelf that extends between the widest points of the island; from the Hindmarsh Island / Goolwa bridge, across to the shoreline adjacent to Rat Island. The northern border of L9 on Hindmarsh Island is shared exclusively with L5. L9 is found within the Hundred of Nangkita. The total area of L9 is approximately 4,630 ha (Table 18).

3.8.1 Climate

Mean annual rainfall in L9 ranges from 440 mm to 491 mm. The mean annual rainfall in L9 is 462 mm (± 11 SD). The mean annual rainfall of L9 is similar to the mean annual rainfall for the project area, which is 485 mm (± 70 SD). The annual evaporation in L9 is 1750 mm.

3.8.2 Landforms

Vegetation Landscape 9 is generally very low-lying with areas that are periodically inundated and/or marshy. For simplicity, all topographical data have been limited to a minimum of 0 m AHD. The highest elevation of L9 is merely 13.5 m AHD and there are many natural drainage lines, waterholes and irrigation canals cut into the landscape (Table 18).

Table 18. Dominant soil types and landform description for Vegetation Landscape 9

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
9	F1	WW, N3	4,630	0 – 13.5	2.9 ± 1.4

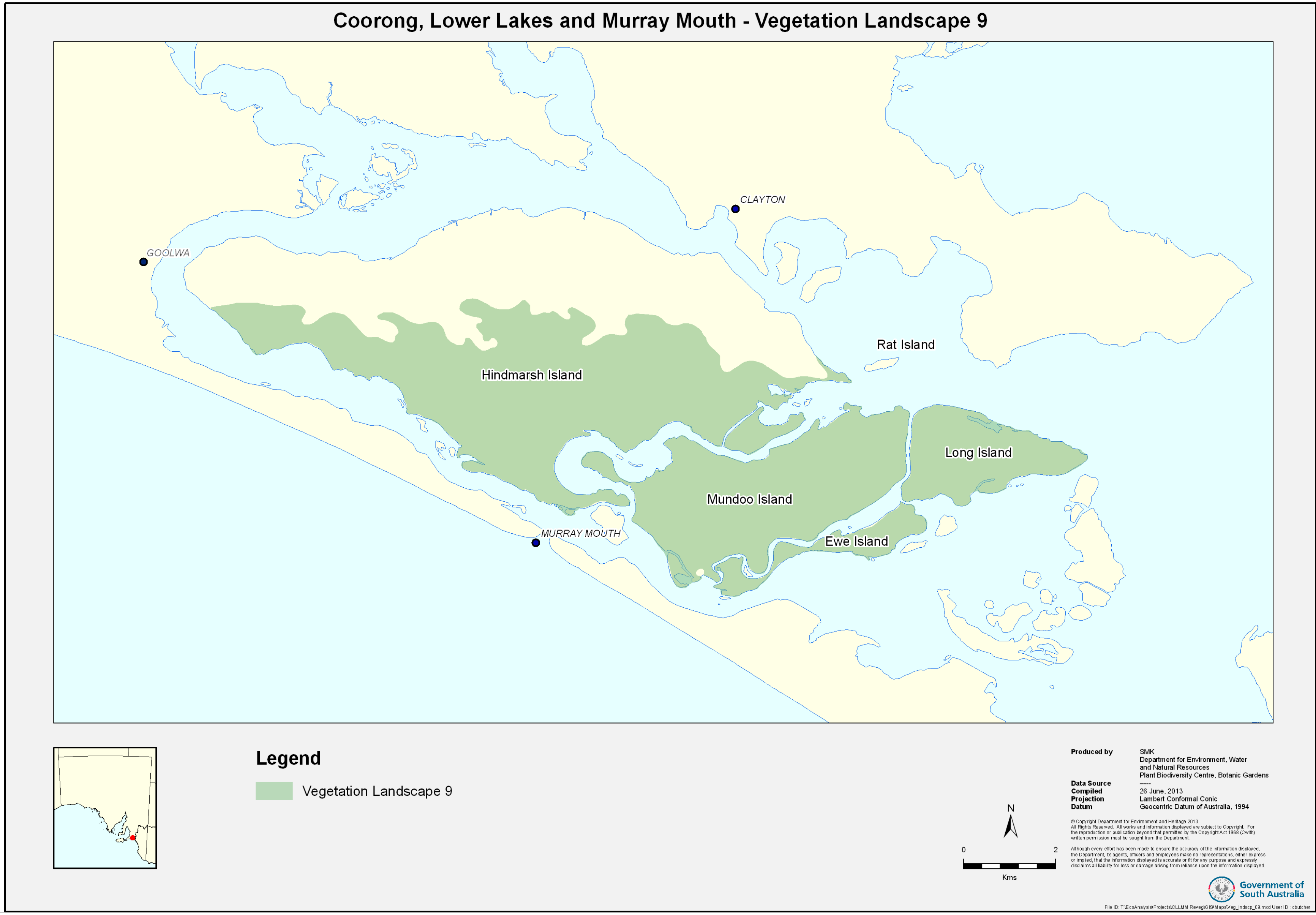


Figure 22. Map showing the location and extent of Vegetation Landscape 9

3.8.3 Soils

Deep loamy texture contrast soils with brown or dark subsoil is the major Soil Type of L9. Each reported Soil Type is in fact simply the major single type of soil in an area; there can be several more types of soil in each 'Soil Type'. Soil Type *F1 – Loam over brown or dark clay* is a common type of soil in other Soil Types of L9. It comprises 20% of all E1, 45% of all A1 and 100% of all F1 Soil Types, which are the three major Soil Types of L9 (except WW – water, Table 19, Figure 23).

There are patches of deep sands across the horizontal centre of L9. A large area of F1 spans across the centre of Hindmarsh and Mundoo Islands. This Soil Type is bordered to the south by a large strip of A1, which is in turn bordered by patches of H1 or E1. The black cracking clay of E1 is found in large patches around most of the border of L9. Several 'channels' of wet *N2 – Saline soil* traverse both Hindmarsh and Mundoo Islands.

Table 19. Soil Types in Vegetation Landscape 9. % values refer to the estimated % of the landscape (by area) of each soil type within the landscape

	Soil subgroup	**%**
F1	Loam over brown or dark clay	37
WW	Water	17
N3	Wet soil (non to moderately saline)	11
A1	Highly calcareous sandy loam	7
A7	Calcareous clay loam on marl	7
E1	Black cracking clay	7
N2	Saline soil	6
-	Others combined (n= 4)	≈ 8

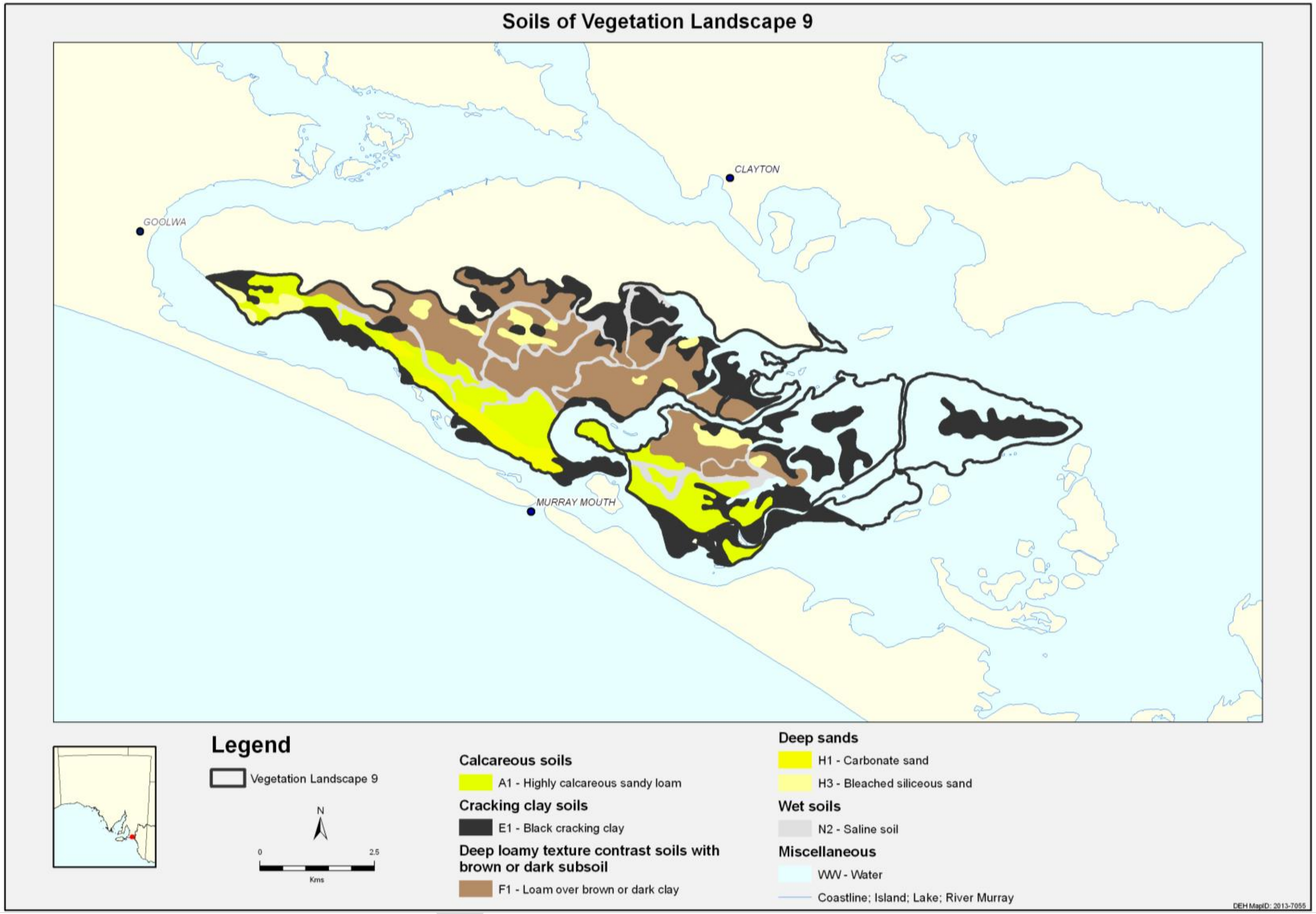


Figure 23. Soil types of Vegetation Landscape 9

3.8.4 Land Types

A Land Type (LT) is a classification that describes the terrain, expressing the geomorphology and soil types found therein. L9 has four LTs (LT-O, V, W and Z) of varying abundance and patchy distribution (Figure 24).

- *Land Type O - Dune/swale systems with mainly acid to neutral, bleached siliceous sand on dunes.*
- *Land Type V - Soils formed on marine/lagoonal clay or limestone. Plains with mainly neutral to alkaline gradational or texture contrast soil, often marginally saline.*
- *Land Type W - Coastal Land. Beaches, dunes, swamps, back plains, mud and samphire plain, shell-grit flats, tidal flats, mangroves and coastal cliffs.*
- *Land Type Z - Saline land, saline to brackish lakes and lagoons, and associated gypsum deposits and lunettes.*

The dune/swale systems match the pattern of deep sands (H1 and H3) that occur laterally across L9. Land Type V is the most abundant land types as it incorporates the F1, N2 and WW soil types listed above and is seen as a low flat plain with several drainage channels.

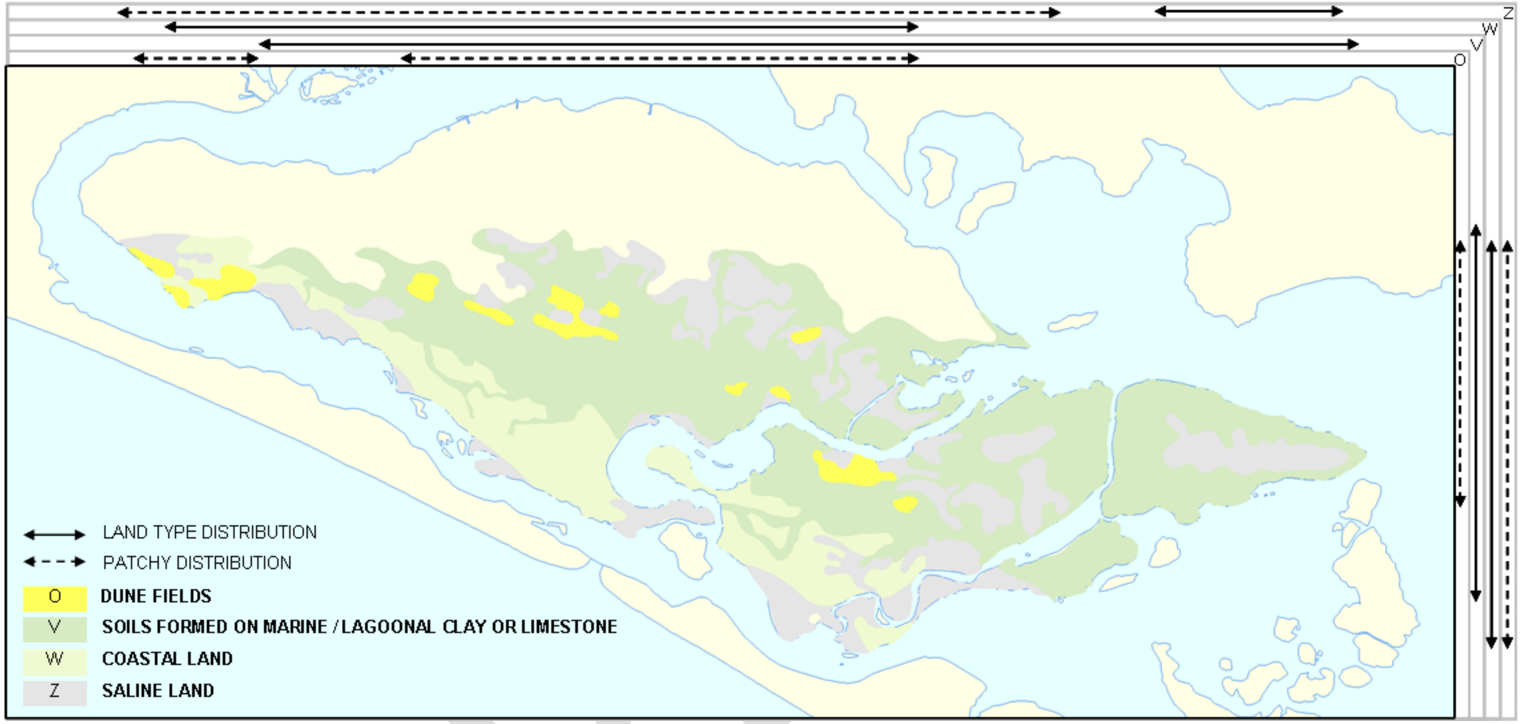


Figure 24. Location of Land Types in Vegetation Landscape 9

3.8.5 Vegetation

There is little information about the pre-European vegetation on the islands of L9. Dense and various reed beds were likely to have growth on the very low land of Long Island and throughout the ephemeral water courses of Hindmarsh Island. The reed beds would have tolerated low to moderate levels of salinity. Tree and shrub species that are likely to have occurred in L9 include *Melaleuca halmaturorum* (Swamp Paperbark), *Myoporum insulare* (Boobialla) and *Muehlenbeckia florentula* (Lignum).

The current vegetation in L9 has been highly modified and greatly reduced; especially on Hindmarsh Island. The current vegetation communities in L9, aside of crops and pastures, are various samphire shrublands, *Phragmites australis* grasslands and patches of *Gahnia filum* sedgeland or *Austrostipa stipoides* grassland (the latter, mostly to the south). *Phragmites australis* grasslands (reed beds) occupy large parts of the three smaller islands and many of the shallow channels on Hindmarsh Island, whereas *Sarcocornia quinqueflora* and *Tecticornia* spp. samphire shrubland occupies most of the remaining areas of native vegetation. There are some small, thin patches of *Melaleuca halmaturorum* woodland near the northern division of Hindmarsh and Mundoo Islands (Mundoo Channel) and approximately 1 km west of the Hindmarsh/Mundoo Barrage. There are some areas of young vegetation, where revegetation efforts have attempted to improve the vegetation community structures and populations.

The amount of native vegetation increases on the remaining three islands of L9. Large areas of tall, closed grasslands dominated with *Phragmites australis* increase in occurrence, often in alternating patches with samphire shrubland.

3.8.6 Post-settlement History and Current Use

In 1830, Hindmarsh Island was discovered by the Europeans by Captain Charles Sturt. By 1849, Dr Rankine was granted an occupational licence by the South Australian Company to run cattle. This would have impacted upon the soil quality and structure, it also would have involved the clearance of native vegetation. As industry increased in the area, by 1850 a flour mill was constructed, which was likely to have been supplied by wheat grown on the Island. It took until 1853 until Hindmarsh Island was surveyed for further development.
In 1853 significant developments occurred around the Lower Lakes. The first steamer on the Murray was driven from the Murray River to Goolwa and a second steamer was successfully navigated out of the Murray Mouth. This opened the area to trading.

The telegraph line of 1855 connected Adelaide to Goolwa, Hindmarsh, Ewe and Tauwichere Islands, and ultimately to Melbourne.

In 1856 the Dodd brothers bought 22 square miles (5700 ha) of land on Younghusband Peninsula opposite McGrath's Flat. Sheep and Cattle were tried but the animals suffered and the property was dedicated to the breeding of horses. Livestock were often swum from Goolwa and across the islands to get to Younghusband Peninsula. This was done to avoid the dangerous crossing of the Murray Mouth.

The first recorded public ferry began operating between Goolwa and Hindmarsh Island in 1858; an indication of the development on the islands. A popular drawcard to the area was fishing and hunting for sport and for the markets. By the 1860s fish and wild fowl were being caught and hunted by settlers and Aborigines. George Taplin, who worked for many years with the Ngarrindjeri, attempted to create and industry for the Aborigines as fishermen and hunters who supply produce for the local and Adelaide markets.

In 1868 Charles Price was the first person to introduce Hereford Cattle and Shropshire Sheep into South Australia. This was done on his Hindmarsh Island property.

The MacBeath family introduced Aleppo pines (*Pinus halipensis*) to Hindmarsh Island in the 1880s. They intended the trees to act as erosion protection to replace that were being felled for land clearance purposes. The trees were also being used as a fuel for the paddle steamers. Since their introduction, the pines have spread widely across Hindmarsh Island.

A cheese factory was establish on Hindmarsh Island in 1900, presumably using milk sourced from dairy cattle on the island. Sheep and cattle grazing has long been established practice on Mundoo Island, Ewe Island and Long Island. Major concerns about salt water intrusions into the Lower Lakes led to the start of the construction of the Goolwa and Coorong Barrages in 1935.

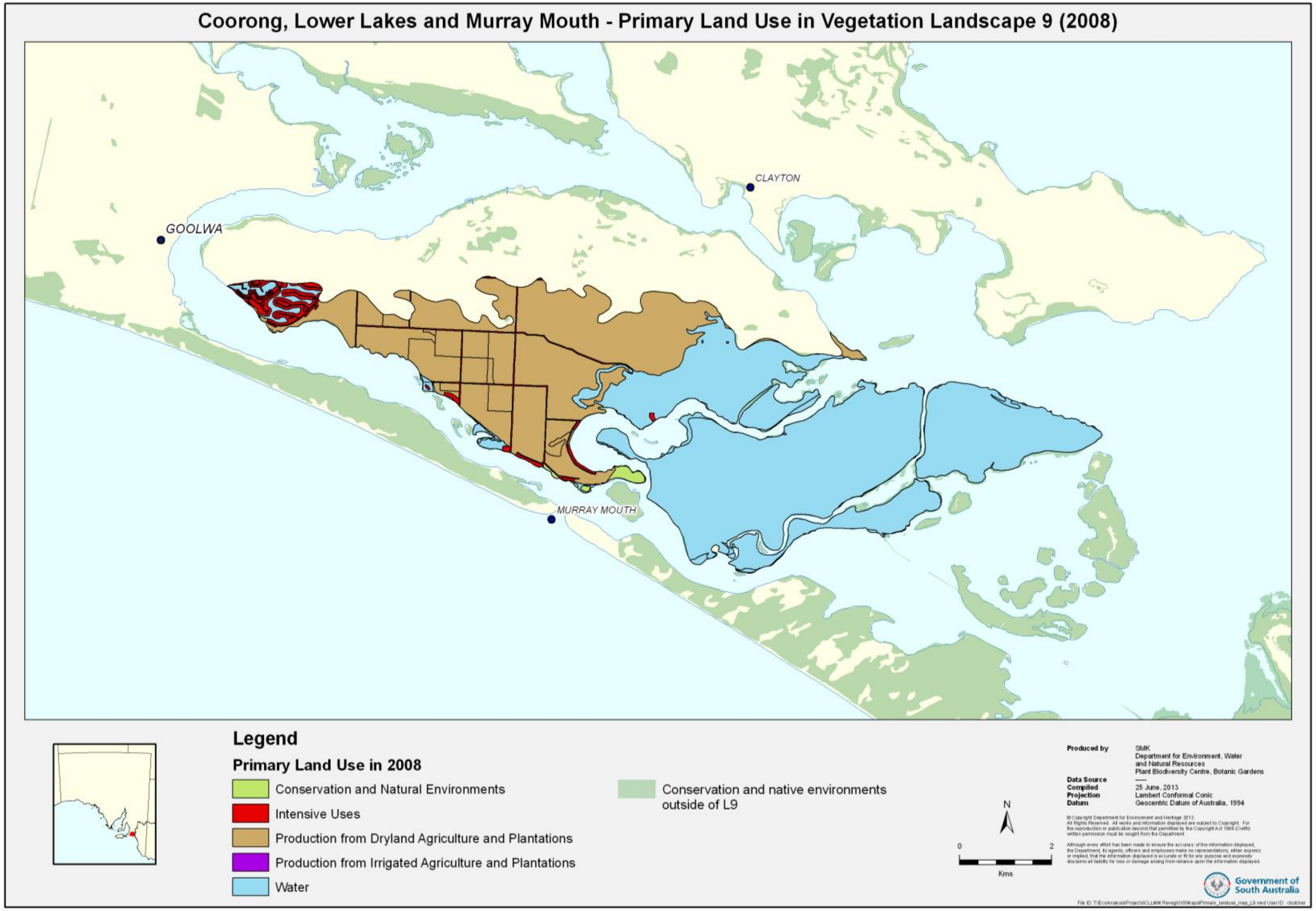


Figure 25. Vegetation Landscape 9 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008).

The islands that form L9 are mostly used for livestock grazing and crops (Figure 25). There are several areas along the lake shores and channels (e.g. Mundoo Channel, Ewe Island, Sugars Beach, etc.) where shacks, houses, boat sheds and other structures have been built; each with a vehicle track leading to it. A marina has been cut into the western shore of Hindmarsh Island, permanently changing the landscape for approximately 2.5 x 1.2 km with houses and docking canals. East from there, the land has been extensively cleared for pasture or crops (Figure 4). There is evidence of flood irrigation being used for low lying areas that are currently areas of samphire. As stated earlier, some revegetation efforts have been made, which can be seen at different stages of development. Despite much of Hindmarsh Island being cleared, there is approximately 53% remnancy of native vegetation in L9, which McIntyre and Hobbs (1999) classified as a 'Fragmented' landscape.

The 2008, Primary Land Use map (Figure 25) shows the remaining three islands of L9 as 'Water'. Aside from there being extensive grazing on each of the islands, there are homesteads and farm structures (dairy, etc.). Mundoo Island is the island most intensively grazed, with clear evidence of paddocks and exotic pastures. Long Island and Ewe Island exhibit evidence of grazing though it appear to be more on native pasture and is perhaps only grazed when the soil conditions can support the livestock with posing a risk to the safety of the animals.

There are some small areas of conservation opposite to the Murray Mouth. This coupled with the coverage of samphire/grassland vegetation on Long Island and Ewe Island culminates to a reasonably good amount of native vegetation.

3.8.7 Summary and Recommendations

L9 comprises the southern half of Hindmarsh Island, along with Mundoo and Ewe Island. This landscape is dominated by low elevation soils that are subject to periodic or permanent inundation (e.g. F1, N3 soils), that support aquatic or semi-aquatic vegetation communities. However, a significant proportion of this landscape is still used for grazing. The landscape is considered Fragmented (53% remnancy). However, remnant vegetation is likely to be skewed towards the more permanently inundated parts of the landscape, and restoration may focus on the more terrestrial components of the landscape.

3.8 Vegetation Landscape 10

Vegetation Landscape 10 (L10) is in the area that is now the Langhorne Creek wine region and on a small patch of land south of Wellington, either side of where the Murray River enters Lake Alexandrina. The segment of L10 surrounding Langhorne Creek will be referred to as L10a, the area near Wellington will be L10b. L10a is on the northwest shore of Lake Alexandrina where there is a thin strip of L2 and is surrounded to the east and the west by L7. L10b is adjacent to L1 on its smaller, western side of the River, while it is adjacent to L5 to the east.

L10 is found within the Hundreds of Freeling, Bremer, Brinkley and Seymour. The total area of L10 is approximately 8373 ha (Figure 26).

3.8.1 Climate

The annual rainfall minima and maxima of L10 range from 364 mm to 435 mm. The mean annual rainfall in L10 is 403 mm (± 13 SD). The mean annual rainfall of L10 is similar to the mean annual rainfall for the project area, which is 485 mm (± 70 SD). There is slightly higher rainfall in the west (L10a) than in the east. The annual evaporation in L10 is 1750 mm.

3.8.2 Landforms

Vegetation Landscape 10 is a drainage line. For simplicity, all topographical data have been limited to a minimum of 0 m AHD. The mean elevation of L10 is 10 m AHD and there are many natural drainage lines, waterholes and irrigation canals cut into the landscape (Table 20).

Table 20. Dominant soil types and landform description for Vegetation Landscape 10

Landscape	Dominant Soils	Subdominant Soils	Area (ha)	Relief (m)	Mean (+- SD) elevation (m AHD)
10	F2, H2	M1, M2, G1	8,373	0 – 42.0	10.0 ± 6.1

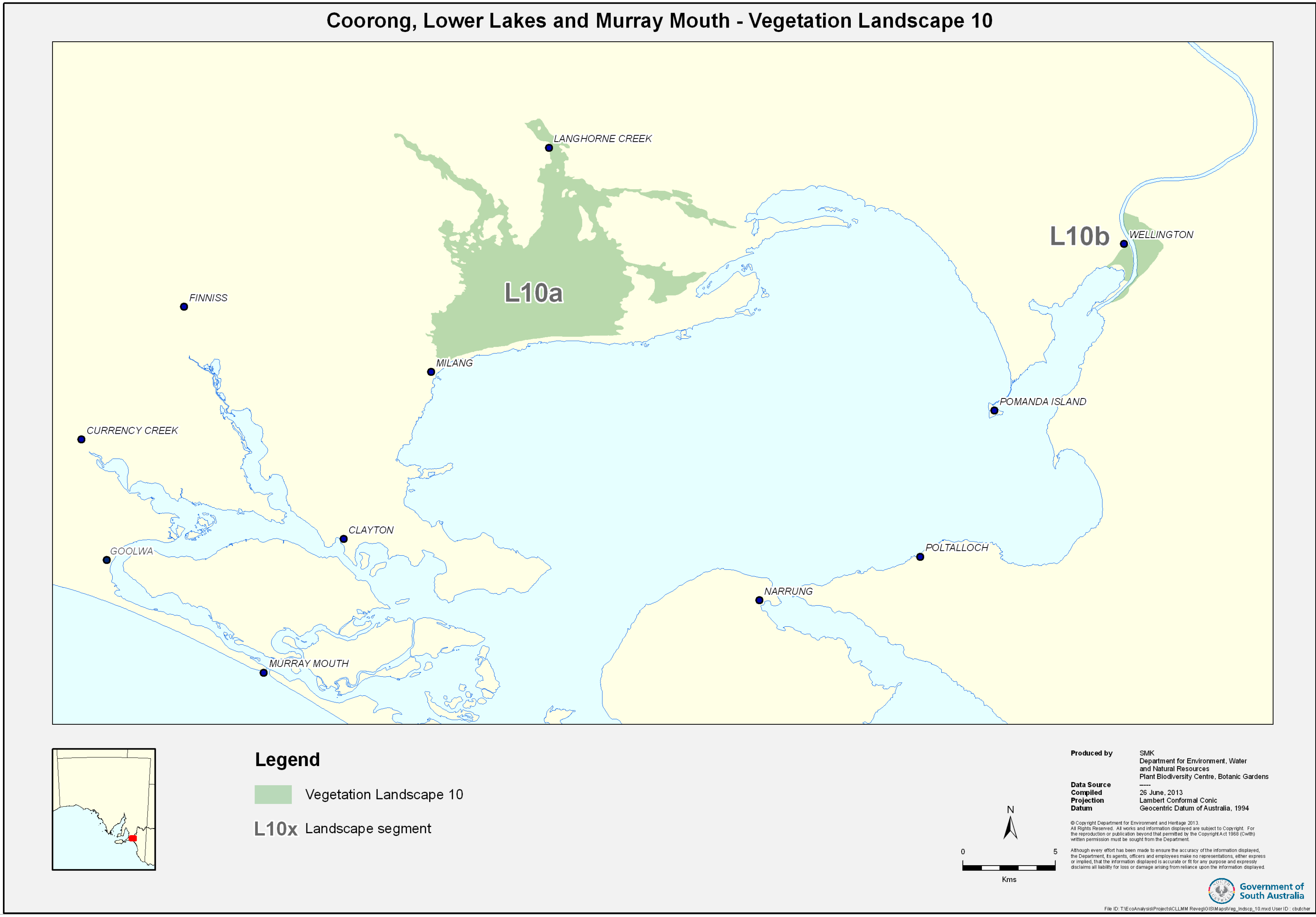


Figure 26. Map of the location and extent of Vegetation Landscape 10

3.8.3 Soils

The indicator soils for L10 are *M2 – Deep friable gradational clay loam*, *G1 – Sand over sandy clay loam* and *E3 – Brown or grey cracking clay*. The soil types exhibit much greater patchiness in the west of L10a than the east of L10a or L10b. There are several types of soil in each Soil Type, which suggests that soil diversity is greater than reported. In other words, only the largest percentage of type of soil is reported below despite there being 4-5 different types of soil with over 10% abundance in each Soil Type. Sub-landscape L10b is at the tail end of the Murray River before it enters Lake Alexandrina. As can be expected, the soil of L10b is mostly heavy soils and sandy soil (*E3* with considerable percentages of *G1* and *H2 – Siliceous sand*, Table 21).

Table 21: Sand or loam over clay were the most abundant Soil Types in Vegetation Landscape 10

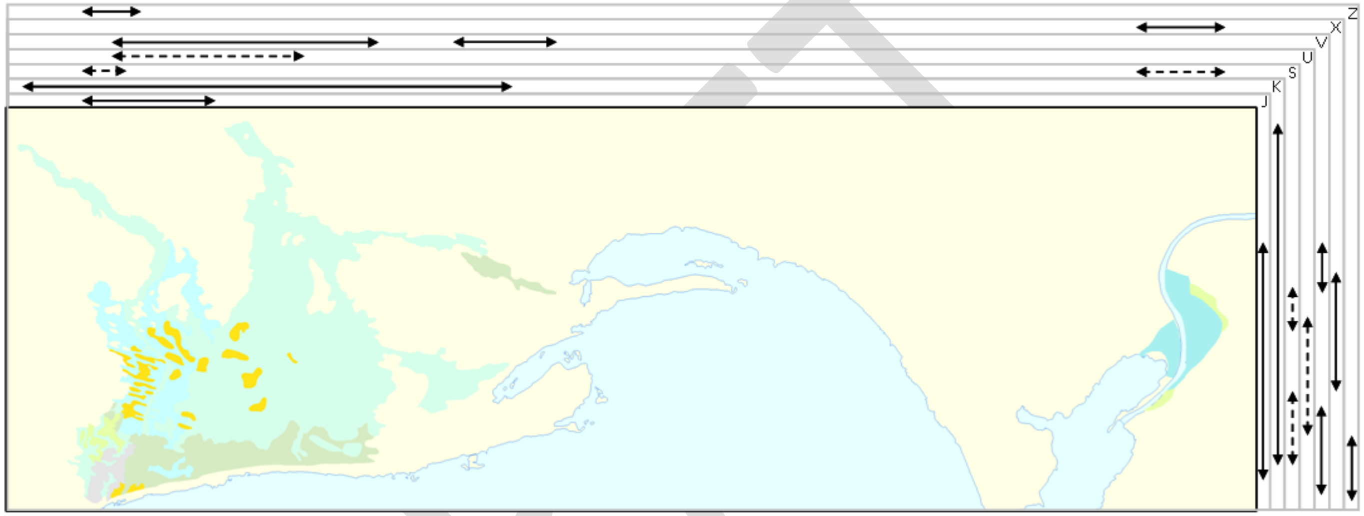
	Soil subgroup	%
F2	Sandy loam over poorly structured brown or dark clay	15
H2	Siliceous sand	15
M1	Deep sandy loam	13
M2	Deep friable gradational clay loam	10
G1	Sand over sandy clay loam	10
D5	Hard loamy sand over red clay	7
M4	Deep hard gradational sandy loam	7
D3	Loam over poorly structured red clay	5
-	Others combined (n= 10)	≈ 18

3.8.4 Land Types

A Land Type (LT) is a classification that describes the terrain, expressing the geomorphology and soil types found therein. L10 has seven LTs (LT- J, K, S, U, V, X and Z) of varying abundance and patchy distribution (Figure 27). The three major LTs of L10 are:

- *Land Type J - Soils formed on outwash sediments derived from basement rock highs. Plains and gentle slopes with mainly deep texture contrast soil with calcareous subsoil*
- *Land Type K - Soils formed on outwash sediments derived from basement rock highs. Plains and gentle slopes with mainly deep calcareous soil or gradational / clayey soil with calcareous subsoil*
- *Land Type V - Soils formed on marine/lagoonal clay or limestone. Plains with mainly neutral to alkaline gradational or texture contrast soil, often marginally saline.*

There is a gradual gradient heading inland from the shore of L10a whereas L10b is very close to the level of the Murray River. The outwash sediments found in L10 are indicative of the Land Types that define it. There is little apparent difference between the two major Land Types, LT-J and LT-K . The variety of the LTs in the southeast of L10a (e.g. *LT-Z – Saline land*) is indicative of the waterways that may deposit salts and other minerals.



SOILS FORMED ON OUTWASH SEDIMENTS DERIVED FROM BASEMENT ROCK HIGHS
SOILS FORMED ON OUTWASH SEDIMENTS DERIVED FROM BASEMENT ROCK HIGHS
SOILS FORMED ON MARINE / LAGOONAL CLAY OR LIMESTONE
SOILS FORMED ON SOFT / RUBBLY CALCAREOUS SEDIMENTS
DUNE FIELDS
MODERN WATERCOURSE / FRESHWATER WETLAND
SALINE LAND
LAND TYPE DISTRIBUTION
PATCHY DISTRIBUTION

Figure 27. Location of Land Types in Vegetation Landscape 10

3.8.5 Vegetation

The pre-European vegetation of L10 is likely to have been mostly *Allocasuarina verticillata* woodland and some areas of *Austrodanthonia* spp. + *Austrostipa* spp. Tussock grassland. There was fairly widespread *Eucalyptus camaldulensis* woodland along the waterways of L10a. There was a reasonably high diversity of various *Eucalyptus* woodlands in L10a. Alternatively, *Callitris gracilis* low open woodland occupied most of L10b on the eastern side of the Murray River.

The native vegetation has been extensively removed and now a thin strip of *Eucalyptus camaldulensis* exists along the waterways of L10a. There are some small patches of *Mairiana pyramidata* chenopod shrubland in L10b along with patches of *Phragmites* australis grassland and Typha *domingensis* sedgeland. Patches of various samphire shrubland can be found near Milang in L10a.

3.8.6 Post-settlement History and Current Use

The history of L10a is nested within the history of L7. The area (L10a) is a wine producing region known as Langhorne Creek. It was given its name in 1840 after Alfred Langhorne who was a cattle drover. He used brought his animals along a stock route in the 1840s to his station.

Traffic in the region increased greatly with the discovery of gold in Victoria in 1851. During this time, it was not uncommon for several hundred prospectors (predominantly Chinese) pass through Langhorne Creek on their way to the gold fields. This increase of traffic would have impacted on the natural environment through the clearing of trees, grasses and other vegetation for firewood and shelter, damage to the shoreline, the killing of wildlife for food and sport and the potential introduction of exotic species.

In 1853 significant developments occurred around the Lower Lakes. The first steamer on the Murray was driven from the upstream to Goolwa and a second steamer was successfully navigated out of the Murray Mouth. This opened the area to trading. In 1853 the township of Milang was formed.

The wine industry in L10(a) began in 1891 and has grown steadily since, creating economic stability for the community. This industry has also required the broad scale clearing of native vegetation (particularly *Eucalyptus camaldulensis*) and major changes to the hydrodynamics of the region.

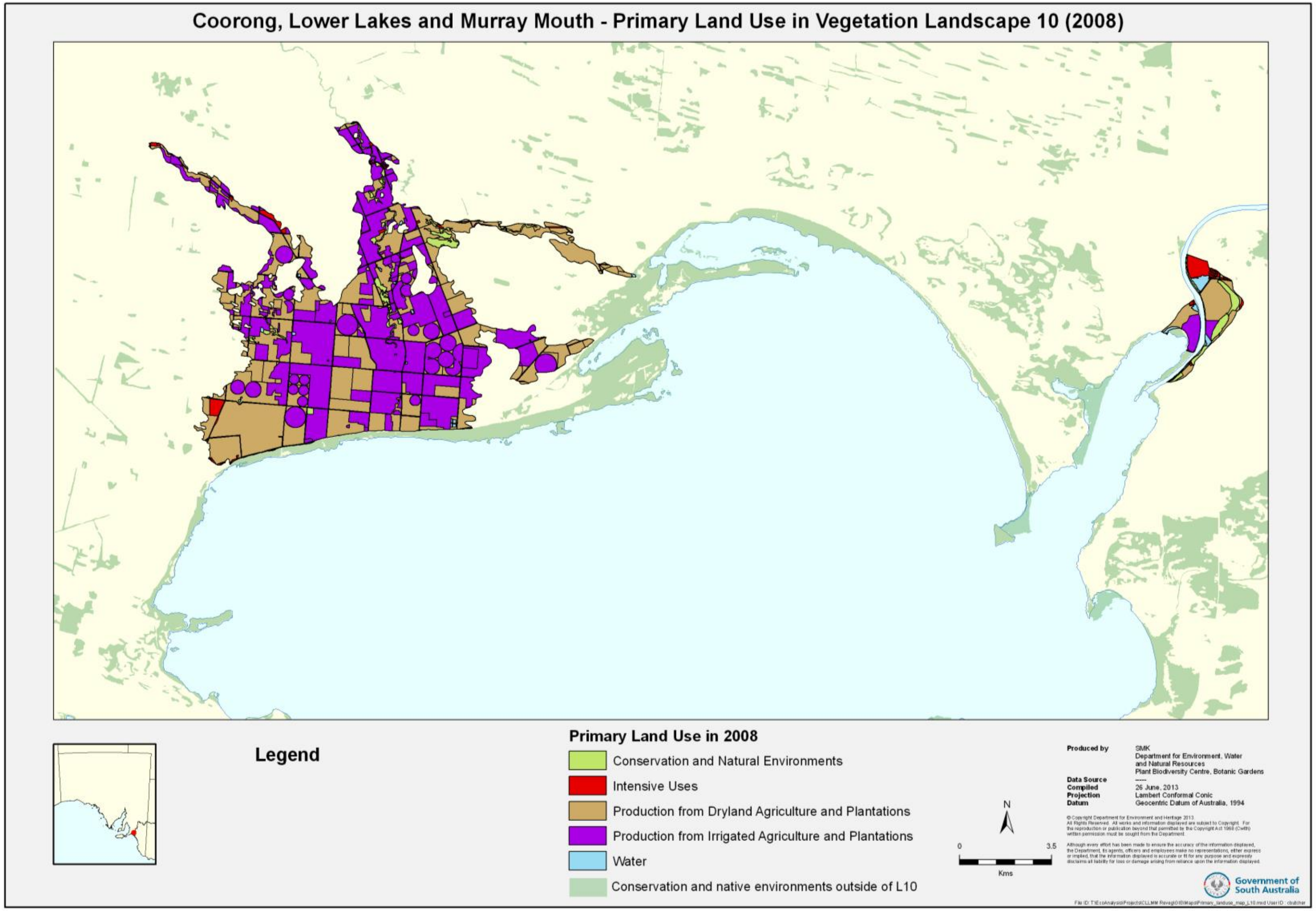


Figure 28. Vegetation Landscape 9 Land Use (2008). Based on the Land Use 2008 SDE Layer (Department of Environment, Water and Natural Resources 2008).

The drainage lines that make up L10 are extensively used for grape growing (L10a) or flood-irrigated pasture (L10b). Langhorne Creek is the name given to the grape growing region. L10 is the only Vegetation Landscape in which irrigated agriculture is (or very close to being) the dominant land use (Figure 28). There are many field of dryland crops and pasture in L10a. Due to the rich soils and the consequent intensive agriculture, there is a remnancy of 4% native vegetation in L10. This has been given the classification of 'Relictual' by McIntire and Hobbs (1997).

3.8.7 Summary and Recommendations

L10 is dominated by relatively flat plains dominated by alluvial soils such as loams over clay or deep uniform loams that have high inherent fertility. 96% of the native vegetation of this landscape has been cleared, and the dominant land use is currently irrigated horticulture (particularly wine grapes). The landscape is considered Relictual, and we recommend that management focus on protecting and buffering remnant patches of vegetation, particularly in light of the limited opportunities for landscape-scale restoration.

5.0 General Discussion and Recommendations

This report describes the physical and biotic features of the Vegetation Landscapes of the CLLMM region, and how land use has influenced the current state and trend of these landscapes. Based on a synthesis of this information, some general recommendations regarding the management of these landscapes for nature conservation are also provided (see Table 1 for a summary of these recommendations). Generally, this synthesis recommends the following:

1. Management in landscapes 4, 7 and 10 (Relictual landscapes) should focus on the protection of remnant patches of vegetation, to prevent further loss;
2. Management of landscapes 1, 5, 8 and 9 should focus on identifying and addressing the landscape-scale systemic issues that are associated with decline of biodiversity (including landscape-scale restoration);
3. Management of landscapes 2 and 6 should focus on maintaining the current extent and ecological processes that support native biodiversity, and identify and address novel threats (e.g. pest plants and animals, change in land use) as they emerge.

The landscape-scale management recommendations presented here provide some general guidance regarding the management of Vegetation Landscapes in the CLLMM for the purposes of nature conservation. In particular, these recommendations suggest that strategic investment in landscape-scale restoration should focus on those landscapes that are considered 'Fragmented', as the presumption is that the opportunity still exists for landscape-scale restoration to provide benefits to nature conservation. This compares with those landscapes that are considered 'Relictual', in which the presumption is that the only extant native biota in these landscapes are well adapted to these highly modified landscapes, and so landscape-scale restoration is unlikely to provide nature conservation benefits to these landscapes.

Definitions of Landscapes

One of the findings of the synthesis presented in this report is that the likely state and trajectory of native biota – and the required management response – can vary between the different sub-landscapes within a single landscape. This is particularly the case where different sub-landscapes are geographically disjunct. In spite of the similarities in soil composition (that defined the extent of Vegetation Landscapes), post-settlement historic, and current, land use may vary among sub-landscapes due to other factors beside soil properties (e.g. climate, distance from large towns or railway lines). Future analyses may require a review of the landscape classification presented here, to both account for this variation, and other landscape and ecosystem assessments undertaken elsewhere (Rogers 2011; Willoughby *et al.* 2011).

Next Steps

The descriptions and recommendations provided here are focused on the landscape level in the biological hierarchy, and have discriminated among landscapes based on the presumed state and trajectory of native biodiversity in them. However, a comparable assessment should be undertaken for lower levels in the hierarchy – namely ecosystems and species, in a way that nests these assessments within the landscape-scale assessment described here. Given the regional recommendations made in this report, however, assessments at the ecosystem level should preferentially focus on those landscapes that have been identified as being at risk in this report, as the drivers responsible for these declines are often associated with different ecosystems within landscapes (Rogers 2011). We recommend, therefore, that ecosystem level assessments be prioritised to landscapes 1, 5, 8 and 9, that have all been identified as requiring landscape-scale intervention to address the systemic issues associated with decline. While similar ecosystem-scale assessments can also be undertaken for the remaining landscapes, these are less likely to provide additional support for strategic conservation activity, beyond what has been provided here.

In addition to this landscape-scale assessment, and a future ecosystem-scale assessment, species level assessments should also be undertaken. The assessment of species at risk is required to account for individual threatened species whose conservation requirements are not met by acting on the recommendations made at higher levels. For example, species-level conservation activity may be required if threatened species occur (and are declining) in Relictual landscapes, where landscape-scale restoration has not been identified as a priority activity. However, this species-level assessment should be done in such a way that it is nested within the higher level assessments, to ensure that conservation activities are identified that are additional to those ecosystem and landscape-level issues, and provide additional benefit to nature conservation in this region.

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