

# ALBANY WATERWAYS MANAGEMENT AUTHORITY

## Fringing estuarine vegetation of Princess Royal Harbour 1992



Waterways Commission  
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# **FRINGING ESTUARINE VEGETATION OF PRINCESS ROYAL HARBOUR 1992**

Report to the Albany Waterways  
Management Authority

**L J Pen**

Waterways Commission  
216 St Georges Terrace  
Perth WA 6000

Report No 55,  
October, 1995

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## SUMMARY

Princess Royal Harbour supports a modest area of fringing vegetation, mainly along the southwestern foreshore where groundwater seepage is strong. The flora is relatively rich and comprises a total of 22 plant communities, which are divided into beachside vegetation (3), salt-marsh (9), coastal seepage zone sedgeland (4), coastal seepage zone forest (3) and estuarine forest (3). Although the vegetation is presently very healthy, it is becoming increasingly disturbed and degraded by increasing human activity along the southern foreshore probably as a result of expanding residential development in that area.



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# 1. INTRODUCTION

Princess Royal Harbour is a marine embayment located about 400 km south-east of Perth on the south coast next to the town of Albany (Fig. 1). It is roughly oval in shape, about 8 km long and 4 km wide, covering an area of about 29 km<sup>2</sup>. The Harbour supports a modest area of fringing vegetation, mostly along the south-eastern and north-western shores. The object of this study was to describe, classify and map the fringing plant communities of the Harbour.

## 2. STUDY AREA AND AIMS

The study area consists of the land along Princess Royal Harbour which supports fringing vegetation (Fig. 1). Generally, it runs about 16 km clockwise from the middle of the Vancouver Peninsula around the inlet to just before the Town Jetty. East of the jetty, the foreshore has been largely replaced by construction works for the Port of Albany.

The aims of the study were to:

1. Identify and record the plant species which occupy the foreshore and adjacent low lying areas of Princess Royal Harbour;
2. Classify the fringing vegetation of the Harbour on a floristic and structural basis;
3. Produce maps showing the distribution of the resultant plant communities; and
4. Consider those factors which influence the health of the vegetation and implications for management.

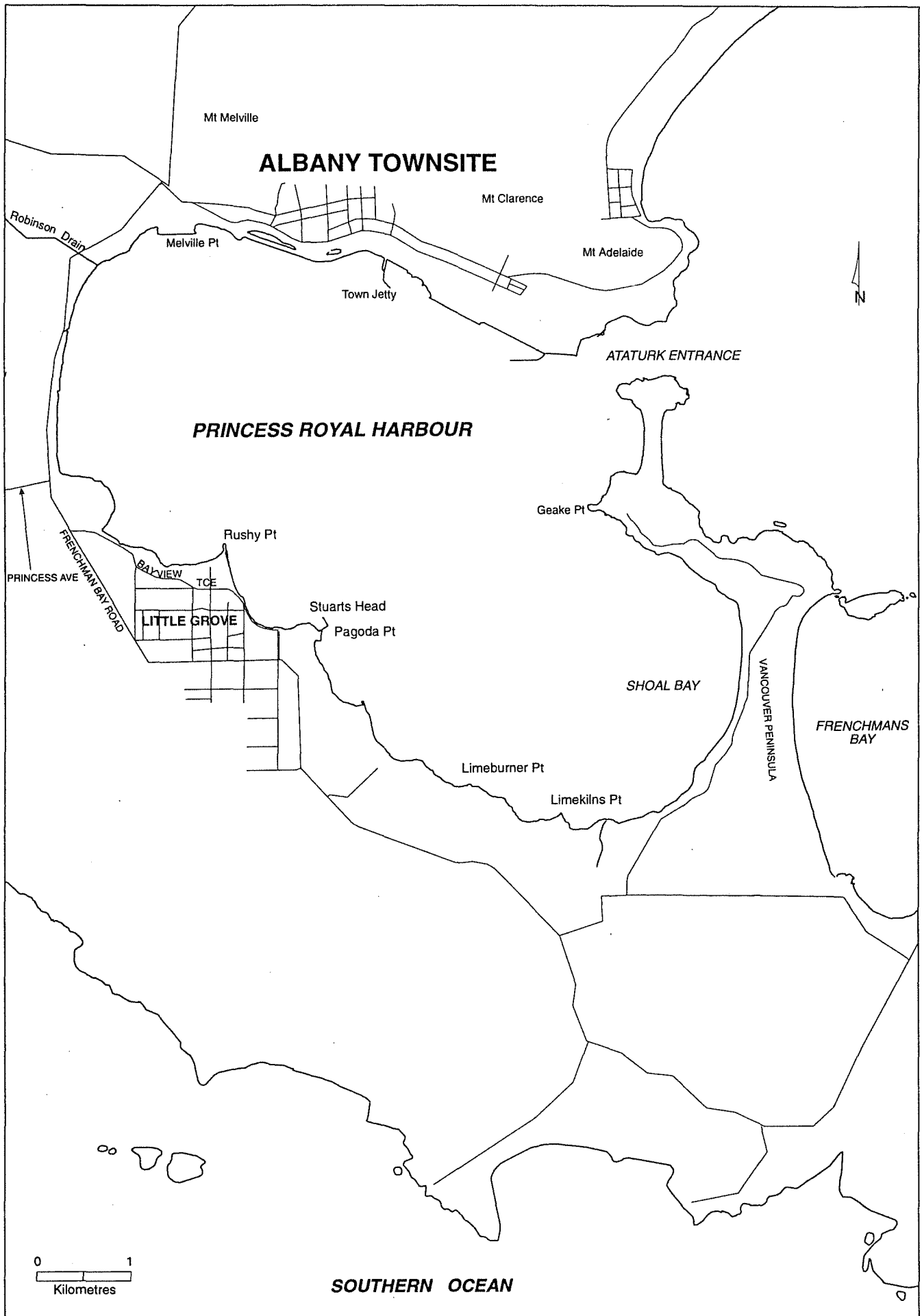
## 3. MATERIALS AND METHODS

### 3.1 Vegetation classification

#### 3.1.1 The floristic approach

This study provided the first opportunity in many years to make a return to a floristic approach to vegetation classification in the description of vegetation fringing waterways in south-western Western Australia. Since the earlier work of Backshall (1977), Pen (1981, 1983) and Brock and Pen (1984), which described the fringing vegetation of the Peel-Harvey and Swan-Canning estuarine systems, resources have limited work to simpler classifications based on vegetation structure and dominant plant species (Pen, 1992, 1993a and b; Siemon et al., 1993).

While this latter method of vegetation classification is adequate to recognise plant communities and groupings of communities, it cannot provide as detailed an analysis of vegetation composition and pattern as floristic methods (Bridgewater, 1981). The particular method used in this study is based on the Zurich-Montpellier system of phytosociology (Muller-Dombois and Ellenberg, 1974). It takes into account the total species composition of plant communities, enabling them to be described by their characteristic species and to be presented systematically to show their interrelationships. Details of the use of this system locally are found in Pen (1983) and Cresswell and Bridgewater (1985).



**FIGURE 1 : Princess Royal Harbour Study Area**

### 3.1.2 The method described

Stands of relatively homogeneous vegetation were sampled in 10 x 10 m quadrats. Each sample consisted of a species list and an assessment of the cover-abundance of each species in the quadrat. The cover-abundance scale used was that of Braun-Blanquet (see Muller-Dombois and Ellenberg, 1974) and is as follows:

- + = occasional, cover less than 5%
- 1 = common, cover less than 5%
- 2 = very common, cover less than 5% or cover 5 - 20%
- 3 = cover 20 - 50%
- 4 = cover 50 - 75%
- 5 = cover 75 - 100%

Quadrats were placed in homogeneous stands of all vegetation types, except those exhibiting a high degree of disturbance, such as pasture, lawn, parkland and areas infested with weeds. Site details were noted for each quadrat. Sampling was conducted on the 31 January, 24 and 27 March and 24 April 1992. Unknown species were collected and identified and curated with the assistance of experts (see Acknowledgements) and a voucher collection lodged at the Albany CALM and Wildflower Society Herbarium.

Classification was achieved by "tabular synthesis": the grouping of similar samples on the basis of floristic similarity, recognising species characteristic of these groups and then using these diagnostic species to further classify the groups into a hierarchy<sup>1</sup>. The basic unit of the classification is the Community. Similar communities are grouped into Complexes, while the community itself can be further divided into subcommunities where sufficient samples are available to distinguish lower level vegetation types.

All three units of the classification are named by their diagnostic species, which are usually also the dominant species, but the community is also named according to its structure following a method adapted from Aplin (1979, cited in Trudgen, 1984) and used previously by Trudgen (1984), Pen (1992, 1993a and b) and Siemon et al. (1993) for the description of estuarine and riverine vegetation associated with the Leschenault and Peel-Harvey estuarine systems. In this way a continuity is achieved between these recent studies, based on dominant species and vegetation structure, and the earlier floristic studies.

## 3.2 Vegetation mapping

Colour aerial photographs of the study area in 1991 at 1:20,000 scale were obtained from the Department of Land Administration (flown for the Waterways Commission) and sketchmaps were produced using a Zeiss Aerosketchmaster to 1:10,000 scale. The sketchmaps were drawn up to convey information on the distribution of vegetation and vegetation type, standing water and land use.

The sketchmaps were then taken in the field on the above sampling dates and annotated with relevant information on plant community composition and structure and weed infestations. The locations of sampling quadrats were recorded on the maps.

The vegetation maps were drafted at about 1:5000 scale using Microstation with topographical data collected between 1980 and 1992 at 1:2000 scale.

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<sup>1</sup>This method mimics the process now usually carried by the multivariate procedure TWINSpan.

## 4. FRINGING PLANT COMMUNITIES OF PRINCESS ROYAL HARBOUR

To help document the distribution of the various plant communities the study area was divided into 14 sections, shown on the vegetation maps.

### 4.1 Beachside vegetation (B)

#### *Calocephalus brownii* open shrubland community (B1)

This very open shrubland of the medium grey to white shrub *Calocephalus brownii* (cushion bush) is found in only one site on the Vancouver Peninsula (see Section 2 Map 1). It is found on rises of sand and shell grit adjacent to salt-marsh dominated by *Sarcocornia* (samphire) and *Juncus kraussii* (shore-rush). Associated species include the small shrub *Pimelia imbricata*, the prostrate succulent herb *Hemichroa pentandra* (trailing jointweed) and the introduced erect herb *Euphorbia terracina* (false caper) (Table 1).

#### *Isolepis nodosa* open-closed sedgeland community (B2)

The medium sedge *Isolepis nodosa* (knotted club-rush) is common on sandy ground just above the beach or salt-marsh and below the coastal vegetation of the consolidated dunes, forming a mostly open sedgeland. Occasionally the large coastal sedge *Lepidosperma gladiatum* (coast sword sedge) forms dense patches amongst the *Isolepis* and creates a closed community. Other species present include *Euphorbia terracina*, the shrub *Atriplex hypoleuca* and the herb *Suaeda australis* (seablite). Less common are *Apium prostratum* (sea celery), *Juncus kraussii*, *Samolus repens* (creeping brookweed), *Sarcocornia quinqueflora* and *Sporobolus virginicus* (saltwater couch) (See Table 1). The community is seldom abundant but is widely distributed on the Harbour (see Sections 1, 5, 10, 11 and 14 on Maps 1, 2, 4 and 5).

#### *Atriplex hypoleuca* open-closed sedgeland community (B3)

This community is found colonising accumulations of dead seagrass leaves and algae which have been washed up on the beaches (see Sections 1, 2, 9 and 10 of Maps 1 and 4). These accumulations can be up to one metre deep and are particularly extensive along the Vancouver Peninsula. While *Atriplex hypoleuca* is the dominant species, the herbs *Cakali maritima* (sea rocket), *Suaeda australis* and *Carpobrotus virescens* (pigface) are sometimes abundant also (Table 1). These species appear to consolidate the seagrass and algae heaps and bring about the build-up of wind-blown sand within it, enabling the coastal vegetation to succeed this community in time. This was deduced by digging into the soil under the adjacent beachside coastal vegetation of the Peninsula to expose the highly organic soil. The organic matter had the same consistency as dried *Cladophora*, suggesting that beachside accumulations of seagrass and algae are an integral part of the successional relationships of the dunal vegetation surrounding the Harbour.

### 4.2 Salt-marsh vegetation (S)

#### *Sarcocornia quinqueflora* complex

The decumbent shrub *Sarcocornia quinqueflora* is the characteristic species of this complex of four samphire communities.

***Hemichroa pentandra* - *Sarcocornia quinqueflora* low open-closed herbland community (S1).** Narrow bands of coarse sand and shell grit occur to the landward of *Sarcocornia* marsh (S2) or *Juncus kraussii* complex in areas which are seldom inundated by high tide. In these conditions *Sarcocornia quinqueflora* and *Hemichroa pentandra* form a low herbland often with scattered low *Juncus kraussii* and sometimes with small patches of *Samolus repens* (Table 2) (see Sections 2, 3, 4, 7 and 9 of Maps 1, 2 and 3).

**Table 1: Beachside plant communities. Quadrats arranged into groups by tabular synthesis (see Bridgewater 1981)**

COMMUNITY	B1	B2					B3							
Quadrat no.	20	1	4	98	45	100	3	10	2	5	7	9	11	12
SPECIES														
<i>Calocephalus brownii</i>	3													
<i>Isolepis nodosa</i>	+	5	3	5	1	1			+					
<i>Lepidosperma gladiatum</i>		1	2	1	+									
* <i>Euphorbia terracina</i>	+	3	3		+			+	1					
<i>Atriplex hyperleuca</i>				2	2	+	1	1	4	2	2	1	5	5
* <i>Cakile maritima</i>				+		+		4	4	+	1	2		
<i>Suaeda australis</i>				2		3	+		+	+				1
<i>Melilotus alba</i>		2												
<i>Apium prostratum</i>		2												
<i>Conyza bonariensis</i>		1	+		1									
<i>Baumea juncea</i>		1												
<i>Sonchus oleraceus</i>		+												
<i>Carpobrotus virescens</i>									3		+			
<i>Olearia axillaris</i>					+				+					
<i>Tetragonia tetragonoides</i>											+			
<i>Atriplex prostrata</i>				+	+									+
<i>Oxalis pes-caprae</i>				+										
<i>Juncus kraussii</i>				+	3									
<i>Lobelia alata</i>				+										
<i>Samolus repens</i>					1	3								
<i>Sarcocornia quinqueflora</i>					3	1								
<i>Sporobolus virginicus</i>					2	3								
<i>Aizoaceae sp.</i>						2								
<i>Dittrichia viscosa</i>					2									
<i>Rhagodia baccata</i>					+									
* <i>Pennisetum clandestina</i>					1									
<i>Eucalyptus megocarpa</i>					+									
<i>Pimelia imbricata</i>	+													
<i>Hemichroa pentandra</i>	2													

B1 *Calocephalus brownii* open shrubland community

B2 *Isolepis nodosa* open-closed sedgeland community

B3 *Atriplex hypoleuca* open-closed herbland community

***Sarcocornia quinqueflora* low closed herbland community (S2).** The most saline and often inundated areas of the salt-marsh support this community (see Sections 2, 4, 7, 9 and 11 of Maps 1, 2, 3 and 4). It mostly consists of little more than the dense growth of *Sarcocornia quinqueflora*. Other species are sometimes present as scattered clumps, including *Juncus kraussii*, *Suaeda australis*, *Samolus repens*, *Sporobolus virginicus* and *Atriplex hypoleuca* (Table 2). *Suaeda australis* enjoys localised success where *Cladophora* has washed up and smothered the *Sarcocornia*.

***Samolus repens* low closed herbland community (S3).** The low herb *Samolus repens* becomes dominant in patches or mats amongst the *Sarcocornia* marsh (S2), typically near tidal creeks and small tidal lagoons (see Table 2). The exact environmental conditions which favour this species are unknown, but its community is known also on the Leschenault Inlet and Oyster Harbour (Pen, 1992, In prep.). On Princess Royal Harbour it is found near Rushy Point (Section 9, Map 3).

***Wilsonia humilis* low open-closed herbland community (S4).** *Wilsonia humilis* is a prostrate silvery herb which forms a very alien looking community with *S. quinqueflora*, *S. australis* and *S. repens* at the tip of Rushy Point (Section 9, Map 3). Less common are *Hemichroa pentandra* and *J. kraussii* (Table 2). It appears to occupy a very saline and exposed part of the intertidal zone.

#### ***Triglochin striata* low closed herbland community (T)**

The small herb *Triglochin striata* (streaked arrowgrass) forms small dense patches on sandy to gravelly beach along Chipana Drive west of the sailing club and also to the east where human activity has cleared the usual fringing bands of *Juncus kraussii* (Sections 6 and 8 of Maps 2 and 3; Table 3). This odd almost single species community is also known from the Leschenault Inlet and the Swan Canning system (Trudgen, 1983; Pen, 1981).

#### ***Juncus kraussii* fringing complex (R)**

The large rush *Juncus kraussii* characterises a complex of four communities which fringe the Harbour waters in areas where inundation by saline tidal waters is the dominant factor.

***Juncus kraussii* - *Hemichroa pentandra* herbland community (R1).** Here clumps of *Juncus kraussii* occur with mats of *Hemichroa pentandra* on slightly raised strips of coarse white sand and shell grit, lying between coastal forest or coastal sedgeland and closed rushland of *Juncus kraussii* (Table 3). The community is uncommon, only found at the southern end of the Vancouver Peninsula (Section 2, Map 1) on land not typically inundated by tidal water.

***Juncus kraussii* closed rushland community (R2).** *Juncus kraussii* forms narrow to broad bands or large stands of rushland in areas fringing the water or salt-marsh where tidal inundation is a common occurrence. As such, the community is common along most if not all estuaries and inlets in the south-west and is indeed the most widespread plant community on Princess Royal Harbour. As elsewhere, *Juncus kraussii* forms stands so dense that other species are not present or are only sparsely present. In the study area, *Sporobolus virginicus*, *Suaeda australis* and *Sarcocornia quinqueflora* are sometimes present (Table 3).

In Section 6, east of Limeburner Point, (Map 2) this community is being smothered by algae and undermined and eroded away through vehicular disturbance. In Sections 7 and 8 (Maps 2 and 3) vehicular disturbance has also crushed and subsequently cleared large areas of rushland.

***Juncus kraussii* - *Samolus repens* closed rushland community (R3).** It is not clear what subtle environmental conditions support this community (Table 3) but it appears to be found in areas similar to that of the above community (R2) in Sections 4, 7 and 9 (see Maps 1, 2 and 3).

**TABLE 2: SAMPHIRE PLANT COMMUNITIES. QUADRATS ARRANGED INTO GROUPS BY TABULAR SYNTHESIS (SEE BRIDGEWATER 1981)**

COMMUNITIES	S1								S2								S3			S4		
Quadrat no.	16	35	39	28	31	58	74	15	13	46	49	51	87	60	38	106	77	88	89	69	70	
SPECIES																						
<i>Hemichroa pentandra</i>	4	5	5	2	2	3	4	2													1	
<i>Sarcocornia quinqueflora</i>	2	1	1	2	+	1	1	4	3	5	2	5	3	4	2	3	+	+	+	2	+	
<i>Juncus kraussii</i>	+	+	2	2	+	1	4	1	3	2	4	1	+	1	2	1	+	1	5	2		
<i>Suaeda australis</i>										2	+	+	4	3	+	3	2	+	+	1	+	
<i>Samolus repens</i>		1	2	3			2		+	1	1			3	3	3	5	5	4	2	1	
<i>Wilsonia humilis</i>																				5	5	
<i>Baumea juncea</i>		2																				
<i>Sporobolus virginicus</i>										2						+						
<i>Atriplex prostrata</i>											+											
<i>Atriplex hypoleuca</i>						+					+			+		1						
<i>Lepidosperma gladiatum</i>						1																
<i>Leptocarpus aristatus</i>						+																
<i>Gahnia trifida</i>						2										+						

S1 - *Hemichroa pentandra* - *Sarcocornia quinqueflora* low open-closed herbland community

S2 - *Sarcocornia quinqueflora* low closed herbland community

S3 - *Samolus repens* low closed herbland community

S4 - *Wilsonia humilis* low open-closed herbland community





*Juncus kraussii* - *Baumea juncea* closed sedgeland community (R4). The small to medium sedge *Baumea juncea* (twig rush) joins *Juncus kraussii* in areas which are commonly inundated by tidal water, but which also receive significant freshwater input via groundwater seepage. The community (Table 3) is typically found between *Juncus kraussii* closed sedgeland (R2, R3) and *Baumea juncea* low closed sedgeland (CS1) (Sections 2, 3, 4 and 9, Maps 1 and 3). On estuaries and inlets *Baumea juncea* is probably an excellent indicator of freshwater seepage.

### 4.3 Coastal seepage zone vegetation (CS)

Although Princess Royal Harbour is a marine embayment with typical ocean salinities, freshwater vegetation is often found well into the intertidal zone. This is because the upper intertidal zone receives heavy freshwater flushing from groundwater seepage in areas between the Vancouver Peninsula and Melville Point (Tomlinson, 1992). The vegetation found in these areas is typically coastal and can be divided into sedgelands and low forests.

#### 4.3.1 Coastal sedge vegetation

##### *Baumea juncea* low closed sedgeland community (CS1)

*Baumea juncea* forms a low closed to medium height sedgeland in zones strongly flushed with fresh groundwater and are occasionally inundated by high tides. The community often forms irregular bands to the landward of *Juncus kraussii* rushlands. Three subcommunities are recognised.

*Baumea juncea* - *Juncus kraussii* low closed sedgeland subcommunity. Clumps of *Juncus kraussii* are interspersed amongst the *Baumea* in areas which are probably subject to greater tidal inundation than is typical of the community (Table 3). The subcommunity is found in Sections 2 and 4 (Map 1) on the Vancouver Peninsula and east of Limekilns Point.

*Baumea juncea* low closed sedgeland subcommunity. This is the typical form of the community (Table 3) and is found in Sections 2, 4 and 9 (Maps 1 and 3).

*Baumea juncea* - *Gahnia trifida* closed sedgeland subcommunity. The tall sedge *Gahnia trifida* (coastal saw sedge) occurs with *Baumea juncea* in Section 9 in an area towards the upper end of the intertidal zone which appears to be relatively dry and saline in summer and autumn but very fresh in winter and spring.

##### *Lepidosperma gladiatum* tall closed sedgeland community (CS2)

The tall sedge *Lepidosperma gladiatum* occurs in patches with the shrubs *Acacia littorea*, *Leucopogon obovatus* and *Olearia axillaris* (coast daisy bush), the sedge *Isolepis nodosa* and the native tufted grass *Poa porphyroclados* (Table 4). The community occurs in depressions which may be sandy or peaty and swampy or on sandy rises, and always in freshwater conditions. It occurs in Sections 1, 8, 9 and 10 (Maps 1, 3 and 4).

##### *Juncus kraussii* coastal sedgeland complex

*Juncus kraussii* characterises another complex of two communities found in areas which are subject to tidal inundation but where freshwater input via groundwater seepage is the dominant factor for at least part of the year. This is expressed by the strong presence of plant species more typical of the adjacent coastal swamps and dunes (see Smith, 1991).

*Juncus kraussii* - *Isolepis nodosa* - *Lepidosperma gladiatum* closed sedgeland community (CS3). This community is found in sandy low lying areas receiving strong freshwater seepage (Sections 2, 3, 4 and 11; Maps 1 and 4). Other characteristic species include *Poa porphyroclados*, the mat grass *Sporobolus virginicus*, *Baumea juncea* and *Atriplex hypoleuca* (Table 4).

*Juncus kraussii* - *Gahnia trifida* open sedgeland community (CS4). The presence of these two salt tolerant species as well as *Sporobolus virginicus*, *Samolus repens* and *Sarcocornia quinqueflora* is not surprising on the saline and sandy sites on which this community is found, but the presence also of the large shrubs *Acacia littorea*, *Melaleuca incana* and *Banksia littoralis* (swamp Banksia) and the sedge *Leptocarpus aristatus* suggests strong freshwater input at times (Table 4). The community is found in Sections 5 and 7 (Map 2).

#### 4.3.2 Coastal forest vegetation (CF)

##### *Agonis juniperina* - *Gahnia trifida* - *Baumea juncea* low woodland community (CF1)

*Agonis juniperina* can grow into a medium size tree, but in this community, on swampy peaty soil, it has a stunted form as a large shrub/small tree. As such it forms a low woodland over the sedges *Gahnia trifida* and *Baumea juncea*. Also present are the small tree *Agonis flexuosa* (WA peppermint), the shrubs *Acacia littorea*, *Allocasuarina humilis* (scrub sheoak), *Rhagodia baccata* (sea berry saltbush), the herb *Lobelia alata* (angled Lobelia) and *Juncus kraussii* (Table 4). The community is restricted to Section 9 (Map 3) where it is slowly being replaced or degraded by residential development.

##### *Agonis flexuosa* complex

The small spreading tree *Agonis flexuosa* is common in patches along the south-western and north-western corners of the Harbour where it characterises a forest complex of two communities. Remnant understorey plants suggest that this community was abundant along the north-western end of the Harbour where Frenchman Bay Road now runs along the beach. Very strong groundwater seepage in this area (Tomlinson, 1992) once sustained this complex very close to marine waters, but now supports pasture and market gardens.

*Agonis flexuosa* - *Banksia littoralis* - *Melaleuca incana* low open closed forest community (CF2). In mostly fresh swampy sites with soils of sand and peat *Agonis flexuosa* is joined by the small trees *Banksia littoralis* and *Melaleuca incana*. The community is sometimes quite close to more saline sites where *M. incana* mixes with sedgeland (CS4) or *Melaleuca cuticularis* (salt-water paperbark) (see EF3 below). The understorey is relatively rich (Table 4) with a variety of sedges such as *Lepidosperma gladiatum*, *L. longitudinale* (common sword sedge), *Baumea juncea*, *Gahnia trifida*, *Loxocarya* aff. *cinerea*, *L. flexuosa*, *L. tenax* and *Isolepis nodosa*, some small to medium shrubs including *Sollya heterophylla* (Australian blue bell), *Pimelia rosea* (rose banjine) and *Leucopogon parviflorus* (coast beard heath) and a number of large shrubs such as *Agonis juniperina* (Warren River cedar), *Hakea varia* (variable leafed Hakea), *Oxylobium lanceolatum* (greenbush), *Acacia littorea* and *Spyridium globulosum* (basket bush). The herb *Lobelia alata* is also common. The only weed of any significance is the grass *Holcus lanatus* (Yorkshire fog). The community is found in Sections 9 and 11 (Maps 3 and 4).

*Agonis flexuosa* low open-closed forest community (CF3). On moist sandy rises *Agonis flexuosa* is the sole dominant tree. The understorey consists of the sedges *Lepidosperma gladiatum*, *Loxocarya* aff. *cinerea*, *Isolepis nodosa* and *Baumea juncea*, the shrubs *Acacia littorea*, *Spyridium globulosum*, *Leucopogon obovatus*, *Rhagodia baccata* and *Sollya heterophylla* and others (Table 4). This community represents the uppermost extent of fringing vegetation where the sand dunes meet the harbour. It is found in Sections 8, 9 and 11 (Maps 3 and 4).

Table 4: Coastal sedgeland and coastal forest plant communities. Quadrats arranged into groups by tabular synthesis (see Bridgewater 1981)

COMMUNITIES	CS2					CS3							CS4						CF1		CF2				CF3			
	Quadrat no.	67	93	6	8	83	68	72	19	27	34	63	99	59	44	55	56	57	81	90	92	94	95	107	108	101	65	66
<i>Acacia littorea</i>	1		+	3	3	2	2						2		2	2	2	+	1	+	+	2		+	1		3	1
<i>Lepidosperma gladiatum</i>	3	3	2	3	3	2	2	2		2	3	2						1		+	2	2	3	2			1	2
<i>Isolepis nodosa</i>	2		1			2	2	+	2	2	3	3			+	+							2		1		2	2
<i>Juncus kraussii</i>						3	3	3	4	2	4	3	5	3	4	3	3	1	2	1							4	3
<i>Leucopogon parviflorus</i>			+		2		1				1				1		2				+		1	+				
<i>Poa porphyroclados</i>	1				2		3			1		+			+		+									1		
<i>Sporobolus virginicus</i>						1	5					2		2	2	3	2									+	5	
<i>Gahnia trifida</i>		2				1							4	2	3	2	3	5	3	3	2	2		1			+	
<i>Agonis flexuosa</i>												3		2					1	+	2	2	5	2	5	4	2	4
<i>Baumea juncea</i>	4				2				2	1		1							3	4	2		3	2			+	2
<i>Banksia littoralis</i>					2										2	1	2	+				1	2	3	4			
<i>Melaleuca incana</i>													2			4						3	4	+	5			
<i>Agonis juniperina</i>		1																	3	4	1	2						
<i>Loxocarya aff. cinerea</i>					2							1								2	1	4	+	+	1			1
<i>Lobelia alata</i>	2	+																	1	+	+	+		+				
<i>Spyridium globulosum</i>	1						+																2	1	1		2	
<i>Leucopogon obovatus</i>	1		+	+	1		+					2											1		2			1
<i>Allocasuarina humilis</i>	1				+	2	3						1						+	1				2	2			
<i>Rhagodia baccata</i>	1				+							1						+	2	3					1			1
<i>Olearia axillaris</i>	2		2	1		2																						
<i>Adenanthos cygnorum</i>			+							+																2		
<i>Hibbertia cuneiformis</i>	2		1	+		3																					+	
<i>Gyrostemon ramulosus</i>			1																									

Table 4 cont'd

COMMUNITIES	CS2					CS3					CS4					CF1		CF2				CF3							
	Quadrat no.	67	93	6	8	83	68	72	19	27	34	63	99	59	44	55	56	57	81	90	92	94	95	107	108	101	65	66	97
<i>Rhagodia baccata</i>			1				1								2														
<i>Atriplex hypoleuca</i>				+		2					+	2		2															
<i>Loxocarya flexuosa</i>				1		3	+										+					2		1	+				
<i>Apium prostratum</i>										1																	+		
<i>Darwinia diosmoides</i>									2	2																	1		
<i>Carpobrotus virescens</i>						1					+					+													
<i>Acacia pullchella</i>											+																		
<i>Dryandra formosa</i>										2																			
<i>Briza maxima</i>											+																		
<i>Olearia dampieri subsp. eremicola</i>					1																								
<i>Leptomeria squarrulosa</i>					1																								
<i>Lepidosperma longitudinale</i>						2																+		1	1	+			
* <i>Pelargonium capitatum</i>	+					2	+					+												+		+			
* <i>Taraxacum officinale</i>	+					+																				+			
<i>Sollya heterophylla</i>																							+	1	1	+		+	
<i>Acacia cyclops</i>									3																				
<i>Sarcocornia quinqueflora</i>						1	+	+							2	+	+	2											
<i>Suaeda australis</i>						+							1		2		+												
<i>Conyza bonariensis</i>															+														
<i>Leptocarpus aristatus</i>																3	4	3											
<i>Samolus repens</i>	1												1		3	3		2											
<i>Hemichroa pentandra</i>								1						+				2											
* <i>Pennisetum clandestina</i>	+										4																		
<i>Atriplex prostrata</i>											2	+															3		
* <i>Sonchus oleraceus</i>												+															+		

Table 4 cont'd

COMMUNITIES	CS2					CS3								CS4						CF1		CF2				CF3				
	Quadrat no.	67	93	6	8	83	68	72	19	27	34	63	99	59	44	55	56	57	81	90	92	94	95	107	108	101	65	66	97	
<b>SPECIES</b>																														
<i>*Aster subulatus</i>																													1	
<i>Villarsia albiflora</i>	4																													
<i>*Cortaderia selloana</i>	1																													
<i>Schoenus aff. nitens</i>	1	2																												
<i>Dittrichia viscosa</i>						1														+	+									
<i>Cythochaeta aff. avenacea</i>						1																								
<i>Adenanthos cuneatus</i>												+																		
<i>Templetonia retusa</i>									+																					
<i>*Solanum nigrum</i>									+																					
<i>Eucalyptus cornuta</i>											2																			
<i>Typha sp.</i>		2																												
<i>Baumea riparia</i>		3																				+								
<i>Villarsia albiflora</i>		+																												
<i>Triglochin procera</i>		2																												
<i>Phebalium anceps</i>		+																				+								
<i>Hakea varia</i>																						1	+		2					
<i>Loxocarya tenax</i>																						2								
<i>Acacia hastulata</i>																						+								
<i>Pimelia rosea</i>					2																		1	1						
<i>Comesperma virgatum</i>																						+								
<i>Schoenus sp.</i>																						+								
? <i>Halorhagus</i>																						1	1							
<i>Patersonia occidentalis</i>																														2
<i>Oxylobium lanceolatum</i>																						+	3		3					

Table 4 cont'd

COMMUNITIES	CS2					CS3					CS4					CF1		CF2				CF3						
Quadrat no.	67	93	6	8	83	68	72	19	27	34	63	99	59	44	55	56	57	81	90	92	94	95	107	108	101	65	66	97
SPECIES																												
<i>Olearia heleophila</i>																							1					
<i>Anigozanthus flavida</i>																								2				
* <i>Rubus sp.</i>																								2				
* <i>Holcus lanatus</i>																								2	1			
<i>Opercularia sp.</i>																								1				
<i>Scaevola crassiflora</i>																									1			
<i>Petrophile sp.</i>																									1			

CS2 - *Lepidosperma gladiatum* tall open sedgeland community

CS3 - *Juncus kraussii* - *Isolepis* - *Lepidosperma gladiatum* closed sedgeland community

CS4 - *Juncus kraussii* - *Gahnia trifida* open sedgeland community

CF1 - *Agonis juniperina* - *Gahnia trifida* - *Baumea juncea* woodland community

CF2 - *Agonis flexuosa* - *Banksia littoralis* - *Melaleuca incana* low open closed forest community

CF3 - *Agonis flexuosa* low open closed forest

## 4.4 Estuarine forest (EF)

### *Melaleuca cuticularis* complex

Low closed forests dominated by the small tree *Melaleuca cuticularis* are found at three sites dotted around the Harbour. They are located at the upper end of the intertidal zone where freshwater input via groundwater seepage is minimal, such as in the north-western corner (Tomlinson, 1992).

***Melaleuca cuticularis* low closed forest community (EF1).** Here the canopy of *M. cuticularis* is particularly dense and the understorey is sparse, consisting of little more than *Samolus repens*, *Sarcocornia quinqueflora*, *Lepidosperma gladiatum*, *Isolepis nodosa* and *Poa porphyroclados* (Table 5). The community is found in Section 11 (Map 4).

***Melaleuca cuticularis* - *Juncus kraussii* low open-closed forest community (EF2).** Sometimes *M. cuticularis* grows out over *Juncus kraussii* rushland in areas commonly inundated by tidal waters (Pen, 1992, 1995a and b). It appears that in some circumstances there is sufficient freshwater intrusion to permit *M. cuticularis* to colonise areas adjacent to inlet waters. Often human alterations to the local environment, such as compacted road base, cut off this freshwater input and cause the death of the *Melaleucas* (see Pen, 1992, 1995, In prep.). This community is found in Sections 2, 9 and 11 (Maps 1, 3 and 4). The only other common understorey species is *Gahnia trifida*; *Samolus repens*, *Suaeda australis*, *Sarcocornia quinqueflora*, *Wilsonia humilis* (silky *Wilsonia*) and *Hemichroa pentandra* are occasional (Table 5).

***Melaleuca cuticularis* - *Gahnia trifida* - *Baumea juncea* low open-closed forest community (EF3).** This community occurs at the upper end of the intertidal zone where freshwater input is probably more marked and *Juncus kraussii* is displaced by *Gahnia trifida* and *Baumea juncea* (Table 5). Two subcommunities are recognised.

***Melaleuca cuticularis* - *Gahnia trifida* - *Baumea juncea* subcommunity (EF3.1).** This subcommunity is basically as described above (Table 5) and is found in Sections 2, 9 and 11 (Maps 1, 3 and 4).

***Melaleuca cuticularis* - *Gahnia trifida* - *Baumea juncea* - *Melaleuca incana* subcommunity (EF3.2).** *Melaleuca incana* joins *Melaleuca cuticularis* in the overstorey in Section 9 (Map 3) where the community fringes with the *Agonis flexuosa* - *Banksia littoralis* - *Melaleuca incana* low open closed forest (CF2) and conditions are probably slightly less saline than for EF3.1. Other species present include *Juncus kraussii*, *Banksia littoralis* and *Leucopogon obovatus* (Table 5).

## 5. VEGETATION CHANGES

### 5.1 Plant community succession

A thorough study of vegetation change over the last 50 years or so is beyond the scope of this study. Certainly there is little evidence of major plant community succession in the remaining fringing vegetation, as would be seen by the new growth of plants or by dead and dying plants and by major weed infestations. On the whole the vegetation appears stable, which probably reflects only minor changes in the hydrological processes (groundwater seepage and tidal inundation) which govern plant community distribution.

### 5.2 Vegetation loss

Although not documented in detail, the loss of fringing vegetation through development has probably been most extensive along the western shoreline between Little Grove and Melville Point along Frenchman Bay Road. Here, remnant plants and the low lying swampy nature of the land suggest that this area once supported sedgeland and forest typical of the coastal seepage zones (see Section 4.3). This is further supported by the current land uses of pasture and market gardening which are sustained by freshwater input.

**Table 5: Estuarine forest plant communities. Quadrats arranged into groups by tabular synthesis (see Bridgewater 1981)**

COMMUNITIES	EF1	EF2							EF3			
Quadrat no.	102	75A	71	73	18	103	104	105	75B	109	26	22
SPECIES												
<i>Melaleuca cuticularis</i>	5	4	3	3	4	5	5	4	3	3	5	4
<i>Juncus kraussii</i>		5	4	4	3	2	2	2	1	2	+	
<i>Gahnia trifida</i>			2	2	4	2	3	1	5	5	4	3
<i>Baumea juncea</i>						1			2	3	2	5
<i>Samolus repens</i>	2		2			3	5	2				
<i>Suaeda australis</i>			2	1				+				
<i>Sarcocornia quinqueflora</i>	1	+	2	+				+				
<i>Wilsonia humilis</i>			4									
<i>Hemichroa pentandra</i>		2		2	2							
<i>Darwinia diosmoides</i>											+	
<i>Allocasuarina humilis</i>											+	
<i>Leptocarpus aristatus</i>											+	
<i>Atriplex hypoleuca</i>			2					1				
<i>Lepidosperma gladiatum</i>	3					1						
* <i>Pelargonium capitatum</i>	1					+						
<i>Acacia littorea</i>	+											
<i>Poa porphyroclados</i>	1							2				
<i>Isolepis nodosa</i>	2							+				
<i>Sporobolus virginicus</i>								1				
<i>Melaleuca incana</i>									2	3		
<i>Banksia littoralis</i>									2			
<i>Leucopogon obovatus</i>										2		
<i>Samolus junceus</i>										+		
<i>Lobelia ovata</i>										+		

EF1 - *Melaleuca cuticularis* low closed forest

EF2 - *Melaleuca cuticularis* - *Juncus kraussii* low open-closed forest community

EF3 - *Melaleuca cuticularis* - *Gahnia trifida* - *Baumea juncea* low open closed forest community



## **5.3 Colonisation of beach sand and algae and seagrass accumulations**

Two introduced species, *Cakali maritima* and *Euphorbia terracina*, colonise the sandy rises just above the beaches. Both species are far more vigorous in this zone than the native species which suggests that beach sand is more quickly stabilised today than it was in the past.

The present eutrophic state of the Harbour has led to large amounts of *Cladophora*, mixed with senescent seagrass leaves, being washed up on beaches, particularly along the Vancouver Peninsula. These accumulations can be up to 10 metres across and about a metre deep. Thrown up on the higher parts of the beach by storm waves, these accumulations bake hard and capture sand.

While the annual species *Cakali maritima* and *Euphorbia terracina* will colonise the algae and seagrass accumulations the perennial native species, *Atriplex hypoleuca*, *Suaeda australis* and *Carpobrotus virescens*, are more vigorous. This suggests that these species have a natural pioneering role on this material and may in time be succeeded by coastal vegetation as further sand accumulates. Indeed excavations in adjacent coastal vegetation showed that the soil had a very high and dry organic content. While this colonisation is today occurring largely on dead algae, it is likely that seagrass leaves made up the bulk of these accumulations in the past, when the Harbour had about ten times the cover of seagrass it has today (see EPA, 1990). Areas exhibiting colonisation of algae and seagrass accumulations are indicated in Figure 2.

## **6. MANAGEMENT**

### **6.1 Foreshore disturbance**

#### **6.1.1 Four wheel drive disturbance**

Significant vegetation loss has occurred between Limeburner Point and Princess Avenue through damage caused by fourwheel drive vehicles (see Figure 3). To the west of the sailing club and south of Rushy Point this has led to the exposure of a high sandy embankments to wave action and serious erosion has resulted. South-east of Princess Avenue samphire is being crushed and subsequently undermined by wave action. If not controlled, the high sandy peninsula which protrudes into the harbour in this area will eventually be eroded by waves.

#### **6.1.2 Boat storage and launching**

The storage of small boats along the southern foreshore is also contributing to vegetation loss. Areas are either cleared for this purpose or boats are simply left lying on the vegetation, ultimately killing it. Clearly there is a need to promote boat mooring below the beach as presently occurs just to the west of the sailing club.

Boat launching is also a problem with some areas of foreshore being excavated to provide access. This activity destroys the vegetation directly and opens adjacent ground to wind and water erosion.

#### **6.1.3 Algae smothering**

The smothering of rushes and samphire by washed up algae is a problem between the Vancouver Peninsula and the sailing club and at points along the western foreshore (Figure 3). In some places this has exposed the upper foreshore to wave action, causing major erosion.

#### **6.1.4 Human trampling**

The steady residential growth of the Little Grove settlement and the area east to Limekilns Point is resulting in an increase in "people pressure" along the foreshore. Human trampling is degrading some areas of fringing vegetation where access tracks have yet to be constructed. In other areas where these tracks are present, they are not managed and are undermining adjacent fringing vegetation. At present human trampling is not a serious problem but access management will be required in the near future to protect remnant fringing and dunal vegetation.

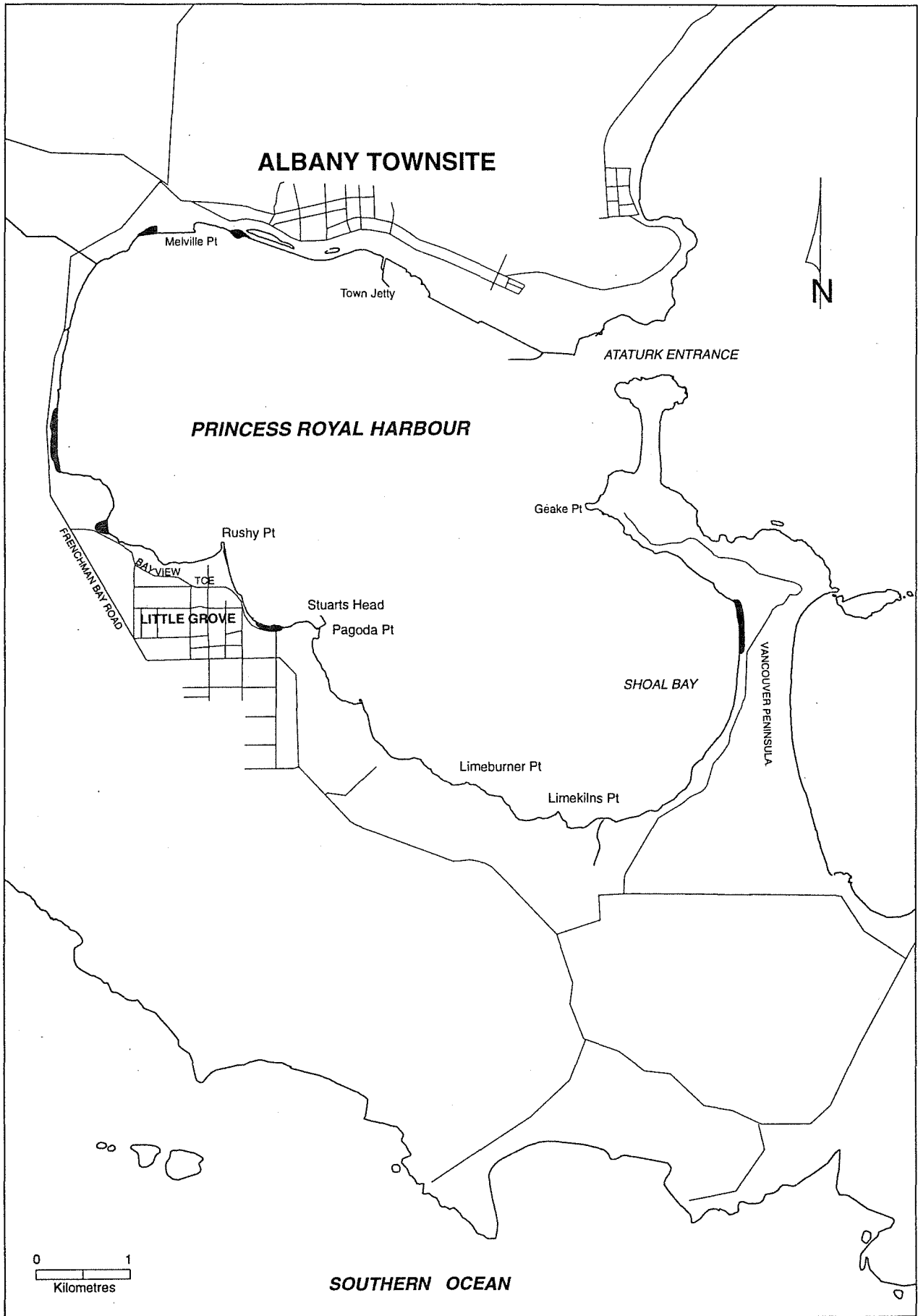


FIGURE 2 : Foreshore areas exhibiting colonisation of algae and seagrass accumulations by fringing plant communities.

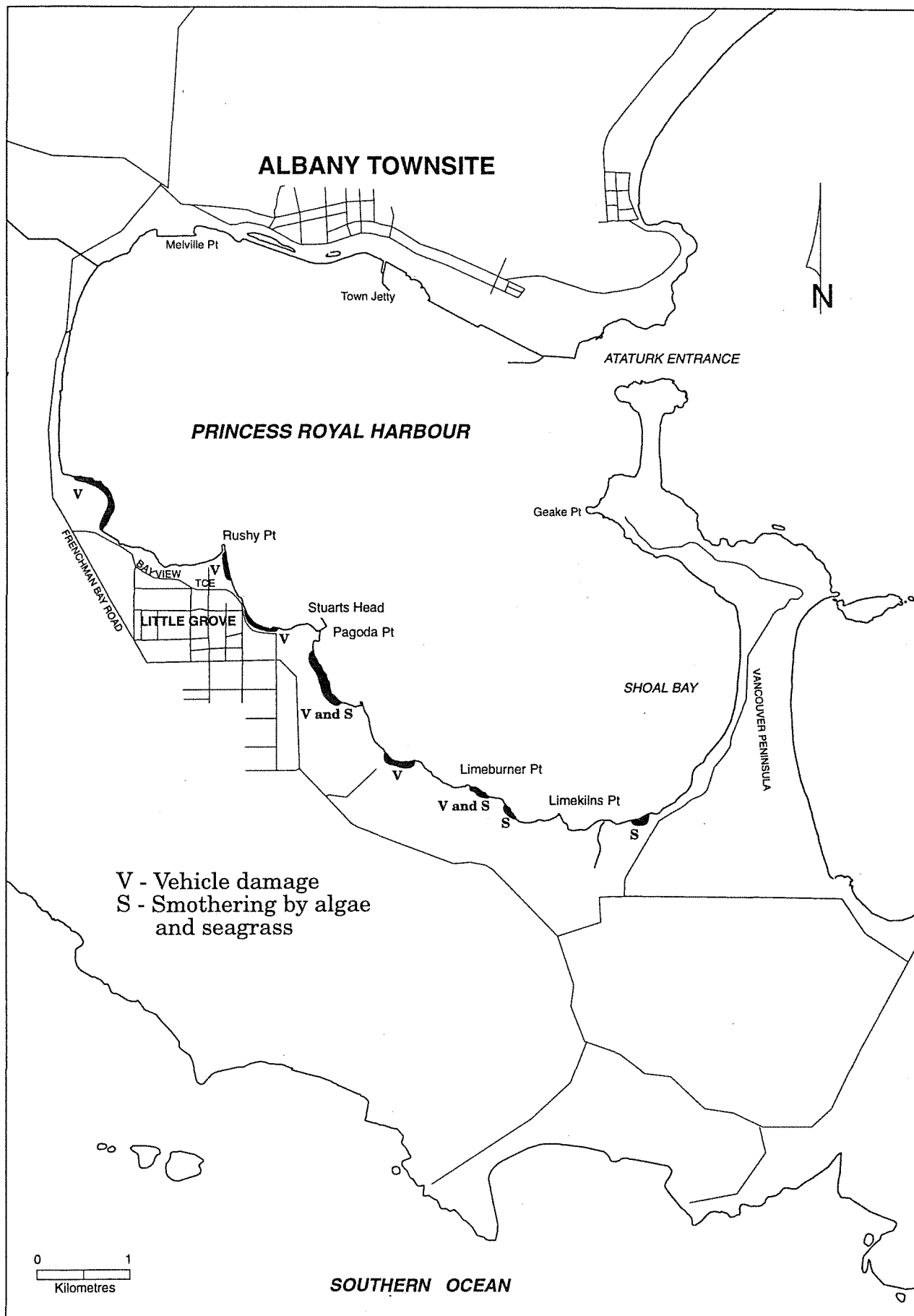


FIGURE 3 : Foreshore areas suffering the loss of fringing vegetation through algae smothering and vehicle damage.

### 6.1.5 Foreshore pruning, clearing, reclamation and walling

The pruning and clearing of fringing vegetation on public land is occurring along the western foreshore and near Little Grove and can be expected to increase with further residential development. Reclamation or landfill is presently occurring west of Rushy Point for housing development. Signage is required to promote the value of fringing vegetation. It should state that fringing vegetation plays a role in nutrient attenuation which is particularly important given the eutrophic state of the Harbour and the fact that Little Grove is not sewered.

## 6.2 Weed infestation

Although there is little serious weed invasion of the fringing vegetation of the Harbour, discarded garden and lawn clippings were observed along the foreshore. This activity is thought to be the main means by which certain garden species become established amongst native fringing vegetation (Pen, 1994). On Princess Royal Harbour only buffalo grass has so far become established and then in only one or two localities.

The tall introduced grass *Phragmites australis*, introduced to the south-west for decoration (Paterson, undated) infests a disturbed site on the northern reclaimed foreshore just to the west of the Town Jetty.

## 6.3 Landscape

Fringing vegetation does not make a large contribution towards the landscape of Princess Royal Harbour. Rather the landscape of the Harbour is dominated by the jarrah/marri scrub of Mounts Adelaide, Clarence and Melville and the jarrah scrub, heath and peppermint, coastal yate (*Eucalyptus cornuta*) and karri forests of the Torndirrup Peninsula. But the low lying forests of Melaleuca and Agonis, bands of *Juncus kraussii* and samphire flats contribute to the lower landscape about the edges of the Harbour and are important for views of the Harbour taken at a raised level such as at Camp Quararup, Limeburner Point and Limekilns Point and Mount Melville and when viewing the Harbour from a car window along Frenchman Bay Rd and Bay View Drive.

## 6.4 Area worthy of conservation and landscape protection

The most extensive and diverse fringing vegetation on Princess Royal Harbour is found between Rushy Point and Princess Avenue (Map 3). Not only does it have a wide range of fringing plant communities which are representative of much of that which is typical of the Harbour, it also supports significant waterbird feeding and a large population of burrowing crabs.

## 6.5 Vegetation rehabilitation

The following is a list of the native plant species recommended for rehabilitation of the native vegetation, broken down into the various zones of the estuary foreshore and associated land.

Sandy beachside foreshore (often inundated)

*Juncus kraussii*

*Suaeda australis*

*Sporobolus virginicus*

Sandy rises near beach (seldom or never inundated)

*Calocephalis brownii*

*Isolepis nodosa*

*Pimelia imbricata*

*Atriplex hypoleuca*

*Carpobrotus virescens*

Saline flats

*Sarcocornia quinqueflora*

*Wilsonia humilis*

*Hemichroa pentandra*

*Samolus repens*

*Suaeda australis*

Saline flats receiving a little freshwater input

*Melaleuca incana* (PRH form)

*Melaleuca cuticularis*

*Gahnia trifida*

*Juncus kraussii*

*Sporobolus virginicus*

*Poa porphyroclados*

*Sarcocornia quinqueflora*

*Hemichroa pentandra*

*Wilsonia humilis*

*Suaeda australis*

*Samolus repens*

Freshwater seepage zone within the intertidal zone

*Melaleuca incana* (PRH form)

*Acacia littorea*

*Baumea juncea*

*Gahnia trifida*

*Lepidosperma gladiatum*

*Juncus kraussii*

*Poa porphyroclados*

*Atriplex hypoleuca*

Freshwater seepage zone above the intertidal zone

*Agonis flexuosa*

*Agonis juniperina*

*Banksia littoralis*

*Oxylobium lanceolatum*

*Leucopogon obovatus*

*Allocasuarina humilis*

*Rhagodia baccata*

*Hakea varia*

*Sollya heterophylla*

*Loxocarya flexuosa*

*Loxocarya tenax*

*Leptocarpus aristatus*

*Poa porphyroclados*

Moist dunal areas

*Agonis flexuosa*

*Allocasuarina humilis*

*Olearia axillaris*

*Spyridium globulosum*

*Hibbertia cunieformis*

*Acacia littorea*

*Leucopogon obovatus*

*Leucopogon parviflorus*

*Sollya heterophylla*

*Loxocarya flexuosa*

*Isolepis nodosa*

*Lepidosperma gladiatum*

Key landscape trees for gardens and parks

*Melaleuca incana*

*Agonis flexuosa*

*Eucalyptus cornuta*

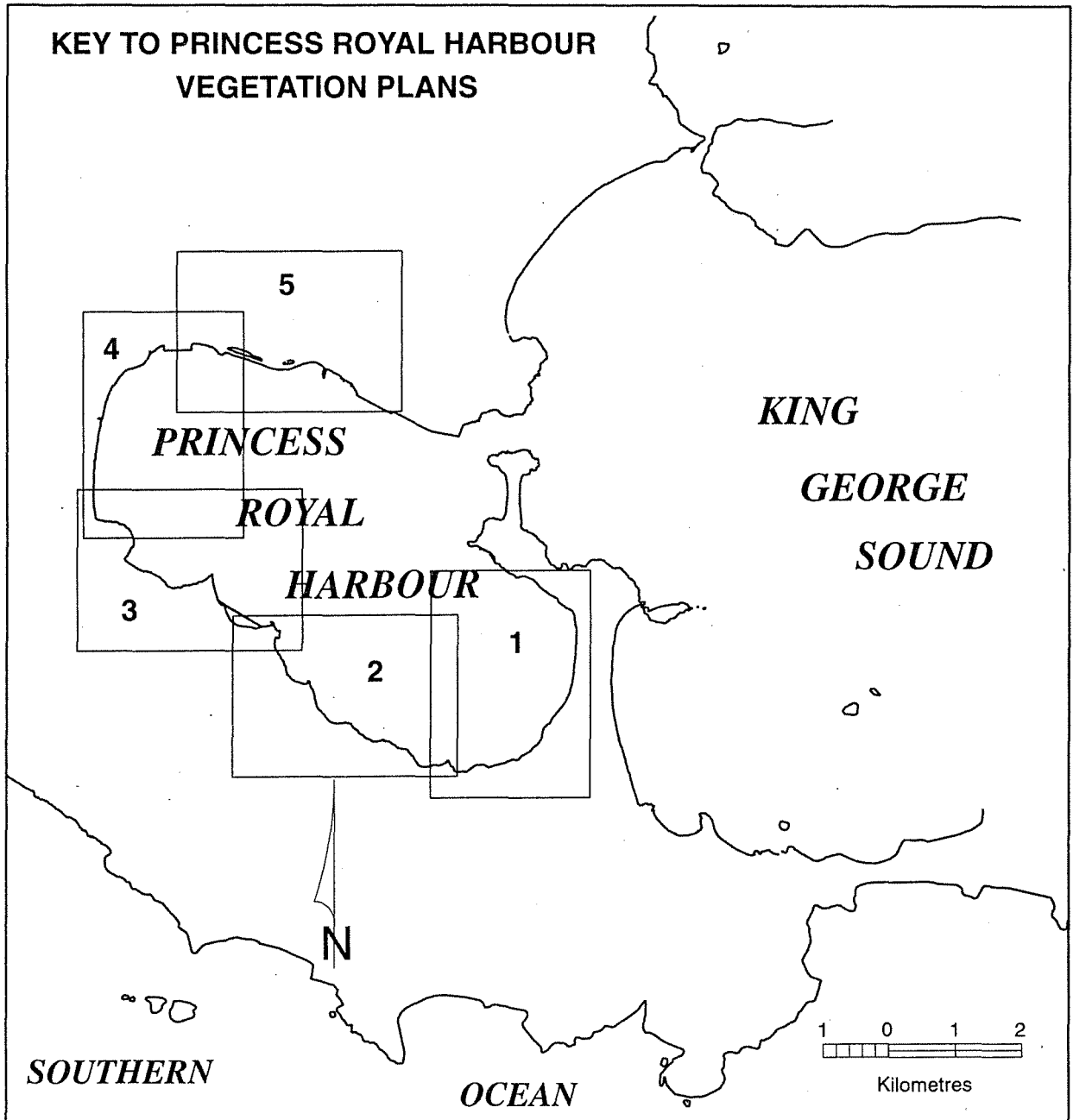
*Eucalyptus megacarpa*

*Eucalyptus diversicolor* (on good soil only)

## 7. REFERENCES

- Backshall D J (1977) The peripheral vegetation of the Peel-Harvey estuarine system. Unpublished B Sc Honours thesis, Murdoch University.
- Bridgewater P B (1981) Potential application of the Zurich-Montpellier system of vegetation description and classification in Australia. In: Gillison, A N and Anderson, D J. *Vegetation Classification in Australia*, pp. 1-9. CSIRO. Australian National University Press, Canberra.
- Brock M A and Pen L J (1984) Ecological studies of the Canning River Wetland. School of Environmental and Life Sciences, Murdoch University.
- Cresswell I D and Bridgewater P B (1985) Dune vegetation of the Swan Coastal Plain, Western Australia. *Journal of the Royal Society of Western Australia*, 67, 137-148.
- Environmental Protection Authority (1990) Albany harbours environmental study. Western Australian Environmental Protection Authority Bulletin 412.
- Muller-Dombois D and Ellenberg H (1974) *Aims and Methods of Vegetation Ecology*, Wiley, New York.
- Paterson J G (Undated) Grasses in South Western Australia. Western Australian Department of Agriculture, Bulletin 4007.
- Pen L J (1981) The peripheral vegetation of the Swan and Canning Rivers: past, present and future. Unpublished B Sc Honours thesis, Murdoch University.
- Pen L J (1983) Peripheral vegetation of the Swan and Canning Estuaries 1981. Department of Conservation and Environment, Bulletin 113, July 1983.
- Pen L J (1992) Fringing estuarine vegetation of the Leschenault Estuary 1941 - 1991. Waterways Commission Report No 31.
- Pen L J (1993a) Fringing vegetation of the Lower Collie and Brunswick Rivers 1992. Waterways Commission Report No 37.
- Pen L J (1993b) Fringing vegetation of the Canning, Southern and Wungong Rivers. Swan River Trust Report No 7.
- Pen L J (1994) Weeds in wetlands. In: *Weeding Western Australia* pp. 11-17. A forum for land managers. Australian Association for Environmental Education (WA).
- Pen L J (1995) The fringing vegetation of the Wilson Inlet bar 1946 - 1993. Waterways Commission Report (In prep.).
- Pen L J (In prep.) The fringing vegetation of Oyster Harbour. Waterways Commission Report.
- Siemon N, Davis G, Hubbard P and Duckworth A (1993) Fringing vegetation of the Serpentine River in the Shire of Serpentine-Jarrahdale and the City of Rockingham. Waterways Commission Report No 38.
- Tomlinson A J (1992) Investigation of the groundwater nutrient load Princess Royal Harbour, Albany. Unpublished report of the School of Civil and Environmental Engineering, University of Western Australia.
- Trudgen M E (1984) The Leschenault Peninsula - a flora and vegetation survey with an analysis of its conservation value and appropriate uses. Department of Conservation and Environment, Bulletin 157, June 1984.

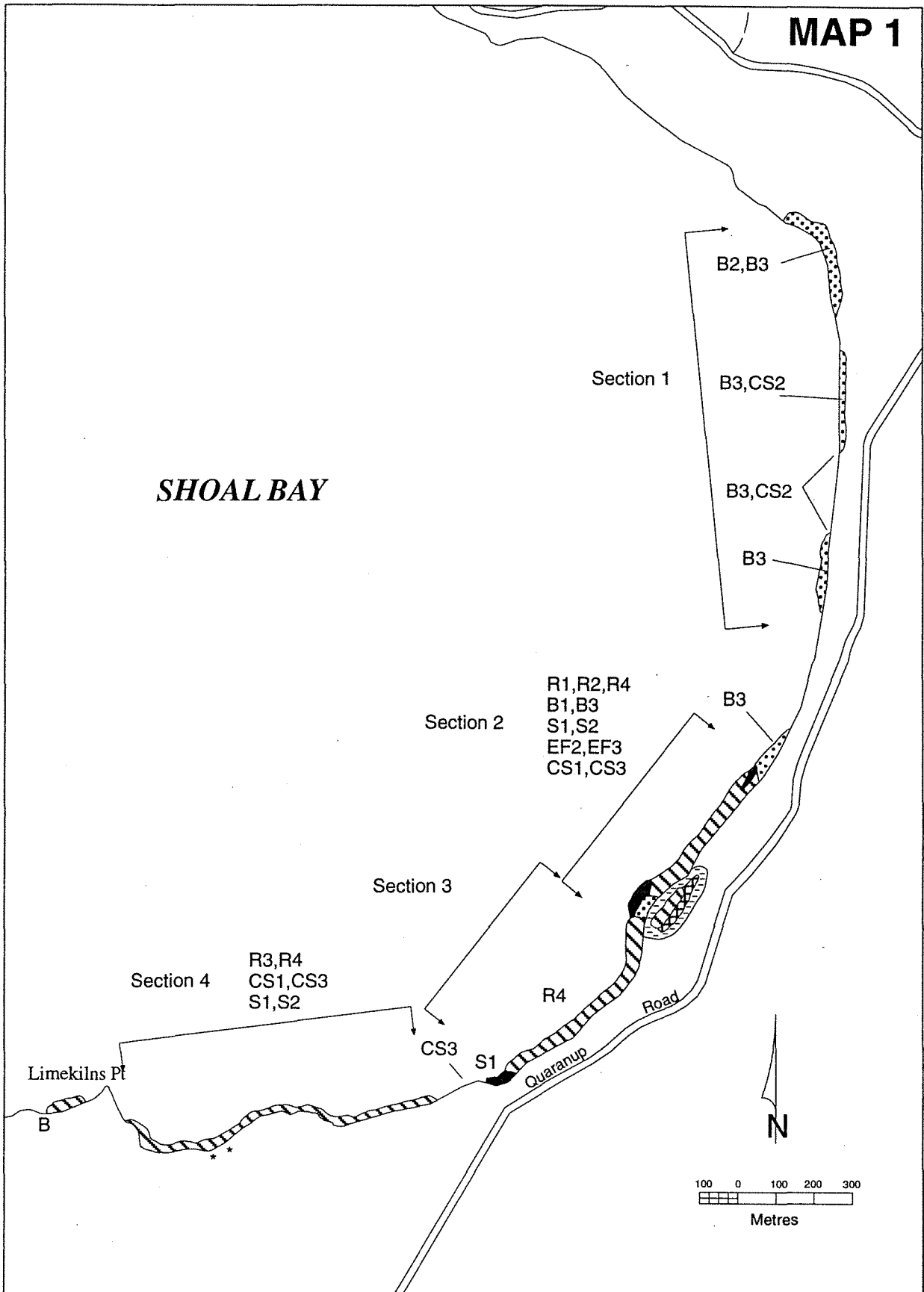
**KEY TO PRINCESS ROYAL HARBOUR  
VEGETATION PLANS**



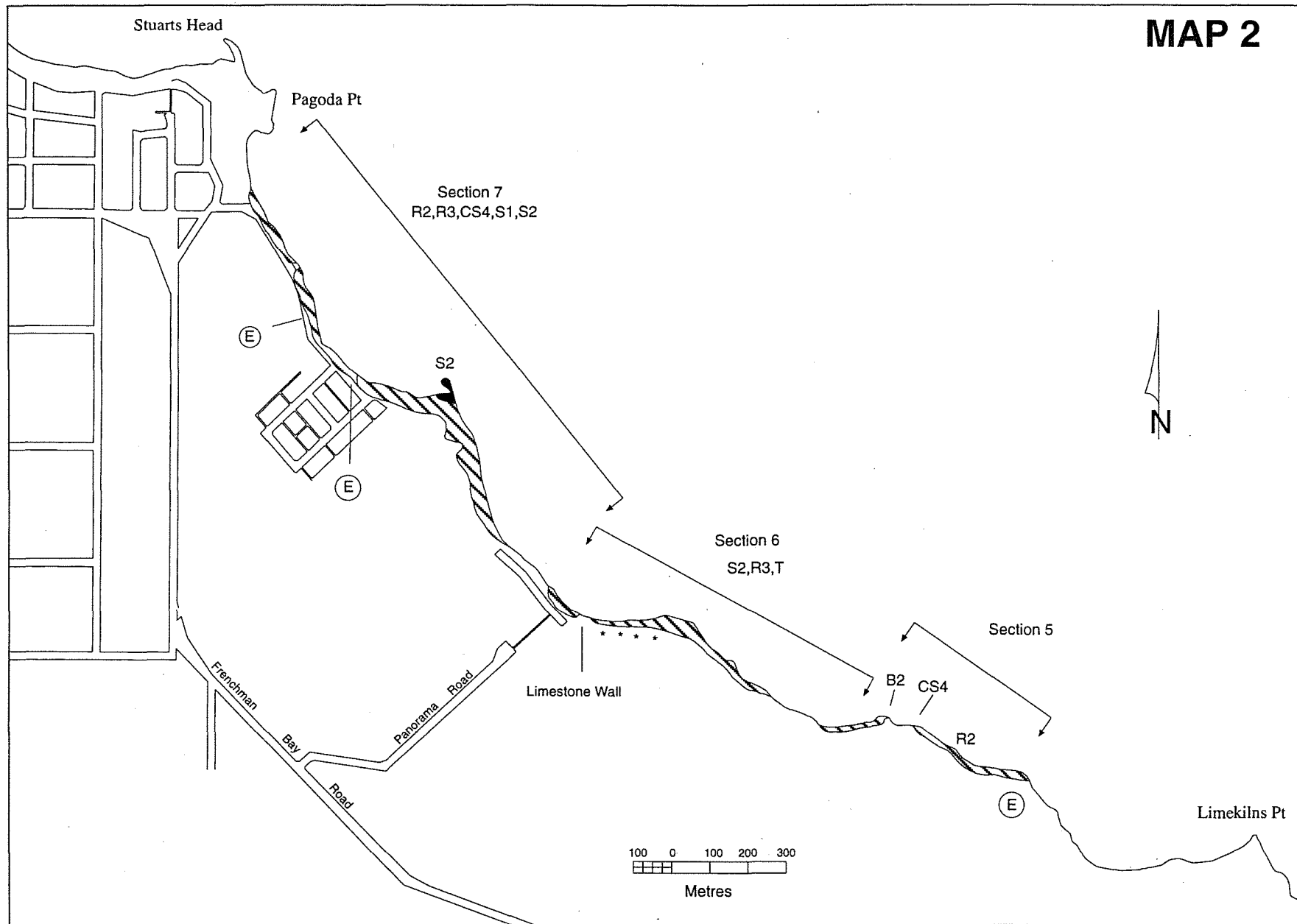


# MAP 1

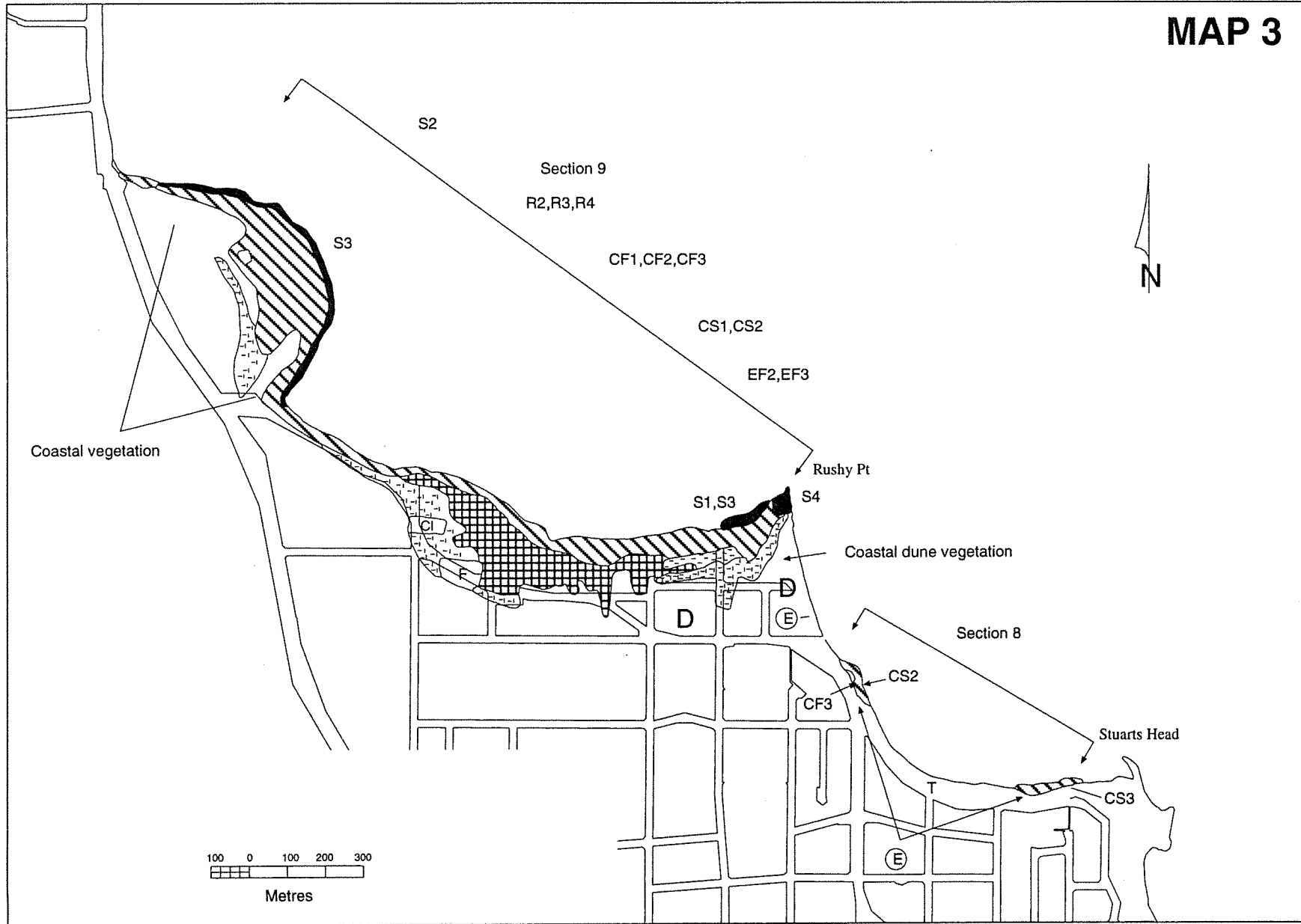
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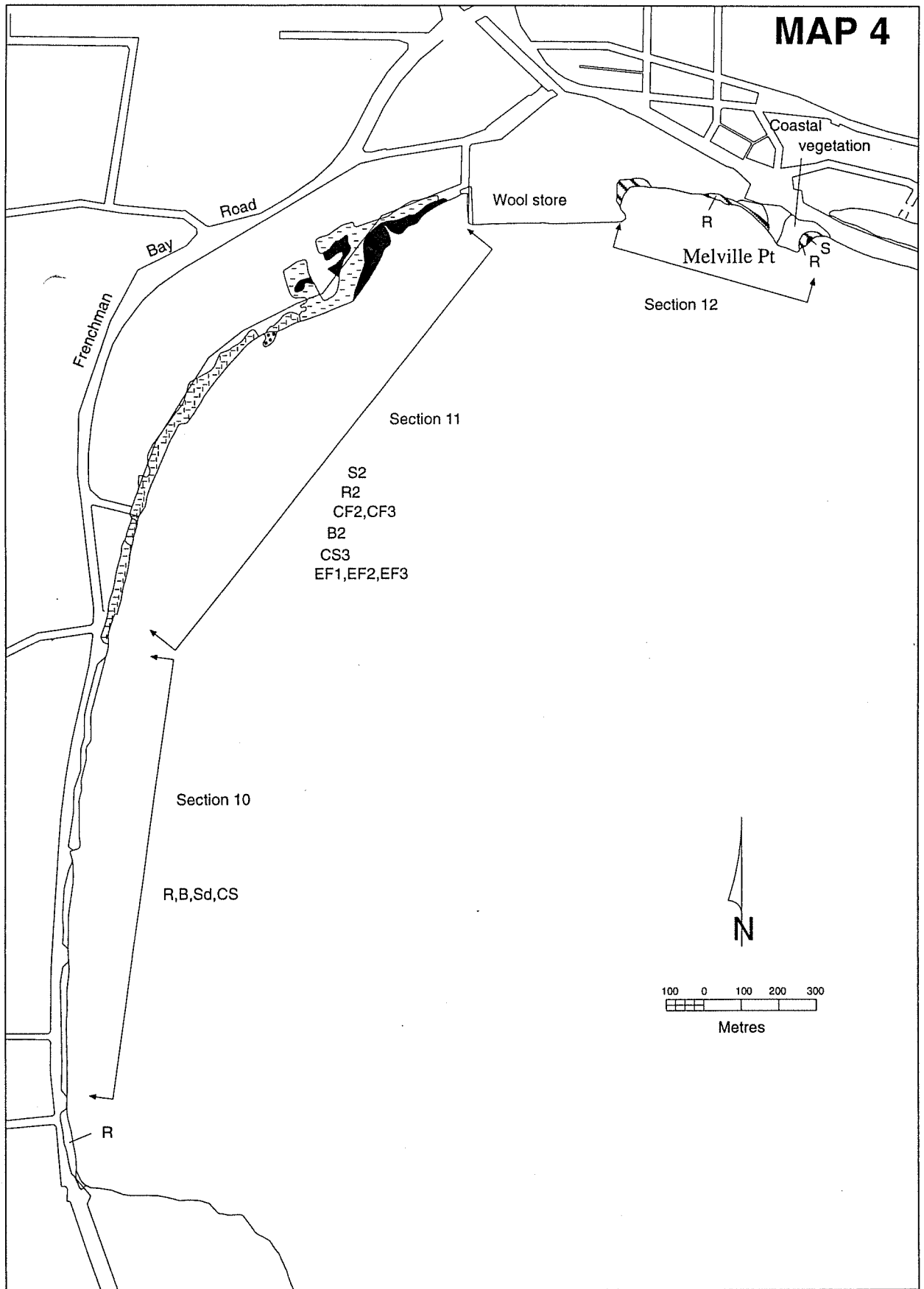


# MAP 2

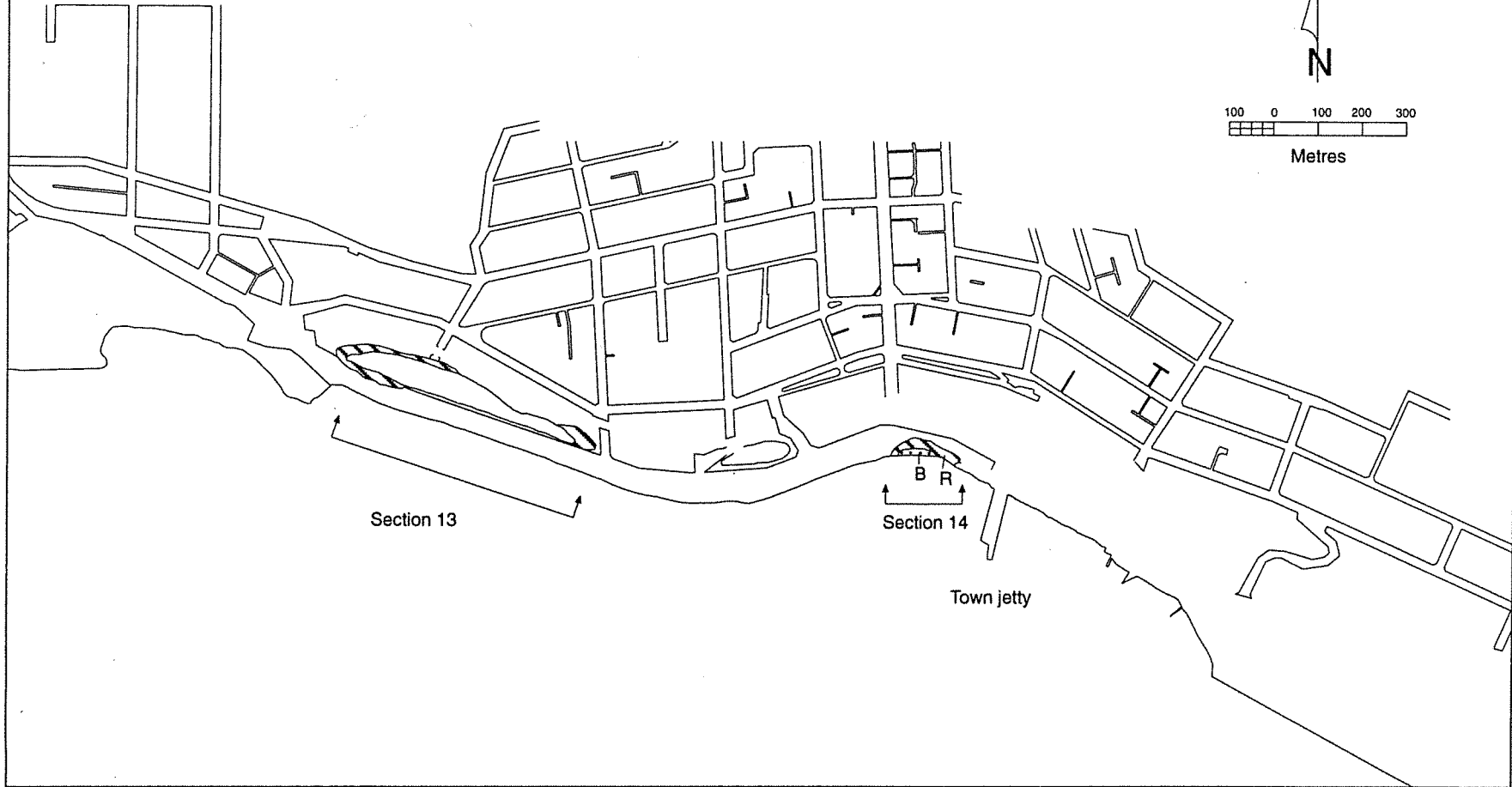
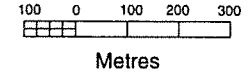


# MAP 3





# MAP 5





## LEGEND

### Princess Royal Harbour

#### Beachside vegetation



*Suaeda australis* - *Atriplex hypoleuca*  
closed herbland Community (B1)

#### Salt-marsh vegetation



*Sarcocornia quinqueflora* (closed herbland)  
Complex (S1.1, S1.2 and S1.3 ; but not S1.4)



*Juncus kraussii* (closed sedgeland) Complex (R1)

#### Estuarine fringing forest



*Melaleuca cuticularis* (low open-closed forest)  
Complex (EF1)

#### Neighbouring vegetation



Coastal seepage zone vegetation  
- sedge communities



Coastal seepage zone vegetation  
- freshwater forest

#### VEGETATION SYMBOLS



Erosion



Pampas grass

B

Buffalo Grass

Cl

Cleared

D

Development

F

Landfill

# APPENDIX 1

Aerial photographs used to map plant communities fringing Princess Royal Harbour

Princess Royal Harbour      29 January 1991 1:20,000      Job no.: 900573

WA2951(C)      Run 1      Nos 5157 - 5166

WA2951(C)      Run 2      Nos 5167 - 5174



## APPENDIX 2

Scientific names, vernacular names and short descriptions of the fringing plant species of Princess Royal Harbour

Scientific name	Common name	Description
<i>Acacia littorea</i>		large shrub
<i>Acacia cyclops</i>	Coastal wattle	large shrub
<i>Acacia hastulata</i>		large shrub
<i>Acrotriche cordata</i>	Coast ground berry	medium erect shrub
<i>Adenanthos cuneatus</i>	Coastal jug flower	large shrub
<i>Adenanthos cygnorum</i>	Woolly bush	large shrub
<i>Agonis flexuosa</i>	WA peppermint	small tree
<i>Agonis juniperina</i>	Warren river cedar	small-medium tree
<i>Allocasuarina humilus</i>	Scrub sheoak	large shrub
<i>Apium prostratum</i>	Sea celery	climbing herb
* <i>Aster subulatus</i>	Wild aster	annual herb
* <i>Atriplex prostrata</i>	Marsh saltbush	succulent herb
<i>Atriplex hypoleuca</i>		perennial herb
<i>Banksia littoralis</i>	Swamp Banksia	small tree
<i>Baumea juncea</i>	Twig rush	small-medium sedge
<i>Baumea vaginalis</i>	Sheath twig rush	medium-tall sedge
* <i>Briza maxima</i>	Quaking grass	annual grass
* <i>Cakile maritima</i>	Sea rocket	annual herb
<i>Calocephalus brownii</i>	Cushion bush	shrub
<i>Carpobrotus virescens</i>	Pigface	prostrate shrub
<i>Comesperma virgatum</i>		erect slender shrub
* <i>Conyza bonariensis</i>	Tall fleabane	annual herb
* <i>Cortaderia selloana</i>	Pampas grass	giant tufted grass
<i>Cyathochaeta avenacea</i>		tufted sedge
<i>Darwinia diosmoides</i>		shrub
* <i>Dittrichia viscosa</i>		
<i>Dryandra formosa</i>	Showy Dryandra	large shrub
* <i>Euphorbia terracina</i>	False caper	erect herb
<i>Gahnia trifida</i>	Coastal saw sedge	tall tufted sedge
<i>Gyrostemon ramulosus</i>	Corkybark	large shrub/small tree
<i>Hakea linearis</i>		large shrub
<i>Hakea varia</i>	Variable leaf hakea	large shrub

<i>Hemichroa pentandra</i>	Trailing jointweed	succulent herb
<i>Hibbertia cuneiformis</i>	Cut-leaf Hibbertia	large shrub
<i>Isolepis nodosa</i>	Knotted club rush	medium sedge
<i>Juncus kraussii</i>	Shore rush	medium rush
<i>Lepidosperma costale</i>		sedge
<i>Lepidosperma gladiatum</i>	Coast sword sedge	large sedge
<i>Lepidosperma longitudinale</i>	Common sword sedge	sedge
<i>Leptocarpus aristatus</i>	Bearded twine-rush	sedge
<i>Leptocarpus tenax</i>	Slender twin rush	sedge
<i>Leptomeria squarrulosa</i>		shrub
<i>Leucopogon obovatus</i>		medium shrub
<i>Leucopogon parviflorus</i>	Coast beard heath	medium-tall shrub
<i>Lobelia alata</i>	Angled lobelia	herb
<i>Loxocarya cinerea</i>		small sedge
<i>Loxocarya flexuosa</i>		small sedge
<i>Melaleuca cuticularis</i>	Salt-water paperbark	small tree
<i>Melaleuca incana</i>	Paperbark	large shrub/small tree
* <i>Melilotus alba</i>	Bokhara clover	erect annual herb
<i>Olearia axillaris</i>	Coast daisy bush	large shrub
<i>Olearia dampieri</i> subsp. <i>eremicola</i>		shrub
<i>Olearia heleophila</i>		small shrub
* <i>Oxalis pes-caprae</i>	Soursob	bulbous annual herb
<i>Oxylobium lanceolatum</i>	Greenbush	large shrub/small tree
<i>Patersonia occidentalis</i>	Purple flag	sedgeliike
* <i>Pelargonium capitatum</i>	Rose pelargonium	shrub
* <i>Pennisetum clandestinum</i>	Kikuyu	perennial grass
<i>Phebalium anceps</i>	Blister bush	shrub
* <i>Phragmites australis</i>		tall grass
<i>Pimelia imbricata</i>		shrub
<i>Pimelia rosea</i>	Rose banjine	medium shrub
<i>Poa porphyroclados</i>		tufted grass
<i>Rhagodia baccata</i>	Sea berry saltbush	large shrub
<i>Sarcocornia quinqueflora</i>	Samphire	succulent shrub
<i>Samolus repens</i>	Creeping brookweed	perennial small herb
<i>Schoenus</i> aff. <i>nitens</i>	Shiny bog rush	sedge
* <i>Solanum nigrum</i>	Black nightshade	annual herb

<i>Sollya heterophylla</i>	Australian bluebell	climbing shrub
* <i>Sonchus oleraceus</i>	Common sow thistle	annual herb
* <i>Sonchus asper</i>	Prickly sow thistle	annual herb
<i>Spyridium globulosum</i>	Basket bush	large shrub/small tree
<i>Sporobolus virginicus</i>	Salt-water couch	low grass
<i>Suaeda australis</i>	Seablite	small shrub
* <i>Taraxacum officinale</i>	Dandelion	herb
<i>Templetonia retusa</i>	Cockies' tongue	large shrub
<i>Tetragonia tetragonoides</i>	New Zealand spinach	prostrate shrub
<i>Triglochin striata</i>	Streaked arrowgrass	small herb
<i>Typha orientalis</i>	Bulrush	bulrush
<i>Villarsia albiflora</i>		erect aquatic herb
<i>Wilsonia humilis</i>	Silky Wilsonia	creeping shrub

\*Denotes exotic species

## Size

Small tree	<10 m
Medium tree	10-30 m
Large tree	>30 m
Small shrub	<0.25 m
Shrub (medium)	0.25-2 m
Large shrub	>2 m
Herb	0.25-1 m
Small herb	0.1-0.25 m
Tiny herb	<0.1 m
Small sedge	<0.5 m
Sedge (medium)	0.5-1 m
Tall sedge	>1 m
Rush	<1.5 m
Large rush	>1.5 m
Grass	<1 m
Tall grass	>1 m